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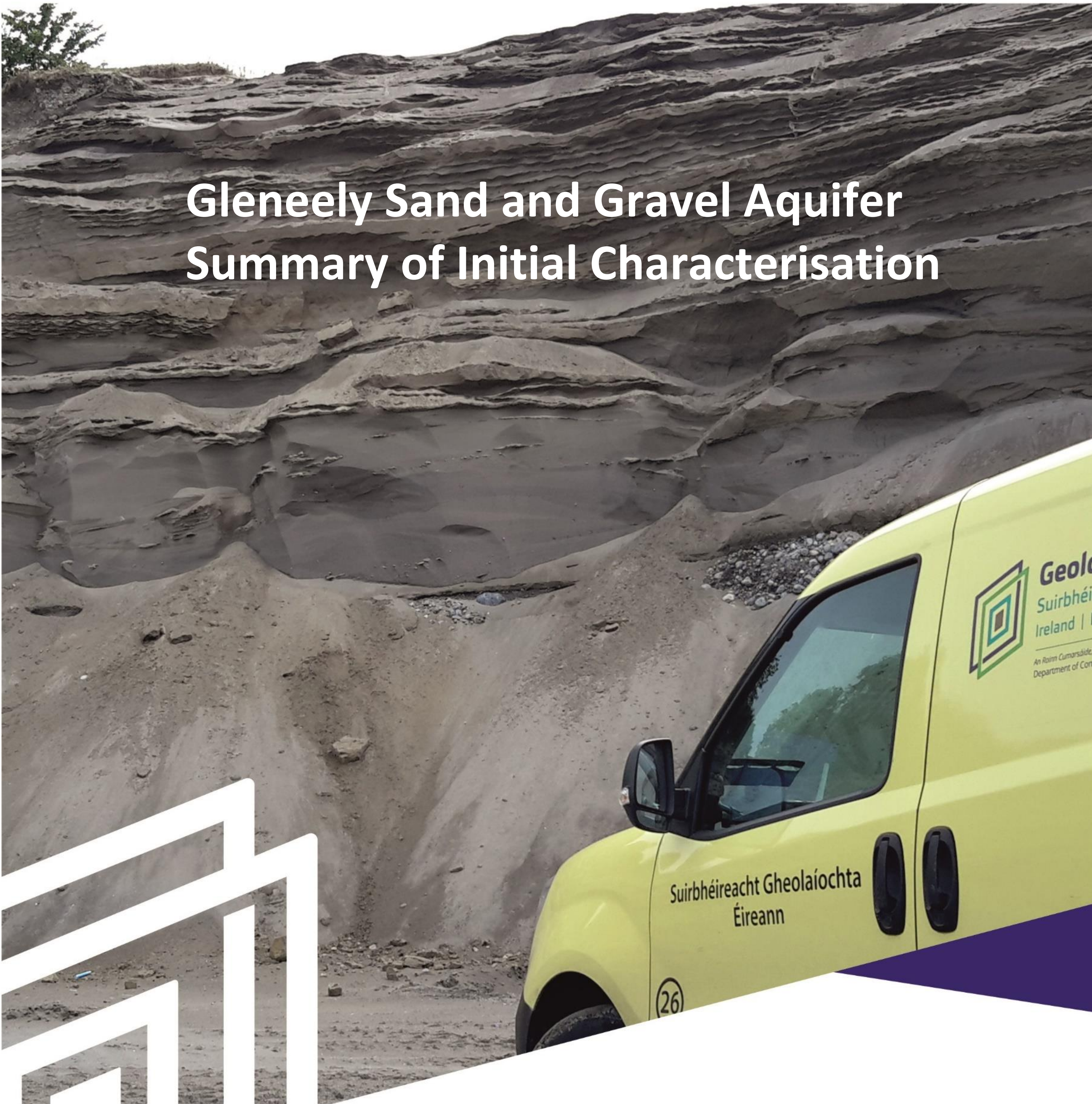
Gleneely Sand and Gravel Aquifer
Summary of Initial Characterisation



GW3D Project Report TR2023/10
January 2023

Geological Survey Ireland is a division of the Department of the Environment, Climate and Communications

Gleneely Sand and Gravel Aquifer Description January 2023

This sand and gravel report forms part of a series representing the output of a body of work undertaken to re-evaluate previously mapped sand and gravel aquifers and to identify new sand and gravel aquifers. This study resulted in the refinement of existing sand and gravel aquifer mapped extents, the modification of some sand and gravel aquifer categories, and the removal of some previously mapped sand and gravel aquifers, as well as identification of new aquifers. In addition to mapping the extent and depths of the sand and gravel aquifers, the investigations consider the hydraulic properties.

The study, undertaken as part of the GW3D project (2015-2019), comprised three parts:

1) Desk study and fieldwork preparation

Sand and gravel bodies above a minimum size criterion were extracted from the GSI Quaternary Sediments 1:50,000 map. Where it was known that the surface expression of the sands and gravels was only a small portion of the subsurface body, such areas were retained. This process left several hundred sand and gravel bodies remaining as a starting point for field work.

2) Fieldwork including mapping and data collection

Field work included a visit to each of the areas which had the potential to be (at least) a Locally Important Sand and Gravel Aquifer owing to its area. In such areas, gravel pits and sand pits were visited and depth and type of sediment recorded, other exposures into the subsurface were visited and logged, wells (whether Public Supply, Group Scheme or private farm or domestic) were dipped and any information on depths recorded, and data was collected where geological and hydrogeological data existed for the area.

3) Data collation, analysis and reporting.

All field data, and information from earlier reports and studies, were compiled and analysed. Where a sand and gravel body had qualifying aquifer properties (either 10 m depth sand and gravel, or 5 m depth saturated sediments), these areas were digitised in a GIS. The aquifer area was then ascertained and drawn up. Such areas formed the basic building blocks for the sand and gravel aquifer map, which included details on the aquifer name, area, aquifer resource value (Rg or Lg), confidence level, county, and any important aspects to note for each body.

The updated mapped sand and gravel aquifers are found on the Geological Survey Ireland site https://www.gsi.ie/en-ie/data-and-maps/Pages/Groundwater.aspx#Aquifers

The GW3D Mapping Team involved in the current revision of delineated sand and gravel aquifers were:

Geological Survey Ireland staff:

- Dr. Sophie O'Connor, Groundwater Programme / Land Mapping Unit
- Dr. Sarah Blake, Groundwater Programme

Consultant support:

- Dr. Robbie Meehan, Talamh Ireland
- Coran Kelly, Tobin Consulting Engineers
- Damien Doherty, independent Consultant Geologist/ Tobin Consulting Engineers
- Natalie Duncan, independent Consultant Geologist
- Sara Raymond, independent Consultant Geologist
- James McAteer, Gavin and Doherty Geosolutions

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Gleneely Sand and Gravel Aquifer: Summary of Initial Characterisation.

Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
40 – Donagh - Moville Donegal County Council	**Rivers:** Tirraboy River, Gleneely River, Carrowmore River, Culdaff River **Streams:** Several unnamed, minor streams **Lakes:** None	None	3.9

Topography		The Gleneely sands and gravels are set within a river valley located 6 km east of Carndonagh, and southwest and south of Culdaff (Figure 2). Elevations vary between 10 m AOD to 30 m AOD within this aquifer body. The deposit is comprised of gravel terraces and flanking alluvial flats, and is generally lowlying, set within a valley base. The alluvium and sand and gravel deposits are surrounded again by higher, bedrock cored ridges. The Culdaff River runs through the centre of the entire length of the deposit, with this watercourse the confluence of several rivers and streams which drain the surrounding upland areas.
Geology and Aquifers	**Aquifer categories**	The Gleneely sand and gravel deposit is confirmed to be greater than 10 m deep, and has a saturated thickness greater than 5 m. The thickness, saturated thickness and areal extent satisfy the criteria of a **Locally Important Sand and Gravel Aquifer (Lg)** (DELG/EPA/GSI, 1999; GSI, 2017).
	Main aquifer lithologies	The aquifer body has three main components; alluvium deposited by river water along the Culdaff River, raised beaches, and the adjacent, glaciofluvial sand and gravel terraces. The alluvium is 12 m deep and is composed of two layers of sand and gravel separated by a clay/peat layer, which lies between 4.5 m and 6.3 m below ground level (Cullen, 1998). The gravel terraces are comprised of glaciofluvial sands and gravels derived chiefly from metamorphic rocks (GSI, 2023).
	Key structures	Borehole logs show the variability of the aquifer material, which consists largely of sands and gravels, with occasional low permeability horizons. The underlying bedrock includes Precambrian Quartzites, Gneisses and Schists (GSI, 2020) which is are classed as Poor Bedrock Aquifers (GSI, 2023).
	Key properties	Borehole logging data indicate that the alluvium is composed largely of well sorted sands and gravels. Clay layers within are up to 2 m thick in places; however these units do not appear in all boreholes and so are not thought to be laterally continuous. Coarse material predominates and therefore permeability and storativity are expected to be high. Using the Logan method (Misstear, 1998) aquifer transmissivity was estimated at $284m^2$/day, from pumping test data collected at the Gleneely Public Water Supply (Cullen, 1998). The aquifer is generally unconfined, but may become locally confined where the lower permeability clay and peat deposits overlie, or are interbedded with, the sands and gravels. The slope of the water table is expected to be relatively subdued, owing to the permeable nature of the aquifer. The bedrock aquifer has a high degree of rejected recharge associated with it, and the retention of recharge in the basal layers of the sand and gravel causes the water table to rest at a relatively shallow depth.
	Thickness	Borehole records indicate sediments are up to 12 m in thickness, with an average saturated thickness of at least 5 m proven within the alluvium (Cullen, 1998). Further work is needed to confirm the thickness and saturation of the gravel deposits flanking the alluvium material.
Overlying Strata	**Lithologies**	The gravel terrace on the eastern side of the aquifer is partially overlain by peat deposits. Historical, six inch scale, GSI bedrock and Quaternary mapping indicates the presence of raised beach deposits beneath the peat here, in Cashel Townland. Based on topography, it is assumed that the raised beach deposits beneath this peat also connect to the aquifer body.
	Thickness	The thickness of the overlying peat is unknown, but is likely to be no more than 3 m deep.
	% area aquifer near surface	20%

	Vulnerability	As some of the aquifer body is at the surface it is vulnerable; consequently pollutants can easily infiltrate the aquifer. Sand and gravel aquifers are categorised as having either 'High or 'Extreme' vulnerability (DELG/EPA/GSI, 1999), with the vulnerability classification determined by the depth to the water table from ground level. In areas where the water table is less than 3 m below ground level, the aquifer vulnerability is mapped as 'Extreme'. The area of the aquifer covered with peat is classified as being of 'High' vulnerability, as the peat is considered to provide some protection to the sand and gravel aquifer beneath. Water level records within the alluvium (Cullen, 1998) and a water level measurement from within the gravel terrace at the east of the aquifer (Groundwater 3D Project, 2015) all suggest that the water table is less than 3 m below ground level.
Recharge	**Main recharge mechanisms**	Diffuse recharge occurs *via* infiltration of rainfall through the unsaturated sand and gravel. The proportion of the effective rainfall that recharges the aquifer is largely determined by the thickness and permeability of the soil and subsoil, and by the slope (DELG/EPA/GSI, 1999). Typically, the proportion of recharge that infiltrates to groundwater in sorted sands and gravels is around 85% (Hunter Williams *et al*., 2011). Rejected recharge from the surrounding hills also increases the amount of available recharge to this valley-setting aquifer. Where the elevation of the water table is lower than that of the river bed, as it would be in summer, the aquifer may receive additional recharge from the river.
	Est. recharge rates	The rainfall in the area of the Gleneely sands and gravels is 1,200 mm (Walsh, 2012), and the estimated recharge rate to the aquifer from direct recharge is 284 mm/yr. The minimum groundwater throughput in the aquifer is estimated to be 2,962 m^3/d, with the majority of this volume coming from rejected recharge from the surrounding hills.
Discharge	**Large springs and large known abstractions (m^3/d)**	The Gleneely Public Water Supply borehole which abstracts groundwater from this aquifer has an 'Excellent' yield of 414 m^3/day. A 42 hour pumping test was undertaken by Cullen (1998) on a trial well close to this public supply, and the drawdown was monitored in both the public water supply and an abandoned trial well. This trial well was found to have a 'Good' yield of 338 m^3/day.
	Main discharge mechanisms	The main discharges are likely to be to the rivers which flow through the aquifer. Where the water table is sufficiently close to the surface such that the river bed elevation is lower than it is, the aquifer will contribute groundwater to the baseflow of the river. There is also likely to be groundwater seepage from the extremities of the gravel body at lower elevations which may appear as seeps at surface.
	Hydrochemical Signature	There are raw water samples available for this public water supply (Cullen, 1998; EPA Drinking Water Returns, 2002, 2005), which indicate that the water quality within this aquifer is generally good (as was the case also in Cullen, 1998). Parameters that exceed EU Drinking Water Limits include iron and manganese. The conductivity ranges between 164 µS/cm and 419 µS/cm, and pH is quite variable. Iron and manganese levels exceed the EU Drinking Water Standard limits (98/83/EC), but these may be naturally high owing to the highly acidic geology of the valley setting. The highest recorded level of iron is 720 µg/l (EPA Drinking Water Returns, 2005), and that of manganese is 540 µg/l (Cullen, 1998). The groundwater is likely to have a calcium bicarbonate signature.
Groundwater Flow Paths		It is assumed generally that the surface water and groundwater flow directions (southeast to northwest) coincide. The length of flowpaths in sand and gravel aquifers depends on the size of the deposit. In general, locally important sand and gravel aquifers are expected to have relatively short flow paths due to their limited extent *i.e*. up to several hundred metres. This is expected to be the case at Gleneely, given the setting and geometry of the deposit.
Groundwater & Surface water interactions		Hydraulic connection between the groundwater in the aquifer and river water is expected to be high, thus water will be able move into and out of the aquifer depending on the river stage.

<table>
<tr><td>Conceptual model</td><td colspan="2">

The aquifer body has three main components; alluvial sands and gravels, raised beach deposits and glaciofluvial sand and gravel terraces, which are all thought to be hydraulically connected at depth.
The sands and gravels also extend under adjacent areas mapped as peat. Due to the increased uncertainty with demarcating these sediments at depth, these areas are delineated conservatively.
The boundaries of the aquifer are delimited for the most part by the extent of the mapped sand and gravel deposit (GSI, 2023). Where the deposits are concealed beneath surficial peat historical mapping and borehole logs are used to infer their extent.
Recharge occurs diffusely across the aquifer area, as well as via rejected recharge from the surrounding, relatively impermeable bedrock and subsoils, at depth.
The aquifer is generally unconfined, but may become locally confined where it is overlain by low permeability deposits.
The water table is generally at a shallow depth and therefore groundwater and surface waters are interpreted to be closely linked.
Groundwater flows are thought to mirror surface water flows, trending southeast to northwest in general.
Groundwater discharge will occur via seeps along the lowest boundary of the sand and gravels body, and also along the river.
There may also be discharge to rivers as baseflow where the water table lies above the river water level.
The minimum groundwater throughput in the aquifer is estimated to be 2,962 m^3/d, with the majority of this volume coming from rejected recharge from the surrounding hills.

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<tr><td>Attachments</td><td colspan="2">Figure 1: Piper Diagram
Figure 2: Location and extent
Figure 3: Cross sections
Figure 4: Groundwater vulnerability</td></tr>
<tr><td>Instrumentation</td><td>Hydrometric gauges:
National Water Monitoring Stations;
River:
Groundwater:</td><td>None present

RS40C020080 Gleneely outlet
None present</td></tr>
<tr><td>Information Sources</td><td colspan="2">

Cullen, K. T. (1998). Report on the Hydrogeological Investigation of the Gleneely-Culdaff Area, County Donegal. Unpublished report for Donegal County Council.
Daly, D. (1987). A preliminary investigation of a water supply for Gleneely, Co. Donegal. Unpublished Report, Groundwater Section, Geological Survey of Ireland.
DELG/EPA/GSI (1999). Groundwater Protection Schemes. Department of the Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland.
EPA Drinking water returns: http://erc.epa.ie/safer/dataAndResources/publiclyAvailableDatasets.
EPA Website: http://gis.epa.ie/Envision/
GSI (2017). A description of Irish aquifer categories. 3 pp. Available from: https://www.gsi.ie/documents/GSI%20Aquifer%20Category%20Descriptions.pdf
GSI (2023). Geological Survey Ireland Spatial Resources Viewer. https://www.gsi.ie/en-ie/data-and-maps/Pages
Hunter Williams, N., Misstear, B., Daly, G., Johnston, P., Lee, M., Cooney, P. and, Hickey, C. (2011). National Groundwater Recharge Map for Ireland. Geological Survey Ireland and Department of Civil, Structural and Environmental Engineering, Trinity College Dublin.
Lee, M. and Fitzsimons, V. (2004). County Donegal, Groundwater Protection Scheme Volume I: Main Report. Geological Survey of Ireland.
Misstear, B.D.R. (1998). The Logan Method for Analysing Pumping Test Data. Article published in: The GSI Groundwater Newsletter, edited by: Donal Daly. GSI publication No. 34.
Ó'Súilleabháin, C. (2000). Assessing the boundary between high and moderately permeable subsoils. Unpublished MSc., University of Dublin. Department of Civil, Structural and

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Information Sources (contd.)	Environmental Engineering, Trinity College Dublin. • Walsh S. (2012). A Summary of Climate Averages 1981-2010 for Ireland, Climatological Note No.14, Met Éireann, Dublin. • Wright, G.R., Aldwell, C.R., Daly, D. and Daly, E.P. (1982). Groundwater resources in the Republic of Ireland, vol 6. In: European community's Atlas of groundwater resources, SDG, Hannover, Germany.
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations and assumptions based on the information sources described above and established hydrogeological formulae. FigureS 1, 2 and 3 are used for illustrative purposes only.

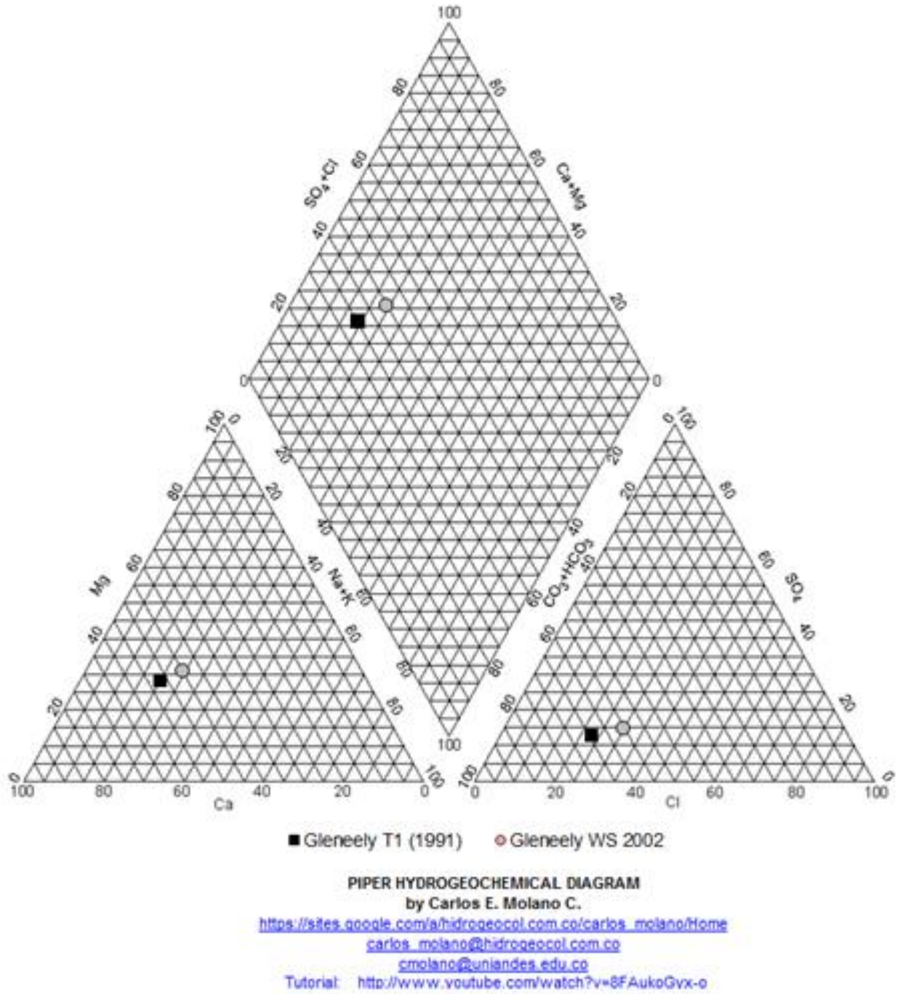

Figure 1. Groundwater chemistry analyses from Gleneely Water Supply Scheme (Cullen, 1998).

Gleneely Sand and Gravel Aquifer

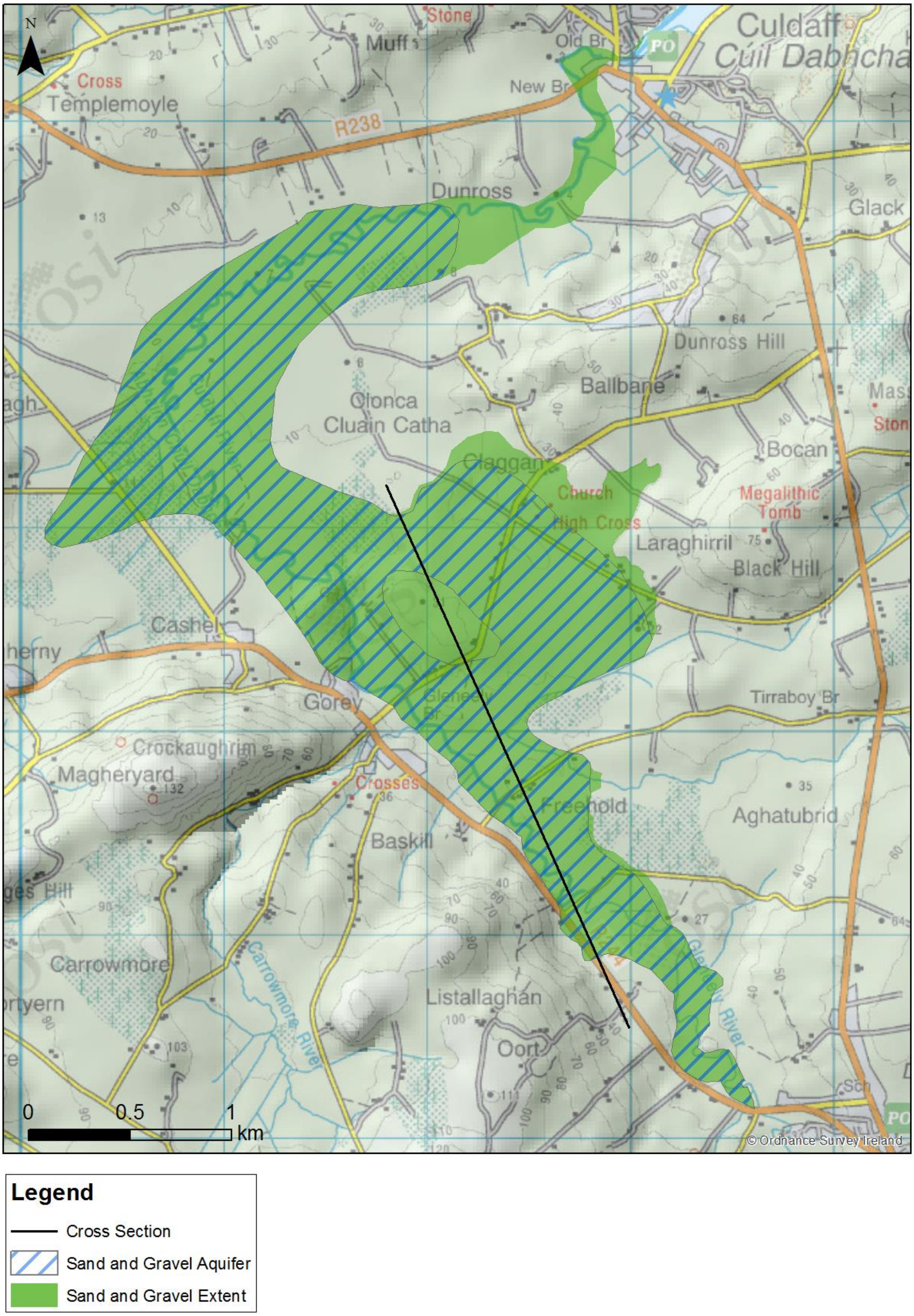

Figure 2. Gleneely Sand and Gravel Aquifer extent with cross section location.

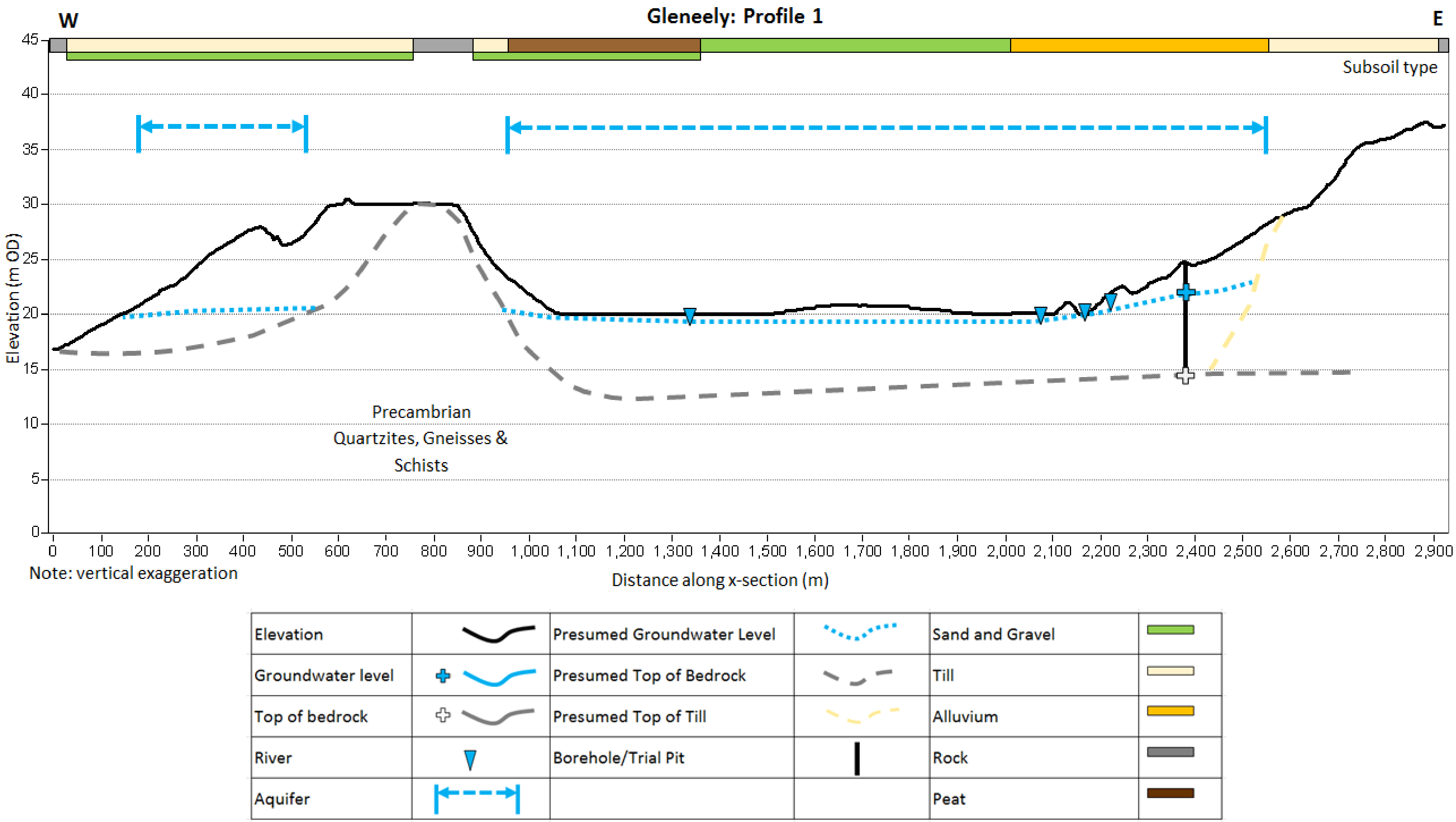

Figure 3. Cross section through the Gleneely Sand and Gravel Aquifer body.

Gleneely Sand and Gravel Aquifer Vulnerability

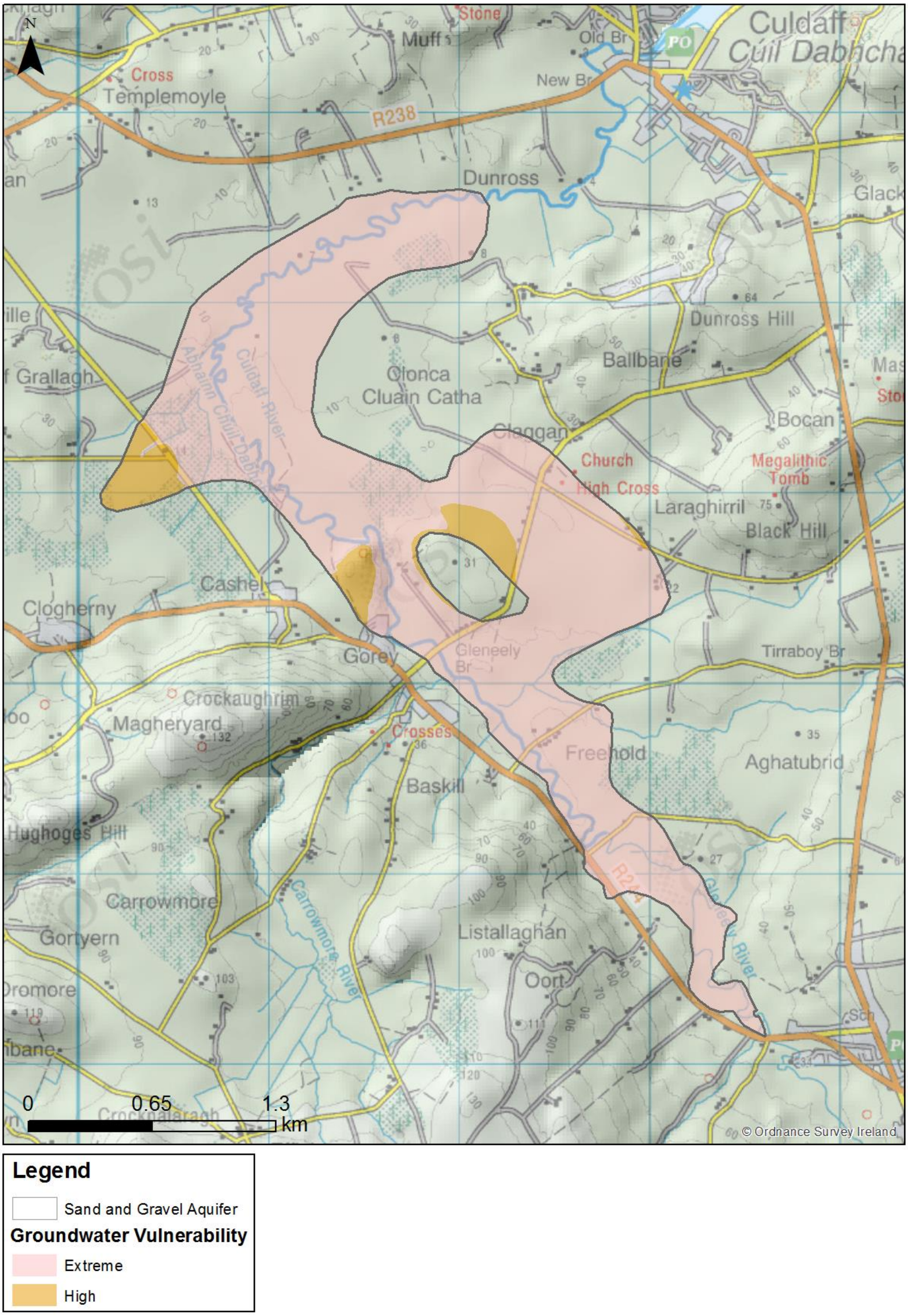

Figure 4. Groundwater vulnerability across the Gleneely Sand and Gravel Aquifer.