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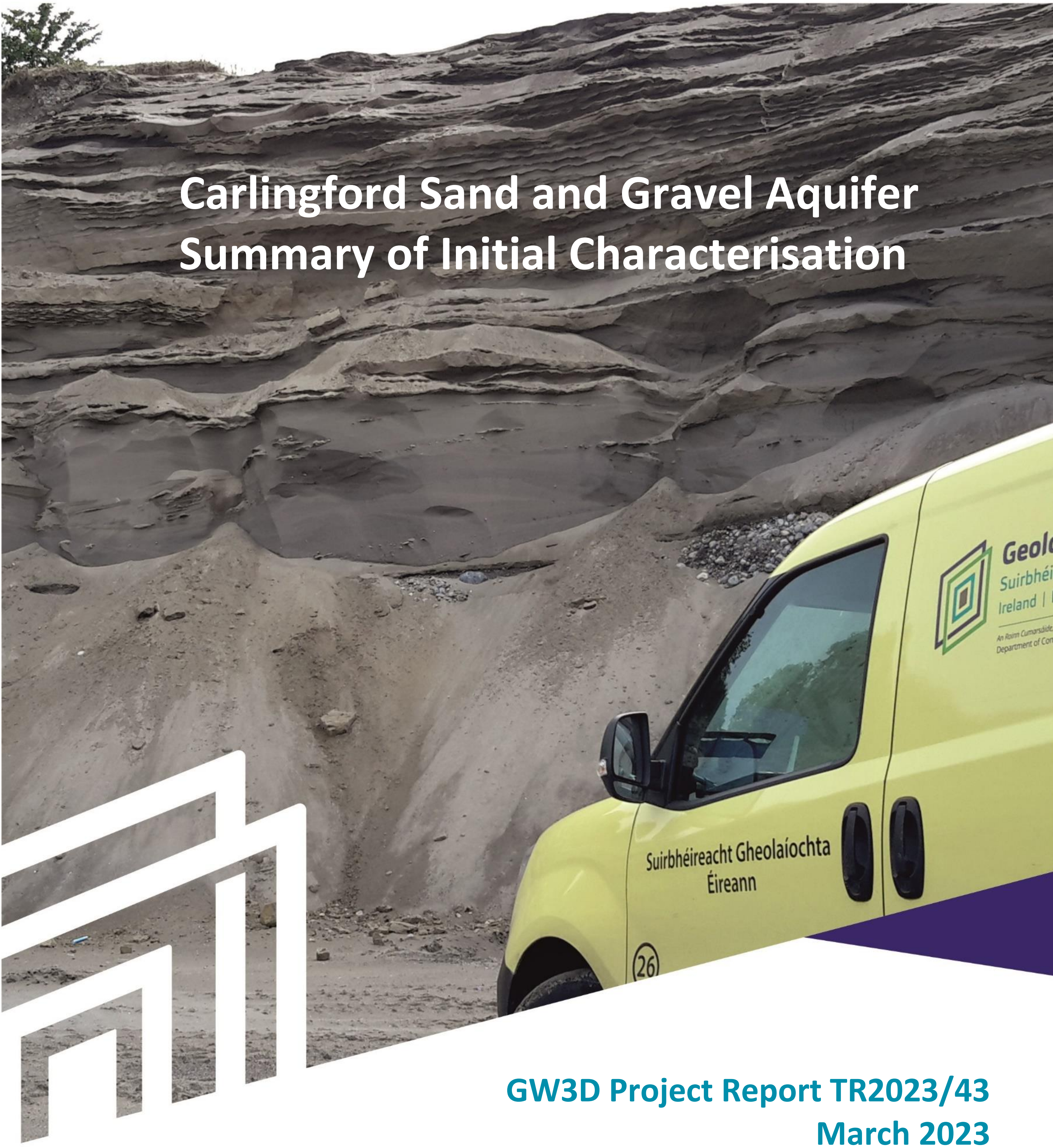
Carlingford Sand and Gravel Aquifer Summary of Initial Characterisation



GW3D Project Report TR2023/43
March 2023

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

Carlingford Sand and Gravel Aquifer Description March 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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Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
06 - Newry, Fane, Glyde and Dee Louth County Council	**Rivers:** Unnamed rivers **Streams:** Several unnamed streams **Lakes:** Shilties Lough, Mill Pond	Carlingford Shore SAC Carlingford Lough SPA Carlingford Lough pNHA	1

Topography		The Carlingford sand and gravel aquifer body is a glaciofluvial outwash deposit (GSI 2023a) situated just inland from the coastline along the eastern foot of Slieve Foye Mountain, at the northeastern end of the Cooley Peninsula. The feature was probably a subaerial outwash fan at the end of the last glaciation (McCabe, 2008). The ground altitude of the body varies between 0 m to 10 m AOD. The deposit is surrounded by glacial till and bedrock outcrop and subcrop on higher slopes to the west, and by the coastline at the east. In the northwest, made ground covers much of the aquifer surface, where the town of Carlingford is situated.
Geology and Aquifers	**Aquifer categories**	The Carlingford sand and gravel deposit is confirmed to be greater than 10 m in thickness and has a saturated thickness greater than 5 m (Meehan, 2010). 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 main components of the deposit are glaciofluvial sands and gravels derived chiefly from granites (GGr) and marine, raised beach gravels and sands (MGs) (GSI, 2023a).
	Key structures	Borehole logs show the variability of the aquifer material, which consists largely of interbedded SAND and GRAVEL horizons. The aquifer is partially underlain by bedrock of Dinantian Limestones, and also by Silurian Metasediments (GSI, 2023a). The limestone is a 'Locally Important' Aquifer; the Metasediments are a 'Poor' Aquifer (GSI, 2023a). Bedrock was not recorded in the logs as being met in any of the boreholes from within the body of the aquifer. Hydrochemistry records for the Cooley Water Supply suggest that the aquifer is being recharged by subsurface flows from the locally important limestone aquifer to the west, indicating that they are in hydraulic connectivity with the sands and gravels (Meehan, 2010).
	Key properties	Pumping tests at the Cooley Water Supply borehole in Carlingford in 1998 reported a combined potential yield of 2,000m^3/day (after Meehan, 2010). Though permeability testing data are limited, productivity and borehole logging indicate that coarse material predominates and that permeability and storativity are high. The aquifer seems to be unconfined (Meehan 2010).
	Thickness	Depth to bedrock is expected to be variable throughout the area of the aquifer. Although depth to bedrock is not confirmed by borehole logs within the aquifer area, GSI's 19th century field mapping sheets (6 inch to 1 mile) indicate the presence of a limestone quarry within the central portion of the deposit, ~230 m northeast of the PWS boreholes. The sand and gravel aquifer itself has a depth of over 24 m at this borehole, and it thins out southwards where is it recorded as being only 4 m in thickness (GSI, 2023b). The aquifer is thought to be at thickest along the western boundary of the body, where it abuts the mountain slopes. South of the delineated aquifer area, borehole logs indicate that depth to bedrock again decreases, meaning that the sand and gravel body occupies a marked depression in the bedrock. A depth of 5 m is a conservative estimate of the average saturated thickness within the sands and gravels.
Overlying Strata	**Lithologies**	There are no sediments overlying any portion of the Carlingford sand and gravel aquifer.
	Thickness	N/A
	% area aquifer near surface	100%

	Vulnerability	The aquifer is at the surface and therefore vulnerable; consequently pollutants can easily infiltrate the body of 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. Measured water levels in the Carlingford sand and gravel body range from 3.6 m to 6.3 m below ground level. In areas where the water table is less than 3 m below ground level the aquifer vulnerability is mapped as 'Extreme'; this accounts for 50% of the area of the aquifer. Where the water table depth it is greater than 3 m below ground level, the aquifer vulnerability is mapped as 'High'.
Recharge	**Main recharge mechanisms**	The aquifer receives both direct and indirect recharge. Direct recharge, which is diffuse, occurs by infiltration of rainfall through the unsaturated sands and gravels. 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 (DoELG/EPA/GSI, 1999). Typically the proportion of recharge that infiltrates to groundwater in sands and gravels is around 85% (Hunter Williams *et al*., 2011)). Rejected recharge from the surrounding hills increases markedly the amount of available recharge to this aquifer (Meehan, 2010). The groundwater chemistry of the water at the PWS indicates that the aquifer receives recharge from the limestone to the west.
	Est. recharge rates	The average recharge rate from infiltration of rainfall, which is 1,067 mm at the source, is estimated as 412 mm/year (Meehan, 2010). The minimum direct groundwater throughput in the aquifer is estimated to be 294 m^3/d, which rises to 3,398 m^3/d when rejected recharge from the mountain slopes to the west is included.
Discharge	**Large springs and large known abstractions (m^3/d)**	The Cooley Water Supply Scheme includes two boreholes which are reported having 'Excellent' yields, and an estimated joint potential yield of 2,000m^3/day (Meehan, 2010).
	Main discharge mechanisms	The main discharge mechanisms are to the springs that rise adjacent to the Cooley Water Supply boreholes (Meehan, 2010), as well as potentially to the marshy areas north of this, and around Shilties Lough. The aquifer also thought to discharge along the coastline, which has been observed at low tide as groundwater seeps.
	Hydrochemical Signature	Meehan (2010) analysed the available data for the Carlingford boreholes which included EPA monitoring data from 2007-2013. The water was found to be "very hard" and have a calcium-bicarbonate hydrochemical signature. There were no exceedances above the EU Drinking Water limits of nitrate, potassium or chloride.
Groundwater Flow Paths		The principal groundwater flow direction within the aquifer body is aligned with topography, and therefore southwest to northeast (after Meehan, 2010). Flow paths are relatively short, owing to the restricted lateral extent of the aquifer. Information on water levels is limited. There are not enough hydrogeological data to calculate precise groundwater gradients, but low gradients are considered to be typical of sands and gravels.
Groundwater & Surface water interactions		The sand and gravel deposits are generally very well drained; however, marshy areas are present in the Liberties of Carlingford Townland. This area is thought to be fed by springs. There are not enough data to determine whether there is sea water intrusion along the coast into the sand and gravel body.
Conceptual model	• The Carlingford sand and gravel aquifer is composed of glaciofluvial sand and gravels derived chiefly from granites, and marine sands and gravels. • The boundaries of the aquifer are delimited for the most part by the extent of the mapped sand and gravel deposit (GSI, 2023a). • The thickness of the aquifer is variable, with an estimated average of saturated material of 5 m. • The groundwater gradient is considered to be shallow, as expected due the high permeability of the aquifer. • Reported yields for this aquifer are 'Excellent'. • The aquifer is recharged by infiltrating rainfall, and rejected rainfall runoff and rejected recharge from the	

	steep slopes of Slieve Foye Mountain at the west. • The aquifer discharges to a series of springs near Carlingford town, and along the coastline as seeps. • The minimum direct groundwater throughput in the aquifer is estimated to be 294 m^3/d, which rises to 3,398 m^3/d when rejected recharge from the mountain slopes to the west is included.	
Attachments	Figure 1: Location and extent Figure 2: Cross section Figure 3: Groundwater vulnerability Figure 4: Piper diagram	
Instrumentation	**Hydrometric gauges:** **National Water Monitoring Stations;** **River:** **Groundwater:**	None present None present GWIE_NB_G_01521000003 Carlingford
Information Sources	• An Foras Forbatha and Geological Survey Office (1982). Groundwater Resources in the N.E.(R.D.O). Region. March 1982. Volumes 1 to 3. • Daly, E. P. (1980). An Interim Report on the Cooley Peninsula Sand and Gravels. Unpublished Report, Groundwater Section, Geological Survey of Ireland. • Daly, E. and O'Connell, Y. (2013). Groundwater and Land Resources in Tellus Border Coastal Zones: Final Report. Geological Survey of Northern Ireland and Geological Survey of Ireland Open Report. 65pp. • DELG/EPA/GSI (1999). Groundwater Protection Schemes. Department of the Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland. • EPA map viewer. https://gis.epa.ie/EPAMaps • GSI (2017). A description of Irish aquifer categories. 3 pp. Available from: https://www.gsi.ie/documents/GSI%20Aquifer%20Category%20Descriptions.pdf • GSI (2023a). Geological Survey Ireland Spatial Resources Viewer. https://www.gsi.ie/en-ie/data-and-maps/Pages • GSI (2023b). Geological Survey Ireland. Internal Groundwater Database. • 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. • McCabe, A.M (2008). Glacial Geology and Geomorphology: The Landscapes of Ireland Dunedin Academic Press, Edinburgh. • Meehan, R.T. (2010). Cooley Water Supply Scheme, Carlingford Boreholes, Groundwater Source Protection Zones Report, Geological Survey of Ireland. • Murphy, O. (2012). County Louth Groundwater Protection Scheme. Report to Louth County Council. Geological Survey of Ireland. • NPWS map viewer. http://webgis.npws.ie/npwsviewer • Ó’ Riain, G. (2004). Water Dependent Ecosystems and Subtypes Draft Report. WFD Support Projects. Compass Informatics in association with National Wildlife and Parks Service (DEHLG). • Robinson, K.W. (1973). A Resistivity Survey on the Cooley Peninsula, County Louth, for the Hydrogeology section. Unpublished MSc. Thesis, 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.	

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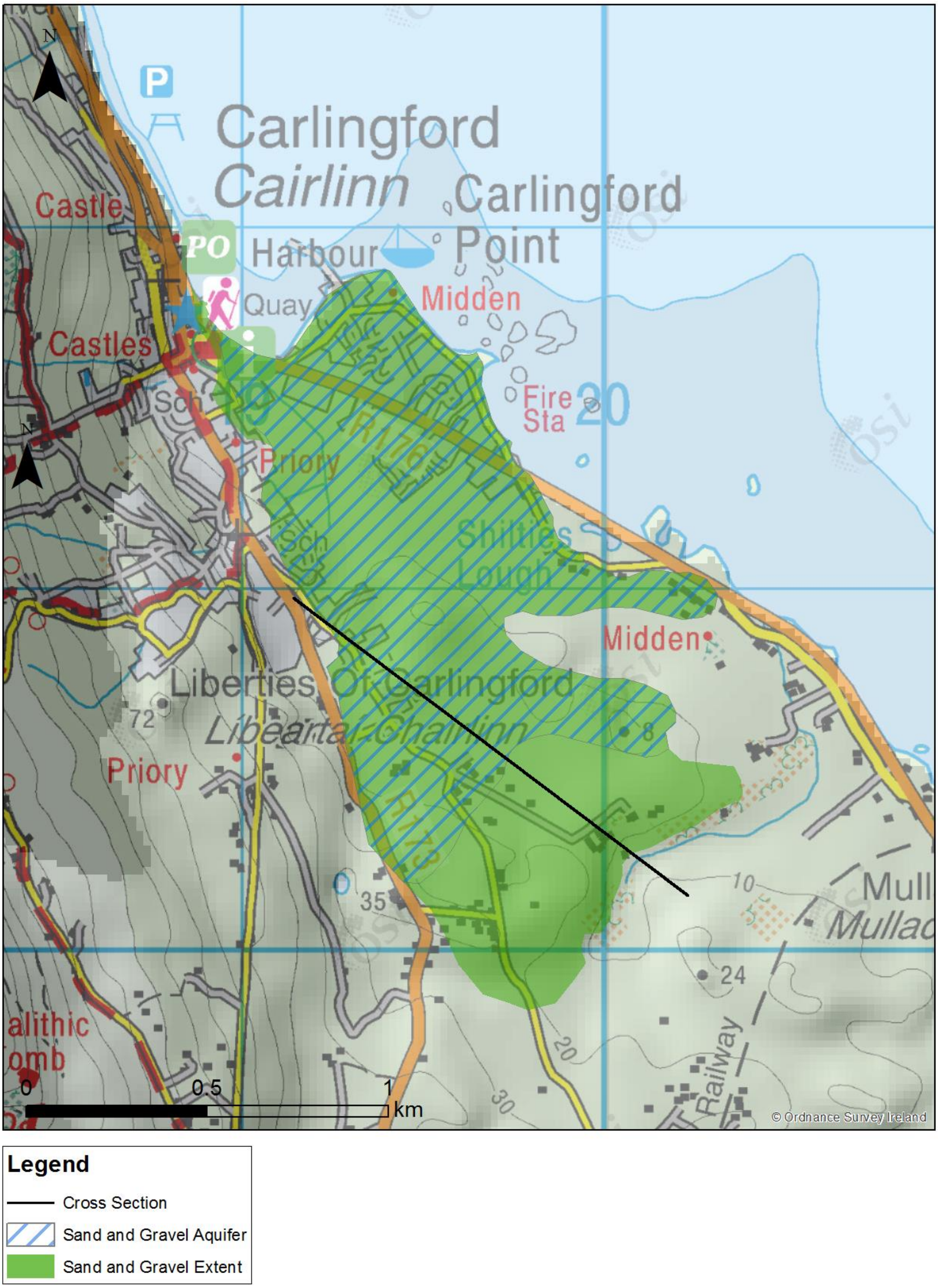
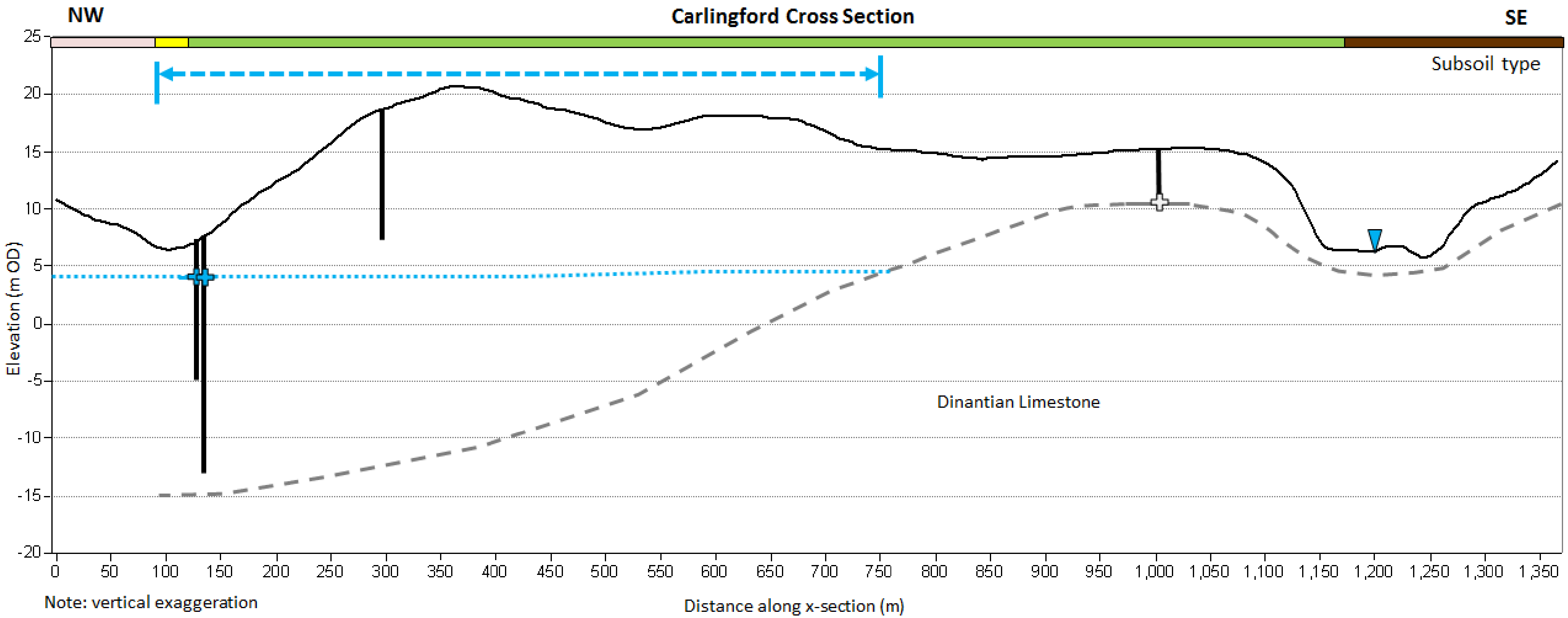


Figure 1. Carlingford Sand and Gravel Aquifer extent with cross section location.



Elevation		Aquifer		Sand and gravel	
Groundwater level		Presumed Groundwater Level		Till	
Top of bedrock		Presumed Top of Bedrock		Alluvium	
River		Borehole/Trial Pit		Peat	

Figure 2. Cross section through the Carlingford Sand and Gravel Aquifer body.

Carlingford Aquifer Vulnerability

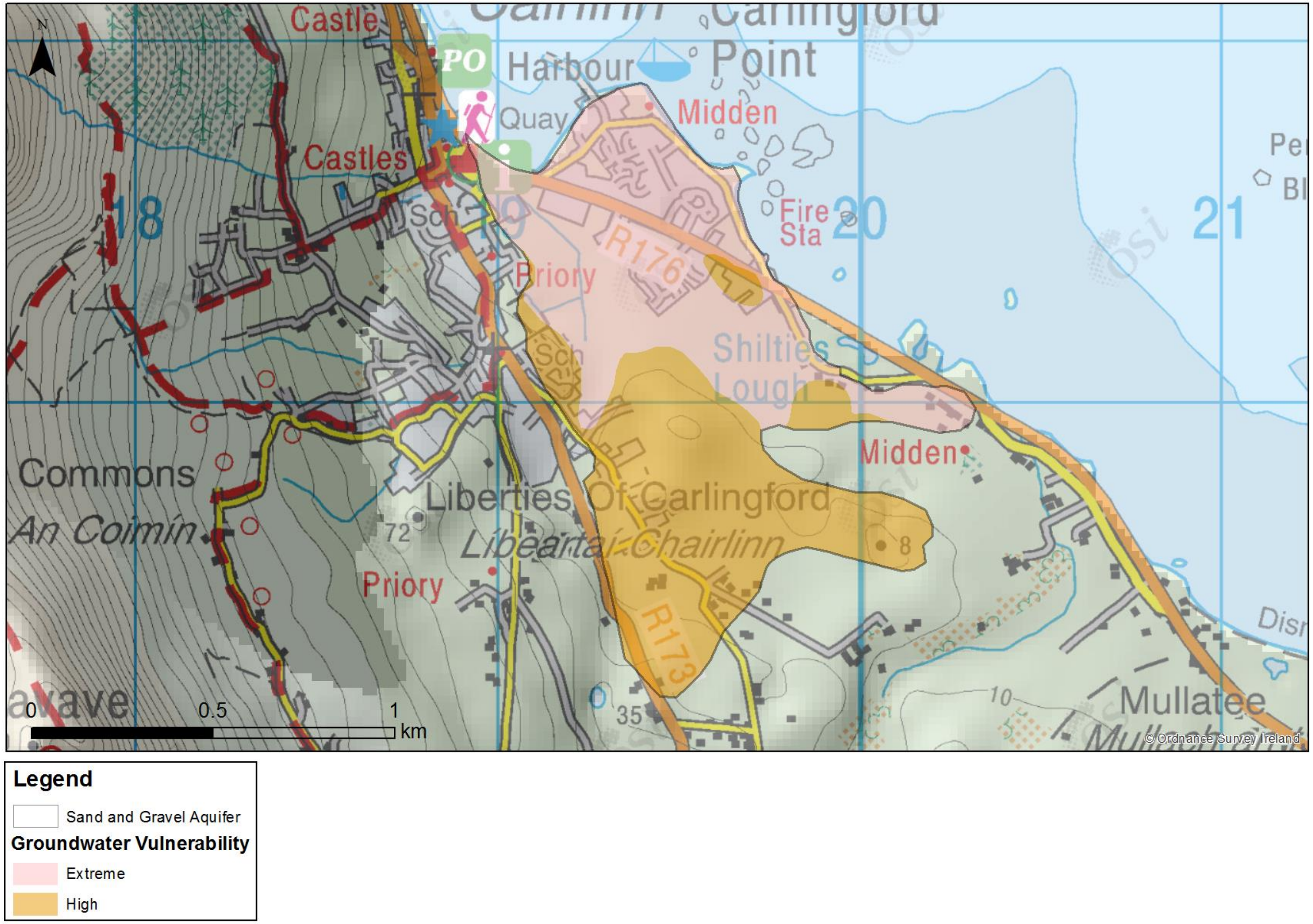


Figure 3. Groundwater vulnerability across the Carlingford Sand and Gravel Aquifer.

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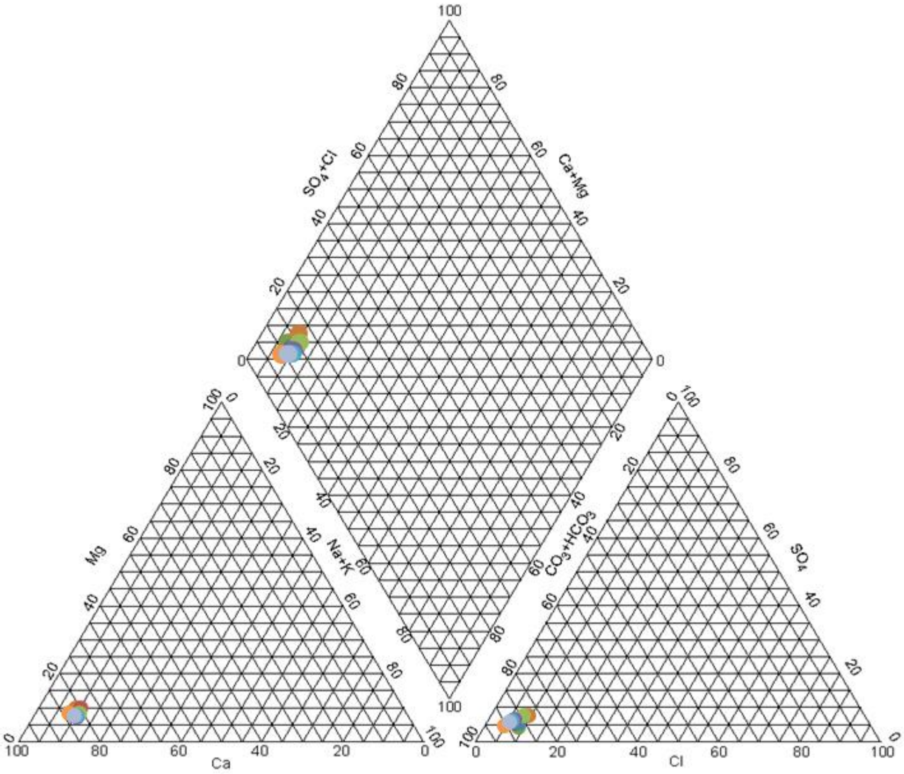

Figure 4. Piper diagram showing EPA Drinking water returns for Cooley Water Supply Boreholes, 2007-2013. The diagram indicates the hydrochemical signature of the groundwater is of the calcium bicarbonate type.