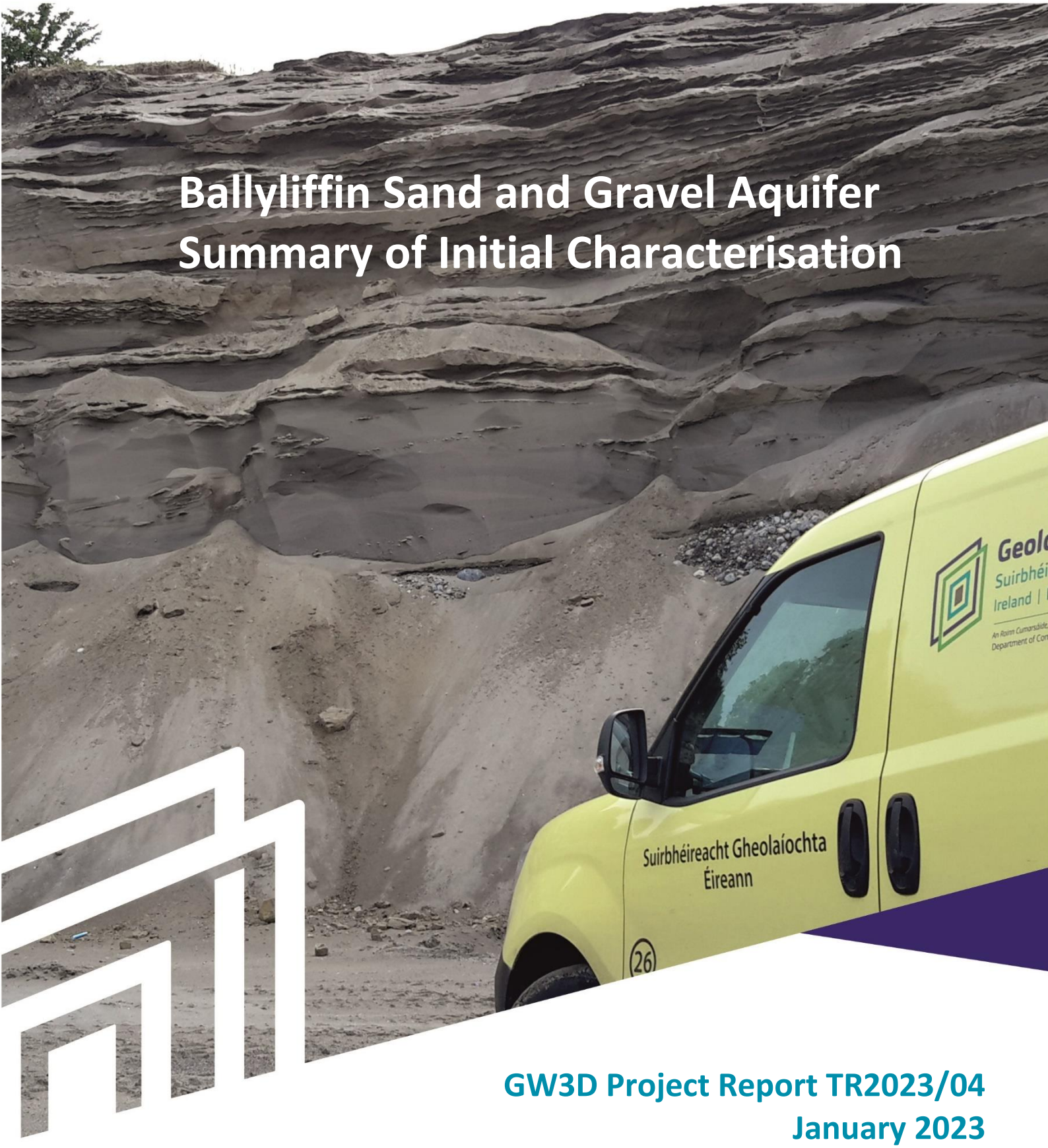
Rialtas na hÉireann
Government of Ireland

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann



Ballyliffin Sand and Gravel Aquifer
Summary of Initial Characterisation

GW3D Project Report TR2023/04
January 2023

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

Ballyliffin 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

Ballyliffin Sand and Gravel Aquifer Description January 2023

Ballyliffin 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:** Irianare River **Streams:** Cloghorna Stream, Ardagh Stream, Lagacurry Stream **Lakes:** None	North Inishowen Coast SAC Trawbreaga Bay SPA	4.8

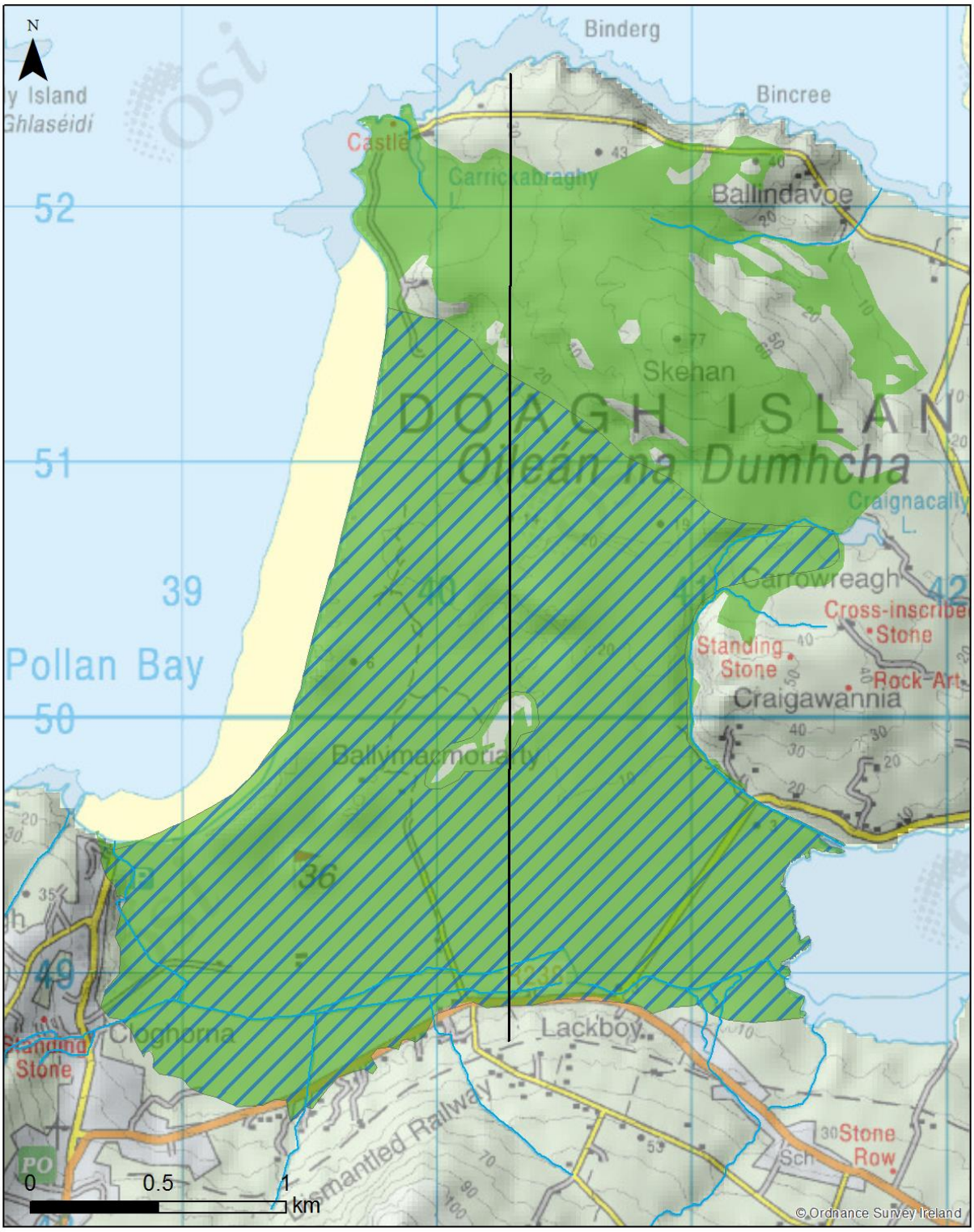
Topography	The land bridge which connects the mainland to Doagh Island is comprised of sands and gravels (Figure1). This deposit is located 1.5 km north of Ballyliffin. The deposit is lowlying, with some minor dunes at the centre of the deposit. Elevations increase towards the north through the body, and ranges between sea level and 30 m AOD. To the north and south the aquifer is bounded by till, which drapes crags of bedrock, and to the east and west by the ocean. Rivers and streams run across the lowlying, southern edge of the deposit.	
Geology and Aquifers	**Aquifer categories**	The sand and gravel deposit covers an area of 4.8 km^2. Bedrock outcrops in the centre of the aquifer body, but the sand and gravel is thought to thicken considerably over short distances from these outcrops. There are records from four boreholes within the area of the deposit which indicate that the sand and gravel thickness ranges from 10 m to 22 m. There are also records of three water level measurements from within the body, all showing that the water table is less than 3 m from the surface. Thus, there is considered to be a minimum saturated thickness of 5 m throughout the sand and gravel body. Based on the areal extent, thickness and degree of saturation, this deposit is classified as a **Locally Important Sand and Gravel Aquifer (Lg)** (DELG/EPA/GSI, 1999; GSI, 2017).
	Main aquifer lithologies	The aquifer has two main components; marine gravels and sands (MGs), and alluvium (A) (GSI, 2023a). Much of the marine gravels and sands have been reworked and are now expressed as windblown sand dunes.
	Key structures	Borehole logs indicate that the deposit is dominated by SAND size sediments, and show the variability of the aquifer material which also has gravel, and occasional low permeability horizons, within. The alluvial deposit along the southern boundary of the body is dominated by clay. The underlying bedrock is classified as a 'Poor' Aquifer' (GSI 2023a).
	Key properties	Though permeability testing data are not available, borehole logging data indicate that coarse material predominates, which suggests that permeability and storativity are high. In the absence of permeability test data, gravels with a fines content of less than approximately 8% are generally considered to have sufficient permeability for aquifer development (O'Suilleabhain, 2000). The aquifer is considered to be unconfined; however, where it is overlain by alluvium it may be confined locally. The water table is inferred as being shallow throughout the area of the aquifer based on three water level measurements, as groundwater gradient are expected to be relatively subdued. The underlying 'Poor' Bedrock Aquifer has a high degree of rejected recharge associated with it. This has the effect of retaining the groundwater within the sand and gravel aquifer.
	Thickness	Bedrock outcrops in the centre of the deposit, however borehole data show that the sand thickens considerably over a short distance (GSI, 2023b). The thicknesses of the sand and gravel aquifer are interpreted to range from between 3 m to at least 22 m, the majority of which is of saturated SAND (Figure 2).
Overlying Strata	**Lithologies**	The alluvium deposit at the south of the aquifer is partially covered with a clay layer (GSI, 2023b). However, the lateral extent of this clay layer is unknown.
	Thickness	The overlying clay is reported to be 4 m thick (GSI, 2023b).
	% area aquifer near surface	An estimated 65% of the aquifer body is at or near the surface.

	Vulnerability	Most of the aquifer is at the surface and therefore vulnerable; consequently pollutants can easily infiltrate the aquifer body. 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' and where it is greater than 3 m below ground level the aquifer vulnerability is mapped as 'High'. Measured water levels range from 0.7 m to 1.1 m below ground level at Ballyliffin.
Recharge	**Main recharge mechanisms**	The aquifer is recharged from rainwater percolating through the topsoil and unsaturated sand and gravel deposits. The alluvial deposit which overlies the aquifer in the south seems to act as a barrier to recharge. Typically, the proportion of recharge that infiltrates to ground water in sand and gravel is around 85% (Hunter Williams *et al*., 2011). 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. Rejected recharge from the surrounding hills at the north increases the amount of available recharge to this aquifer.
	Est. recharge rates	The rainfall in the area of the Ballyliffin sand and gravels is 1,230 mm (Walsh, 2012), and the estimated recharge rate to the aquifer from direct recharge is 490 mm/yr. The minimum groundwater throughput in the aquifer is estimated to be 4,492 m^3/d.
Discharge	**Large springs and large known abstractions (m^3/d)**	One well recorded from within the aquifer has an estimated yield of 545m^3/day (GSI, 2023b)
	Main discharge mechanisms	Groundwater discharges to springs within the deposit, and as seepages along the coast. There is also likely to be discharge to the streams along the southern edge of the aquifer.
	Hydrochemical Signature	Delaney (2016) has recorded aspects of the hydrochemistry at a dug well within the aquifer. Conductivity ranges between 565 µS/cm to 581 µS/cm; this is reflective of hard water. Chloride levels range between 37.3 mg/l and 40.7 mg/l. Iron staining is also present. The elevated chloride levels are most likely a consequence of the proximity to the ocean, as the well is only ~1 km from the coast.
Groundwater Flow Paths		Groundwater flow path length depends on the extent of the sand and gravel deposit, and also upon the spacing of internal groundwater divides and the distance between streams. In general, locally important sand and gravel aquifers are expected to have relatively short flow paths, due to their restricted areal extent. This is expected to be the case at Ballyliffin, given the setting and geometry of the deposit.
Groundwater & Surface Water interactions		Due to the shallow expression of groundwater flow in this aquifer, the groundwater and surface waters are closely linked. Groundwater-fed springs present within the aquifer highlight this connection. Water will be able move between the river and streams at the south, and the aquifer, depending on the river stage and water table. The groundwater is also assumed to interact with seawater along the coast, but the extent of this mixing zone is unknown.
Conceptual model	• This locally important aquifer is located northeast of Ballyliffin on the north coast of Donegal. • The body is bounded by elevated slopes to both the north and southeast, and by the coastline to the east and west. • The boundaries of the aquifer are limited to a large extent by the limits of the blown sand body, which rests atop an earlier beach deposit. • North of the aquifer are areas where the sand deposit is expected to be thin and unsaturated, and though comprised of blown sands, are not considered a part of the aquifer. • Recharge occurs diffusely through the unsaturated zone. Surface runoff from areas of higher elevation also contributes to recharge within the aquifer. • The aquifer is generally unconfined, but may be locally confined where it is overlain by alluvium at the south. • The water table is shallow and the groundwater gradient is generally subdued; therefore the depth to	

Ballyliffin Sand and Gravel Aquifer Description January 2023

	water table will depend on elevation. • Groundwater is thought to flow eastwards and westwards to the lowlying coastline either side of the deposit, and discharges to springs, streams and seeps at the coast. • Due to the shallow depth of groundwater flow in this aquifer the groundwater and surface waters are interpreted to be closely linked. • The minimum groundwater throughput in the aquifer is estimated to be 4,492m^3/d.	
Attachments	Figure 1: Location and extent Figure 2: Cross sections Figure 3: Groundwater vulnerability	
Instrumentation	**Hydrometric gauges:** **National Water Monitoring Stations;** **River:** **Groundwater:**	None present RS40C760750 Cloghorna RS17CO10250 (Br near Kiladangan) None present
Information Sources	• Delaney, A. (2016). Investigation into the relationships between the plant and invertebrate communities of dune slacks, and how they are influenced by environmental factors including groundwater. Unpublished PhD. Thesis, Trinity College Dublin • DELG/EPA/GSI (1999). Groundwater Protection Schemes. Department of the Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland. • EPA mapviewer. 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. • NPWS viewer. http://webgis.npws.ie/npwsviewer/ • O'Suilleabháin, C. (2000). Assessing the boundary between high and moderately permeable subsoils. Unpublished MSc., University of Dublin. Department of Civil, Structural and Environmental Engineering, Trinity College Dublin. • Walsh S. (2012). A Summary of Climate Averages 1981-2010 for Ireland, Climatological Note No.14, Met Eireann, 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.	

Ballyliffin Sand and Gravel Aquifer



Legend

- Cross Section
- Sand and Gravel Aquifer
- Sand and Gravel Extent

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

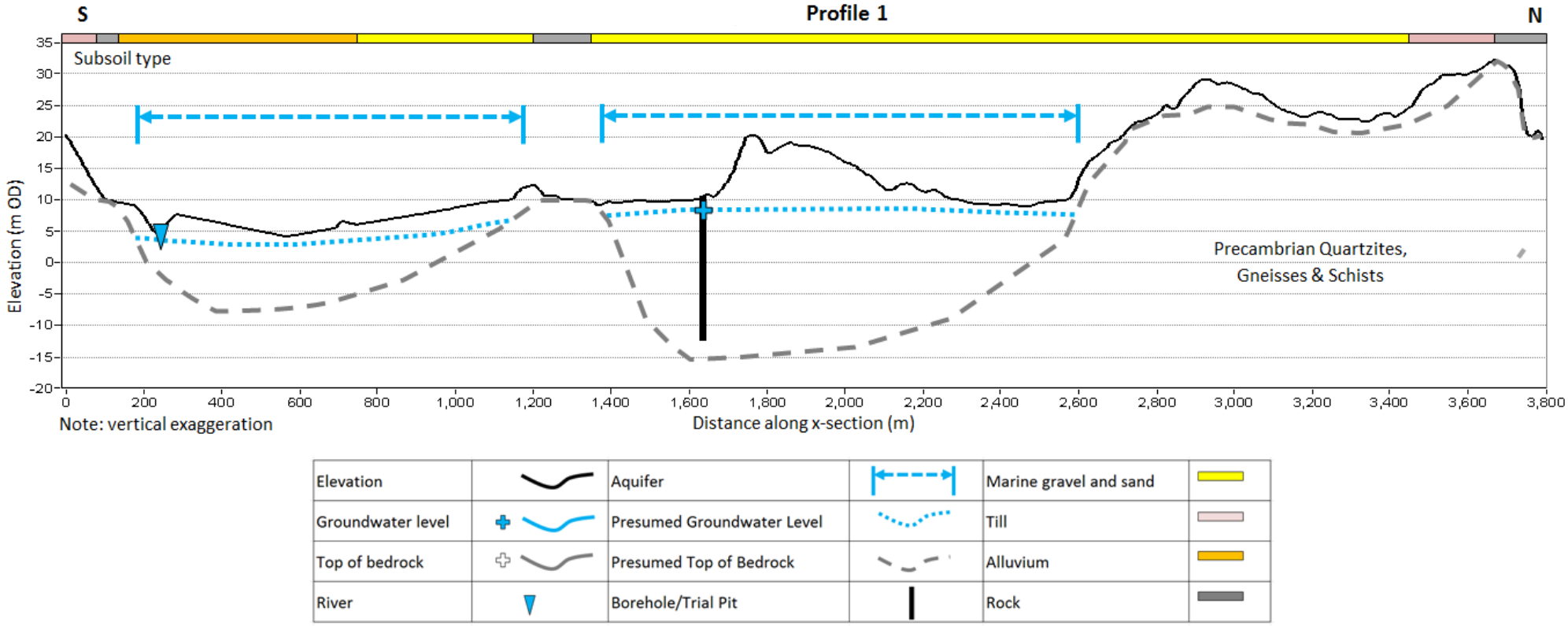


Figure 2. Cross section through the Ballyliffin Sand and Gravel Aquifer body.

Ballyliffin Sand and Gravel Aquifer Vulnerability

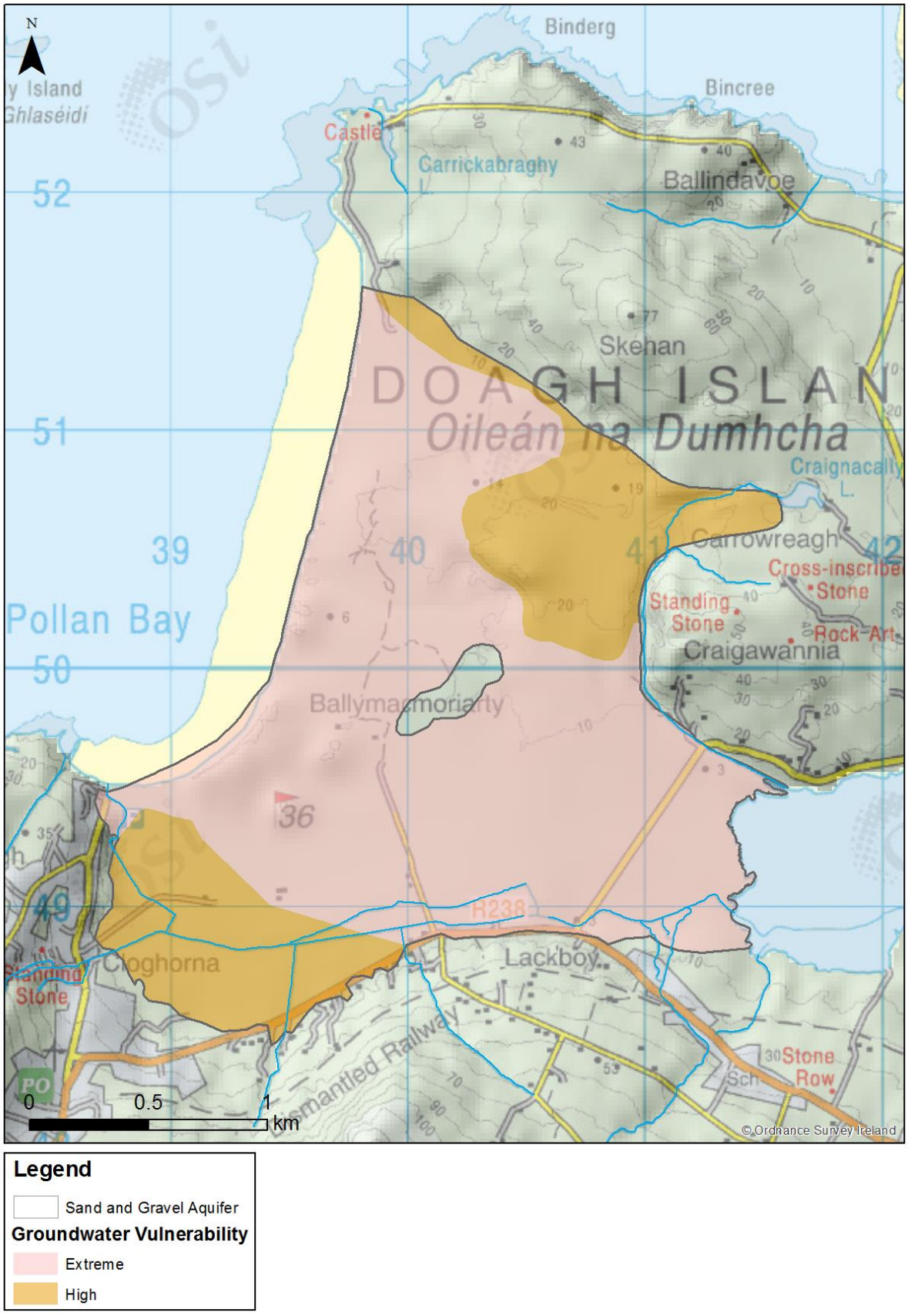


Figure 3. Groundwater vulnerability across the Ballyliffin Sand and Gravel Aquifer.