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Knockaunnagat Sand and Gravel Aquifer Summary of Initial Characterisation



GW3D Project Report TR2023/38
March 2023

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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)
30 – Corrib Galway County Council		Rivers: None Streams: Several unnamed streams Lakes: None	None	1.64
Topography	The sand and gravel aquifer at Knockaunnagat is part of a long, narrow sand and gravel deposit that extends from Dunmore in the northeast, to Castletown c. 5 km to the north of Tuam. The sands and gravels here are part of the wider Tuam-Dunmore-Ballyhaunis Esker system (Warren and Ashley, 1994). The hummocky deposits at Knockaunnagat are situated in a generally low-lying, gently undulating area, with elevations ranging between 50 m and 70 m AOD. The sand and gravel deposits are bounded by tills derived chiefly from Carboniferous sandstones and cherts. These tills, and small areas of the sand and gravels, are partially covered by cutover raised peat, where a relatively high drainage density is in evidence. The sand and gravel body itself has low drainage density in general, but streams issue from the boundary area between the sands and gravels and the peat.			
	Geology and Aquifers	Aquifer categories	It is considered that a large portion of the delineated aquifer area has >10 m depth sands and gravels, based on analysis of topography, geotechnical data and exposures. There are six water level data points from wells within the extent of sands and gravels; these are in line with the nearby stream levels and are close to the ground surface at lower elevations. Based on likely geometry and extent, this deposit is classified as a Locally Important Sand and Gravel Aquifer (Lg) (DELG/EPA/GSI, 1999; GSI, 2017). The subsoils overlie bedrock of Dinantian Pure Bedded Limestones, which is a regionally important karstified bedrock aquifer (Rkc) (GSI, 2017).	
		Main aquifer lithologies	Glaciofluvial sands and gravels derived chiefly from limestones (GLs) and eskers comprised of gravels of basic reaction (BasEsk; GSI, 2023b).	
		Key structures	Exposures from within the area of sands and gravels show poorly sorted sediments, with interspersed sand lenses.	
		Key properties	Sand and gravel aquifers generally consist of unconsolidated, coarse-grained material, usually containing less than 8% fines (Ó'Súilleabháin, 2000). Typically, transmissivity ranges from 200 – 1500 m ² /d (Kelly et al., 2015). Specific yield is expected to be high (10%). Groundwater is considered to be unconfined within the aquifer at Knockaunnagat. The data are inadequate to calculate groundwater gradients, but these are expected to be relatively flat, in the order of 0.001, typical of sand and gravel aquifers.	
		Thickness	Exposures of up to 15 m depth of esker sands and gravels are evident in Finnegan's Quarry in Knockaunnagat Townland. Southwest of this, c. 1 km away, exposures of 8 m depth of esker sands and gravels are in evidence. Depth to bedrock is recorded as 27 m below ground level at Menus Park, in the northern part of the aquifer. At Ballymoney South, situated 300 m from the delineated aquifer body, the depth to bedrock is 1.3 m below ground level. It is considered that the majority of the delineated aquifer body has >10 m sand and gravel thickness.	
	Overlying Strata	Lithologies	Sands and gravels at surface, with small portions at the edge of the delineated aquifer body covered by cutover raised peat.	
		Thickness	There are no data that show the thickness of the overlying strata, but these are likely to be less than 3 m thick.	
		% area aquifer near surface	Approximately 95% of the delineated aquifer area has glaciofluvial sands and gravels just below the surface.	
		Vulnerability	The groundwater vulnerability of the sands and gravels aquifer is 'Extreme' wherever the water table is <3 m from the surface, whereas in all other areas where the water table is at depths >3 m from surface, the vulnerability is classed as 'High'. Extreme vulnerability occurs over approximately 27% of the aquifer area, generally at the lower edges of the body.	



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Recharge	Main recharge mechanisms	Diffuse recharge occurs <i>via</i> rainfall percolating through the unsaturated sands and gravels. Due to the high permeability of sand and gravel, a high proportion of the available recharge will percolate down to the water table where the sands and gravels are uncovered and at surface. Rejected recharge feeding the aquifer is considered negligible at Knockaunnagat, based on the macro-topography and the nature of the underlying karstified bedrock.
	Est. recharge rates	Recharge to the aquifer is estimated at 582 mm/yr, based on an average annual rainfall of 1,160 mm/yr (Walsh, 2012). This means a minimum direct throughput of the aquifer at approximately 1,284 m ³ /d.
Discharge	Large springs and large known abstractions (m ³ /d)	The Cat Hill Group Water Scheme is located on the northwestern boundary of the sand and gravel deposits, in Knockaunnagat Townland. Groundwater is collected from a spring within a 1 m wide, 1 m deep chamber, and the supply is reported to yield 65 m ³ /d.
	Main discharge mechanisms	Groundwater is expected to discharge <i>via</i> some small lowlying springs as seen on OSI 6 inch raster map (1830s – 1930s) at, for example, Knockaunnagat and Menus Park Townlands. The wetland at Kilnaslieve also seems to be spring-fed, and groundwater is also expected to discharge, <i>via</i> seeps, to small streams.
	Hydrochemical Signature	There are no data readily available to assess the hydrochemistry of this aquifer, but given the bedrock and subsoils geology of the locality, the groundwater is likely to have a calcium bicarbonate (CaHCO ₃) signature.
Groundwater Flow Paths		The length of flow paths depends on the size of the sand and gravel deposit. In general, locally important sand and gravel aquifers are expected to have relatively short flow paths, <i>i.e.</i> up to several hundred metres. Despite the fact that the drainage density is low across the sand and gravel aquifer at Knockaunnagat, this is also expected to be the case here given the setting and geometry of the deposit.
Groundwater & Surface water interactions		Groundwater is expected to discharge to the streams, as specified above. Hydraulic connection between the groundwater in the aquifer, and the adjacent streams, is therefore expected to be high.
Conceptual model		- The Knockaunnagat sand and gravel aquifer consists of glaciofluvial sands and gravels derived chiefly from limestones (GLs) and eskers comprised of gravels of basic reaction (BasEsk). - The deposits are situated in a generally low lying, flat to hummocky area, at elevations between 50 m and 70 m AOD. - The aquifer is covered with relatively small portions of cutover raised peat, covering approximately 5% of the delineated area of the aquifer. - The subsoils overlie bedrock of predominantly Dinantian Pure Bedded Limestones, which is classified as a regionally important karstified bedrock aquifer (Rkc). - The sands and gravels within the delineated aquifer area are inferred to be greater than 10 m thick over much of their extent, with c. 50% of the aquifer estimated as having ≥5 m depth sand and gravel saturation. - Across approximately 27% of the aquifer area, groundwater levels are mapped as <3 m below ground level. - Groundwater discharges <i>via</i> seeps, to an unnamed stream that runs along the south and southeast of the aquifer. - The length of the flow paths is expected to be in the order of several hundred metres. - Diffuse recharge occurs <i>via</i> rainfall percolating through the unsaturated sands and gravels. Recharge to the aquifer is estimated as 582 mm/yr, and there is considered to be little or no rejected recharge entering the aquifer body. - The estimated minimum direct throughput of the aquifer is approximately 1,284 m³/d. - There is one known relatively large abstraction in the area, where the Cat Hill Group Water Scheme abstracts from a spring source (shallow well), reported to yield 65 m³/d.

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Attachments	Table 1: Raw water analysis of Cat Hill GWS spring discharge, 2007 Figure 1: Location and extent Figure 2: Cross section Figure 3: Groundwater vulnerability
Instrumentation	Hydrometric gauges: None present National Water Monitoring Stations; River: None present Groundwater: None present
Information Sources	• DELG/EPA/GSI (1999). Groundwater Protection Schemes. Department of the Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland. • EPA (2023). Environmental Protection Agency 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 internal groundwater database. • GSI (2023b). Geological Survey Ireland Map Viewer. https://www.gsi.ie/en-ie/data-and-maps • Kelly, C., Hunter Williams, T., Misstear, B.M. and Motherway, K. (2015). Irish Aquifer Properties – A reference manual and guide. Prepared on behalf of the Geological Survey of Ireland and the Environmental Protection Agency. 110 pp. • NPWS (2023). National Parks and Wildlife Service Map Viewer. http://webgis.npws.ie/npwsvviewer • Ó'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. • Pat Byrne Consultants, Ltd. (2008). An Environmental Impact Statement to accompany the Planning Application relating to the existing quarry development at Knockaunnagat, Tuam, Co. Galway (Galway Co. Co. Planning Reference Number: 08334). • Walsh, S. (2012). A Summary of Climate Averages 1981-2010 for Ireland, Climatological Note No.14, Met Éireann, Dublin. • Warren, W. and Ashley, G. (1994). Origins of the ice-contact stratified ridges (eskers) of Ireland. Journal of Sedimentary Research, 64A, 433-449.
Disclaimer	Note that all calculations 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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Parameter	Concentration	¹ Drinking Water Limit (DWL) or ² Threshold Value (TV)
pH (pH Units)	7.1	6.5-9.5 (DWL)
Conductivity (µS/cm)	552	2,500 (DWL), 800-1875 (TV)
Alkalinity (mg/l CaCO ₃)	-	(-)
Total Hardness (mg/l CaCO ₃)	296	(-)
Ammonium (mg/l NH ₄)	0.014	0.3 (DWL), 0.065-0.175 as N (TV)
Nitrate (mg/l NO ₃)	12.775	50 (DWL), 37.5 (TV)
Sulphate (mg/l SO ₄)	17.04	250 (DWL), 187.5 (TV)
Chloride (mg/l)	-	250 (DWL), 24-187.5 (TV)
Sodium (mg/l)	-	200 (DWL), 150 (TV)
Potassium (mg/l)	-	(-)
Potassium:Sodium	-	0.4 (indicator)
Calcium (mg/l)	252	(-)
Magnesium (mg/l)	-	(-)
Iron (mg/l)	<10	200 (DWL)
Manganese (mg/l)	<0.5	50 (DWL)
Total Coliforms (MPN/100ml)	3.1	0 (DWL)
Faecal Coliforms (<i>E. coli</i>) (MPN/100ml)	0	0 (DWL)

¹S.I. No. 122/2014 - European Union (Drinking Water) Regulations 2014

²S.I. No. 9/2010 – European Communities Environmental Objectives (Groundwater) Regulations 2010

Table 1: Raw water analysis of the Cat Hill GWS spring discharges, 2007 (Pat Byrne Consultants, Ltd., 2008).



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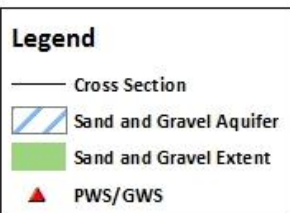
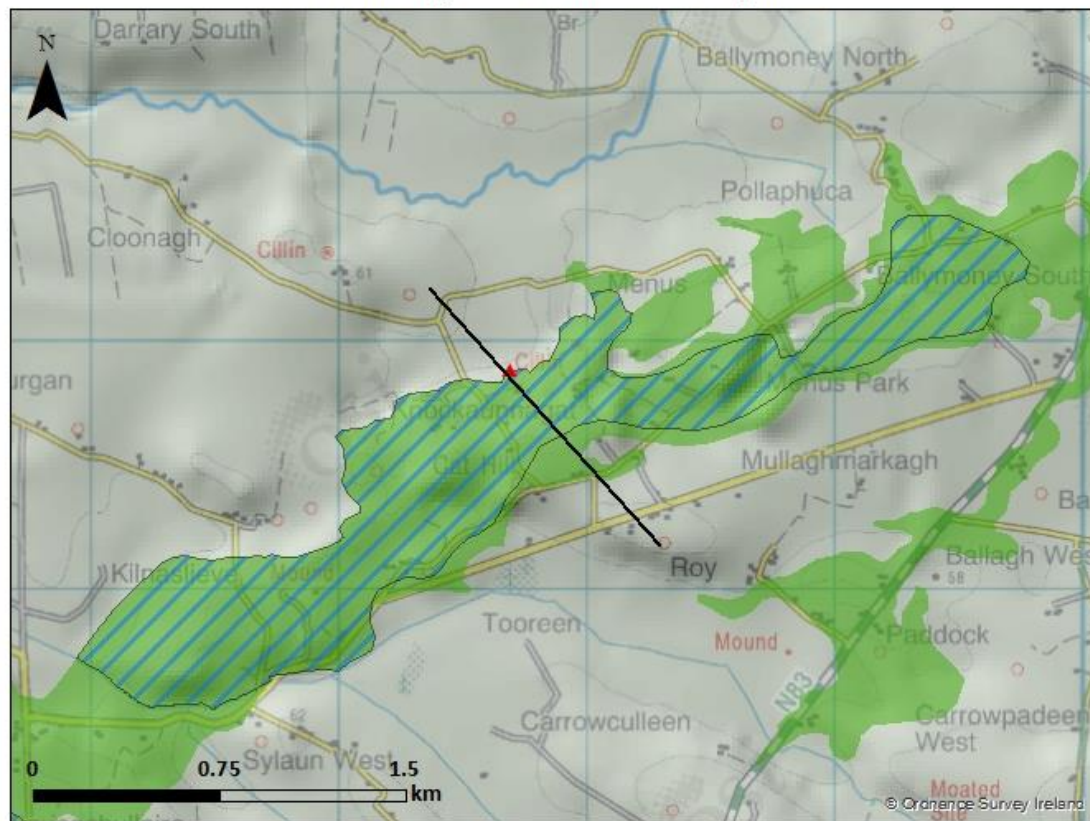
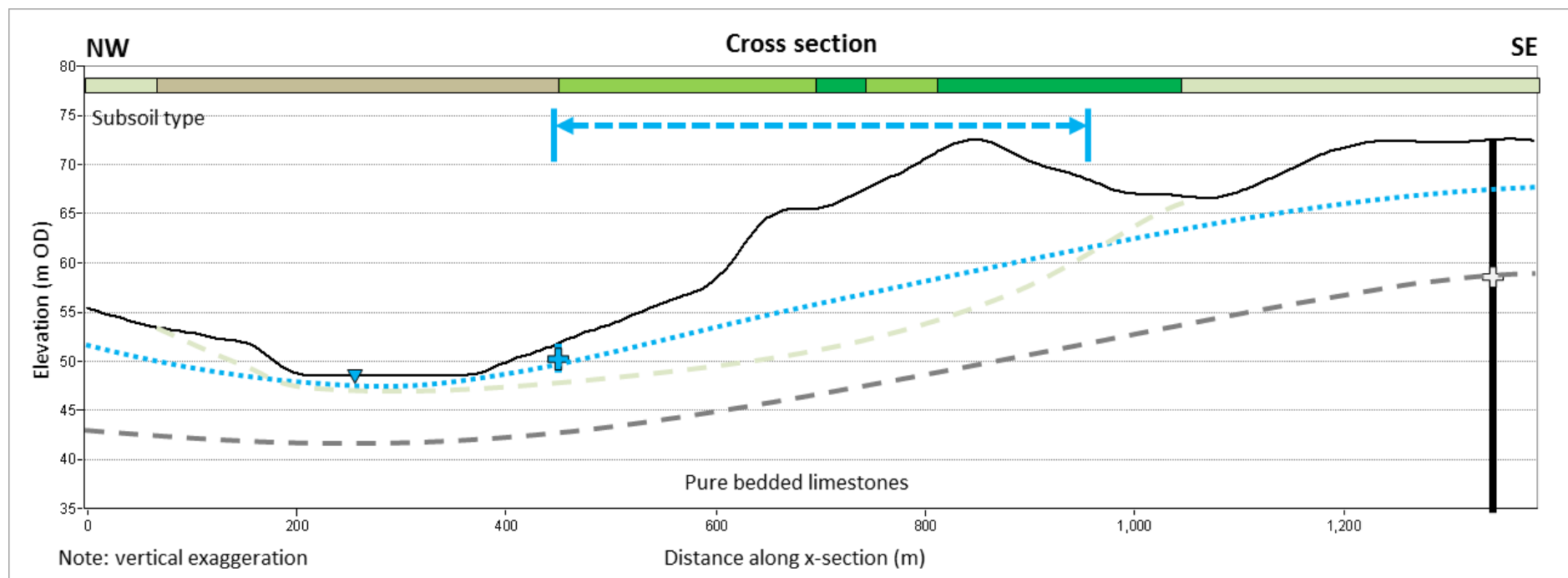


Figure 1: Knockaunnagat Sand and Gravel Aquifer extent with cross section location.

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LEGEND			
Feature		Subsoil Type	
Topography		Sands and gravels	
Groundwater level		Esker	
Top of bedrock		Windblown sands	
Borehole/Trial Pit		Till	
Dug well		Peat	
S&G exposure		Rock outcrop	
Active quarry		Alluvium	
Freshwater lake		Lake sediments	
GW Ponding		Top of S&G	
River		Top of till	
Stream/drainage channel		Karst Feature	
Spring		Spring	
Aquifer envelope		Turlough	

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

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Knockaunnagat Sand and Gravel Aquifer Vulnerability

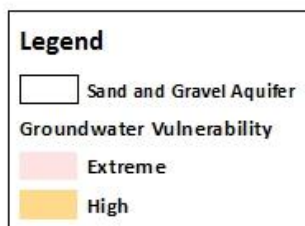
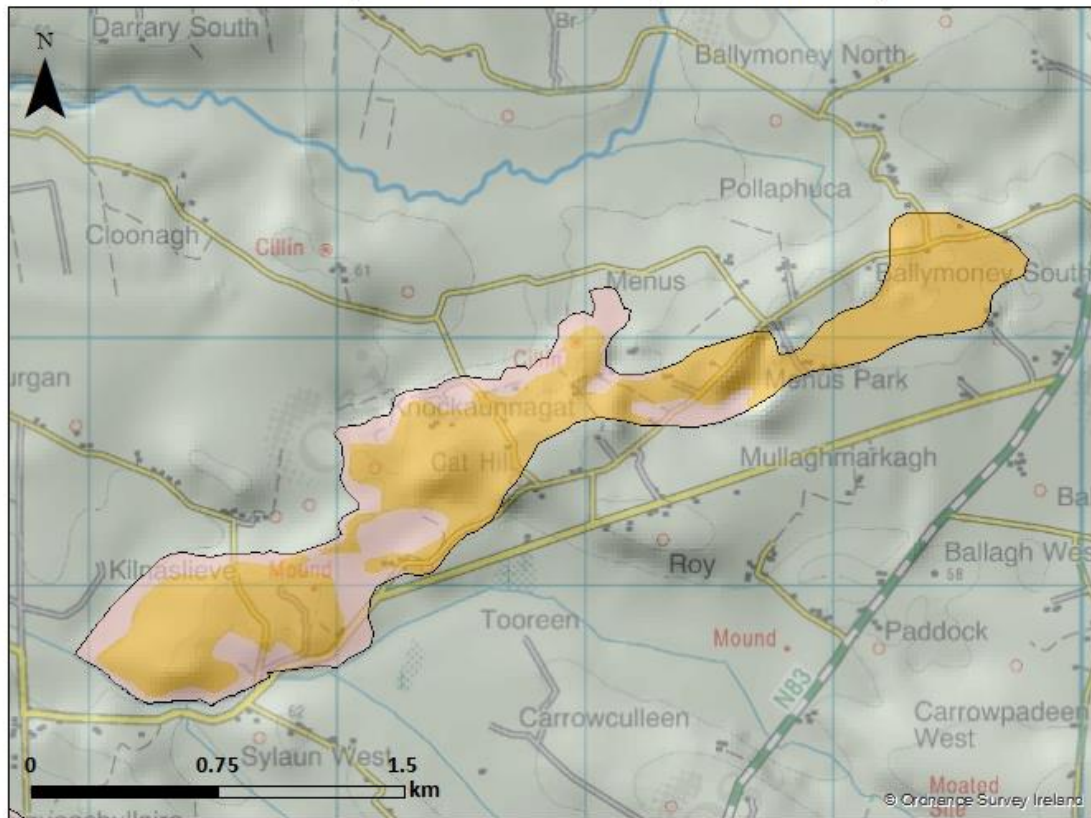


Figure 3: Groundwater vulnerability across the Knockaunnagat Sand and Gravel Aquifer.