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Swilly Sand and Gravel Aquifer Summary of Initial Characterisation

GW3D Project Report TR2023/12
January 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)
39 – Lough Swilly Donegal County Council		Rivers: River Swilly, Farnoge Burn, Coravaddy Burn, Corranagh Burn, Fergaug Burn Streams: Several unnamed streams Lakes: None	Lough Swilly SAC Lough Swilly SPA	4.9
Topography	This sand and gravel deposit is located along the River Swilly valley, which flows from WSW to ENE, south of Letterkenny (Figure 1). The sand and gravel comprises glaciofluvial outwash sands and gravels overlain by alluvium of varying grain sizes, and is set within the valley, bounded by till and bedrock at higher elevations on either side of the valley. The elevation across the aquifer area ranges from sea level to 10 m AOD. The River Swilly, which flows eastwards into Lough Swilly, is tidal as far west as Sallaghagrane, 4.5 km inland (Lee and Fitzsimons, 2004).			
Geology and Aquifers	Aquifer categories	The 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 alluvial deposits along the Swilly river floodplain are considered to comprise sands and gravels at depth, overlain by finer silts and clays material (Meehan, 2006). Ground investigations 2.5 km WSW of Letterkenny show that sand and gravel layers are not uniform throughout the deposit; generally they are > 5 m thick and overlain by 10 m to 15 m of silt or clay (Minerex Environmental Ltd., 2001). In some areas, there are only thin (0.5 m to 2 m) gravel layers. In general, the sand and gravels thicken towards the centre of the deposit, where they are >10 m deep (GSI, 2005).		
	Key structures	There are a number of borehole logs from within this aquifer which provide some insight into the structure of the body, and which record the variability within the sediments. The aquifer is overlain by silt and clay of varying thicknesses. Clay and silt layers are also interbedded with the sand and gravel throughout the deposit. The sand and gravel is generally deposited directly on bedrock for the most part; however, discontinuous till deposits may also be found separating the gravel and the bedrock (Meehan, 2006). The sand and gravel deposit sits mainly upon a 'Poor' bedrock aquifer which has a high degree of rejected recharge associated with it. This has the effect of retaining the water within the basal layers of the sand and gravel aquifer.		
	Key properties	Productivity and yield data indicate that the gravel layers are transmissive and capable of providing yields in excess of 400 m ³ /d (Lee and Fitzsimons, 2004). In any gravel layers, transmissivity will probably be at least >200 m ² /d. In areas where the aquifer is fine-grained, transmissivity will be lower. Storativity is expected to be high (10-20%; GSI, 2005). The groundwater is considered to be generally confined due to the presence of overlying silt and clay layers. There are eight records of well yields in the aquifer ranging from 200 m ³ /day to 1,091 m ³ /day. Five of the eight wells have 'Excellent' yields. The aquifer is close to the coast and is therefore vulnerable to sea water intrusion; yet there is no evidence of saltwater intrusion into this aquifer. The tidal range along the river reaches Port Bridge (Minerex, 2001) at the northeastern boundary of the aquifer.		
	Thickness	Borehole logs within the aquifer area indicate depth to bedrock varies between 6 m bgl and 22 m bgl. The thickest sequence of gravel recorded is 18 m, however most logs record interbedded sand and gravel with clay and silt. Generally, gravel layers vary between 1.5 m to 6 m in thickness (Minerex, 2001).		
Overlying	Lithologies	Alluvial clay and silt layers overlie the sand and gravel deposit in places.		
	Thickness	The overlying alluvial clay and silt layers vary in thickness from 4 m to 14 m, but are generally within the range of 5 m to 7 m in thickness.		



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	% area aquifer near surface	Unknown, but estimated at less than 20%.
	Vulnerability	It is thought that much of the sands and gravels are overlain by low permeability sediments, which provide some protection to the underlying gravel aquifer. However, this thickness and the areal extent of these low permeability deposits varies and their spatial extent are not mapped in any detail. 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 range from 1 m to 5 m below ground level in the Swilly Sand and Gravel aquifer. 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'
Recharge	Main recharge mechanisms	The aquifer receives both direct and indirect recharge. Diffuse recharge occurs directly <i>via</i> infiltration of rainfall through the unsaturated sand and gravel. This may be inhibited slightly across some of the aquifer body by the presence of overlying silt and clay deposits. Minerex (2001) consider that most of the recharge is likely to be at the top of the valley at the top of the glaciofluvial gravels, with smaller amounts seeping through the silts above them throughout the valley area. It is also likely that there is more recharge through the silts to the sides of the valley as they are thinner, as well as through the alluvial sediments up valley as these are more porous (Minerex, 2001). Typically, the proportion of recharge that infiltrates to ground water in sands and gravels is around 85% (Hunter Williams <i>et al.</i> , 2011). Rejected recharge from the surrounding hills will also increase the amount of available recharge to this valley-setting aquifer. Depending on the relationship between the water table and river stage, some of the streams may recharge the aquifer in some localities.
	Est. recharge rates	The rainfall in the area of the Swilly sands and gravels is 1,350 mm (Walsh, 2012), and the average recharge rate from diffuse recharge across the aquifer extent is estimated to be 270 mm/yr. The minimum groundwater throughput in the aquifer is estimated to be 4,754 m ³ /d, with the majority of this volume coming from rejected recharge from the surrounding hills.
Discharge	Large springs and large known abstractions (m³/d)	There are a number of wells within the Letterkenny Water Supply Scheme (WSS) that abstract from the Swilly sands and gravels and that have 'Excellent' yields (Minerex, 2001).
	Main discharge mechanisms	Groundwater discharges to the river and stream tributaries at low elevations, as well as along the coast to Lough Swilly.
	Hydrochemical Signature	There are no data available to assess the hydrochemistry of this aquifer.
Groundwater Flow Paths		The length of groundwater flow paths 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 <i>i.e.</i> up to several hundred metres. The variability in the composition of this aquifer disrupts flow, shortening groundwater flow paths. The groundwater is probably moving in a general sense down the valley 'seaward' through the glaciofluvial sediments (Minerex, 2001). The principal groundwater flow direction is therefore to the ENE (GSI, 2005). Generally, along the valley sides, the surface water and groundwater flow directions coincide.
Groundwater & Surface water interactions		Hydraulic connection between the groundwater and surface water is expected to be high.



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	- The Swilly Sand and Gravel Aquifer is a Locally Important aquifer, located near Letterkenny along the valley of the River Swilly. - The deposit is formed of alluvium and underlying glaciofluvial sands and gravels. - The boundaries of the aquifer are for the most part delimited by the extent of the mapped alluvial deposit (GSI, 2020), however areas where the sands and gravels are thought to extend under 'Made' ground are also included.	
Conceptual model	- The aquifer is generally confined due to the presence of overlying low permeability layers and, for the most part, is deposited directly on top of the bedrock. The bedrock itself is classified as a 'Poor Bedrock Aquifer' (GSI Aquifer Map) and the retention of recharge in the basal layers of the sand and gravel causes the water table to be at a relatively shallow depth. - There is therefore a considerable saturated thickness within the body where thick sand and gravel layers are present. - Borehole logs within the deposit show the heterogeneity of the aquifer material which makes the behaviour of the groundwater difficult to predict, and as a result the permeability of the deposit is expected to vary considerably throughout the aquifer extent. - It is thought that the variability in the recorded yields from numerous boreholes is a reflection in the variability in composition of the subsurface materials. - Although there are a number of 'Excellent yields', 'Good' yields are also recorded. Recharge to the aquifer occurs diffusely through the unsaturated zone, as well as from rejected recharge at depth from the valley sides. - Water enters the aquifer as diffuse recharge from rainfall and <i>via</i> rejected recharge, and discharges at ditches and streams, to the river, and at the estuary. - The minimum groundwater throughput in the aquifer is estimated to be 4,754 m³/d, with the majority of this volume coming from rejected recharge from the surrounding hills.	
Attachments	Figure 1: Location and extent Figure 2: Cross sections Figure 3: Groundwater vulnerability	
Instrumentation	Hydrometric gauges: National Water Monitoring Stations; River: Groundwater:	39061 Port Bridge RS39S020600 Thorn Quay RS39S020500 Torn Quay TW06007073LS1002 Blackwoods Burn TW06007073LS1001 LS010 - Port Bridge RS39S020370 Sprack Burn N Drumnahough RS39S110800 Swilly R.; RS39S110700 Bridge u/s Swilly R. RS39S020350 Sprack Burn near Church RS39S020310 Old Town STW RS39S020300 Old Town Letterkenny RS39S110600 Br on N13 NW of Port B RS39S020190 75m u/s Br at Newmills RS39S020200 Bridge at Newmills 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. - GSI (2005). Swilly Gravel Groundwater Body Description. 8pp. - 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	

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Information Sources (contd.)	• 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 1 Main Report, Draft, July 2004. 58 pp. Geological Survey of Ireland. Meehan, R.T. (2006). Subsoils Map for County Donegal. Map produced as part of EPA Soil and Subsoil Mapping Project (formerly FIPS-IFS). Teagasc, Kinsealy. • Minerex Environmental Ltd (2001). Letterkenny Water Supply – No. 2 Augmentation Scheme. Groundwater resource development in Glen Swilly. Data Review, Geophysics, Core Logging, Replacement Well Drilling, Pumping Tests & Reporting. Fieldwork July – November 2000. MEL Report Ref:- 1009-828 (Final).doc. • 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 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.

Swilly Sand and Gravel Aquifer

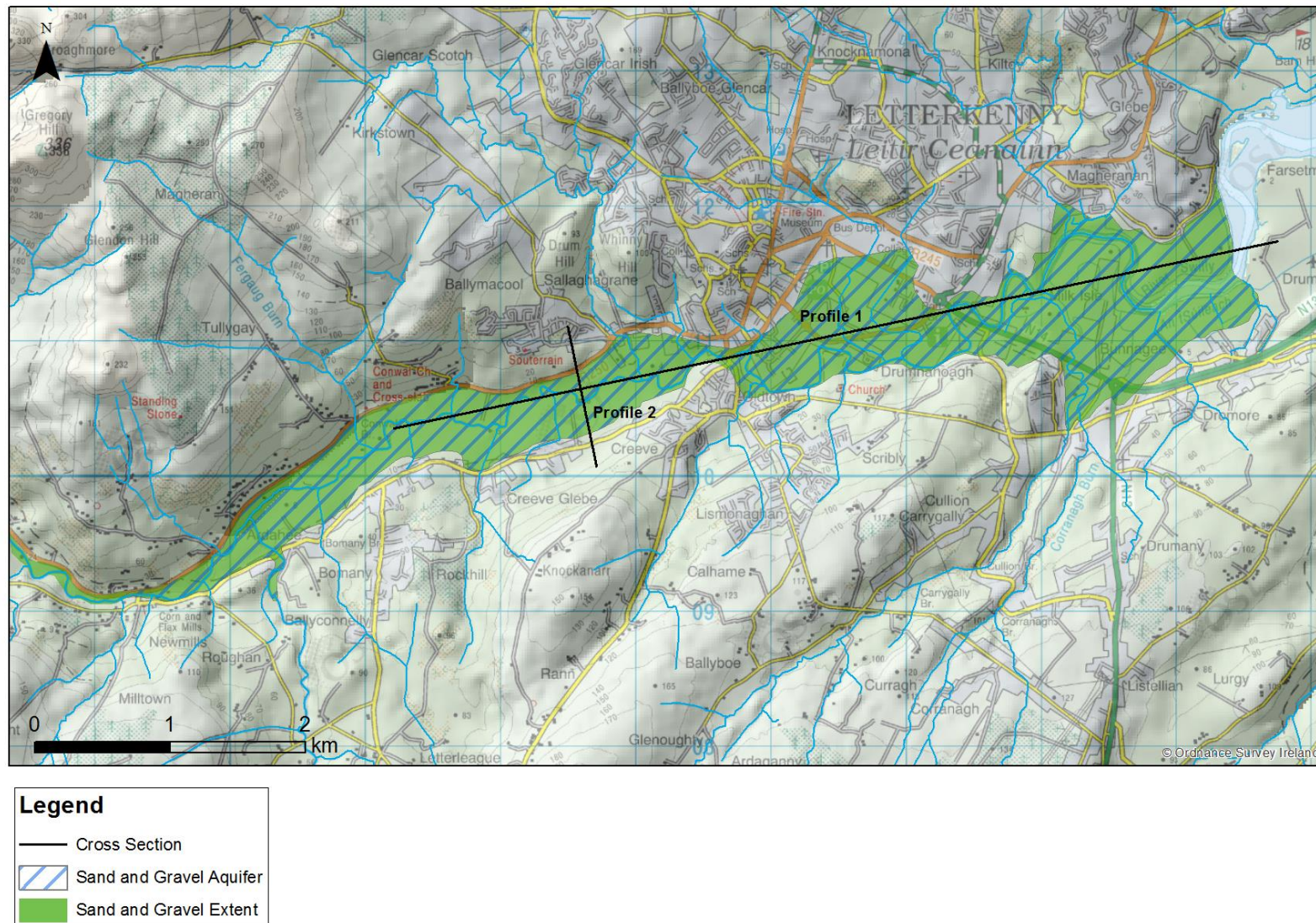


Figure 1. Swilly Sand and Gravel Aquifer extent with cross section locations.

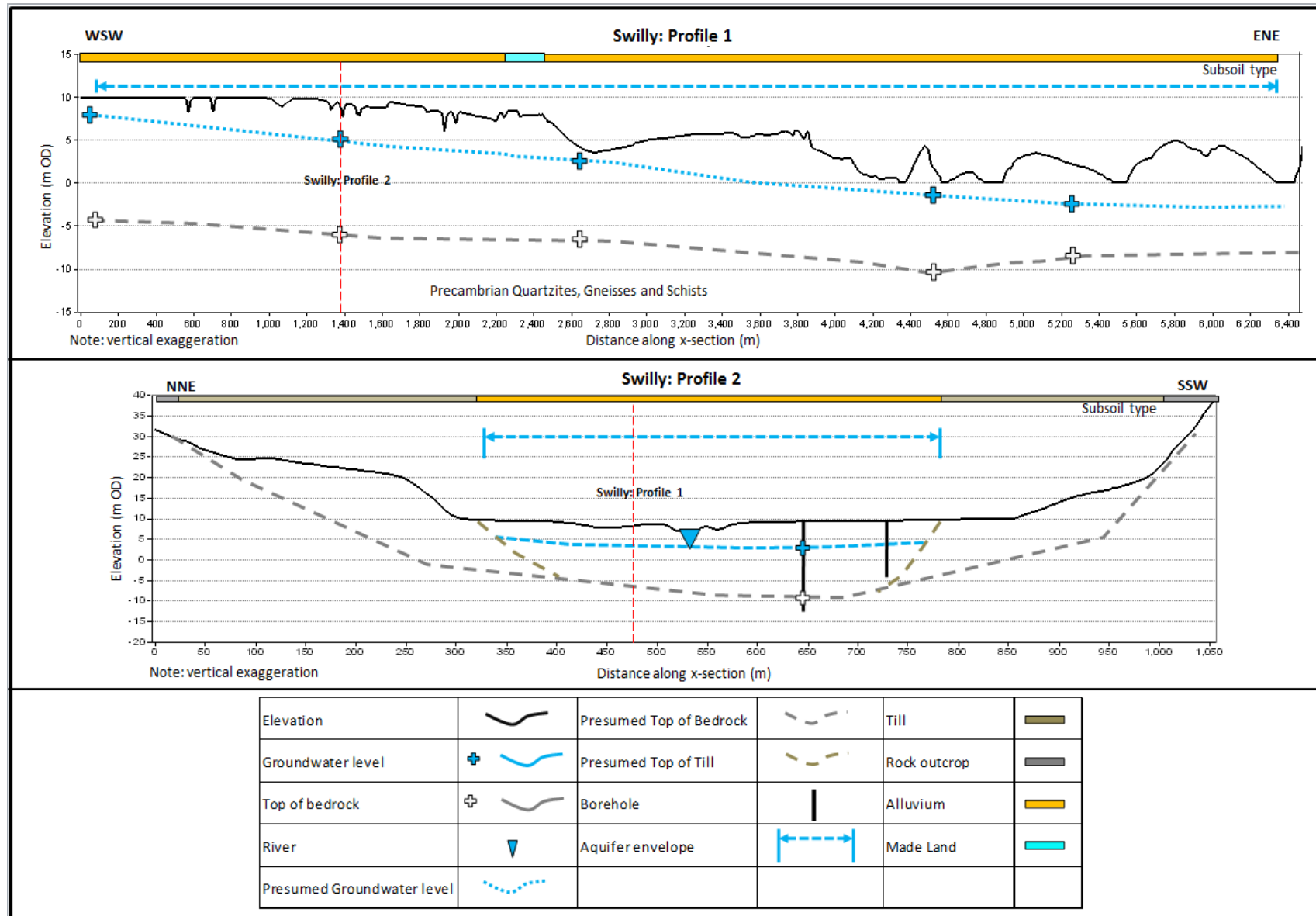


Figure 2. Cross sections through the Swilly Sand and Gravel Aquifer body.

Swilly Sand and Gravel Aquifer Vulnerability

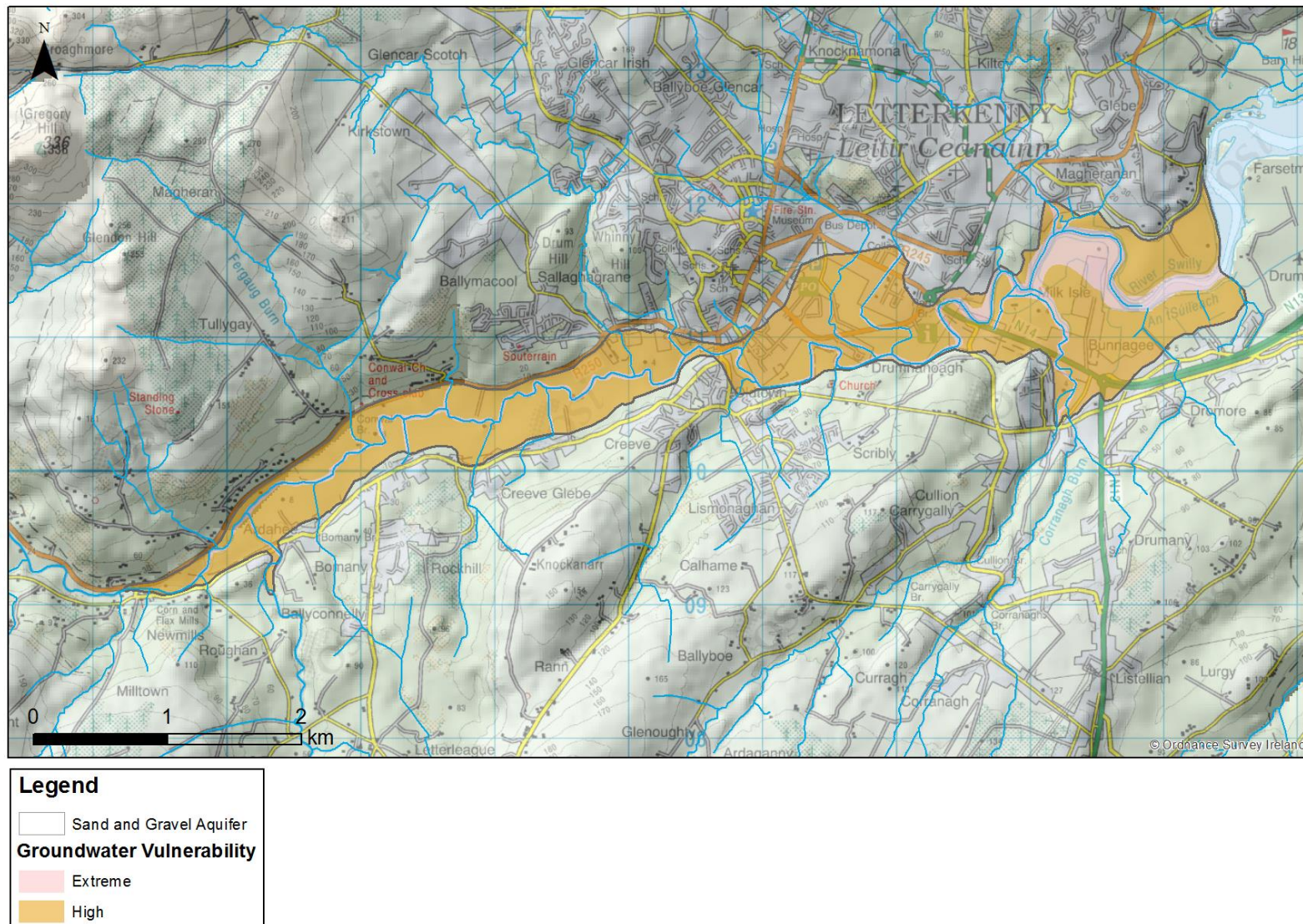


Figure 3. Groundwater vulnerability across the Swilly Sand and Gravel Aquifer.