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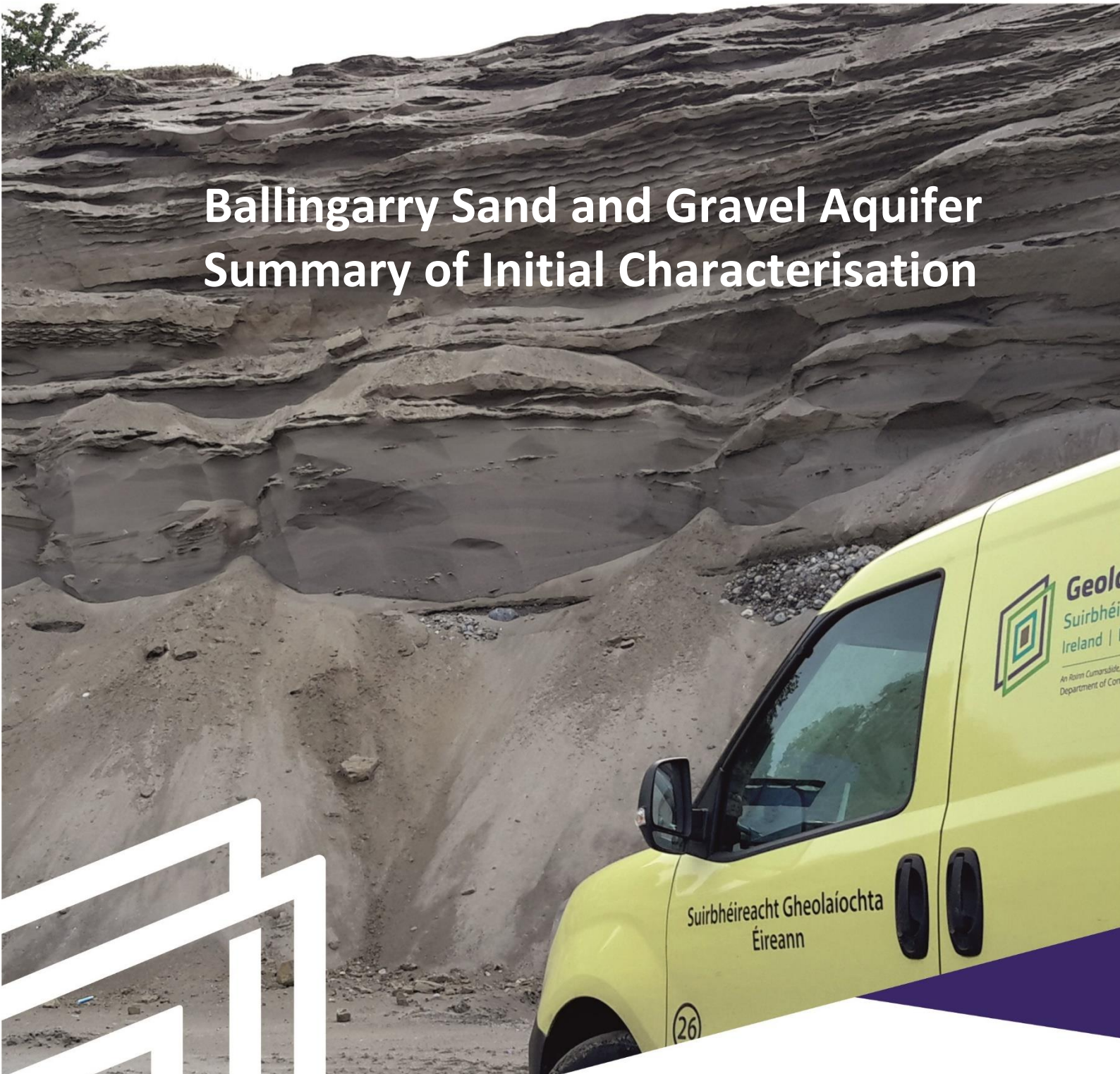
Ballingarry Sand and Gravel Aquifer
Summary of Initial Characterisation



GW3D Project Report TR2023/56
July 2023

Ballingarry Sand and Gravel Aquifer Description July 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

Ballingarry Sand and Gravel Aquifer Description July 2023

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Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystems	Area (km^2)
24 - Shannon Estuary South Limerick County Council	**Rivers:** Clonshire River **Streams:** Several unnamed, minor streams **Lakes:** None	None	1.7 km^2

Topography		The Ballingarry sand and gravel body comprises a hummocky terrace which onlaps onto the northern flank of the sandstone-cored ridge north and northwest of Ballingarry Village. The sands and gravels rest at elevations between 60 m and 110 m AOD, and the topography across the terrace is gently undulating to hummocky. The bedrock ridge south of the deposit rises to an elevation of 214 m AOD.
Geology and Aquifers	**Aquifer categories**	The PWS at Ballingarry receives inputs from both the sand and gravel, and bedrock, aquifers (Conroy, 2008). It is considered that approx. 50% of the area of the sand and gravel aquifer is unconfined, with the remainder of the deposit confined beneath glacial till (Conroy, 2008). Based on its areal extent, inferred thickness, groundwater throughput and position in the landscape the deposit is classified as a **Locally Important Sand and Gravel Aquifer (Lg)** (DELG/EPA/GSI, 1999; GSI, 2017).
	Main aquifer lithologies	Glaciofluvial sands and gravels derived chiefly from limestones (GLs). These are beneath a cap of glacial till which is also derived chiefly from limestones (TLs) on the northern side of the ridge, but is till derived chiefly from Devonian Sandstones (TDSs) on the southern side (GSI, 2023a).
	Key structures	There are data from 10 water well records from within the body, including two dug wells. The shallow wells are dug into sediment described as GRAVEL at Ballyea, on the western side of the body, where till has been mapped as the subsoil type (Conroy, 2008). The material is described as fine SAND and GRAVEL at Ballymucky, in the central portion of the body (GSI, 2023b). Elsewhere in the body the presence of dug wells into sands and gravels, but recorded as covered by limestone till which has a CLAY matrix at surface, again shows that the geometry of the material within the body is complex.
	Key properties	There are four water level data points from dug wells and boreholes within this aquifer body that have allowed for inferences to be made on water levels throughout the area. Using these data, along with other desk study data, it has been inferred that approx. 90% of the aquifer area has a depth of saturated sands and gravels greater than 5 m. In general, sand and gravel aquifers consist of unconsolidated, coarse-grained material, usually containing less than 8% fines (Ó'Súilleabháin, 2000).
	Thickness	From desk study of boreholes (GS1, 2023b), the sands and gravels have proven depths varying from 6 m to 25 m at Ballymucky. It is expected that the majority of the area delineated as within the aquifer body has sands and gravels of at least 10 m depth.
Overlying Strata	**Lithologies**	Approximately 46% of the aquifer area is covered with glacial tills derived chiefly from either sandstones or limestones. A further 4% of the area of the aquifer is overlain with alluvium, with sand and gravel assumed beneath.
	Thickness	Where present, the tills are recorded as no more than 5 m deep (Conroy, 2008). The alluvial deposits are inferred to be less than 3 m thick.
	% area aquifer near surface	Approximately 50% of the sand and gravel aquifer is at the surface, with the remainder beneath the alluvium deposits and/or tills.
	Vulnerability	The groundwater vulnerability of the sand and gravel is 'Extreme' where the water table is inferred as < 3 m from the surface, and this accounts for only 3% of the aquifer area. In all other areas where the water table is at a depth > 3 m, the vulnerability is classed as 'High' (97% of the aquifer area, Figure 3). There is thus only a small portion of the area of the aquifer mapped as 'Extreme' vulnerability, owing generally to the elevated nature of the body.

Ballingarry Sand and Gravel Aquifer Description July 2023

Recharge	**Main recharge mechanisms**	Diffuse recharge occurs by the infiltration of rainfall 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 alluvium or till overlies the sands and gravels, the proportion of rainfall that recharges the water table will be significantly less. It is also considered that there is rejected recharge from the high ridge south and southwest of the aquifer area contributing to the groundwater resource at Ballingarry.
	Est. recharge rates	The annual average rainfall for the aquifer is 995 mm (Walsh, 2012), thus providing an estimated diffuse groundwater recharge of 364 mm/year. The minimum direct groundwater throughput in the aquifer is consequently estimated to be 1,595 m^3/d, which rises to a minimum potential of just over 2,712 m^3/d when rejected recharge is included.
Discharge	**Large springs and large known abstractions (m^3/d)**	There is a public water supply spring at Ballingarry, pumping 550 m^3/d (Deakin, 1995). Approximately 120 m^3/d of this water is estimated to emerge from the sands and gravels, and there is a proven sustainable yield at this spring of up to 622m^3/day (Conroy, 2008).
	Main discharge mechanisms	Groundwater in the area is assumed to generally flow perpendicular to the topographic gradient. Discharge is to large springs such as Ballingarry PWS, Sunday Well and John's Well along the Clonshire River (both near the Abbey at Ballingarry), as well as directly to streams.
	Hydrochemical Signature	Hydrochemical analyses of groundwater at the source in Ballingarry indicates that the water is hard (265 – 289 mg/l $CaCO_3$), with moderately high alkalinity (229 – 243 mg/l $CaCO_3$). Conductivities are in the range 535 – 610 µS/cm (data from both Deakin, 1995 and Conroy, 2008). These analyses are indicative of calcium bicarbonate ($CaHCO_3$) type water, which may derive either from carbonate-rich sandstone gravels or which may lie at the softer end of the limestone carbonate water scale. The hardness values would be more typical of the sandstones in County Limerick, but values this low may also occur in limestones (Conroy, 2008). The water quality at the source is variable. Nitrate values vary from 3.37 – 29.4 mg/l, chloride reached 38 mg/l in two of the recorded analyses, and when analysed in total this may also suggest that contamination is occurring occasionally (Deakin, 1995). In all groundwater samples analysed in the more recent work (Conroy, 2008) there were exceedances of the Drinking Water limits for a number of analysed parameters; ammonia, nitrite, nitrate, phosphate, faecal coliforms, total coliforms and potassium, as well as for total metals concentrations for aluminium, iron, manganese and mercury. The nitrate concentrations observed in the Ballingarry PWS in spring 2007 were in excess of 50 mg/l as NO_3 and as such, were in breach of the Drinking Water Regulations (2000). A detailed study on the risk to groundwater in the PWS source catchment from the various sources of nitrate was therefore completed by Tobin Consulting Engineers at this time (Conroy, 2007). The bedrock aquifer has concentrations of nitrate above background levels, but which are unlikely to ever exceed the Drinking Water threshold owing to dilution. The sand and gravel aquifer is heavily contaminated by microbiological parameters, and by nitrates.
Groundwater Flow Paths		Water enters the aquifer as diffuse recharge from rainfall, and discharges *via* springs and directly to streams. The principal groundwater flow directions are downslope, radially out from the bedrock-cored ridge.
Groundwater & Surface water interactions		Groundwater is believed to discharge into the Clonshire River that flows along the southeastern edge of the aquifer body, flowing downslope from the higher edges of the body which onlap to the bedrock-cored ridge. From this, connectivity between the groundwater and surface water is expected to be relatively high.

Ballingarry Sand and Gravel Aquifer Description July 2023

Conceptual model	• The aquifer consists of a terrace of hummocky sand and gravel deposits, which onlap onto a high, bedrock cored ridge west and northwest of Ballingarry. • The deposits occur at elevations between 60 m and 110 m AOD. • The highest elevations, around 110 m AOD, are in the central portion of the aquifer body, where the sand and gravel is draped across the highest elevation bedrock, with the land sloping down from this locality to the northwest, north, and northeast. • Depth to bedrock varies throughout the aquifer body, but generally depths are in the majority >10 m, with the maximum depth to bedrock value of 25 m recorded at Ballynamucky. • Approximately 70% of the aquifer is inferred to have greater than 5 m depth of saturated sands and gravels. The remainder of the aquifer is inferred to have a saturated thickness of between 0 – 5 m. • Diffuse recharge occurs *via* rainfall percolating through the unsaturated sands and gravels, with reduced recharge in the areas that are covered with alluvium and/or till. • Rejected recharge also recharges the sand and gravel aquifer, with groundwater flowing downslope from the bedrock-cored ridges into it's area. • Groundwater discharge occurs *via* some major springs, and smaller seeps, along the lowest boundary of the sand and gravel body. There may also be discharge to rivers as baseflow where the water table lies above the river stage. • The minimum direct groundwater throughput in the aquifer is consequently estimated to be 1,595 m^3/d, which rises to a minimum potential of just over 2,712 m^3/d when rejected recharge is included.
Attachments	Figure 1: Location and extent Figure 2: Cross sections Figure 3: Groundwater vulnerability
Instrumentation	**Hydrometric gauges:** Rylanes - 24044 **National Water Monitoring Stations;** **River:** RS24C30200 (Clonshire) RS24C03190 (U/s Ballingarry WDLM26) **Groundwater:** None present
Information Sources	• Conroy, P. (2007). Interpretative Report on Nitrate Contamination, Ballingarry Public Water Supply. Report by Tobin Consulting Engineers for Limerick County Council, 360 pp. • Conroy, P. (2008). Ballingarry Source Protection Plan. Report by Tobin Consulting Engineers for Limerick County Council, 73 pp. • DELG/EPA/GSI (1999). Groundwater Protection Schemes. Department of the Environment and Local Government, Environmental Protection Agency and Geological Survey Ireland. • Deakin, J. (1995). Ballingarry Public Water Supply, Groundwater Source Protection Zones. Report for Limerick County Council, Geological Survey of Ireland, Dublin. • 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 Map Viewer, Geomorphology Map. • GSI (2023b). Geological Survey Ireland Map Viewer, Quaternary Sediments Map. • GSI (2023c). Geological Survey Ireland, Internal groundwater databases. • Hunter-Williams, N.H., Misstear, B.D.R., Daly, D. and Lee, M. (2011). National Groundwater Recharge Map for Ireland. Geological Survey Ireland and Department of Civil, Structural and Environmental Engineering, Trinity College Dublin. • NPWS Mapviewer: http://webgis.npws.ie/npwsviewer • Ó'Súilleabháin, C. (2000). Assessing the boundary between high and moderately

Information Sources (contd.)	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.
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations 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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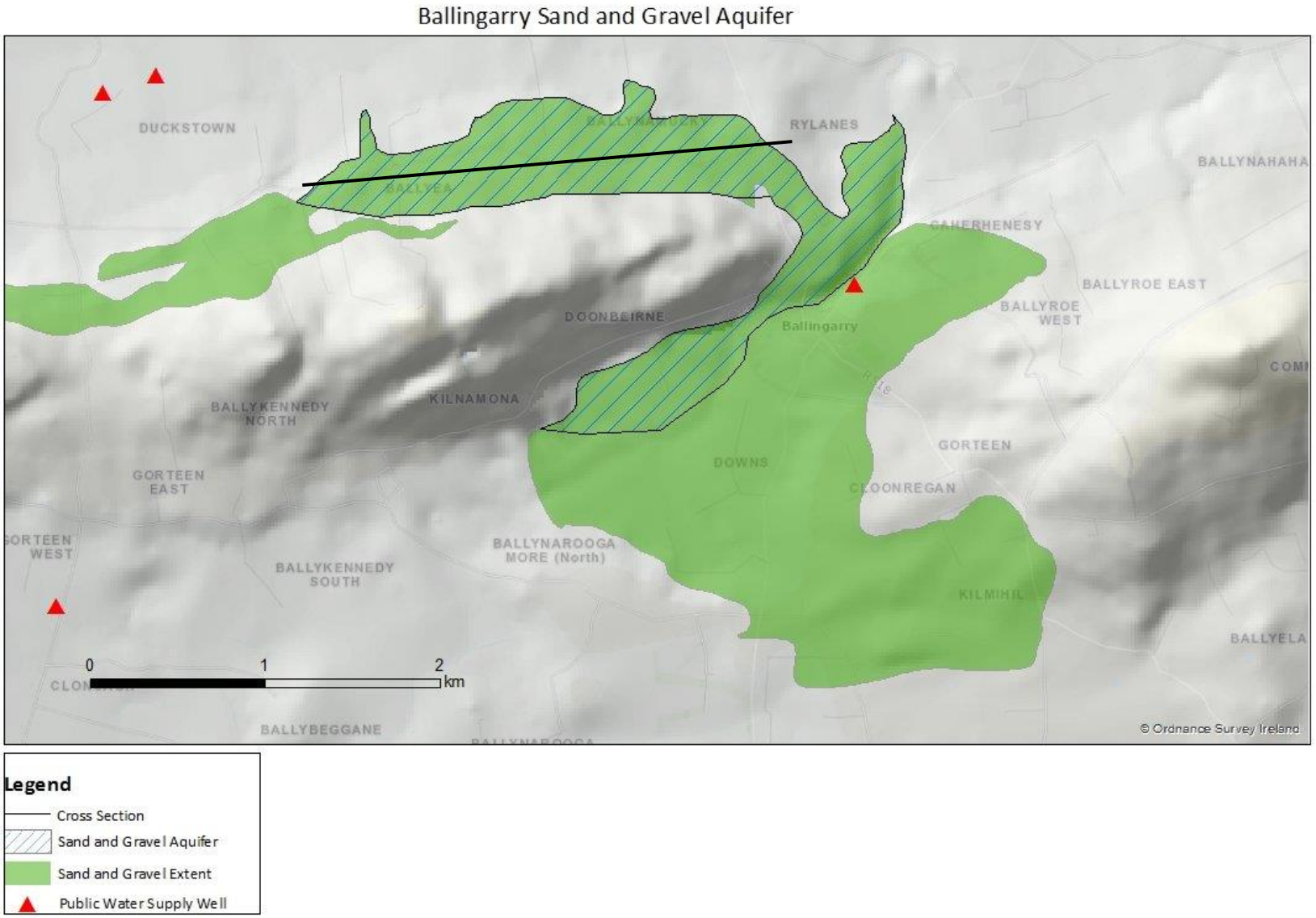

Figure 1: Ballingarry Sand and Gravel Aquifer extent with cross section location.

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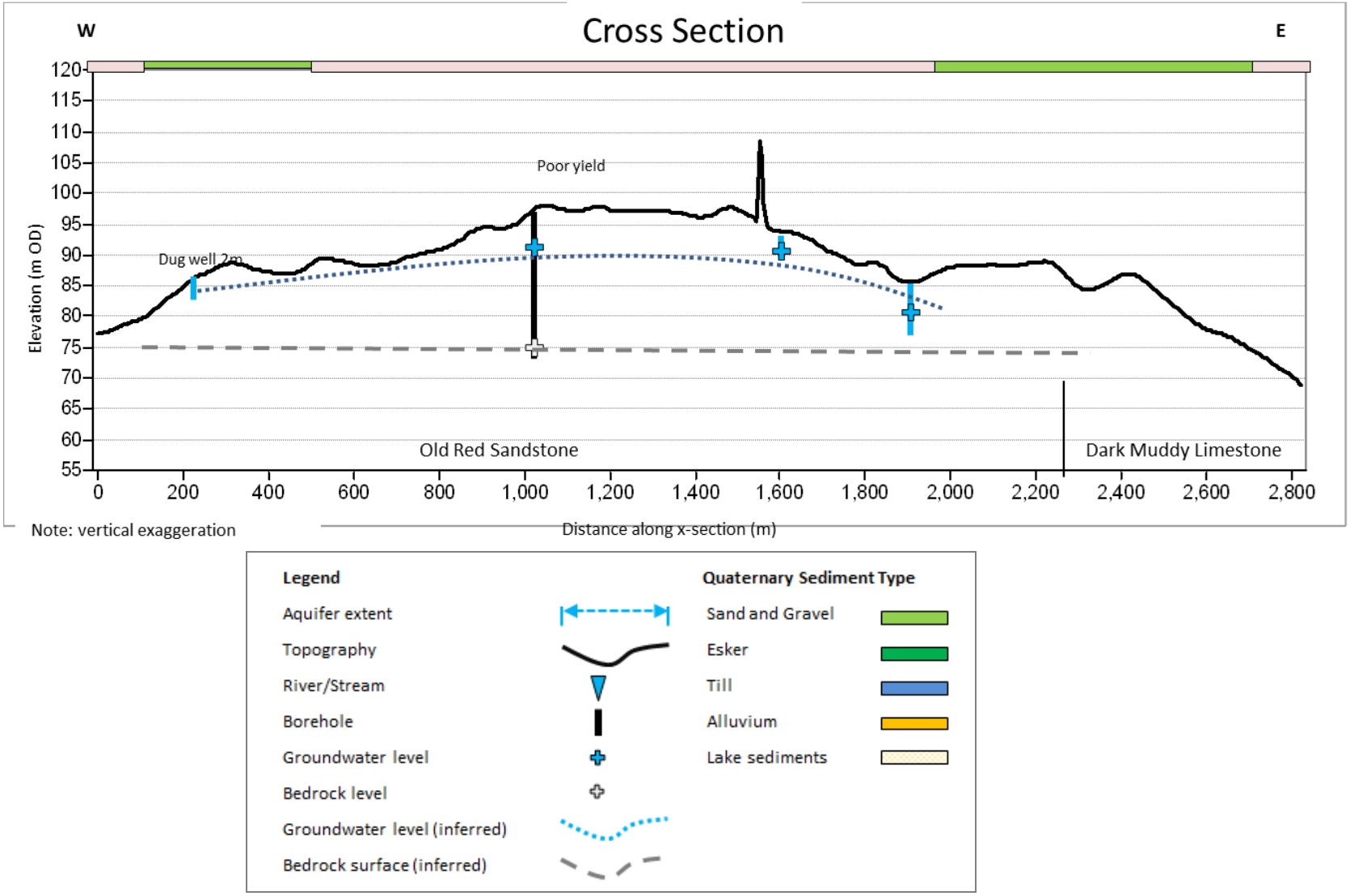

Figure 2: Cross section through the Ballingarry Sand and Gravel Aquifer body.

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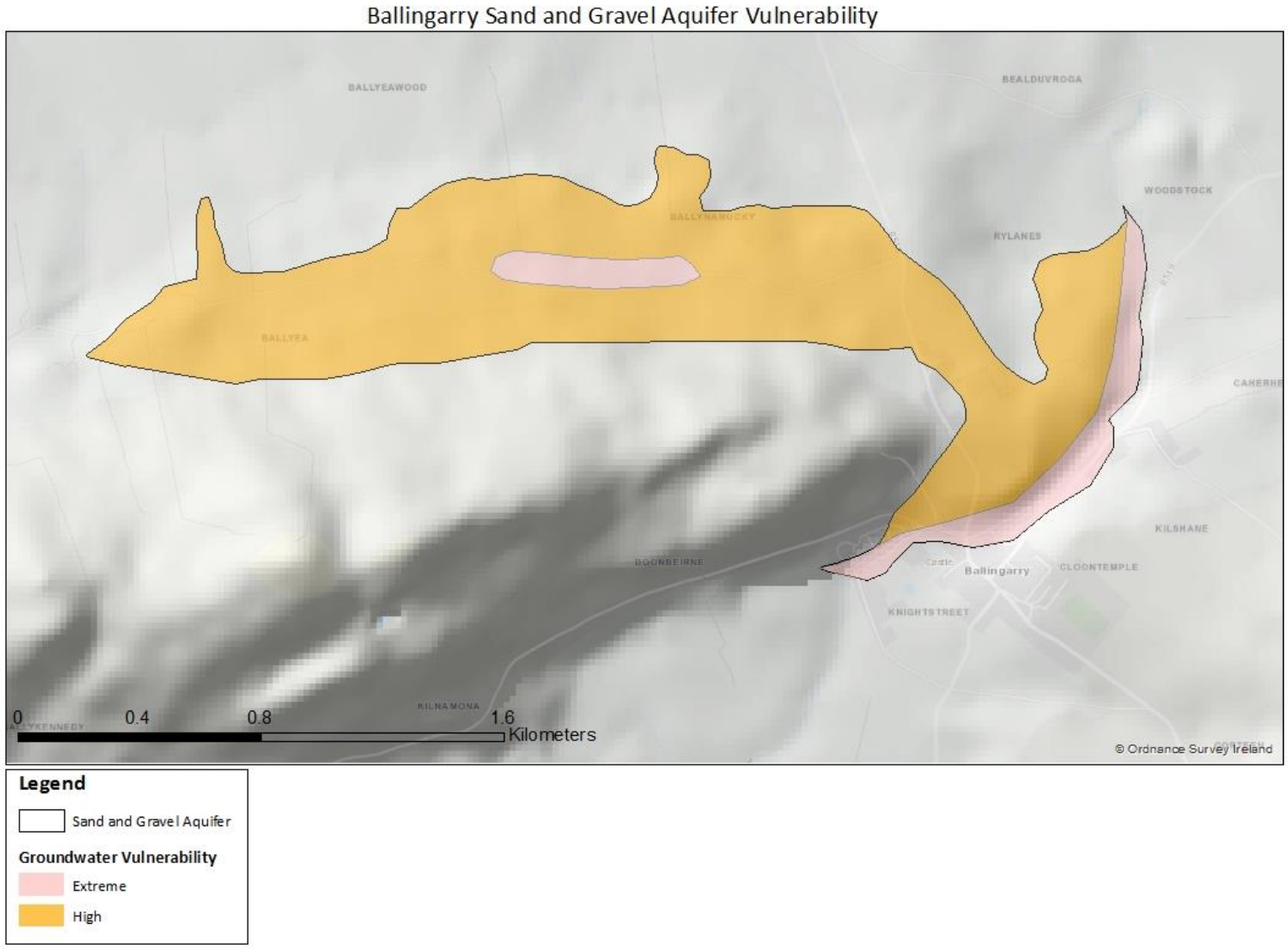

Figure 3: Groundwater vulnerability across the Ballingarry Sand and Gravel Aquifer.