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Geological Survey
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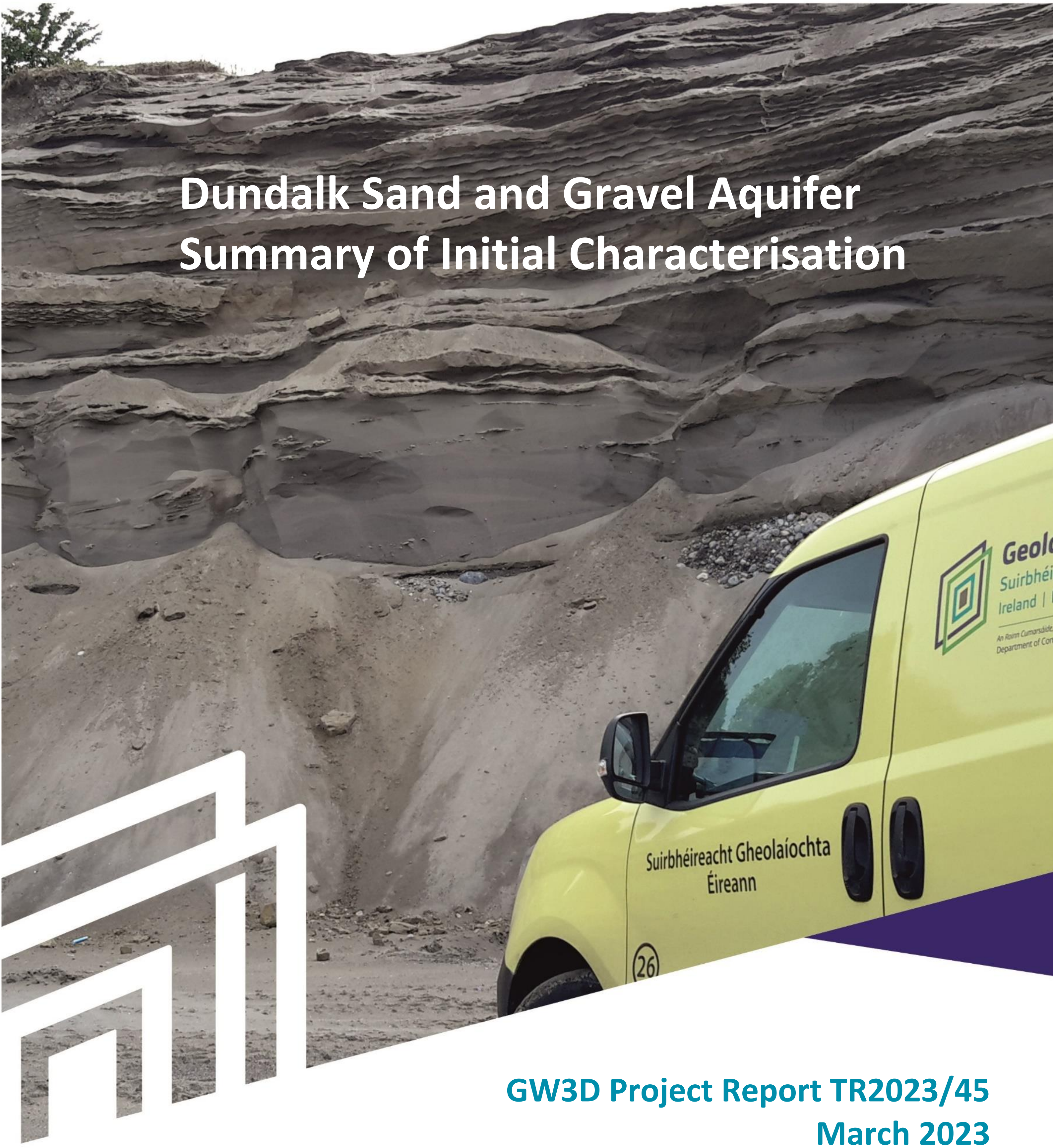
Dundalk Sand and Gravel Aquifer
Summary of Initial Characterisation



GW3D Project Report TR2023/45
March 2023

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

Dundalk 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

Dundalk Sand and Gravel Aquifer: Summary of Initial Characterisation.

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:** Castletown River, Blackwater River, Ramparts River **Streams:** Several unnamed streams **Lakes:** None	Dundalk Bay SPA Dundalk Bay SAC Dundalk Bay pNHA	7.9

Topography

The Dundalk sand and gravel body is located for the most part beneath the urban structure of the town of Dundalk, and beneath its' surrounding environs (Figure 1). The deposit is comprised in the majority of marine, raised beach sands and gravels, with some glaciofluvial sands and gravels also present along the Blackwater River. All of the sands and gravels are generally lowlying, and the elevation of the body is below 10 m AOD throughout. Till, at a higher elevation, surrounds the sands and gravels to the south and west, Dundalk Harbour is to the north and a salt marsh occurs at the east, bounding Dundalk Bay. The Rampart River flows from west to east through the deposit, and the Castletown River Estuary is to the immediate north (Figure 1).

Geology and Aquifers

Aquifer categories

The Dundalk sand and gravel deposit is confirmed to be greater than 10 m in thickness and have 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 aquifer body is comprised of both marine, raised beach sands and gravels (MGs), and some glaciofluvial sands and gravels derived chiefly from Lower Palaeozoic sandstones and shales (GLPSsS, GSI, 2022a).

Key structures

The body comprises raised beach sands, which have been deposited around a linear belt of glaciofluvial sands and gravels along the Blackwater River, as well as the glaciofluvial materials themselves. Borehole logs show the variability of the aquifer material, which consists largely of sands and gravels, with occasional low permeability horizons. The presence of less permeable layers in the deposit, even if thin, can create localised perched water tables. The underlying bedrock is of greywacke which is classified as a 'Poor' Aquifer (GSI,2023a).

Key properties

There are thirteen borehole log records available for localities within this aquifer body, sourced from various geotechnical reports (GSI, 2023c) and the NERDO report (1982). Low permeability deposits are commonly recorded interbedded with and overlying the sands and gravels, with overlying clay varying in thickness from 1.5 m to 14 m. The presence of overlying clay is recorded more frequently in borehole logs towards the west of the deposit. However coarse material predominates in the sands and gravels themselves, and therefore permeability and storativity are expected to be 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 NERDO report (1982) undertook nine pumping tests in on five wells in this aquifer body and estimated the permeability of the aquifer in the vicinity of four of these wells. The heterogeneity of the aquifer is apparent in the range of estimated permeability and transmissivity values, between and within boreholes, as shown in the table below:

Well Name (NERDO, 1982)	Permeability (m^2/m/d)	Transmissivity (m^2/d)
L7/10j	41	1,000
L7/10j	35	800
L7/11a	2.6	61
L7/10h	3.2	77
L7/10h	5.5	131
L7/10h	6.5	155
L7/10k	1	23
L7/10k		3
L7/6j		19

The aquifer is generally unconfined, but becomes locally confined where the overlying lower permeability clay deposits occur. The bedrock aquifer beneath the sands and gravels

		has a high degree of rejected recharge associated with it, and the retention of recharge in the basal layers of the sands and gravels causes the water table to be at a relatively shallow depth. There are 32 water level records available; these include records from both unconfined and confined areas within the aquifer. The water table depth ranges from between 0.5 m to 5 m bgl. The NERDO report (1982) found that the annual variation in water levels ranged from 0.6 m to 1.88 m in 1978-1979 (based on the monitoring of 15 wells). The total storage in the raised beach deposits at Dundalk was estimated to be 24 x 10^6 m^3 (An Forás Forbartha and GSI, 1982). Groundwater storage was calculated by estimating the average saturated thickness (24 m) of the aquifer and multiplying it by the area (10 km^2) and the specific yield (0.1). Further investigation of this aquifer as part of this current 'GW3D' project revises down the estimated average saturated thickness to 10 m and the area to 7.9 km^2, and therefore the estimated groundwater storage is recalculated to be 7.9 x 10^6 m^3. The aquifer is close to the coast and is therefore vulnerable to sea water intrusion, and the NERDO report (1982) highlights that abstractions in dry years may lower the water table and could potentially cause this. However, NERDO investigations of sampling groundwater (1982) determined that there was no evidence of seawater intrusion under natural, non-pumping conditions.
	Thickness	Boreholes logs record interbedded sands and gravels, with some clays, throughout the area of the sand and gravel body. The greatest depth of sediment recorded is 27 m bgl at James' Street in Dundalk, however the sand and gravel is confined by 22 m of clay at this borehole. The thickest continuous layer of sand and gravel recorded is 16.4 m (An Forás Forbartha and GSI, 1982) and is found under Meadow Grove Estate, also in Dundalk.
Overlying Strata	**Lithologies**	54% of the area of the aquifer is covered by 'Made Ground' (concrete and tarmacadam mostly, GSI, 2023c). Small pockets at the west of the body are covered by a confining clay layer.
	Thickness	Where 'Made Ground' occurs it is usually between 1 m and 5 m thick (GSI, 2023c). The clay units at the west are very deep in some localities, reaching up to 22 m (An Forás Forbartha and GSI, 1982).
	% area aquifer near surface	Based on the distribution of 'Made Ground' mapped (GSI,2023a) approximately, 46% of the aquifer is at or near the surface.
	Vulnerability	The permeable nature of sand and gravel aquifers leaves groundwater vulnerable to contamination. 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 0.1 m to 6 m below ground level in the delineated Dundalk 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'; this accounts for 88% of the area of the aquifer body. Where the water table is greater than 3 m below ground level, the aquifer vulnerability is mapped as 'High'.
Recharge	**Main recharge mechanisms**	Diffuse recharge occurs *via* 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). Where the aquifer is covered by 'Made Ground', average recharge is reduced. Overlying clay deposits will also inhibit recharge in localised areas. Typically, the proportion of recharge that infiltrates to ground water in sand and gravel is around 85% (Hunter Williams *et al*., 2011).
	Est. recharge rates	Using water level variations the NERDO report (An Forás Forbartha and GSI, 1982) estimated annual renewable recharge for the year 1978-1979 to be 1.1 x 10^6 m^3/year. According to the GSI recharge map (GSI,2023a), recharge through the 'Made Ground' is very low, at an average rate of 94 mm/yr. Recharge rates though the sand and gravel are much higher, estimated to be 400 mm/yr (GSI,2023a). The rainfall in the area of the Dundalk sands and gravels is 830 mm (Walsh, 2012), and the estimated average recharge rate to the aquifer from direct recharge is 192 mm/yr. The minimum direct groundwater throughput in the aquifer at Dundalk is consequently estimated to be 1,848 m^3/d.

<table>
<tr><td rowspan="3">Discharge</td><td>Large springs and large known abstractions (m³/d)</td><td>The highest yielding well recorded in the aquifer is at the Fire Station in Dundalk and has a yield of 1,953 m^3/day, and the lowest recorded yielding well in the aquifer has a yield of 10.9 m^3/day (An Forás Forbartha and GSI, 1982). According to the NERDO report (1982) the yield of the wells is directly related to the type of sediment in which the borehole was completed; the coarser the sediment, the greater the yield.
<table>
<tr><th>Well Name (NERDO, 1982)</th><th>Yield m³ /day</th><th>Well Name (NERDO, 1982)</th><th>Yield m³ /day</th></tr>
<tr><td>L7/6a</td><td>1,964</td><td>L7/10c</td><td>327</td></tr>
<tr><td>L7/14a</td><td>153</td><td>L7/6c</td><td>55</td></tr>
<tr><td>L7/14b</td><td>87</td><td>L7/e</td><td>16.4</td></tr>
<tr><td>L7/10d4</td><td>654</td><td>L7/10f</td><td>10.9</td></tr>
<tr><td>L7/10di</td><td>163</td><td>L7/6j</td><td>109</td></tr>
<tr><td>L7/10b</td><td>1,964</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>Main discharge mechanisms</td><td>The main discharges are likely to be to the rivers and streams flowing through the aquifer, as well as groundwater discharging directly along the coast.</td></tr>
<tr><td>Hydrochemical Signature</td><td>The groundwater has a calcium bicarbonate signature. The hydrochemistry analyses from the NERDO report (An Forás Forbartha and GSI, 1982) indicate elevated iron and manganese levels within the aquifer; these can be seen in Table 1 below.</td></tr>
<tr><td colspan="2">Groundwater Flow Paths</td><td>It is assumed that, within the Dundalk sand and gravel body, the surface water and groundwater flow directions generally coincide (and are therefore southwest to northeast). The length of flowpaths in sand and gravel aquifers depends on the size and extent of the deposit. In general, locally important sand and gravel aquifers are expected to have relatively short flow paths i.e. up to a few hundred metres. This is also expected to be the case at Dundalk, given the setting and geometry of the aquifer.</td></tr>
<tr><td colspan="2">Groundwater & Surface water interactions</td><td>In the natural environment a sand and gravel aquifer with a shallow water table would be expected to have significant interaction with surface water. However, at Dundalk, the ‘Made Ground’ which covers the aquifer acts as a barrier between the surface water and groundwater, and keeps them separate and discrete over large portions of the aquifer body.</td></tr>
<tr><td>Conceptual model</td><td colspan="2">
The Dundalk sand and gravel aquifer is a lowlying deposit located along the coast, comprised of raised beach sands and gravels, and glaciofluvial sands and gravels.
The aquifer consists of sands and gravels interbedded with, and, in places, overlain by, layers of clay.
The presence of clay layers dissects the aquifer bedding and can cause the aquifer body to become locally confined.
The water table is at a shallow depth, which leaves the aquifer vulnerable to contamination.
The disjointed nature of the aquifer owing to both clay units and the preponderance of ‘Made Ground’, sealing it over a large area, causes variations in flow path length, recharge rate and well yield.
Yield has been shown to vary considerably across the aquifer (An Forás Forbartha and GSI, 1982).
Recharge occurs diffusely over the aquifer but is limited where the aquifer is overlain by ‘Made Ground’.
Groundwater is thought to discharge to surface water in the Castletown River at the north, as well as to other rivers and streams flowing through the deposit, and along the coast.
The minimum direct groundwater throughput in the aquifer is estimated to be 1,848 m^3/d.
</td></tr>
<tr><td colspan="2">Attachments</td><td>Table 1: Hydrochemical analysis
Figure 1: Location and extent
Figure 2: Cross sections
Figure 3: Groundwater vulnerability</td></tr>
<tr><td colspan="2">Instrumentation</td><td>Hydrometric gauges: 06036 LADYSWELL
06061 DUNDALK PORT
National Water Monitoring Stations;
River: TW21006031CN3002 (CN020 - St George Quay)
TW21006031CN3003 (CN030 – Towers)
Groundwater: None present</td></tr>
</table>

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. • 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 • GSI (2023c). Geological Survey Ireland. Internal Geotechnical 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 map viewer. http://webgis.npws.ie/npwsviewer/ • Murphy, O. (2012). County Louth Groundwater Protection Scheme. Report to Louth County Council. Geological Survey of Ireland. • 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. • Walsh S., (2012). A Summary of Climate Averages 1982-2010 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.

Parameter	PH	Conductivity	TDS	Alkalinity	Hardness	Calcium Hardness	Sodium	Potassium	Iron	Manganese	Sulphate	Nitrate	Chloride
Unit		uS/cm	mg/l	mg/l CaCO3	mg/l CaCO3	mg/l CaCO3	mg/l Na	mg/l K	mg/l Fe	mg/l Mn	mg/l SO4	mg/l N	mg/l Cl
Max Level	7.7	1390	1137	426	760	726	44	11.4	9.9	25.2	350	11.2	300
Mean	7.3	815	577	289	372	304	20	5.8	1.17	2.05	91	4.04	52
Minimum Level	6.7	500	355	142	222	181	7.6	1.5	0.01	n.d	n.d	Trace	22

Based on analysis from 20 wells (NERDO, 1981)

Table 1. Hydrochemical analyses of groundwater in the Dundalk Sand and Gravel Aquifer (from NERDO, 1982).

Dundalk Sand and Gravel Aquifer

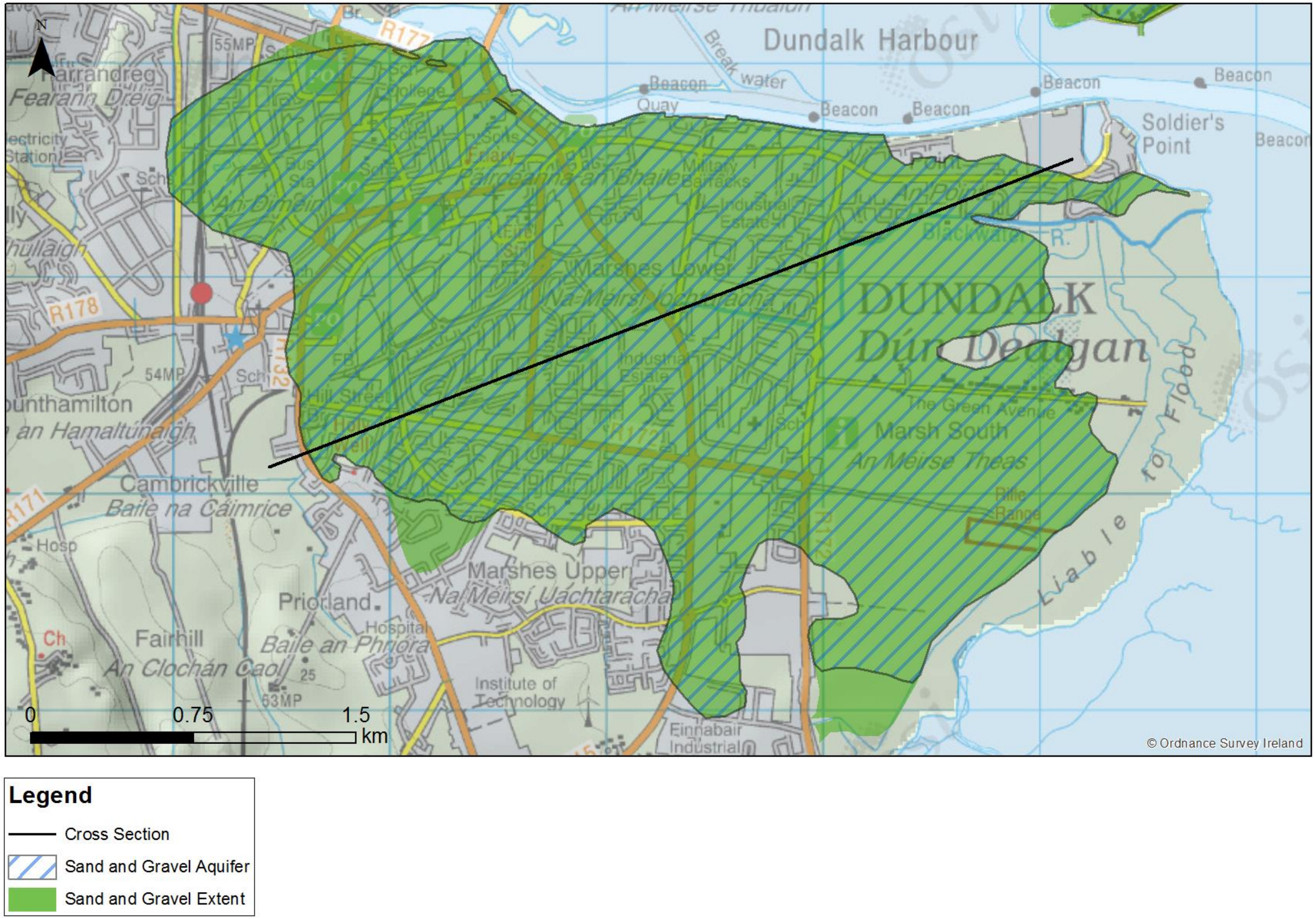
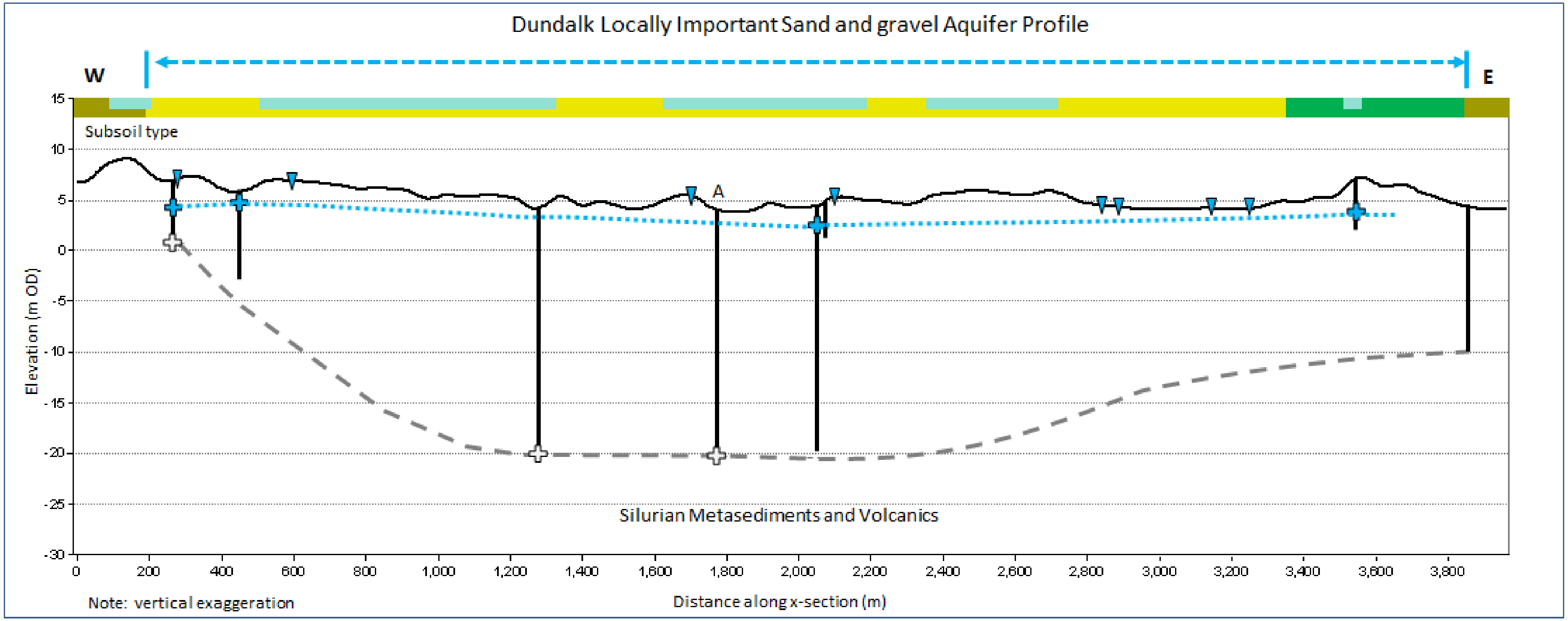


Figure 1. Dundalk Sand and Gravel Aquifer extent with cross section location.



Elevation		Aquifer		Made Ground	
Groundwater level		Presumed Groundwater Level		Sand and Gravel	
Top of bedrock		Presumed Top of Bedrock		Marine Gravel and Sand	
River		Borehole/Trial Pit		Esturine silts and clays	

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

Dundalk Sand and Gravel Aquifer Vulnerability

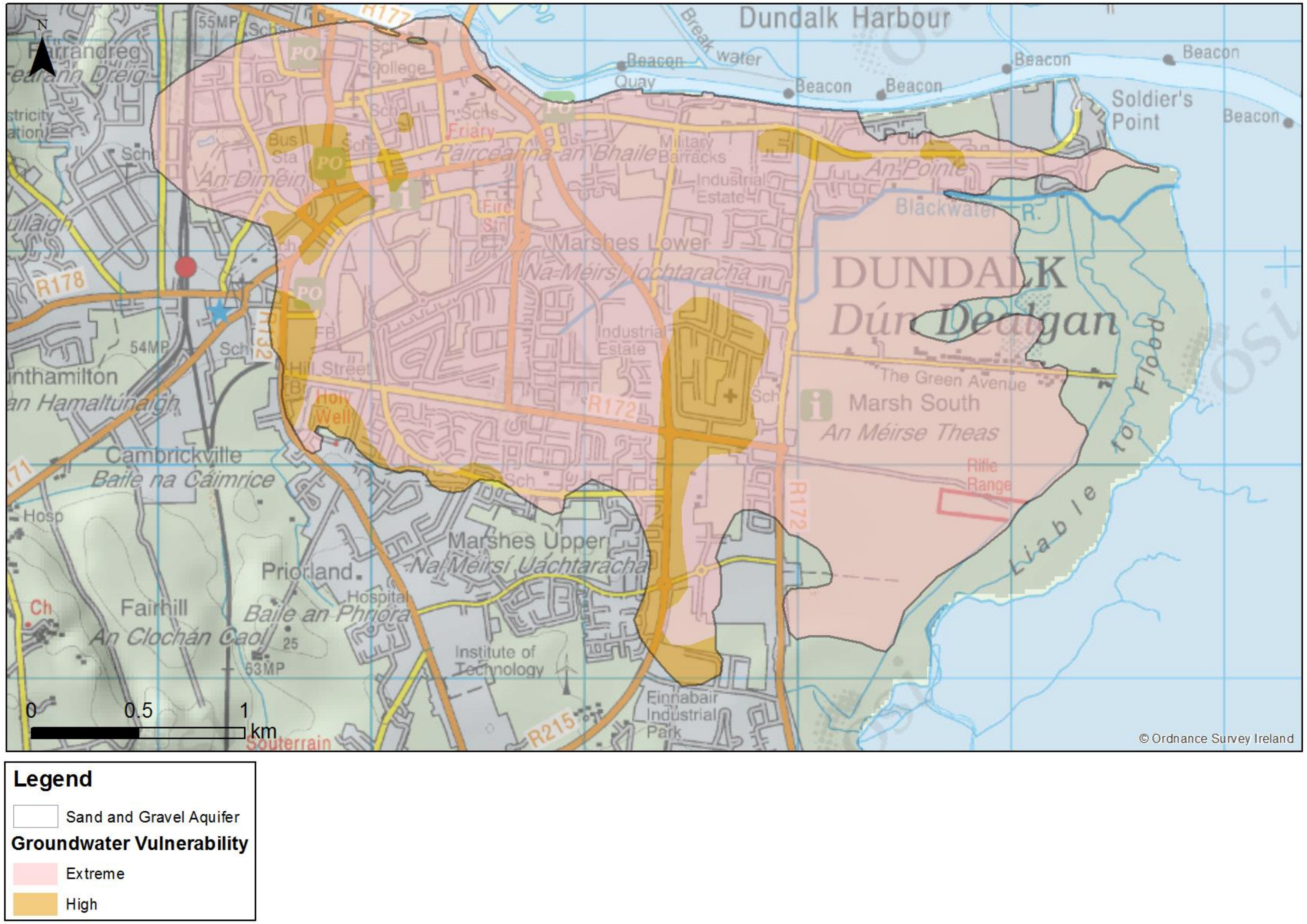


Figure 3. Groundwater vulnerability across the Dundalk Sand and Gravel Aquifer.