

Establishment of Groundwater Zones of Contribution

Templeport Group Water Scheme, Co. Cavan

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ENVIROLOGIC



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Project description

Since the 1980s, the Geological Survey of Ireland (GSI) has undertaken a considerable amount of work developing Groundwater Protection Schemes throughout the country. Groundwater Source Protection Zones are the surface and subsurface areas surrounding a groundwater source, i.e. a well, wellfield or spring, in which water and contaminants may enter groundwater and move towards the source. Knowledge of where the water is coming from is critical when trying to interpret water quality data at the groundwater source. The 'Zone of Contribution' (ZOC) also provides an area in which to focus further investigation and is an area where protective measures can be introduced to maintain or improve the quality of groundwater.

This report has been prepared for the Templeport Group Water Scheme as part of the Rural Water Programme funding initiative of grants towards specific source protection works on Group Water Schemes (DECLG Circular L5/13 and Explanatory Memorandum).

The report has been prepared in the format developed during an earlier pilot project "Establishment of Zones of Contribution" which was undertaken by the Geological Survey of Ireland (GSI), in collaboration with the National Federation of Group Water Schemes (NFGWS), and with support from the National Rural Water Services Committee (NRWSC).

The methodology undertaken by the GSI included: liaising with the GWS and NFGWS to facilitate data collection, a desk study, a site visit to inspect the supply, the local area, and to record groundwater level(s). The data was then analysed and interpreted in order to delineate the ZOC.

The maps produced are based largely on the readily available information in the area, a field walkover survey, and on mapping techniques which use inferences and judgements based on experience at other sites. As such, the maps cannot claim to be definitively accurate across the whole area covered, and should not be used as the sole basis for site-specific decisions, which will usually require the collection of additional site-specific data.

The report and maps are hosted on the GSI website (www.gsi.ie). A glossary of acronyms and terms used in this report is included in the Appendices.

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1 Overview: Groundwater, Groundwater Protection and Groundwater Supplies

Groundwater is an important natural resource in Ireland. It originates from rainfall that soaks into the ground. If the ground is permeable, the rainfall will filter down until it reaches the main body of groundwater, which is usually within either the bedrock, or a sand/gravel deposit. If the bedrock or sand/gravel deposit can hold enough groundwater and allow enough flow to supply a useful abstraction, it is referred to as an aquifer.

In Irish bedrock aquifers, groundwater predominantly flows through interconnected fractures, fissures, joints and bedding planes, which can be envisaged as a 'pipe network', of various sizes, with varying degrees of interconnectivity. The speed of flow through this network is relatively fast, delivering groundwater, and a large proportion of the contaminants present in the groundwater, to its destination e.g. borehole, spring, river and sea.

In sand/gravel aquifers, the groundwater flows in the interconnected pore spaces between the sand/gravel grains. Generally, this is equivalent to a filter system that may physically filter out contaminants to varying degrees, depending on the nature of the spaces and grains. It also slows down the speed of flow giving more time for pathogens to die off before they reach their destination e.g. borehole, spring, river and sea.

Further filtration of contaminants may occur where the aquifers are protected by the overlying soil and subsoil; thick, impermeable clay soil and subsoil provide good protection while thin gravel will provide limited protection. Therefore variation in subsoil type and thickness is important when characterising the 'vulnerability' of groundwater to contamination.

The karst limestone aquifers provide significant and important groundwater supplies in Ireland. Karst landscapes develop in rocks that are readily dissolved by water e.g. limestone (composed of calcium carbonate). Consequently, conduit, fissure and cave systems develop underground¹. Groundwater typically travels very fast in karst aquifers, which has a significant impact on the water quality; neither filtration nor pathogen die-off are associated with these aquifers.

The interaction between abstraction and geology is shown in **Diagram 1**. In this scenario, a borehole is pumping groundwater from the bedrock aquifer. As the water is abstracted through the well, the original water table (a) is drawn down to level (b), where it induces a drawdown curve of the natural water table (c). The shape of this curve depends on the properties of the aquifer, for example, if the borehole is intersecting an aquifer with few fractures that are poorly interconnected, the groundwater from that system will soon be exhausted, and therefore the pumping will have to pull from deeper depths to maintain supply, which results in the steep, deep drawdown curve. Alternatively, if the borehole is intersecting an aquifer with a large number of well-connected groundwater-filled fractures, the abstraction will be met by pulling water from farther away, at a shallower depth, resulting in a shallow, wide drawdown curve.

By knowing the rate of abstraction (output), how much rainfall there is (input), and by assessing the geological elements outlined above (nature of the bedrock fractures or sand/gravel deposit; how permeable the soil and subsoil are) to determine what happens in between input and output, the catchment area, or 'Zone of Contribution' (ZOC), to any groundwater water supply can be determined.

Templeport GWS (CN42) is supplied by two boreholes that abstract water flowing through conduits in a regionally important karstified limestone aquifer. The current abstraction rate is 152 m³/d.

¹ Geological Survey of Ireland, 2000.

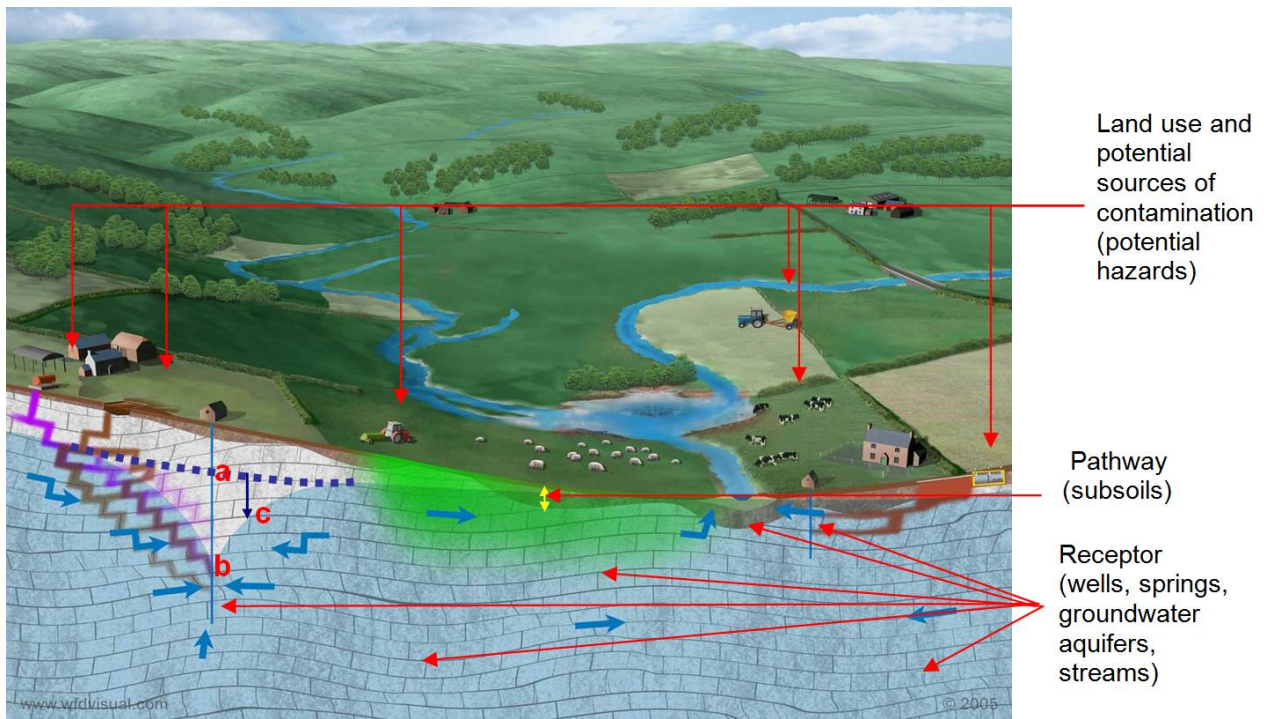


Diagram 1. Rural Landscape Highlighting the Interaction between Surface Water, Groundwater and Potential Land Use Hazards

2 Location, Site Description, Supply Details and Wellhead Protection

The zone of contribution (ZOC) for the Templeport Group Water Scheme (GWS) has been delineated according to the principles and methodologies set out in 'Groundwater Protection Schemes'² and in the GSI/EPA/IGI Training course on Groundwater SPZ Delineation.

Templeport GWS site is in the townland of Cloneary, approximately 3 km southeast of Bawnboy and 5 km southwest of Ballyconnell (**Figure 1**). The GWS is supplied from two boreholes located in a fenced enclosure on the western side of a local road. A working agricultural store exists immediately south and west of the site, on what was previously Templeport Creamery (**Diagram 2, Photograph 1**).

The scheme serves 235 connections (both domestic and agriculture connections), with an average usage of approximately 152 m³/d. The network was upgraded in 2008 to deal with leaks³, which reduced demand from 250 m³/d to current levels.

The scheme consists of two production boreholes, each fitted with submersible pumps. Wellheads are enclosed in separate concrete chambers below ground level, each covered with a manhole. Pumping alternates between these boreholes on a fortnightly cycle, typically for about 6 hours per day. Groundwater is passed to a sump and then through the treatment plant before being transferred to one of two reservoirs which distribute to the network via gravity. Two-thirds of abstracted water is pumped to Ballymagauran

² DELG/EPA/GSI, 1999

³ private communication, P. Boyle

reservoir (2 km south) with the remaining third to Corran reservoir (3 km east). These reservoirs were part of Corran GWS and Ballymagovern GWS, prior their amalgamation into Templeport GWS.

Treatment consists of two sand filters which remove any sediment. The disinfection system consists of chlorination. The sand filter and chlorine dosing system are located inside a plant house adjacent to the boreholes. The sand filters are backwashed every other day and sludge returns are reportedly negligible. Washwater is passed to an underground wastewater tank, from which it can be recycled or disposed of to a percolation area west of the site.

Summary details are presented in **Table 1**.



Diagram 2. Aerial photo showing location of GWS abstraction points

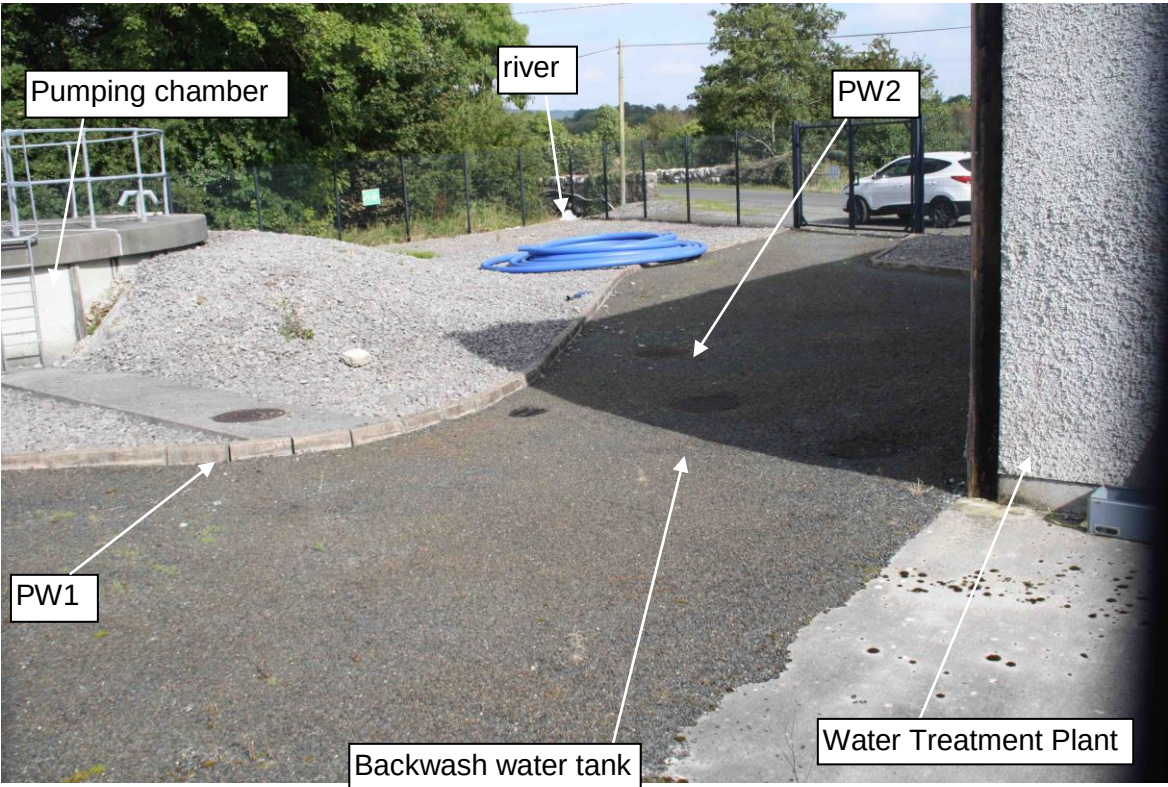


Photo 1 Templeport borehole pad



Photo 2 PW1 Wellhead arrangement

Table 1. Water Supply Details

NFGWS No. CN42	PW1	PW2
Grid reference	Irish Grid: E222,028 N316,397	Irish Grid: E222031 N316,395
Townland	Cloneary	Cloneary
Source type	Borehole	Borehole
Drilled	2002	2002
Drilling Contractor	Dunnes Drilling	Dunnes Drilling
Owner	Templeport GWS	Templeport GWS
Elevation in metres above Ordnance Datum	ground level = 54.85 mOD top of casing = 54.06 mOD	ground level = 54.68 mOD top of casing = 54.09 mOD
Total depth (m)	69 m (225 ft)	Assumed as per PW1
Construction details	Drill 300 mm from 0 – 6 m Install 250 mm steel casing from 0 – 6 m Drill 200 mm from 6 – 11 m Install 150 mm steel casing from 0 – 12 m Drill open hole to base	Construction assumed to be as per PW1
Depth to rock in metres below ground level	4.5 m bgl	4.5 m bgl
Inflow zones (water strikes) mbgl	Estimated 1,600 m ³ /d between 4.5 – 8.5 m, sealed off with 150 mm steel casing (ungROUTED). Inflows at 49 m and 68.5 m	Assumed as per PW1
Static water level (SWL) (m bgl)	Not known, assumed to be equal to or slightly higher than river level, i.e. 1.85 mbgl	Not known, assumed to be equal to or slightly higher than river level, i.e. 1.60 mbgl
Pumping water level (PWL) (m bgl) (PW1 pumping rate = 31 m ³ /h)	28/09/15 = 1.93 mbgl	21/08/15 = 1.69 mbgl 28/09/15 = 1.68 mbgl
Pump intake depth (m bgl)	Unconfirmed, assumed to be 30 m bgl	As per PW1
Current abstraction rate (GWS)	Pumping rate = 31 m ³ /hr Daily abstraction = 152 m ³ /d (based on information provided by caretaker and averaged bulk meter readings for the period 18/08/15 to 21/08/15).	As per PW1 Boreholes alternated on a fortnightly rotation
Reported yield (m ³ /d)	Estimated yield from drilling ⁴ = 545 m ³ /d (only one borehole pumped during testing so yield is combined yield)	Assumed as per PW1
Specific Capacity (m ³ /d/m)	Not available	Not available
Transmissivity (m ² /d)	Not available	Not available

⁴ Dunnes Drilling, 2002, drill log (Appendix 5)

3 Physical Characteristics and Hydrogeological Considerations

3.1 Physical characteristics of the area

An overview of the relevant information on rainfall, land use, topography, hydrology and geology for the area around the GWS is provided in **Table 2**.

Table 2. Physical Characteristics of the Area of Interest

		Description/Comments
Topography (Figure 1 & Figure 2)		The general landscape setting is a low-lying area of lakes and drumlins at the base of Slieve Rushen, in which the drumlins are predominantly up to 100 mOD, and the flatter valley floors are between 50 – 60 mOD. Slieve Rushen (400 mOD) peaks 6 km to the north.
Land use		Predominantly grassland supporting low to moderate intensity cattle and sheep grazing. Low-lying lands are poorly drained and prone to seasonal flooding. An agricultural store, which includes a covered shed and yard area, is located immediately south of the site. There is an unused well in this yard area (which has not been decommissioned). A one-off house is sited to the immediate west, with two more in close proximity to the north and south. Wastewater from these goes to on-site septic tanks. A cluster of 3 houses is located 100 m southwest. Wastewater from these, and the agricultural store, is transferred to a mechanical WWTP west of site. Disused railway station 50 m to the south. Few farmyards in the area. Graveyard 400 m to northwest.
Surface Hydrology (Figure 1 & Figure 2)		A series of interconnected streams and lakes occupy local hollows and valleys. One such river passes to the immediate north of the GWS site. This is prone to winter flooding at the adjacent bridge. The river flows east to west, into Templeport Lough, which is 400 m west of the boreholes at its nearest point. Lake water drains westwards to the Blackwater River which subsequently enters a small series of lakes at Ballymagauran Lough to the south, before flowing northeast via the Woodford River and ultimately discharging to Upper Lough Erne, 15 km to the northeast.
Topsoil http://gis.epa.ie/envision		General area dominated by deep, poorly drained soils. Peat soils occur in depressed grounds around the site, primarily flanking the river channel, lake margins and lands to the east.
Subsoil (Figure 3) www.gsi.ie/mapping		Low permeability chert and sandstone till ('boulder clay'). Peats have formed on depressed ground prone to waterlogging.
Groundwater Vulnerability (Figure 4) www.gsi.ie/mapping		Extreme (E) (see Appendix 1) extends from eastern shore of Templeport Lough to raised grounds 1 km to the east. Vulnerability quickly falls to low on raised drumlin mounds with thick subsoil coverage.
Geology (Figure 5) www.gsi.ie/mapping		The water supply boreholes are located in pure limestone bedrock. A significant bedrock fault (large fracture zone) is mapped as passing through the site, in a northwest-southeast orientation. This potentially transmits significant amounts of groundwater.
Aquifer Classification (Figure 6) www.gsi.ie/mapping		The pure limestone bedrock is classified as a Regionally important karstified aquifer (RK_c), dominated by conduit flow. The shale and sandstone bedrock formations to the north and west are classified as Locally important aquifers which are moderately productive only in local zones only (LI).
Groundwater Body (GWB) www.wfdireland.ie		The borehole is located in the Newtown-Ballyconnell groundwater body, which is categorised as having "good" status. www.gsi.ie/Programmes/Groundwater/Projects/Groundwater+Body+Descriptions
Recharge Coefficient (Appendix 2)	15 – 30 %	The regionally important aquifer is considered to have sufficient capacity to accept recharge compared to less productive, poorer aquifers. However, relatively low recharge rates occur where poorly drained gley soils overlie less than 3 m of till subsoil. The bulk recharge coefficient for the ZOC area is estimated at 22.5%. Using this figure the calculated recharge of 220 mm/yr approximates to the range shown on the national recharge map.
Recharge (mm/yr) www.gsi.ie/mapping	220	

3.2 Hydrochemistry and water quality

GWS monthly status reports for the years 2005 to 2015 were made available. Data for the period January 2013 to June 2015 were used to summarise the hydrochemistry and water quality for Templeport GWS. Water quality data are presented in **Appendix 3**, which includes graphs showing how key water quality parameters have varied over time.

The data are summarised in **Table 3**, where they have been compared to the drinking water limits (DWL) from the Drinking Water Regulations (S.I. No. 122 of 2014) and/or threshold values (TV) from the European Communities Environmental Objectives (Groundwater) Regulations 2010 (S.I. No. 9 of 2010).

Table 3. Key Hydrochemistry and Water Quality values in untreated water samples

Parameter	No. of samples	Min	Max	Average	Drinking Water Limit (DWL) or Threshold Value (TV)
Electrical Conductivity ($\mu\text{S}/\text{cm}$)	30	386	970	596	800 (TV), 2,500 (DWL)
Laboratory pH	30	6.9	7.9	7.3	6.5 – 9.5 (DWL)
Turbidity (NTU)	30	<0.5	9.53	<0.5	
Total Coliforms (MPN ⁵ /100 ml)	30	<1	9560	1087	0 (DWL)
Faecal Coliforms (<i>E. Coli</i>) (MPN/100 ml)	30	<1	1846	219	0 (DWL)
Clostridium perfringens (MPN/100 ml)	30	<1	95	<1	
Nitrate (mg/l NO_3)	30	<8.9	17.2	<8.9	50 (DWL) 37.5 (TV)
Ammonium (mg/l NH_4)	30	<0.013	0.15	<0.013	0.3 (DWL), 0.225 [0.175 as N] (TV)
Iron ($\mu\text{g}/\text{l}$)	30	<7.2	363	48	200 (DWL)
Manganese ($\mu\text{g}/\text{l}$)	30	<0.7	54	6	50 (DWL)
Aluminium ($\mu\text{g}/\text{l}$)	30	<5	640	40	200 (DWL)

Raw groundwater abstracted from the Templeport GWS boreholes had microbial contamination in most of the samples. Faecal coliform numbers showed gross contamination (MPN>100) in 9 of the 30 samples.

Nutrient concentrations, i.e. nitrate and ammonium, are generally low and below the drinking water limits. However, both are subject to fluctuating concentrations, indicating variable and rapid input of pollutants.

Iron and manganese concentrations are generally low but were above the drinking water limits on two of the sampling events (09/05/13 and 10/06/14). Similarly, aluminium was elevated above drinking water limits on one sampling occasion.

Groundwater quality in the Templeport boreholes is impacted by microbial contamination. Peaks in microbial contamination do not coincide with elevated turbidity. Nitrate, ammonium, iron and manganese concentrations are generally low, reflective of relatively low land use pressures. Potential point sources of contamination in the vicinity include septic tanks serving local houses, the adjacent agricultural store, the adjacent river and the nearby graveyard. The intermittent low electrical conductivity concentrations, microbial contamination, occasional elevated iron and manganese concentrations, and variable ammonium and nitrate concentrations, suggest rapid influxes linked to rainfall of shallow groundwater, or influx of surface waters into the groundwater system.

⁵ MPN is most probable number

The chemistry data suggest occasional connectivity between the borehole and surface water, most likely in the adjacent river. The treatment plant caretaker reported that the local river is flashy and prone to frequent flooding, due in part to the constriction in the channel at the local bridge. During intense rainfall the borehole pad can also become flooded due to it being located in a slight hollow, and the stormwater outfall being blocked by the rising river level.

The manholes covering the wellheads are not impermeable and during local flooding the wellhead chambers can become submerged and fill with surface water. Furthermore, the underground wastewater tank, which contains backwash from the sand filter, can become inundated and overflow. The treatment plant operator turns off backwash to the wastewater tank during flood events. The caretaker estimates on average ten such flooding events per year. Between January and August of 2015 the backwash system was turned off for these reasons on 25/02/15, 03/05/15 and 27/07/15.

Treated water samples were not available to this project so no statement can be made about the effectiveness of the treatment system in removing all microbes.

A cryptosporidium risk assessment was carried out in 2008⁶ and concluded that the weighted groundwater risk assessment score was -3, putting the borehole into the low risk category. The ubiquitous presence of coliforms, faecal coliforms and clostridium perfringens contradicts this assessment.

4 Zone of Contribution

4.1 Conceptual model

The current understanding of the geological and hydrogeological setting is given as follows and is shown schematically in **Diagram 3**. Templeport GWS sources water from two boreholes located next to one another in a securely fenced site adjacent to an agricultural store (previously a creamery). The boreholes are pumped alternately on a fortnightly basis. The contributing area to each borehole is therefore assumed to be the same.

Groundwater is replenished by rainfall percolating diffusely through the soils and subsoils down to the water table in the bedrock. The subsoils are classified as having a low permeability, which permit a limited proportion of rainfall to infiltrate downwards. Depth of low permeability subsoil varies, being thinner on the valley floors, and thicker on the drumlin mounds.

Localised inflows into the groundwater system are indicated by spikes in chemical concentrations, the persistent presence of coliforms, and dips in groundwater electrical conductivity.

Once the downward percolating rainfall reaches the top of the bedrock, a proportion of it will move along the top of the bedrock, which is highly weathered (broken) and therefore has interconnected fractures and fissures (i.e. more flow paths), until it reaches a point of discharge which in this case is the local river. The drilling log showed the upper layer of limestone bedrock to be very broken and transmitting large volumes of groundwater during the pumping test. Given the proximity of the local river it is likely that this upper groundwater and river water are connected. Deeper groundwater inflows draw groundwater from the regional karst conduit network.

The regional groundwater and surface water flow directions are southwards from Slieve Rushen. Shallow groundwater may flow towards nearby smaller surface watercourses. Under pumping conditions, the pumping borehole reverses the local hydraulic gradient slightly, such that the groundwater level in the pumping borehole is below the river water level. This indicates, together with chemistry data, that some water from the local river makes its way to the borehole.

⁶ Jennings O'Donovan & Partners (JOD)

The driller encountered two significant groundwater inflows in deeper bedrock. These are likely to be large fractures or conduits in the karstified limestone, fed by a network of smaller cracks and fractures. A geological fault is shown to cut through bedrock at the boreholes. These faults are preferential pathways and this is likely to contribute significant volumes of groundwater flowing into the borehole. This faulting may be responsible for the large volumes of groundwater encountered near the surface during drilling.

The delineation of the zone of contribution boundaries includes a safety margin for some variability in groundwater flow direction and for seasonal variability in abstraction rates and water levels.

4.2 Boundaries

The Zone of Contribution (ZOC) delineated for Templeport GWS is based mainly on a combination of hydrogeological mapping and inferences, and geological boundaries.

The **northern** boundary is defined by the transition from karst aquifer to the less productive sandstone aquifer on higher ground. Recharge to the sandstones is limited. A 100 m buffer is applied to account for small inflows from the fractured sandstone into the karstified limestone aquifer, and any inaccuracies in the mapped geological boundary.

The **southern** boundary is defined by a mapped fault which may act as a preferential pathway for groundwater to reach the borehole. Again a 100 m buffer is applied.

The **western** and **eastern** boundaries are based on an assessment of local groundwater flow directions, and are located along interpreted groundwater flow lines. The primary groundwater flow direction is north to south, driven by raised grounds towards Slieve Rushen. The western boundary provides a downgradient buffer against localised groundwater flow directions, and assumes that Templeport Lough receives groundwater into it.

Due to the potential connectivity between the borehole and the nearby stream, a 10 m buffer has been applied to surface watercourses upstream of the borehole.

The recharge and water balance calculations are used to support the hydrogeological mapping and to confirm that the ZOC delineated is big enough to supply the quantity of water at the source.

The current demand for the Templeport GWS is 152 m³/d. The hourly pumping rate is equal to 31 m³/hr (744 m³/d). The maximum sustainable yield for the borehole is not confirmed but from drilling estimates is 545 m³/d (assuming the driller successfully sealed off the potential yield of 1600 m³/d in the uppermost section of weathered bedrock). The ZOC invoked by the daily demand rather than the hourly pumping rate is deemed to be the most appropriate approach.

Recharge to the ZOC is estimated as 220 mm/yr (see **Table 2**). For the purpose of the ZOC delineation and water balance a rate of 228 m³/d is used, which is 150% of the current abstraction rate. Based on an estimated recharge rate of 220 mm/yr and a conservative abstraction rate of 228 m³/d, the required catchment area to sustain the well is 0.38 km².

The area described above and shown in **Figures 2 to 7** is 3.9 km². This is substantially larger than the area required to sustain an abstraction rate of 228 m³/d.

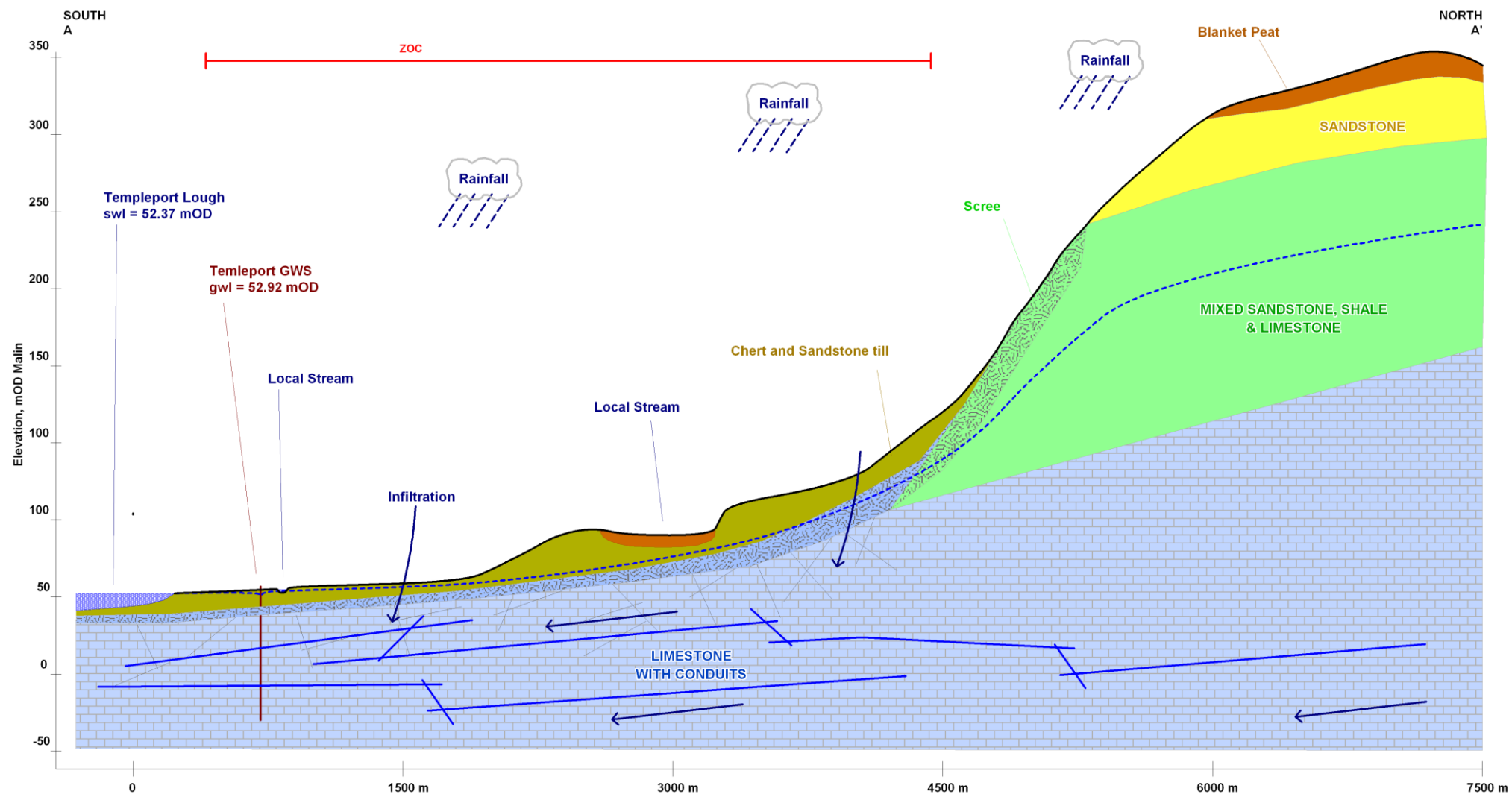


Diagram 3. Vertical cross-section through soils, subsoils and bedrock aquifers, showing the conceptual model of groundwater flow

5 Conclusions

Templeport GWS is sourced from a pair boreholes which pump alternately on a fortnightly basis at an hourly rate of 31 m³/d, and supply 152 m³/d over 24 hours per day from a karstified limestone aquifer.

Rainfall infiltrates to the groundwater system indirectly through chert and sandstone till and directly through exposed bedrock. The ZOC, which encompasses an area of 3.9 km² is mostly a valley floor, classified as being of Extreme vulnerability. The peats and gleyed soils restrict the infiltration of rainwater into the underlying karstified limestone aquifer. Groundwater flows through an upper zone of heavily weathered rock, and a deeper zone of conduits and fractures in the karstified limestone. The wells have been designed to abstract groundwater from the deeper zone only.

The available water quality data suggest that groundwater is prone to gross microbial contamination on a regular basis. The intermittent faecal coliforms suggest rapid influxes of shallow groundwater. It is assumed that this is from the local river, probably following heavy rainfall.

Localised flooding occurs several times each year and is attributed to the constriction at the nearby bridge, and rainwater accumulating in the borehole pad area. During flood events ponding occurs on the borehole pad. As the wellheads are below ground level, surface waters can enter the top of the borehole directly. This problem is furthered by the tendency of the wastewater tank to overflow during such events.

Based on the collection and analysis of the available data for this project, it is recognised that this scale of study (i.e. predominantly desk study) cannot delineate a definitive ZOC for the Templeport GWS with a high degree of confidence, due to the complicated nature of the karst aquifer in this region. It is probable that additional areas are also contributing to the source so the GWS may want to consider further hydrogeological work/measures if water quality issues persist, which will provide supporting evidence as to the most likely areas that should be included within the ZOC.

6 Recommendations

Essential:

- Monthly sampling of raw water quality should be continued as per present sampling protocol.
- Hazard mapping in the ZOC to identify potential sources of microbial contamination. This should include surface water sampling of the local river on the same date raw water sampling is performed.
- Prevent possibility of river floodwaters and/or contents of the wastewater tank (which contains unsterilised backwash water and any sludge residue) from mixing with the raw water supply at the wellheads. There are two possible approaches:
 - Install a flood defence wall around the manhole covers to prevent surface water from entering the boreholes during flood events.
 - Raise the wellheads to approximately 1 m above ground level. This would involve welding sections of steel casing to those in place. The manhole cavity surrounding the wellheads could then be backfilled with concrete. A small roofed structure could be constructed over the raised wellhead.
- A landspreading assessment should investigate timings of landspreading on grasslands within the ZOC. Emphasis should be placed on lands surrounding Gortnaleck Lough (and any watercourses into same), current setback distances, and whether surface waters are fenced off to prevent animal access.
- Perform an audit to identify any leaks in the network and repair accordingly.

- A well survey to clarify groundwater flow direction. Ideally this would be performed when the GWS boreholes are not pumping.
- The driller attempted to seal off the upper groundwater flow component using steel casing. However, as cement grout was not used to fill the space between the drilled hole and the steel casing, it is unlikely that this seal is completely impermeable. It is recommended that the annulus between the various steel (and PVC) casings be filled using cement grout to prevent migration of shallow groundwater into the deeper water-yielding section of the borehole. This will need consultation with the original driller to see explore feasibility.

Desirable:

- Consider incorporating domestic dwelling on single septic tank into the mechanical WWTP used by the agricultural supplies store and other dwellings.
- Ensure that the effluent of the mechanical WWTP complies with relevant discharge standards, and is downstream of the boreholes (if the discharge is to surface water).
- Consider running the borehole pumps on a continuous 24 hour cycle at a lower pumping rate, in the order of 6.3 m³/hr. This could be trialled for a 6-month period to see if any improvement in microbial quality results.

Other:

- The following EPA guidelines may serve as future useful reference documents for the GWS:
 - EPA Guidance on Landspreading of Organic Waste⁷
 - EPA Drinking Water Advice Note No. 7: Source Protection and Catchment Management to Protect Groundwater Sources. Of particular interest would be Section 4.1 – Step 2 – Hazard Mapping⁸.
 - EPA Drinking Water Advice Note No. 8: Developing Drinking Water Safety Plans. This document contains checklists for hazards which would assist in hazard mapping within the ZOC⁹.
 - EPA Drinking Water Advice Note No. 14. Borehole Construction and Wellhead Protection¹⁰

7 References

DELG/EPA/GSI (1999). Groundwater Protection Schemes. Dept. of the Environment & Local Government; Environmental Protection Agency; Geological Survey of Ireland.

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⁷ http://www.epa.ie/pubs/advice/waste/waste/EPA_landspread_organic_waste_guide.pdf

⁸ http://www.epa.ie/pubs/advice/drinkingwater/epadrinkingwateradvisenote-advisenoteno7.html#.UpNP_eJ9KEp

⁹ <http://www.epa.ie/pubs/advice/drinkingwater/epadrinkingwateradvisenote-advisenoteno8.html#.UpNQf-J9KEo>

¹⁰ <http://www.epa.ie/pubs/advice/drinkingwater/advisenote14.html#.UpNR8eJ9KEo>

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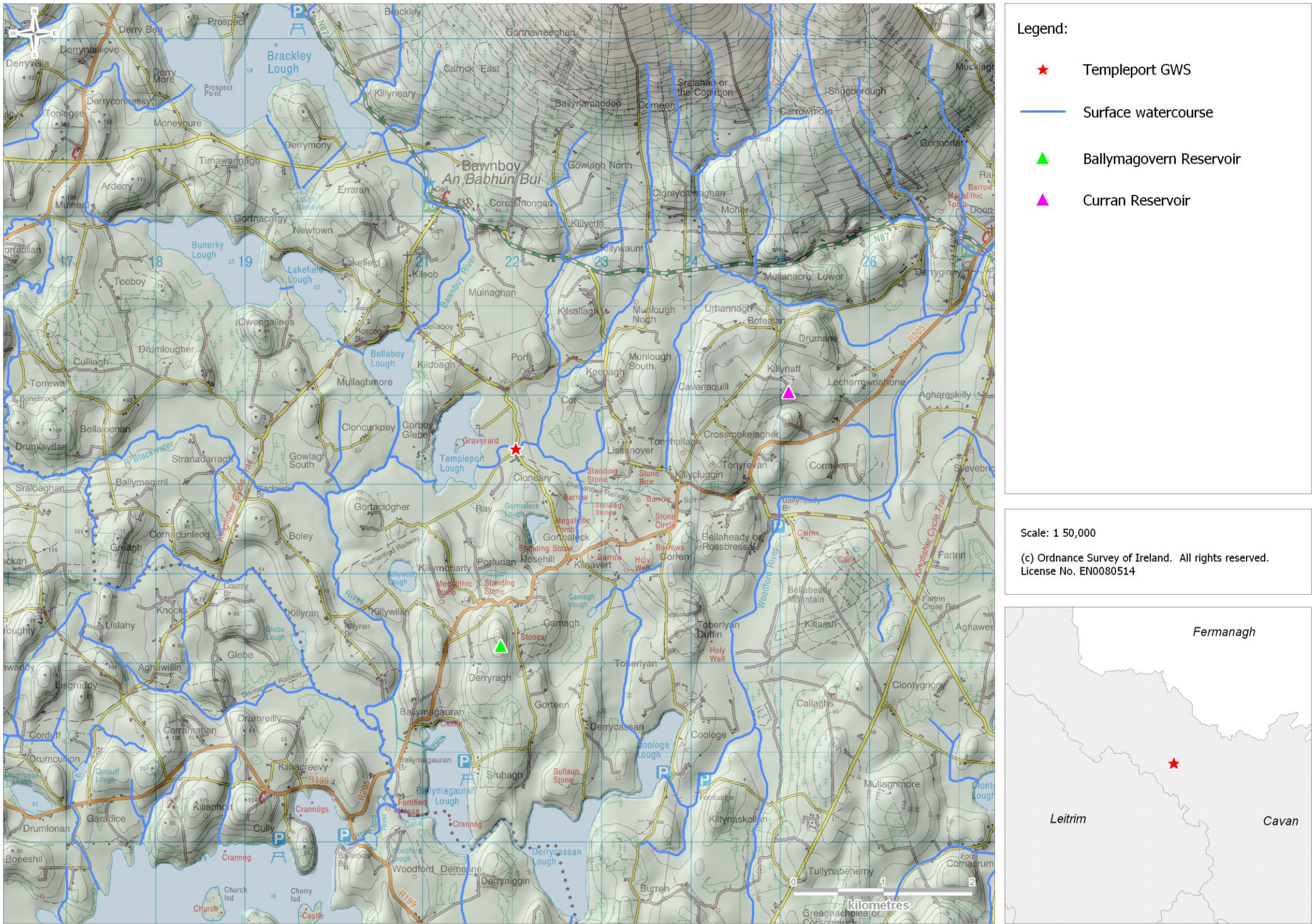
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Figures



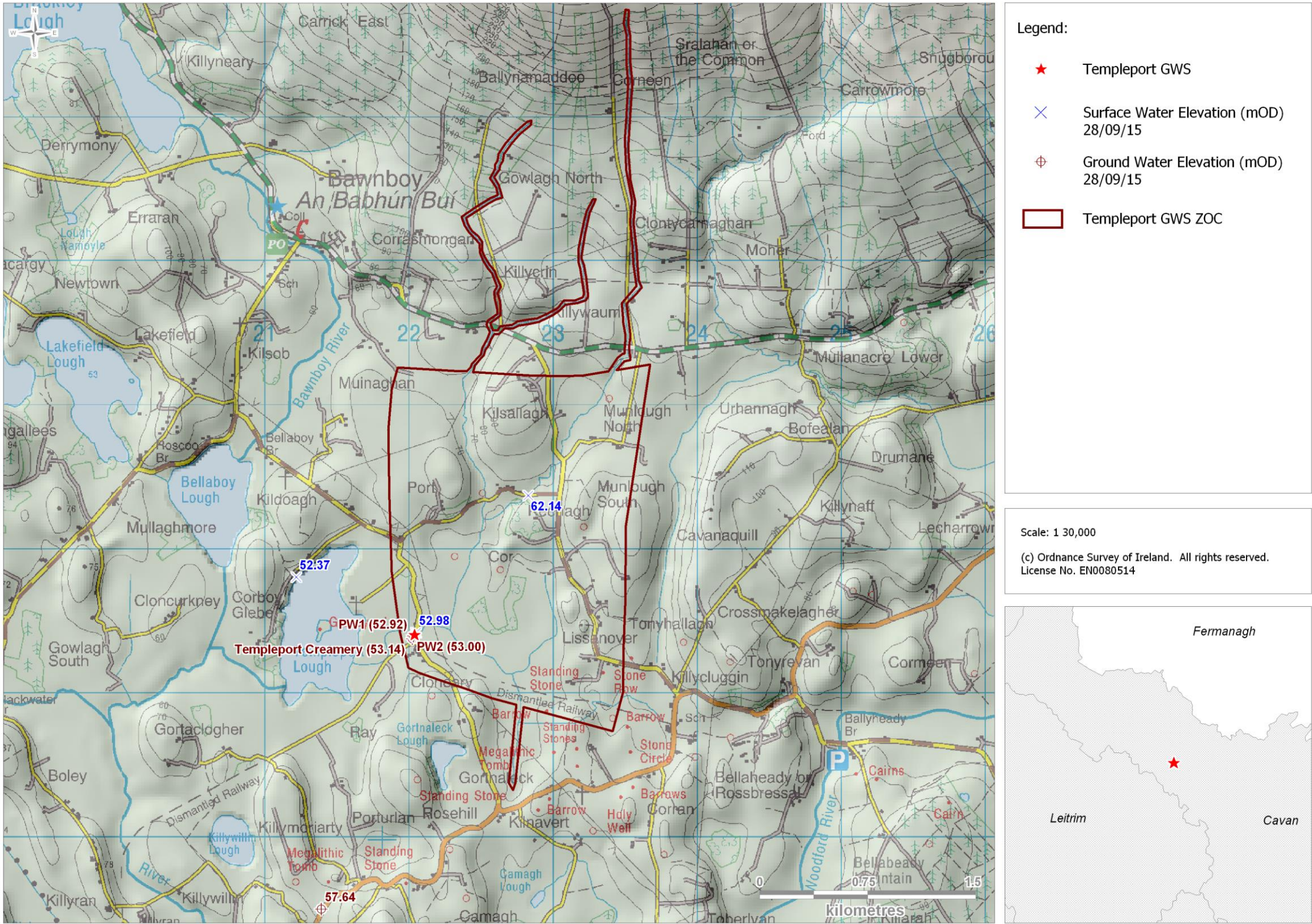


Figure 2 Topography, hydrology and karst features

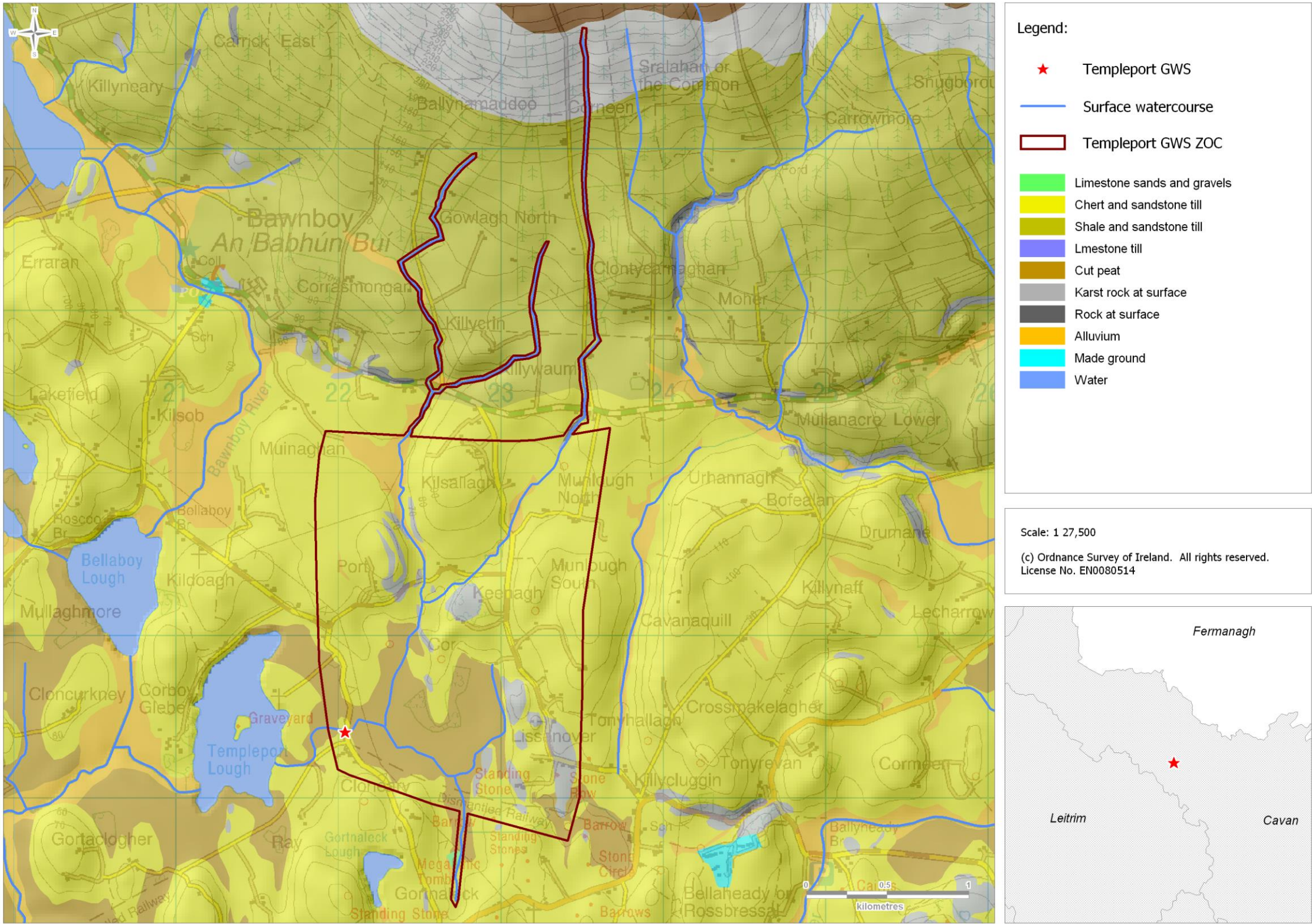


Figure 3 Subsoils

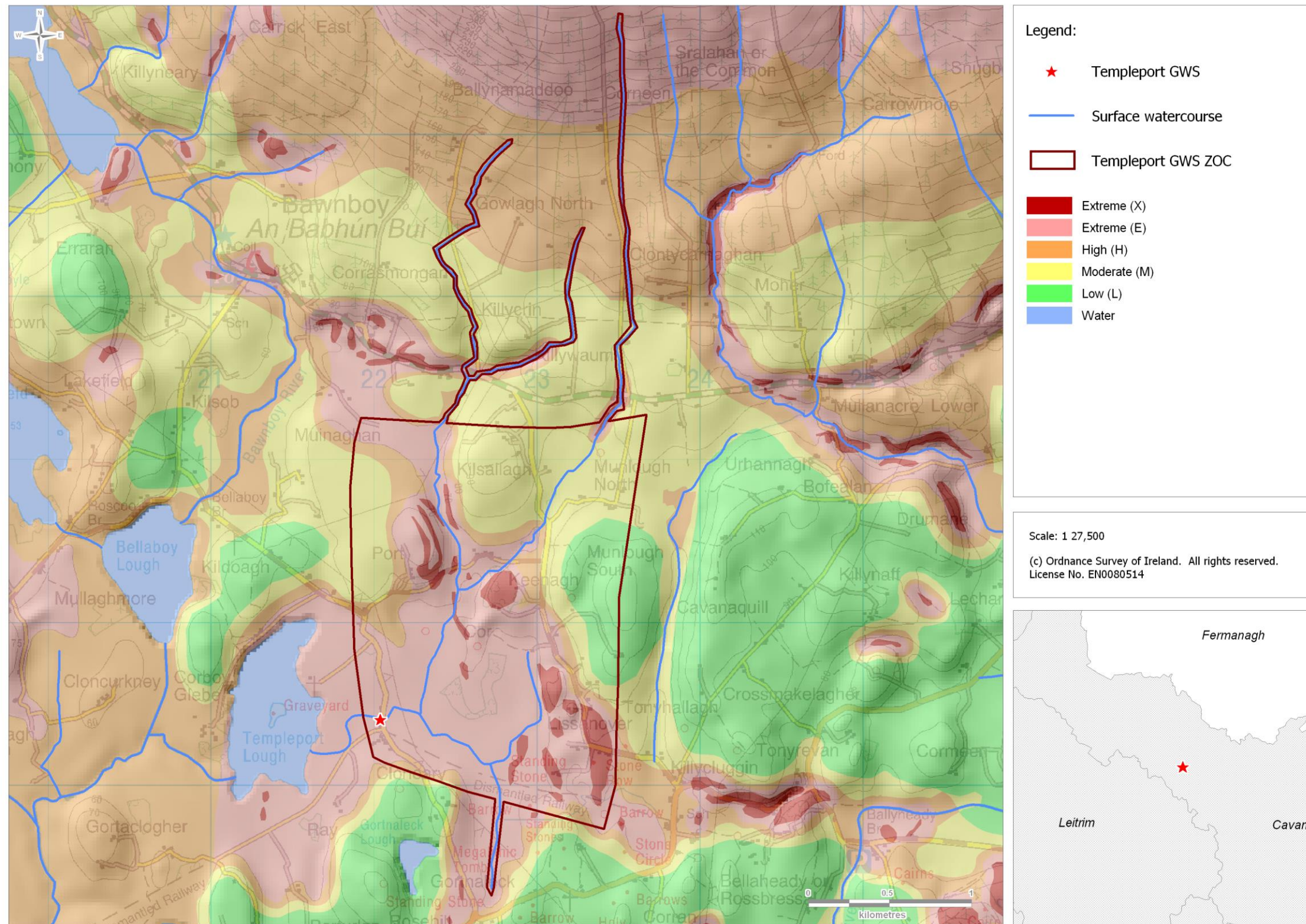


Figure 4 Groundwater Vulnerability Map

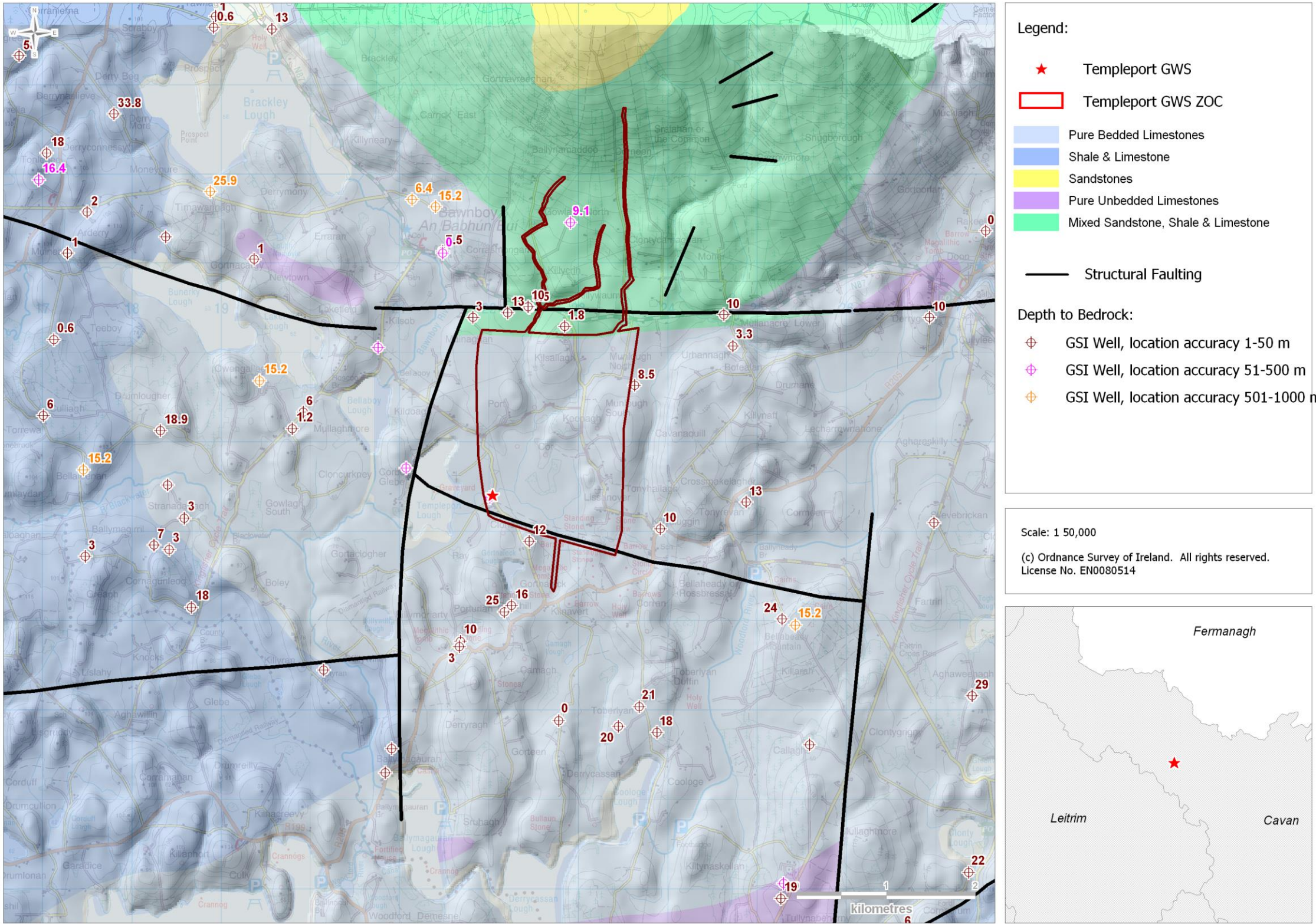


Figure 5 Rock Unit Group Map

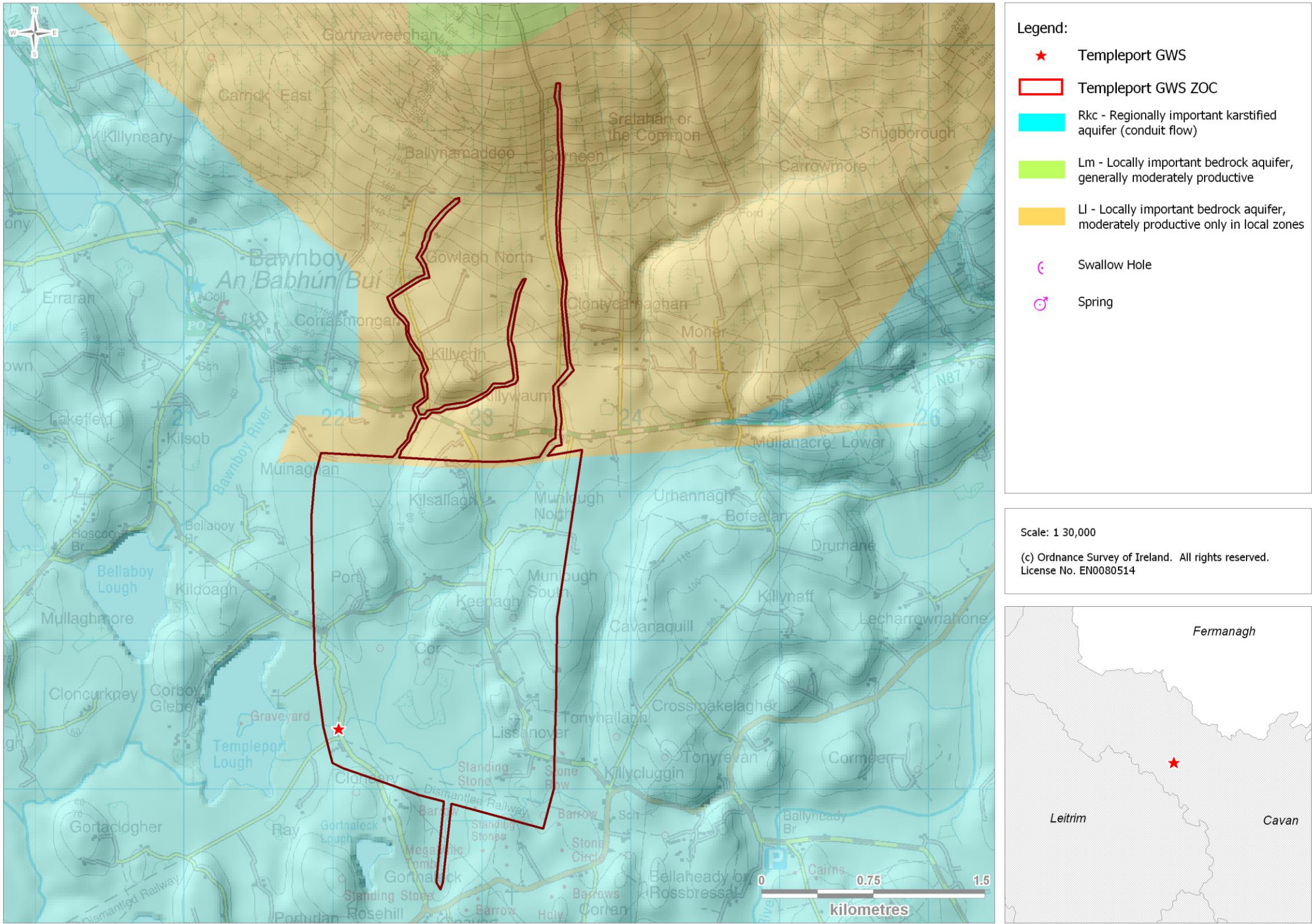
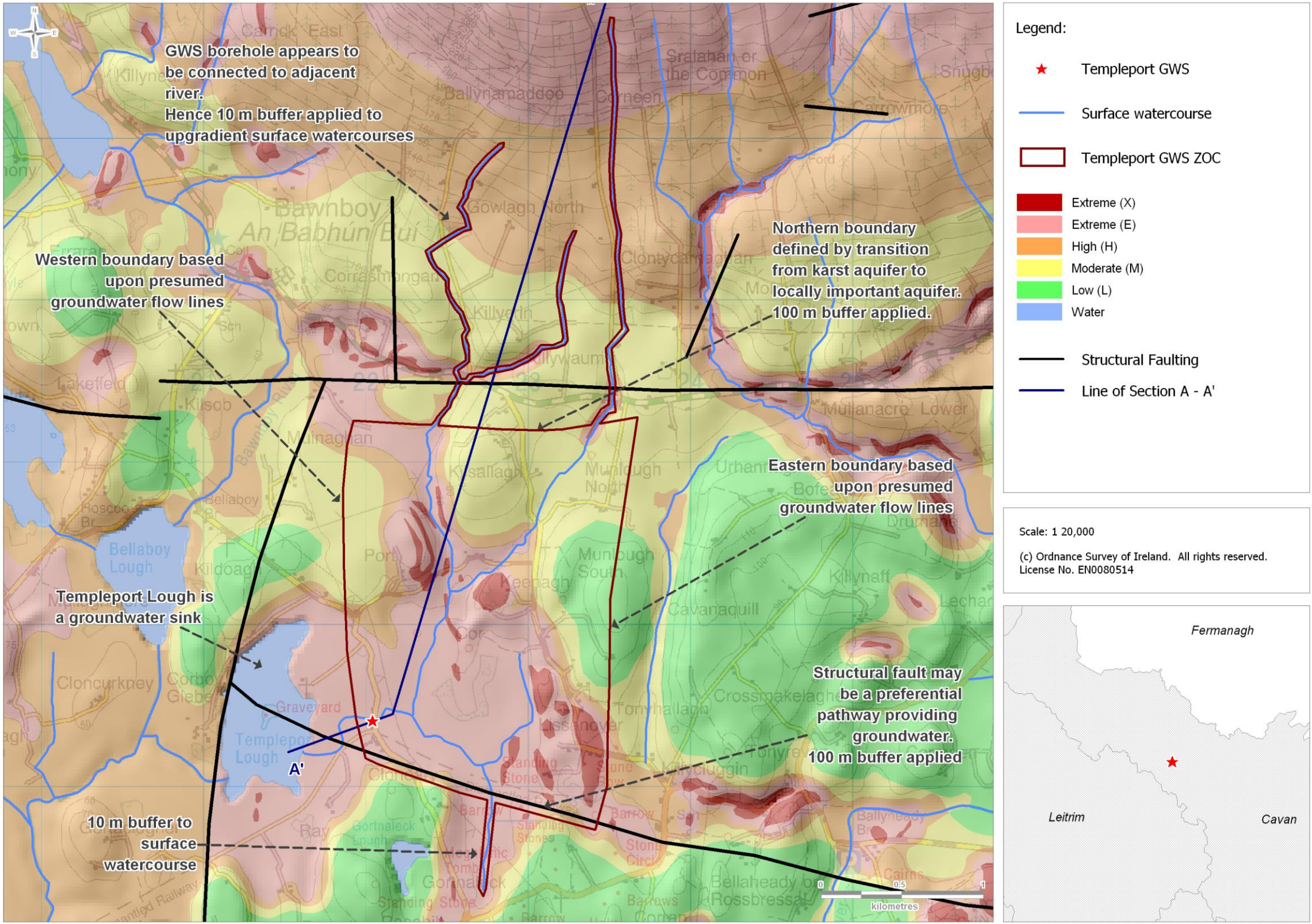


Figure 6 Aquifer Map with karst features



Appendix 1

Groundwater Vulnerability

Introduction

The term 'vulnerability' is used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities (DELG *et al.*, 1999). The vulnerability of groundwater depends on:

- the time of travel of infiltrating water (and contaminants)
- the relative quantity of contaminants that can reach the groundwater
- the contaminant attenuation capacity of the geological materials through which the water and contaminants infiltrate.

All groundwater is hydrologically connected to the land surface; the effectiveness of this connection determines the relative vulnerability to contamination. Groundwater that readily and quickly receives water (and contaminants) from the land surface is more vulnerable than groundwater that receives water (and contaminants) more slowly and in lower quantities. The travel time, attenuation capacity and quantity of contaminants are a function of the following natural geological and hydrogeological attributes of any area:

- the type and permeability of the subsoils that overlie the groundwater
- the thickness of the unsaturated zone through which the contaminant moves
- the recharge type – whether point or diffuse.

In other words, vulnerability is based on evaluating the relevant hydrogeological characteristics of the protecting geological layers along the pathway, and the possibility of bypassing these layers. In summary, the entire land surface is divided into four vulnerability categories: **Extreme**, **High**, **Moderate** and **Low**, based on the geological and hydrogeological characteristics. Further details of the hydrogeological basis for vulnerability assessment can be found in 'Groundwater Protection Schemes' (DELG *et al.*, 1999).

The Groundwater Vulnerability Map shows the vulnerability of the first groundwater encountered, in either sand/gravel or bedrock aquifers, by contaminants released at depths of 1-2 m below the ground surface. Where the water-table in bedrock aquifers is below the top of the bedrock, the target needing protection is the water-table. However, where the aquifer is fully saturated, the target is the top of the bedrock. The vulnerability map aims to be a guide to the likelihood of groundwater contamination, if a pollution event were to occur. It does not replace the need for site investigation. Note also that the characteristics of individual contaminants are not considered.

Except where point recharge occurs (e.g. at swallow holes), the groundwater vulnerability depends on the type, permeability and thickness of the subsoil.

The groundwater vulnerability map is derived by combining the permeability and depth to bedrock maps, using the three subsoil permeability categories: high, moderate and low; and four depths to rock categories: <3m, 3–5m, 5–10m and >10m. The resulting vulnerability classifications are shown below.

Vulnerability mapping guidelines (adapted from DELG *et al.*, 1999)

Thickness of Overlying Subsoils	Hydrogeological Requirements for Vulnerability Categories				
	Diffuse Recharge			Point Recharge	Unsaturated Zone
	Subsoil permeability and type				
	High permeability (sand/gravel)	moderate permeability (sandy subsoil)	low permeability (clayey subsoil, clay, peat)	(swallow holes, losing streams)	(sand & gravel aquifers <u>only</u>)
0–3 m	Extreme	Extreme	Extreme	Extreme (30 m radius)	Extreme
3–5 m	High	High	High	N/A	High
5–10 m	High	High	Moderate	N/A	High
>10 m	High	Moderate	Low	N/A	High
Notes: (i) N/A = not applicable. (ii) Release point of contaminants is assumed to be 1–2 m below ground surface. (iii) Permeability classifications relate to the engineering behaviour as described by BS5930. (iv) Outcrop and shallow subsoil (i.e. generally <1.0 m) areas are shown as a sub-category of extreme vulnerability (amended from Deakin and Daly (1999) and DELG/EPA/GSIa (1999))					

Sources of Vulnerability Data

Specific vulnerability field mapping and assessment of previously collected data were carried out as part of this project. Fieldwork focused on assessing the permeability of the different subsoil deposit types so that they could be subdivided into the three permeability categories. This involved:

- Describing selected exposures/sections according to the British Standard Institute *Code of Practice for Site Investigations* (BS 5930:1999).
- Collection of subsoil samples for laboratory particle size analyses
- Assessing the recharge characteristics of selected sites using natural and artificial drainage, vegetation and other recharge indicators.

The following additional sources of data were used to assess the vulnerability and produce the map:

- Subsoils Map (EPA/Teagasc Subsoil Map, 2006), which is the basis for the main permeability boundaries. 'Clean' sands and gravels are usually high permeability. Alluvium deposits are either moderate or low permeability.
- Depth to bedrock map, compiled by the mapping team for the current project in the Geological Survey of Ireland, using data compiled from GSI, consultant and county council reports, along with purpose-drilled auger holes
- Geological Survey of Ireland Bedrock Geology Map
- Geological Survey of Ireland well and karst database, which supplied information on well yields and depth to bedrock, as well as locations of point recharge.
- General Soils Map of Ireland (Gardiner and Radford, 1980). This gives additional, indirect information on subsoil permeability in the areas mapped by Teagasc as 'till'.

Thickness of the Unsaturated Zone

The thickness of the unsaturated zone, or the depth of ground free of intermittent or permanent saturation, is only relevant in vulnerability mapping over unconfined sand and gravel aquifers. As described in Table 6.1, the critical unsaturated zone thickness is 3m; unconfined gravels with unsaturated zones thicker than 3m are classed as having a 'high' vulnerability, while those with unsaturated zones thinner than 3m are classed as having an 'extreme' vulnerability.

Appendix 2

Groundwater Recharge

Introduction

The term 'recharge' refers to the amount of water replenishing the groundwater flow system. The recharge rate is generally estimated on an annual basis, and is assumed to consist of the rainfall input (i.e. annual rainfall) minus water loss prior to entry into the groundwater system (i.e. annual evapotranspiration and runoff). The estimation of a realistic recharge rate is critical in source protection delineation, as this dictates the size of the zone of contribution to the source (i.e. the outer Source Protection Area).

The main parameters involved in the estimation of recharge are: annual rainfall; annual evapotranspiration; and a recharge coefficient (Table 1). The recharge coefficient is estimated using Hunter Williams et al (2013), which is based on Guidance Document GW5 (Groundwater Working Group 2005).

Table 1. Recharge coefficients for different hydrogeological settings.

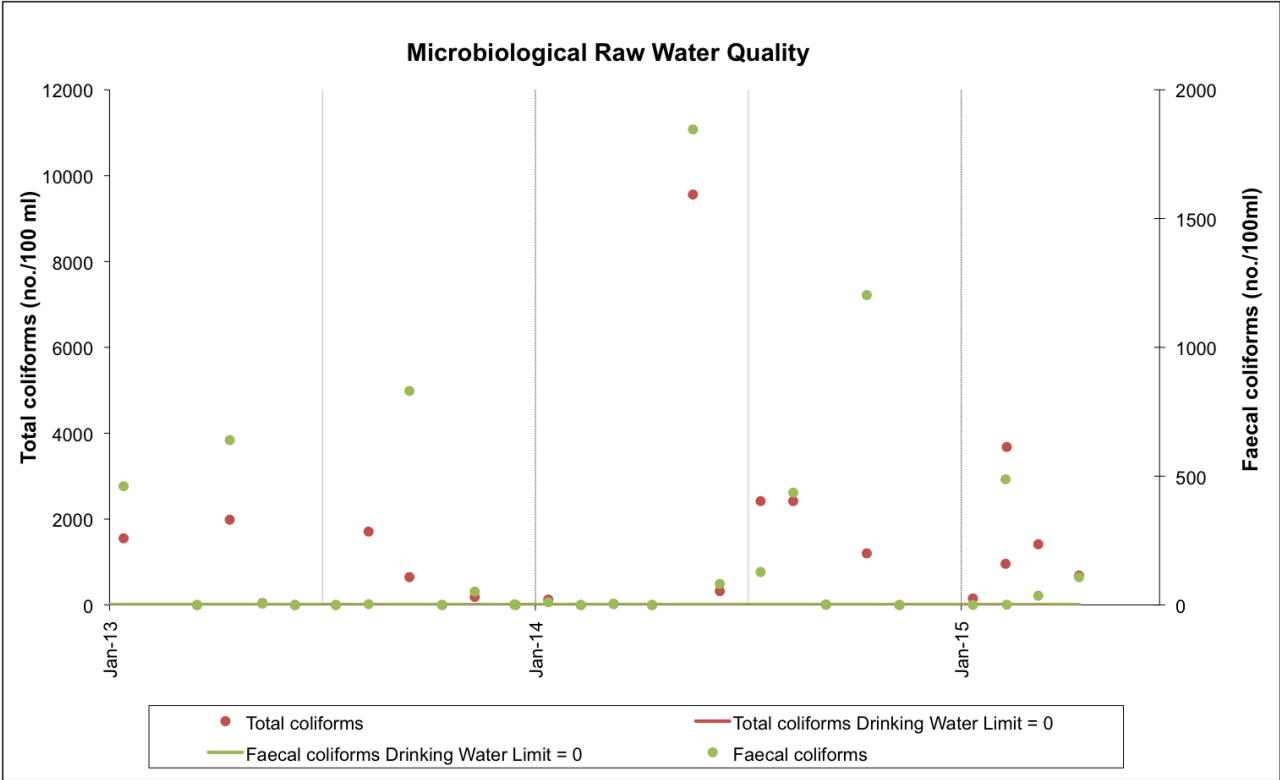
Groundwater vulnerability category	Hydrogeological setting		Recharge coefficient (RC)		
			Min (%)	Inner Range	Max (%)
Extreme (X or E)	1.i	Areas where rock is at ground surface	30	80-90	100
	1.ii	Sand/gravel overlain by 'well drained' soil	50	80-90	100
	1.iii	Sand/gravel overlain by 'poorly drained' (gley) soil	15	35-50	70
	1.iv	Till overlain by 'well drained' soil	45	50-70	80
	1.v	Till overlain by 'poorly drained' (gley) soil	5	15-30	50
	1.vi	Sand/ gravel aquifer where the water table is ≤ 3 m below surface	50	80-90	100
	1.vii	Peat	1	15-30	50
High (H)	2.i	Sand/gravel aquifer, overlain by 'well drained' soil	50	80-90	100
	2.ii	High permeability subsoil (sand/gravel) overlain by 'well drained' soil	50	80-90	100
	2.iii	High permeability subsoil (sand/gravel) overlain by 'poorly drained' soil	15	35-50	70
	2.iv	Sand/gravel aquifer, overlain by 'poorly drained' soil	15	35-50	70
	2.v	Moderate permeability subsoil overlain by 'well drained' soil	35	50-70	80
	2.vi	Moderate permeability subsoil overlain by 'poorly drained' (gley) soil	10	15-30	50
	2.vii	Low permeability subsoil	1	20-30	40
	2.viii	Peat	1	5-15	20
Moderate (M)	3.i	Moderate permeability subsoil and overlain by 'well drained' soil	35	50-70	80
	3.ii	Moderate permeability subsoil and overlain by 'poorly drained' (gley) soil	10	15-30	50
	3.iii	Low permeability subsoil	1	10-20	30
	3.iv	Peat	1	3-5	10
Low (L)	4.i	Low permeability subsoil	1	5-10	20
	4.ii	Basin peat	1	3-5	10

The recharge coefficients in this table are summarised in a paper by Hunter Williams *et al.* (2013) in the Quarterly Journal of Engineering Geology and Hydrogeology. Aquifer recharge acceptance capacity is generally limited in LI aquifers (200 mm/yr) and PI and Pul aquifers (100 mm/yr). Made ground has recharge coefficient of 20%.

Appendix 3

Water quality results

	Nitrite as NO2 mg/l	Turbid- ity NTU	Colour, true hazen	Conducti- vity us/cm	pH	Ammonia as NH4 mg/l	Alumin- ium ug/l	Colour, apparent hazen	Mangan- ese ug/l	Iron ug/l	Nitrate as NO3 mg/l	Clostridium perfringens cfu/100ml	coliforms mpn/100ml	e. coli mpn/100ml
10/01/13	<0.016	<0.5	<5	591	7.13	<0.0129	<5	<5	<0.7	<7.2	17.23	<1	2419.6	9.8
07/02/13	<0.016	<0.5	<5	690	7.11	<0.0129	<5	<5	<0.7	<7.2	11.87	<1	1553	461
06/03/15	<0.016	<0.5	<5	695	7.17	<0.0129	5	<5	2	13	<8.9	<1	3680	1
11/04/13	<0.016	0.76	<5	848	7.17	0.03	6	<5	4	12	<8.9	<1	<1	<1
09/05/13	0.03	9.53	6	657	7.33	0.06	640	102	5	363	11.25	95	1986	640
06/06/13	<0.016	<0.5	<5	970	6.97	0.15	<5	<5	1	<7.2	<8.9	<1	43.1	5.1
04/07/13	0/03	<0.5	<5	624	7.36	<0.0129	<5	<5	<0.7	<7.2	9.61	<1	<1	<1
08/08/13	0.03	<0.5	<5	633	7.46	0.04	8	<5	38	40	<8.9	<1	<1	<1
05/09/13	<0.016	<0.5	<5	646	7.4	<0.0129	13	<5	2	267	<8.9	<1	1710	3.1
10/10/13	<0.016	<0.5	<5	651	7.21	<0.0129	<5	<5	3	11	<8.9	<1	649	831
07/11/13	<0.016	<0.5	<5	622	7.19	0.1	<5	<5	1	8	12.67	<1	<1	<1
05/12/13	<0.016	<0.5	<5	555	7.29	0.1	<5	<5	1	18	<8.9	<1	187	52
09/01/14	<0.016	<0.5	<5	585	7.33	<0.0129	11	<5	17	24	11.78	<1	<1	<1
06/02/14	<0.016	1.02	<5	554	7.86	<0.0129	<5	<5	<0.7	<7.2	13.73	<1	126.7	10.7
06/03/14	<0.016	<0.5	<5	562	7.42	<0.0129	<5	<5	2	<7.2	11.7	<1	<1	<1
03/04/14	<0.016	<0.5	<5	538	7.23	<0.0129	7	<5	3	13	10.68	<1	23.3	5.2
06/05/14	0.13	<0.5	<5	537	7.2	0.04	6	<5	2	15	<8.9	<1	<1	<1
10/06/14	<0.016	3.73	<5	592	6.92	0.04	151	30	54	326	10.23	9	9560	1846
03/07/14	<0.016	<0.5	<5	386	7.01	<0.0129	<5	<5	1	<7.2	10.01	<1	325	81.7
07/08/14	<0.016	<0.5	<5	532	6.98	0.05	<5	<5	<0.7	<7.2	<8.9	<1	2419	128
04/09/14	0.1	<0.5	<5	545	7.35	0.1	67	<5	6	23	<8.9	<1	2419	436
02/10/14	<0.016	0.97	<5	518	7.48	<0.0129	15	<5	26	57	<8.9	<1	7.5	1
06/11/14	<0.016	1.5	<5	498	7.33	<0.0129	130	15	<0.7	79	<8.9	<1	1203	1203
04/12/14	<0.016	<0.5	<5	552	7.19	<0.0129	<5	<5	<0.7	<7.2	<8.9	<1	<1	<1
08/01/14	<0.016	<0.5	<5	546	7.31	0.08	5	<5	<0.7	33	10.01	<1	8.8	1
05/02/15	<0.016	<0.5	<5	534	7.4	<0.0129	<5	<5	<0.7	18	9.08	<1	153	<1
05/03/15	0.03	<0.5	<5	526	7.4	0.03	10	<5	<0.7	<7.2	<8.9	3	960	488
02/04/15	<0.016	<0.5	<5	560	7.2	0.05	6	<5	<0.7	<7.2	16.3	1	1414	36
07/05/15	0.03	<0.5	<5	534	7.05	0.03	6	<5	<0.7	<7.2	14.18	<1	686	108



Appendix 4

Acronyms & Glossary

Acronyms

EPA – Environmental Protection Agency
DEHLG – Department of Environment Heritage and Local Government
EU – European Union
GSI – Geological Survey of Ireland
GWB – Groundwater Body
GWD – Groundwater Directive (European Union)
GWS – Group Water Scheme
IGI – Institute of Geologists of Ireland
IG – Irish National Grid Reference
m aOD – metres above Ordnance Datum
m bgl – metres below ground level
TVs – Threshold Values
UV – Ultra-Violet
ZOC – Zone of Contribution
WFD – Water Framework Directive

Glossary of Terms

Aquifer

A subsurface layer or layers of rock, or other geological strata, of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater (Groundwater Regulations, 2010).

Attenuation

A decrease in pollutant concentrations, flux, or toxicity as a function of physical, chemical and/or biological processes, individually or in combination, in the subsurface environment.

Borehole

A particular type of well - a narrow hole in the ground constructed by a drilling machine in order to gain access to the groundwater system.

Boulder Clay

See 'Till'

Conceptual Hydrogeological Model

A simplified representation or working description of how a real hydrogeological system is believed to behave on the basis of qualitative analysis of desk study information, field observations and field data.

Diffuse Sources

Diffuse sources of pollution are spread over wider geographical areas rather than at individual point locations. Diffuse sources include general land use activities and landspreading of industrial, municipal wastes and agricultural organic and inorganic fertilisers.

Direct Input

An input to groundwater that bypasses the unsaturated zone (e.g. direct injection through a borehole) or is directly in contact with the groundwater table in an aquifer either year round or seasonally.

Doline

Dolines, or enclosed depressions, are relatively shallow bowl or funnel shaped depressions that form in karst landscapes, and serve to funnel or concentrate recharge underground. Their presence indicates that subterranean drainage is in operation.

Dolomitisation

Is a process, whereby the calcite crystals in limestone is replaced by magnesium. This results in an increase in the porosity and permeability of the rock. Dolomitised rocks are a highly weathered, yellow/orange/brown colour and are usually evident in boreholes as loose yellow-brown sand with significant void space and poor core recovery. Dolomitisation often occurs preferentially in both fault zones and purer limestones.

Down-gradient

The direction of decreasing groundwater levels, i.e. flow direction. The area of the groundwater system that has lower groundwater levels than other areas. Opposite of upgradient.

Enclosed Depression

See doline

Fissure

A natural crack in rock which allows rapid water movement.

Groundwater

All water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil (Groundwater Regulations, 2010).

Groundwater Body (GWB)

A volume of groundwater defined as a groundwater management unit for the purposes of reporting to the European Commission under the Water Framework Directive. Groundwater bodies are defined by aquifers capable of providing more than 10 m³/d, on average, or serving more than 50 persons.

Groundwater Recharge

Two definitions: a) the process of rainwater or surface water infiltrating to the groundwater table; b) the volume (amount) of water added to a groundwater system.

Groundwater Resource

An aquifer capable of providing a groundwater supply of more than 10 m³/d as an average or serving more than 50 persons.

Hydraulic Conductivity (also known as 'Permeability')

The rate at which water can move through a unit volume of geological medium under a potential unit hydraulic gradient. The hydraulic conductivity can be influenced by the properties of the fluid, including its density, viscosity and temperature, as well as by the properties of the soil or rock.

Hydraulic Gradient

The change in total head of water with distance; the slope of the groundwater table or the piezometric surface.

Igneous Rock

Igneous rock is formed through the cooling and solidification of magma or lava.

Indirect Input

An input to groundwater where the pollutants infiltrate through soil, subsoil and/or bedrock to the groundwater table.

Input

The direct or indirect introduction of pollutants into groundwater as a result of human activity.

Karst

A distinctive landform characterised by features such as surface collapses, sinking streams, swallow holes, caves, turloughs and dry valleys, and a distinctive groundwater flow regime where drainage is largely underground in solutionally enlarged fissures and conduits.

Karstification

Karstification is the process whereby limestones are slowly dissolved by acidic waters moving through them. This results in the development of an uneven distribution of permeability with the enlargement of certain

fissures at the expense of others and the concentration of water flow into these high permeability zones. Karstification results in the progressive development of distinctive karst landforms such as caves, swallow holes, sinking streams, turloughs and dry valleys, and a distinctive groundwater flow regime. It is an important feature of Irish hydrogeology.

Metamorphic Rock

A rock made out of highly altered existing rock. Common types include marble, schist and quartzite.

Pathway

The route which a particle of water and/or chemical or biological substance takes through the environment from a source to a receptor location. Pathways are determined by natural hydrogeological characteristics and the nature of the contaminant, but can also be influenced by the presence of features resulting from human activities (e.g., abandoned ungrouted boreholes which can direct surface water and associated pollutants preferentially to groundwater).

Permeability

A measure of a soil or rock's ability or capacity to transmit water (synonymous with hydraulic conductivity).

Point Source

Any discernible, confined or discrete conveyance from which pollutants are or may be discharged. These may exist in the form of pipes, ditches, channels, tunnels, conduits, containers, and sheds, or may exist as distinct percolation areas, integrated constructed wetlands, or other surface application of pollutants at individual locations. Examples are discharges from waste water works and effluent discharges from industry.

Pollution

The direct or indirect introduction, as a result of human activity, of substances or heat into the air, water or land which may be harmful to human health or the quality of aquatic ecosystems or terrestrial ecosystems directly depending on aquatic ecosystems which result in damage to material property, or which impair or interfere with amenities and other legitimate uses of the environment (Groundwater Regulations, 2010).

Poorly Productive Aquifers (PPAs)

Low-yielding bedrock aquifers that are generally not regarded as important sources of water for public water supply but that nonetheless may be important in terms of providing domestic and small community water supplies and of delivering water and associated pollutants to rivers and lakes via shallow groundwater pathways.

Preferential Flow

A term used to describe water movement along favoured pathways through a geological medium, bypassing other parts of the medium. Examples include pores formed by soil fauna, plant root channels, weathering cracks, fissures and/or fractures.

Saturated Zone

The zone below the water table in an aquifer in which all pores and fissures and fractures are filled with water at a pressure that is greater than atmospheric.

Sedimentary Rock

A rock composed of sediments (sand, silt, clay, calcium carbonate fragments, shell fragments, etc.) that have been buried and lithified (cemented). Common types include sandstone, shale and limestone.

Soil (topsoil)

The uppermost layer of soil in which plants grow.

Spring

A spring is a natural feature where groundwater emerges at the surface. Springs usually occur where the rate of flow of groundwater is too great to remain underground. The position of a spring usually reflects a change in soil or rock type, or a change in slope.

Subsoil

Unlithified (uncemented) geological strata or materials beneath the topsoil and above bedrock. Common types include Till/Boulder Clay, sand/gravel and peat.

Surface Water

An element of water on the land's surface such as a lake, reservoir, stream, river or canal. Can also be part of transitional or coastal waters. (Surface Waters Regulations, 2009.).

Swallow Hole (also known as 'Sinkhole')

The point where concentrated inflows of water sink underground. They are found in karst environments.

Threshold Values (TVs)

Chemical concentration values for substances listed in Schedule 5 of the Groundwater Regulations (2010), which are used for the purpose of chemical status classification of groundwater bodies.

Till (also known as 'Boulder Clay')

Unsorted glacial Sediment deposited directly by the glacier. It is the most common Quaternary deposit in Ireland. Its components may vary from gravel, sands and clays.

Unsaturated Zone

The zone between the land surface and the water table, in which pores, fractures and fissures are only partially filled with water. Also known as the vadose zone.

Up-gradient

The direction of increasing groundwater levels, i.e. the direction from which groundwater is flowing. The area of the groundwater system that has higher groundwater levels than other areas. Opposite of down-gradient.

Vulnerability

The intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities (Fitzsimmons et al, 2003).

Water Table

The uppermost level of saturation in an aquifer at which the pressure is atmospheric. This is the level to which water naturally settles in the cracks, cavities and pore spaces underground. Above the water table, the spaces in the rock or sediments are air-filled. Below the water table, the spaces are filled with water.

Weathering

The breakdown of rocks and minerals at the earth's surface by chemical and physical processes.

Well

A construction into the ground in order to access groundwater. Can be a dug well, which is generally shallow, with a diameter of a metre or more, or a borewell (see 'Borehole'), which is narrower in diameter and generally deeper.

Zone of Contribution (ZOC)

The area surrounding a pumped well or spring that encompasses all areas or features that supply groundwater to the well or spring. It is defined as the area required to support an abstraction and/or overflow (in the case of springs) from long-term groundwater recharge.

Appendix 5

Drilling Log

DUNNES

WATER SERVICES LTD.

No. 02739

Well Drilling and Horizontal Drilling Engineers

DRILLERS LOG

DUBLIN ROAD,
 DROMISKIN,
 DUNDALK.

Tel.: (042) 72188

Borehole for CAVAN County Council
 at Templeport Cemetery Bawnbeg
Ballynagowan G.W.S. T.W. 1

Date	Depth metres/ft.	Diam.	Conditions
16 July 02	0- 20FT	12"	Broken Rock and Stones falling in around tools
	20- 28FT	8"	Broken Weathered Ls Rock
	28- 39FT	8"	fairly Solid Ls Rock
	39- 125	6"	fairly Solid Ls Rock
	125- 150	6"	Limestone Rock Broken at 135FT with Water and BROWN CLAY.
	150- 175	6"	Brown and grey limestone Rock.

Total Depth of well.....

Estimated yield..... 3,000

Depth to Rock..... 15

Steel casing installed..... 40FT of 6" + 14FT of 10" Casing

P.V.C. casing installed.....

Well screen.....

Other remarks..... water at 135FT Collapsing at 20ft.

LOT OF WATER IN Broken Rock - Est. 15,000 gal.

Close off shallow water with 6" steel lining.

Operator..... Eugene Sta. Gole

DUNNES

WATER SERVICES LTD.

Nº 02740

Well Drilling and Horizontal Drilling Engineers

DRILLERS LOG

DUBLIN ROAD,
 DROMISKIN,
 DUNDALK.

Tel.: (042) 72188

Borehole for Cavan County Council

at Temple Port Bawn Boy Twp.

Rallymagowan LWS.

6" Well

Date	Depth metres/ft.	Diam.	Conditions
17 July 07	195. 200	6"	gray limestone Rock Broken from 195. 200 FT With trace water.
	200. 225	6"	gray limestone Rock.

Total Depth of well... 225 FT 68.58.

Estimated yield... 5000 gph

Depth to Rock... 15 FT 4.57

Steel casing installed... 40 FT of 6" + 17 FT of 10" Casing 17.37m

P.V.C. casing installed... NONE

Well screen...

Other remarks... Water at 135' ~~Rock~~ - 3.500 gph Est.

Water at 200 ft - 5.000 gph Estimated.

Operator... C. J. Roche

Cavan County Council
Courthouse
Cavan

30 August 2002

Trial Well Drilling at Milltown and Ballymagarran

<u>Daily Log</u>	<u>Measurement No. 4</u>
Wed 10-07-02	Mobilise to site. <u>Milltown</u> . Attempt to set up on location – site very soft, insufficient hardcore. Drill rig stuck. Waiting for hymac and load of stone. Remove drill rig. Spread stone. Move rig into position.
Thurs 11-07-02	Set up on location. Drill to 175ft. Place 80ft of 6" steel lining. Airlift for 30 minutes. Estimated yield 7,000 gals per hour.
Fri 12-07-02	Move to <u>Templeport Creamery, Bawnboy for Ballymagarran G.W.S.</u> Set up on location Drill 200mm dia. to 20ft. Collapsing at 20ft. Unable to place 8" steel due to concrete surface. Need to open at 300mm dia. Additional equipment required.
Mon 15-07-02	Not on site
Tue 16-07-02	Drill 300mm dia. to 20ft. Place 250mm dia. steel lining to 17ft. Drill 200mm dia to 35ft. Place 150mm dia. steel lining to 39ft. Lot of water in broken rock at 15ft to 28ft – estimate 15,000 gals per hour. Close off water with 150mm dia. steel lining.
Wed 17-07-02	Drill from 40ft to 225ft. At 160ft yield 3,500 gph, estimated. At 225ft yield 5,000 gph, estimated. Pack up and move off site.