Killeigh Group Water Scheme

Danganbeg Spring (Tobernanoge)

Groundwater Source Protection Zones

(April 2001)

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1. Introduction

The Groundwater Section, Geological Survey of Ireland, have prepared this report at the request of Offaly County Council.

Danganbeg spring supplements the Killeigh Group Water Scheme (KGWS). It is the second source used for the KGWS; Toberfin springs are the main source and is examined in a separate source protection report (Kelly, 1999).

The objectives of the report are as follows:

- To delineate source protection zones for Danganbeg spring.
- To outline the principle hydrogeological characteristics of the Danganbeg area.
- To assist Offaly County Council in protecting the water supply from contamination.

2. Location, Site Description and Well Head Protection

Danganbeg spring is located 3 km east of Killeigh village, in the townland of Danganbeg, close to the boundary with Co. Laois.

Danganbeg spring comprises a large rectangular sump, collecting water that emerges from bedrock at the bottom of the sump.

The site area is closed off with a fence. The sump is covered with concrete. The rest of the site is grassed over.

3. Summary of Well / Spring Details

GSI no.	:	2321SW W0004
Grid ref. (1:25,000)	:	N 2420 2185
Townland	:	Danganbeg
Well type	:	Spring
Owner	:	Killeigh Group Water Scheme (KGWS)
Elevation (ground level)	:	~ 116 m (380 ft)
Depth & Diameter of sumps	:	3 m x 6 m
Depth to rock	:	2.8 m (9.2 ft)
Static water level	:	2 m bgl.
Normal Abstraction	:	110 m^3 d^{-1}

4. Methodology

The assessment involved three stages: (a) a desk study; (b) site visits and fieldwork; and (c) analysis of the data.

The desk study was conducted in the Geological Survey: details about the group scheme and spring such as elevation, and abstraction figures were obtained from GSI records and County Council personnel; geological and hydrogeological information was provided by the Groundwater Protection Scheme (Daly et al, 1998).

The second stage comprised site visits and fieldwork in the Danganbeg area. This included carrying out spring overflow measurements, depth to rock drilling and subsoil sampling. Field walkovers were also carried out to investigate the subsoil geology, the hydrogeology and vulnerability to contamination.

Analysis of the data utilised field studies and previously collected data to delineate protection zones around the spring.

5. Topography, Surface Hydrology and Land Use

Danganbeg spring emerges at 116 m OD, close to the bottom of a hill, the highest point of which is 143 m OD.

There are few surface streams, except at the spring itself, where there are some surface drains.

Agricultural activity dominates the area with most of the land used for grassland. A number of houses and farmyards are present in the vicinity of the spring.

6. Geology

6.1 Introduction

This section briefly describes the relevant characteristics of the geological materials that underlie the Danganbeg spring source. It provides a framework for the assessment of groundwater flow and source protection zones that will follow in later sections.

Bedrock information was taken from a desk-based survey of available data, which comprised the following:

- County Offaly Groundwater Protection Scheme (Daly *et al*, 1998)
- Information from geological mapping in the nineteenth century (on record at the GSI).

Subsoils information was taken from the Offaly Groundwater Protection Scheme (Daly *et al*, 1998) and gathered from a drilling programme that was undertaken by GSI personnel to investigate the subsoils of the area.

6.2 Bedrock Geology

The area is underlain by Calp Limestone; a dark grey bedded, fine grained, muddy limestone.

Movements in the earth's crust have caused the rocks to be folded, faulted and jointed. The rock unit has a NE-SW trend or strike and dips either north-westwards at a low angle. Two major fault sets are present — NE-SW and SE-NW. The joint pattern is likely to have similar orientations. There are two mapped faults in the region and there are probably other faults that haven’t been noted because of the lack of outcrop in the area.

6.3 Subsoil (Quaternary) Geology

6.3.1 Introduction

The subsoils comprise a mixture of coarse and fine grained materials, namely; tills, tills with gravels and gravels and are influenced by the underlying bedrock, which in the area is primarily the Calp limestone. The muddy, dark nature of this rock type in this part of Offaly could mean that the subsoils will have proportionally higher percentages of fine grained material than subsoils produced over bedrock of a ‘cleaner’ nature. The gravel sized component (2-60 mm) are dominated by limestone fragments, mostly angular to subangular. The logs of the auger holes drilled are given in Appendix 1.

The characteristics of each category are described briefly below:

6.3.2 Tills

'Till' is an unsorted mixture of coarse and fine materials laid down by ice. Angular limestone fragments are abundant in the tills. Tills dominate the subsoils in the Danganbeg locality. The tills comprise sandy SILT with clay and frequent gravel.

6.3.3 Till with gravels

The matrix is composed mostly of clayey SAND with gravel. The reconnaissance work in Offaly has shown that many of the sand/gravel units are small and are interbedded with tills. In many places it is not possible to map out separately the sand/gravel units and the till units during a reconnaissance mapping project. This has led to the term "till with gravel" being employed to categorise the sediments over relatively large areas (Daly *et al*, 1998).

6.3.4 Gravels

Extensive fluvioglacial sand and gravels are present in County Offaly. The sands and gravels in the area are generally coarse, poorly sorted but often contain lenses of better sorted material (BS5930: sandy GRAVELS with clay). The boulders and cobbles are limestone in composition.

6.3.5 Depth to Bedrock

A drilling programme was carried out to ascertain the depth, thickness and permeability of the subsoils. Using this information and knowledge of sites that have rock cropping out, the depth to rock is estimated across the area. The borehole locations are given in Figure 1. The depth to bedrock varies between 2 and 4 metres.

7. Hydrogeology

7.1 Introduction

This section presents our current understanding of groundwater flow in the vicinity of the Danganbeg source. The interpretations and conceptualisations of flow are used to delineate source protection zones around the spring.

Hydrogeological and hydrochemical information for the study was obtained from the following sources:

- Offaly Groundwater Protection Scheme (Daly *et al* 1998).
- An Assessment of the Quality of Public and Group Scheme Groundwater Supplies in County Offaly, (Cronin *et al*, 1999).
- GSI files. Archival Offaly County Council data for the years 1977, 1989, 1991. C1–C2 type parameters.
- Offaly County Council annual drinking water returns 1992–1999 inclusive (C1, C2, C3 and C4 type parameters). Some raw water analyses were also carried out.
- Limited additional fieldwork.

7.2 Meteorology and Recharge

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 generally assumed to consist of an input (i.e. annual rainfall) less water losses 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 it will dictate the size of the zone of contribution (i.e. the outer source protection area).

In areas where point recharge from sinking streams, etc., is discounted, the main parameters involved in recharge rate estimation are annual rainfall, annual evapotranspiration, and annual runoff and are listed as follows:

- Annual rainfall: 825 mm. Rainfall data for the area are taken from a contoured rainfall map of Co. Offaly, which is based on data from Met Éireann.
- Annual evapotranspiration losses: 431 mm. Potential evaporation (P.E.) is estimated to be 454 mm $yr.^{-1}$ (from Met Éireann data). Actual evapotranspiration (A.E.) is then estimated as 95 % of P.E.
- Potential recharge: 394 mm $yr.^{-1}$. This figure is a calculation based on subtracting estimated evapotranspiration losses from average annual rainfall. It represents an estimation of the excess soil moisture available for either vertical downward flow to groundwater, or lateral soil quickflow and overland flow direct to surface water.
- Annual runoff losses: 39.4 mm. This estimation is based on the assumption that 10% of the potential recharge will be lost to overland flow and shallow soil quickflow prior to reaching the main groundwater system.

These calculations are summarised below:

Average annual rainfall (R)	825 mm
Estimated A.E.	431 mm
Potential Recharge (R – A.E.)	394 mm
Runoff losses	39 mm
Estimated Actual Recharge	355 mm

This is an estimation of recharge which allows for surface water outflow, particularly during periods of heavy rainfall.

7.3 Groundwater Levels, Flow Directions and Gradients

There are no water level data for the area south of the spring.

The water table in the area is generally assumed to be a subdued reflection of topography; as the topography slopes northwards, the water table slopes northwards toward the spring. The dominant driving head is the hill to the south of the spring in the townland of Parkbeg. The flow directions are assumed to be perpendicular to the contour lines. In simple terms, rainfall reaching the water table anywhere in the catchment of the spring will flow in a northerly direction toward the spring.

The groundwater gradient is assumed to somewhat less than the topographic gradient, i.e. is estimated as 0.015.

7.4 Aquifer Characteristics

The Calp unit provides the groundwater to the Danganbeg source. The muddy nature of the unit suggests generally poor potential for water storage and abstraction (Offaly Groundwater Protection Scheme, Daly *et al*, 1998), however, localised high permeability zones may be present in the Calp Limestone.

A fracture network probably underlies the source and causes the water to concentrate in this area.

There are no surface streams above 122 m (400 ft), indicating that the land is free draining and the bedrock is probably of a higher permeability. It is possible that the Calp in this locality is cleaner and

thus more permeable than normal. In the locality of the spring there are quite a few surface drains and streams, however, the streams and spring occur at the bottom of relatively steep slopes and it would be expected that there would be streams and surface drains present at the bottom of slopes.

Permeability and porosity for the Calp in this locality are based on evaluation of data for the Calp in other areas. Estimates for these parameters are as follows:

Permeability ~ 5 m d^{-1};

Porosity ~ 1 %.

These estimates are lower than at Toberfin Springs in Killeigh (Kelly, 1999), reflecting lower discharge rates at Danganbeg.

7.5 Aquifer Category

The Calp limestone has a wide variation in hydrogeological characteristics across the country. The Calp limestone is described in County Offaly as a Locally Important aquifer which is moderately productive only in local zones **(Ll)** (Daly et al, 1998).

7.6 Hydrochemistry and Water Quality

There are only a few datasets available for analysis and they are for treated water only.

The hydrochemical analyses show that the Danganbeg spring water is a very hard water with total hardness values > 350 mg l^{-1} $CaCO_3$.

Nitrate levels range from 26-32 mg l^{-1} and there is no apparent upward trend in the dataset.

Chlorides range from 20-25 mg l^{-1}, which are higher than typical background levels (12-15 mg l^{-1}). Chloride is a constituent of organic wastes and levels higher than 25 mg l^{-1} may indicate significant contamination.

Sodium (Na) Potassium (K) ratios are about 0.3 with one very high exceedence of 0.86 in May 1999. This exceedence may indicate organic contamination. High Na:K ratios usually indicate contamination from farmyard wastes.

Faecal bacteria is present in two samples taken in 1995, and is the only parameter to exceed the EU Drinking Water Directive maximum admissible concentrations (MAC), indicating pollution of the spring has occurred at least twice.

The limited dataset shows that the spring water is hard, and is occasionally contaminated with organic wastes and faecal bacteria.

7.7 Spring Discharge

There has been only one estimate of the total yield and this was measured in July 1999 to be 110 m^3 d^{-1}. According to the caretaker there has not been overflow since the winter months of 1997/98, of which there is no estimate. It is probable that the discharge is considerably higher in winter.

7.8 Conceptual Model

- The highest measured discharge was 110 m^3 d^{-1}; it is probably greater during wetter weather.
- The available hydrogeological information does not allow a definitive understanding of the hydrogeology. It is considered the bedrock is providing the groundwater to the spring.
- Groundwater flow is present in fractures in the limestone. The discharge indicates relatively high velocities close to the spring.
- It is possible that a fracture system associated with a fault is causing the groundwater to focus in

this area. A "window" in the subsoils, perhaps due to the presence of a localised sand/gravel unit, may have allowed the spring water to emerge from the underground system at the spring. Alternatively, the change in slope that occurs at the spring may also influence the presence of the spring at this location.

8. Delineation Of Source Protection Areas

8.1 Introduction

This section delineates the areas around the spring that are believed to contribute groundwater to the spring, and that therefore require protection. The areas are delineated on the basis of the conceptualisation of the groundwater flow pattern, and are presented in Figures 1 and 2.

Two source protection areas are delineated:

- Inner Protection Area (SI), designed to give protection from microbial pollution;
- Outer Protection Area (SO), encompassing the zone of contribution (ZOC) of the well.

8.2 Outer Protection Area

The Outer Protection Area (SO) is bounded by the complete catchment area to the source, i.e. the zone of contribution (ZOC), and is defined as the area required to support an abstraction from long-term recharge. The ZOC is controlled primarily by a) the total discharge, b) the groundwater flow direction and gradient, c) the rock permeability and d) the recharge in the area.

Two methods were used to delineate the ZOC for Danganbeg spring and are as follows:

- hydrogeological mapping and
- water balance estimations.

The shape and boundaries of the ZOC were determined using hydrogeological mapping and the conceptual model. The ZOC catchment boundaries are as follows:

1. The **Northern Boundary** is constrained by the location of the spring. Groundwater to the north of the spring cannot flow to the spring as the groundwater is downgradient. An arbitrary buffer of 30 m is placed on the downgradient side of the spring.

2. The **Eastern Boundary** is defined by small topographic ridge which runs north-south from the spring to the highest point in the southern part of the catchment.

3. The **Southern Boundary** is constrained by a watershed divide to south, created by the high ground which lies in the townland of Parkbeg.
4. The **Western Boundary** is topographically constrained. A ridge runs from the highest point in the catchment to the spring. This boundary is uncertain as water in this part of the catchment may be discharging in the streams to the west of the spring rather than to the spring itself.

These boundaries delineate the physical limits within which the ZOC is likely to occur. The area constrained by the hydrogeological mapping is about 1 km^2.

The ZOC straddles the boundary between Co. Offaly and Co. Laois. The county boundary is shown in Figure 1.

If it is assumed that the average daily flow is double the discharge (220 m^3 d^{-1}), the water balance calculation indicates that ZOC of 0.23 km^2 is required to provide enough groundwater to supply the

spring. The area constrained by hydrogeological mapping is far greater than the area required by the water balance. However, it is impossible to be more definitive as to what part of the delineated ZOC is providing groundwater to the spring. Therefore the area defined by the hydrogeological mapping is regarded to be the ZOC.

8.3 Inner Protection Area

The Inner Protection Area (SI) is the area defined by a 100 day time of travel (ToT) to the source and it is delineated to protect against the effects of potentially contaminating activities which may have an immediate influence on water quality at the source, in particular microbial contamination. Estimations of the extent of this area cannot be made by hydrogeological mapping and conceptualisation methods alone. Analytical modelling is also used and by using the aquifer parameters for permeability and hydraulic gradient 100 day ToT estimations are made. From Section 7.4 parameters used give velocities of 7.5 m d^{-1}, and so it is assumed that for a 100 day time of travel, groundwater would travel 750 m, using a hydraulic gradient of 0.015. Thus the upgradient extent of the SI zone is 750 m. The SI is presented in Figure 2. Part of the SI zone is falls into Co Laois.

9. Vulnerability

The distribution of interpreted groundwater vulnerability in the ZOC is presented in Figure 1. The subsoils in the ZOC are of high to moderate permeability and are less than 3m thick. Therefore the groundwater in the ZOC is classified 'extremely' vulnerable to contamination.

10. Groundwater Protection Zones

The groundwater protection zones are obtained by integrating the two elements of land surface zoning (source protection areas and vulnerability categories) – a possible total of 8 source protection zones. In practice, the source protection zones are obtained by superimposing the vulnerability map on the source protection area map. Each zone is represented by a code e.g. **SI/H**, which represents an Inner Protection area where the groundwater is highly vulnerable to contamination. There are 2 groundwater protection zones present around the Danganbeg Source as shown in Table 1. The final groundwater protection map is presented in Figure 2.

It is not within the scope of this report to delineate the resource protection zones in the surrounding area and this is dealt with at the regional resource protection scale. For further details refer to Groundwater Protection Scheme for County Offaly (Daly et al, 1998).

Table 1 Matrix of Source Protection Zones for Danganbeg Spring, Killeigh.

VULNERABILITY RATING	**SOURCE PROTECTION**	
	Inner	***Outer***
Extreme (E)	SI/E	SO/E
High (H)	Absent	Absent
Moderate (M)	Absent	Absent
Low (L)	Absent	Absent

11. Potential Pollution Sources

The land in the vicinity of the source is largely grassland-dominated and is primarily used for grazing.

Agriculture is the principal activity in the Danganbeg area. The main potential sources of pollution within the ZOC are farmyards, septic tank systems and landspreading of organic fertilisers. The main potential pollutants are faecal bacteria, viruses, cryptosporidium and nitrogen.

12. Conclusions and Recommendations

- The source at Danganbeg is located in the Calp Limestone, classified a Locally Important aquifer **(Ll)**.

- The area around the supply is extremely vulnerable to contamination.

- It is recommended that:

1) a full **raw** water analysis should be carried out on a regular basis at the spring.
2) particular care should be taken when assessing the location of any activities or developments which might cause contamination at the GWS.
3) the potential hazards in the ZOC should be located and assessed.

- The protection zone delineated in the report is based on our current understanding of groundwater conditions and on the available data. Additional data obtained in the future may indicate that amendments to the boundaries are necessary.

- A more definitive understanding of the hydrogeology would require a site investigation that would include drilling and geophysics.

13. References

Cronin, C. and Daly, D., 1999. *"An Assessment of the Quality of Public and Group Scheme Groundwater Supplies in County Offaly"*. Geological Survey Report, 30 pp.

Daly, D., Cronin, C., Coxon, C. and Burns, S.J., 1998. *"County Offaly Groundwater Protection Scheme"*. Geological Survey Report for Offaly County Council, 60 pp.

Kelly, C., 1999. *"Killeigh and Meelaghans Group Water Scheme. Toberfin springs. Groundwater Source Protection Zones"*. Geological Survey Report for Offaly County Council, 16 pp.

APPENDIX 1 GEOLOGICAL LOGS OF THE AUGER BOREHOLES.

All borehole depths are maximum depths drilled by the auger. The depths are the depth at which the auger would not go any further. It assumed that the auger has reached bedrock, the evidence being that in most cases floured bedrock is recovered on the teeth of the auger.

Danganbeg No. 1 **National Grid Reference: N 23995 21851**

Depth (m)	Subsoil Type	BS 5930 Description	Permeability Category
0-0.30	Topsoil	peaty SILT with clay and stones	MODERATE
0.30-3.5	Till	sandy SILT with clay and frequent stones	MODERATE

Danganbeg No. 2 **National Grid Reference: N 24019 21846**

Depth (m)	Subsoil	BS 5930 Description	Permeability Category
0-0-2.0	Till	sandy SILT with clay and frequent gravel	MODERATE
2.0-2.8	Till	sandy SILT with clay and abundant gravel	MODERATE

Danganbeg No. 3 **National Grid Reference: N 24035 21848**

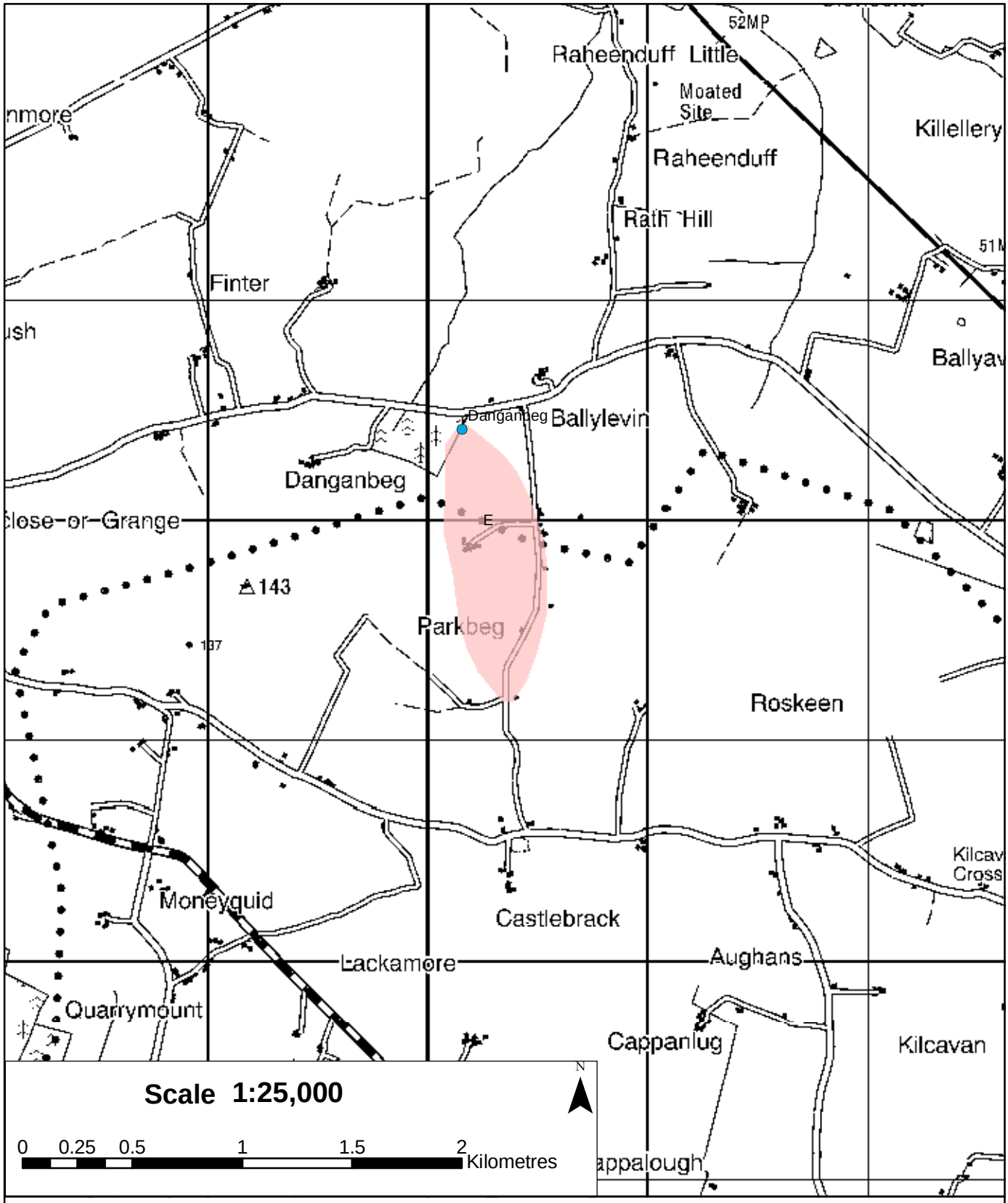
Depth (m)	Subsoil	BS 5930 Description	Permeability Category
0-0.0.50	Till	sandy SILT	MODERATE
0.5-1.7	Till	sandy SILT with abundant gravel	MODERATE
1.7-2.0	Till	sandy GRAVEL with silt	HIGH
2.0-3.6	Till	sandy SILT with clay and frequent gravel	MODERATE

Danganbeg No. 4 **National Grid Reference: N 24046 21788**

Depth (m)	Subsoil	BS 5930 Description	Permeability Category
0-2.75	Till with gravel	clayey SAND with gravel	HIGH

Danganbeg No. 5 **National Grid Reference: N 24042 21745**

Depth (m)	Subsoil	BS 5930 Description	Permeability Category
0-2.0	Gravel	sandy GRAVEL with clay	HIGH



Vulnerability Categories

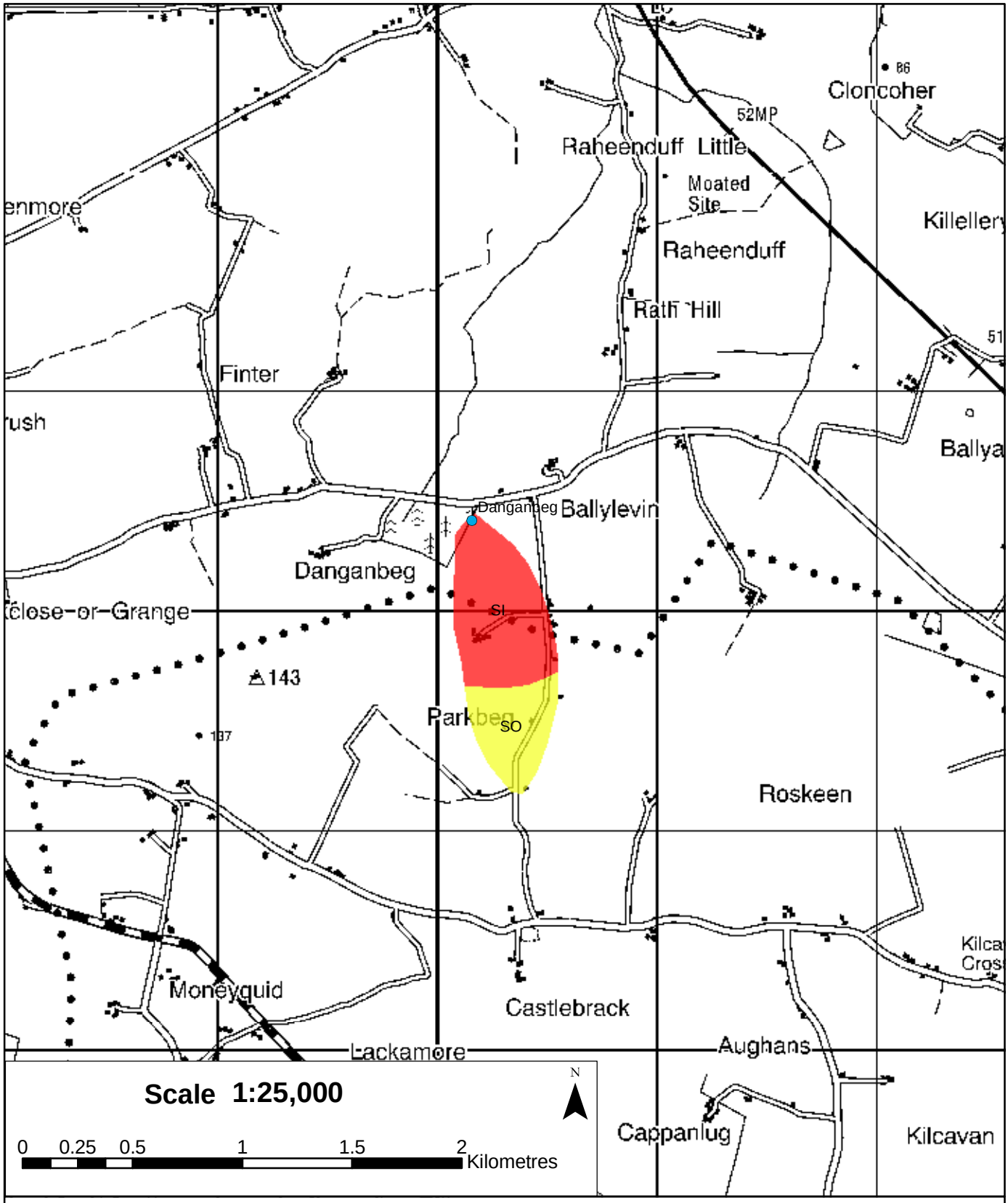
E - Extreme

Spring

This Source Protection Area map is designed for general information and strategic planning usage. The boundaries are based on the available evidence and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessements and will frequently require site investigations to determine the risk to groundwater.

The map is intended for use in conjunction with groundwater protection responses for potentially polluting activities, which lists the degree of acceptability of these activities in each zone and describes the control measures necessary to prevent pollution.

Project Hydrogeologist: Coran Kelly
Project Manager: Donal Daly
Digital Map Production: Antonio Manna



LEGEND

SI Inner Protection Zone

SO Outer Protection Zone

Spring

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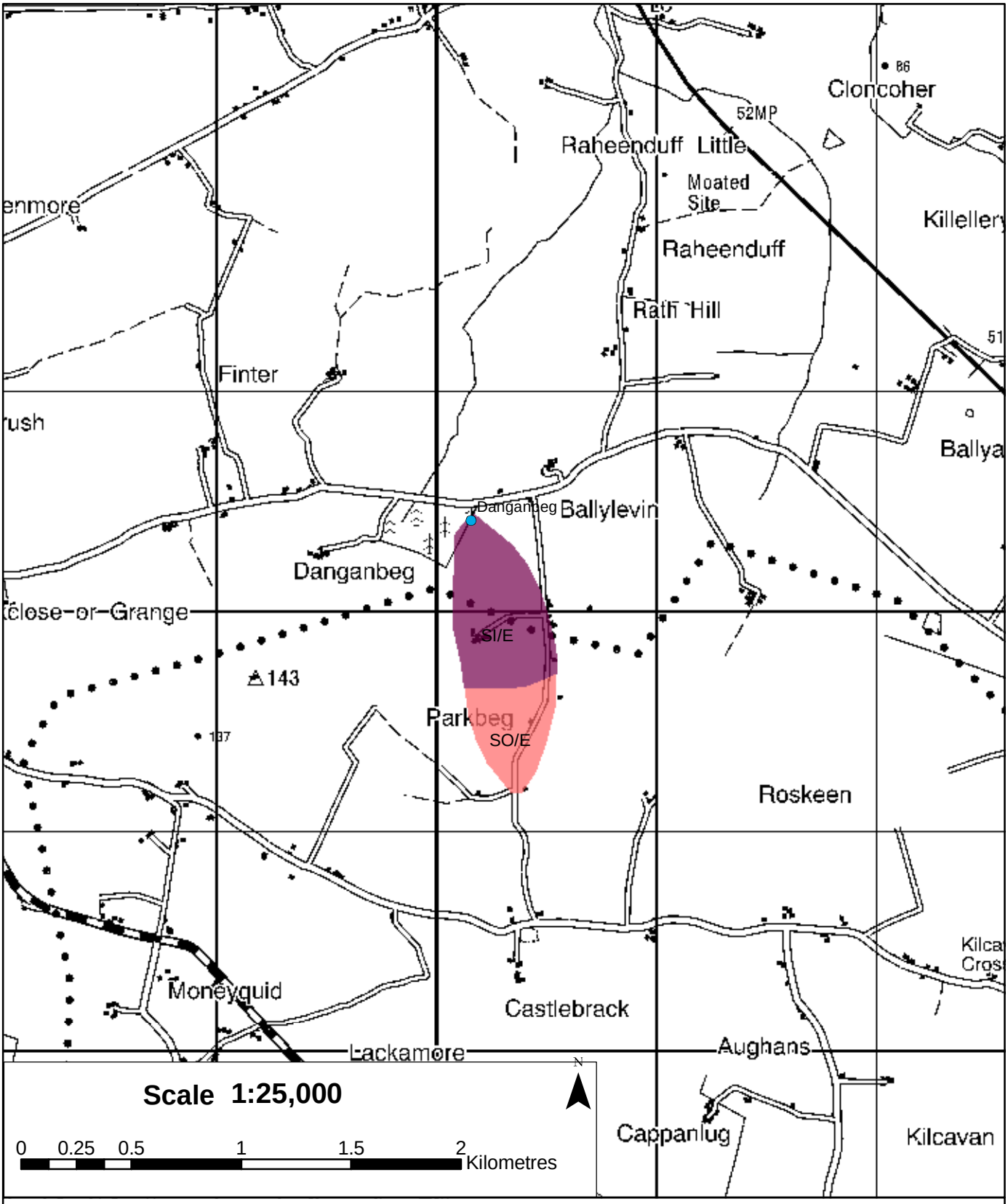

SOURCE PROTECTION ZONES

VULNERABILITY RATING	SOURCE PROTECTION ZONES	
	Inner SI	Outer SI
Extreme (E)	SI/E	SO/E
High (H)	Not Present	Not Present
Moderate (M)	Not Present	Not Present
Low(L)	Not Present	Not Present

Spring

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