Daingean Water Supply Scheme

Daingean Springs

Groundwater Source Protection Zones

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1 Introduction

The objectives of the report are as follows:

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

The protection zones are delineated to help prioritise certain areas around the source in terms of pollution risk to the spring. This prioritisation is intended to provide a guide in the planning and regulation of development and human activities. The implications of these protection zones are further outlined in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999).

The report forms part of the groundwater protection scheme for the county (Daly, *et al*, 1998). The maps produced for the scheme are based largely on the readily information in the area 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.

2 Location and Site Description

The pumphouse and springs are located approximately 450 m west of Daingean, immediately south of the Grand Canal as shown in Figure 1.

The source was commissioned in 1974 and originally consisted of two springs - "Toberronan Well" and "Morris's Well" (originally named "Cassidy's Well", on the first edition of the archival Ordnance Survey six inch maps). The groundwater is pumped into a central sump beside the pumphouse, and is then pumped to a reservoir with a storage capacity of approximately 500 m^3 (110,000 gallons). The chlorination tank and chemicals are stored in the pumphouse and a tap is present for raw water samples. The scheme serves approximately 1000 people and there are approximately 10 farms on the scheme (Burns, 1993). The pumphouse is fenced off, but the springs are located in the field outside the Council site. Toberronan Well is no longer accessible. Morris's Well is located on the edge of the road leading to the canal, and is accessible. In July 2003, a trial borehole was drilled beside the pumphouse.

3 Summary of Spring and Borehole Details

GSI No.	2321NEW002	2321NEW029	2321NEW030
Well Name	Toberronan	Morris's Well	Trial Well
Grid reference	24682 22772	24687 22772	24684 22768
Townland	Toberronan	Toberronan	Toberronan
Owner	Offaly County Council	Offaly County Council	Offaly County Council
Well Type	Spring	Spring	Borehole
Elevation (ground level)	Approximately 78m OD.	77.98m OD.	77.98m OD.
Static water level	Ground level	Ground level	Artesian
Depth to rock	>10	>10	>10
Normal abstraction	500 m^3d^{-1} (110,000 gallons per day) (Caretaker 29/1/03)		Not applicable
Maximum Abstraction	500 m^3d^{-1} (110,000 gallons per day) (Caretaker 29/1/03)		Not applicable
Maximum Yield	Unknown		1831 m^3 d^{-1} A 2 day test carried out 7/8/03
Maximum Drawdown	Unknown	Approximately 2 m	1 m
Hours Pumping	24 hours		N/A
Depth of sump	Unknown	2.58 m	N/A

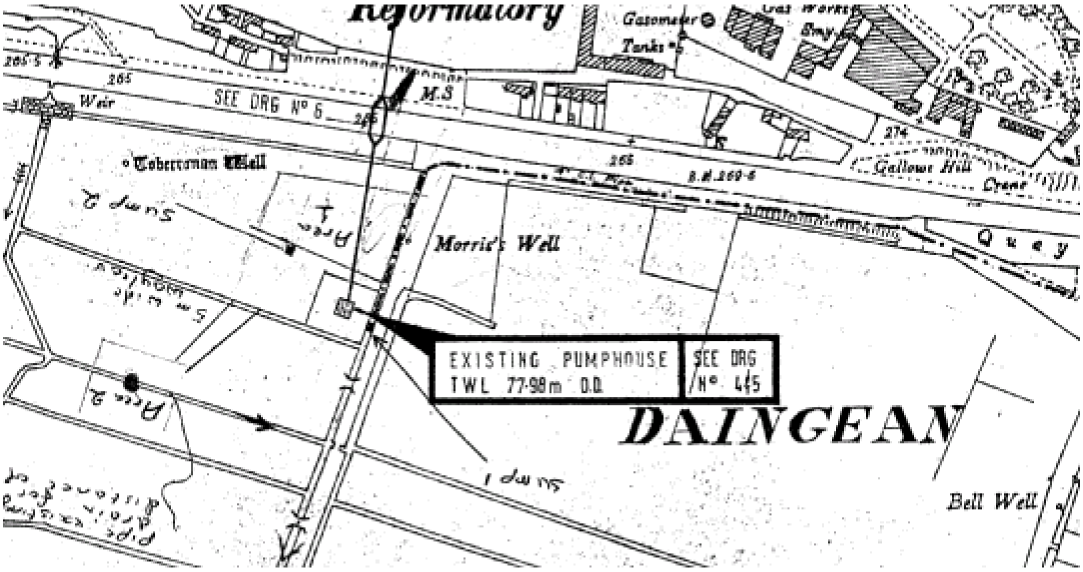


Figure 1 Location of springs and pumphouse

4 Methodology

Details about the springs and borehole such as depth, date commissioned, and abstraction figures were obtained from County Council personnel; geological and hydrogeological information was provided by the GSI.

The data collection process included the following:

- Interview with the caretaker 29/1/03.
- Field mapping walkovers to further investigate the subsoil geology, the hydrogeology and vulnerability to contamination.
- A drilling programme carried out by GSI to ascertain depth to bedrock and subsoil permeability 2/5/2003.
- Analysis of the data utilised field studies and previously collected data to delineate protection zones around the source.

5 Topography, Surface Hydrology and Land Use

The springs are located at approximately 78 m OD. The land rises northwards to 95 m OD, at Killaderry. To the south of the source the land is low lying and flat. The average topographic gradient from Killaderry to the springs is approximately 0.014.

The natural and artificial drainage density in the immediate vicinity of the source area is high. Figure 1 shows the relatively high number of artificial drains in the immediate vicinity of the source. To the north of the source area around Killaderry, the artificial drainage density is lower. There are two main streams to the northwest of the source area that flow from the north toward the springs and the Philipstown river. They are now used to supply the Grand Canal, located approximately 80 m to the north of the pumphouse. The Philipstown river is the main river that drains the area, and is part of the River Barrow catchment. The springs are located in Hydrometric area 14 of the South Eastern River Basin District.

The land in the vicinity of the source is primarily agricultural, dominated by tillage and cattle rearing. Daingean is located approximately 450 m to the east, however, there are several housing estates, north of the springs in Killaderry. There are also a number of farmyards in the area north of the springs. A disused sand/gravel pit is located approximately 270 m to the north of the source and a disused rock quarry lies approximately 460 m to the north of the source. A timber/furniture yard is located within 0.5 km of the springs.

6 Geology

6.1 Introduction

This section briefly describes the relevant characteristics of the geological materials that underlie the Daingean source. It provides a framework for the assessment of groundwater flow and source protection zones that will follow in later sections. Geological information was taken from a desk-based survey of available data, which comprised the following:

- Gately, S., Sleeman, A.G., and G. Emo. A geological description of Galway - Offaly, and adjacent parts of Westmeath, Tipperary, Laois, Clare and Roscommon to accompany the Bedrock Geology 1:100,000 Scale Map Series, Sheet 15, Galway - Offaly.
- Offaly Groundwater Protection Scheme (Daly *et al,* 1998).
- Information from geological mapping in the nineteenth century (on record at the GSI).
- Subsoil mapping by the GSI.
- Auger drilling of two holes carried out by GSI (2/5/2003).

6.2 Bedrock Geology

The area underlying the springs is occupied primarily by limestones, comprising the Upper Impure Bedded Limestone. An extract from the available geology map is given in Figure 2.

The **Upper Impure Bedded Limestone** (Lucan Formation (commonly referred to as the "Calp") is a dark grey, fine grained limestone, and is the dominant rock type in the area.

In addition to the Upper Impure Bedded Limestone, there are a number of volcanic knolls protruding through the limestone, of which Croghan and Lackan hills are examples.

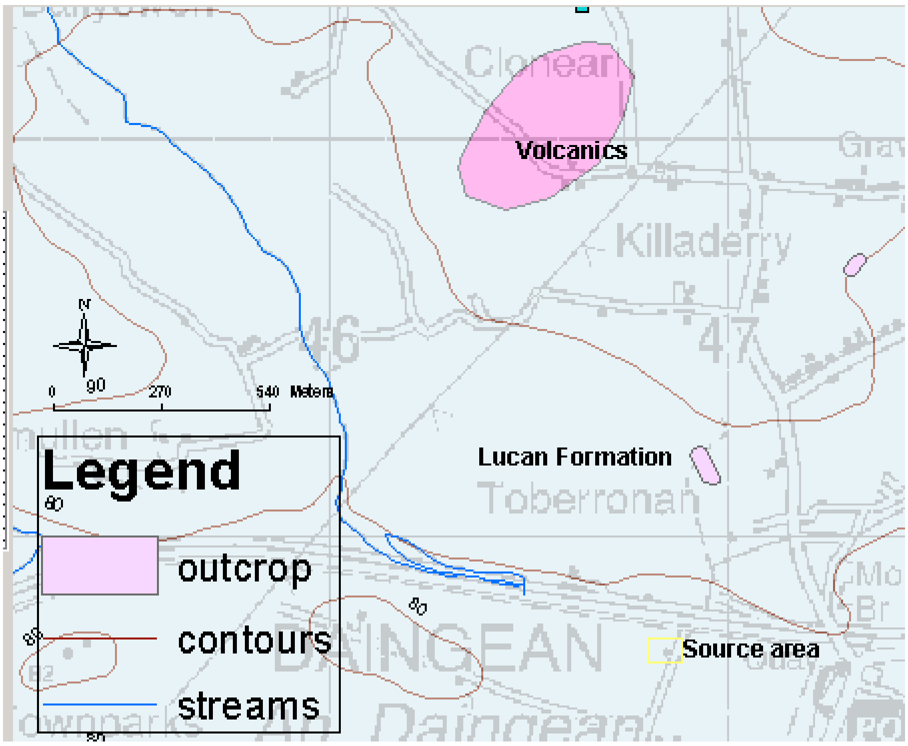


Figure 2 Bedrock Geology around Daingean Spring

6.3 Subsoil Geology

Sand/gravel, limestone tills and peat are the dominant subsoils in the area. The characteristics of each category are described briefly below.

- Peat occupies the low-lying area around the springs, and extends northwards as far as the canal. The thickness of the peat is approximately 2 m at the borehole drilled beside the pumphouse. It is less than half a metre at auger hole 1, located 60 m north of the pumphouse and there is no peat present at auger hole 2, which was drilled 100 m northwest of the pumphouse. This shows the peat thins northwards and upslope toward the canal.
- 'Till' or 'Boulder clay' is an unsorted mixture of coarse and fine materials laid down by ice. Till dominates the area to the north of the canal and 4.7 m is present at the borehole drilled beside the pumphouse.
- The springs are located in a sand/gravel deposit. Sand/gravel is present at both auger holes, and 6 m is present at the borehole beneath the till and peat. The borehole did not reach bedrock, thus the 6 m present is a minimum thickness. It seems that a pocket of sand/gravel protrudes through the till and peat where the springs and auger holes are located. The water table was present at approximately 2 m below ground in auger hole 1, and approximately 3 m below ground in auger hole 2. In addition, sand/gravel occupies a small area 600 m to the east, and 270 m to the north of the canal there is a disused sand/gravel pit. The extent of the sand/gravel is unknown, however, the northern extent would seem to be limited by the presence of outcrops 460 m north of the springs and decreasing subsoil thickness, as described below.
- The subsoil thickness varies from 0 m (outcrop) to greater than 12.8 m, over a distance of approximately 500 m. Shallow rock and outcrops occur in the higher areas to the north. The deeper areas coincide with the low lying areas covered by peat. The borehole reached 12.8 below ground level without meeting bedrock. Auger holes 1 and 2 both reached depths 7 m, without meeting bedrock.

7 Groundwater Vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater 'target'. Consequently, vulnerability relates to the thickness of the unsaturated zone in the sand/gravel aquifer, and the permeability and thickness of the subsoil in areas where the sand/gravel aquifer is absent. A detailed description of the vulnerability categories can be found in the Groundwater Protection Schemes document (DELG/EPA/GSI, 1999) and in the draft GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination. (Fitzsimons, 2003).

- The source of the groundwater is the sand/gravel, thus for the purposes of vulnerability mapping, the "**water table**" is the target. Further north, toward Killaderry, where the sand/gravel is absent, then the "**top of the rock**" is the target.
- The permeability of the till is assumed to be "**moderate**", the permeability of the sand/gravel is "**high**" and the permeability of the peat "**low**".
- Depth to bedrock varies from being greater than 10 m beside the source to where the outcrops occur in the northern part of the area.
- As the water table at the borehole is above ground level for part of the year, the vulnerability to contamination at the springs is classed as "**extreme**". The extent of the extreme vulnerability is estimated to extend for 80 m northwards, over the surface area of the sand/gravel.
- Throughout the rest of the area, the vulnerability is classed as "**moderate**", "**high**", or "**extreme**", with "**high**" covering the majority of the area.

Depth to rock and depth to the water table interpretations are based on the available data cited here. However, depth to rock can vary over short distances. As such, the vulnerability mapping provided will not be able to anticipate all the natural variation that occurs in an area. The mapping is intended as a guide to land use planning and hazard surveys, and is not a substitute for site investigation for specific developments. Classifications may change as a result of investigations such as trial hole assessments for on-site domestic wastewater treatment systems. The potential for discrepancies between large scale vulnerability mapping and site-specific data has been anticipated and addressed in the development of groundwater protection responses (site suitability guidelines) for specific hazards. More detail can be found in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999).

8 Hydrogeology

This section presents our current understanding of groundwater flow in the area of the source.

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

- Offaly Groundwater Protection Scheme (Daly *et al,* 1998).
- GSI files and archival Offaly County Council data.
- Offaly County Council drinking water returns.
- County Council personnel.
- Hydrogeological mapping carried out by GSI.
- A drilling programme carried out by GSI to ascertain depth to bedrock and subsoil permeability 2/5/2003.

8.1 Meteorology and Recharge

The term 'recharge' refers to the amount of water replenishing the groundwater flow system. The estimation of a realistic recharge rate is critical in source protection delineation, as it will dictate the size of the zone of contribution to the source. In Daingean, the main parameters involved in recharge rate estimation are: annual rainfall; annual evapotranspiration; and a recharge coefficient. The recharge is estimated as follows.

Annual rainfall: 850 mm.
The contoured data map for the Offaly Groundwater Protection Scheme (Daly *et al*, 1998) show that the springs are located approximately at the 850 mm average annual rainfall isohyet.

Annual evapotranspiration losses: 450 mm.
Potential evapotranspiration (P.E.) is estimated to be 475 mm yr.$^{-1}$ (based on data from Met Éireann). Actual evapotranspiration (A.E.) is then estimated as 95 % of P.E., to allow for seasonal soil moisture deficits.

Effective Rainfall: 400 mm.
The effective rainfall is calculated by subtracting actual evapotranspiration from rainfall.

Recharge coefficient: 80%.
Recharge is variable across the area: low in the peat covered, low-lying area in the vicinity of the springs; whilst, to the north of source, in areas of till, sand/gravel and outcrop, recharge is higher. Thus, a representative value for the recharge coefficient is estimated to be in the order of 80%.

These calculations are summarised as follows:

Average annual rainfall (R)	850 mm
estimated P.E.	475 mm
estimated A.E. (95% of P.E.)	450 mm
effective rainfall	400 mm
recharge coefficient	80%
Recharge	**320 mm**

8.2 Groundwater Levels, Flow Directions and Gradients

Water levels are close or above the ground surface in the immediate vicinity of the springs, trial well and in the low lying area to the south of the source area. The streams to the northwest and the Philipstown river are assumed to be groundwater fed streams and represent the groundwater table. The canal is located approximately 80 m north of the springs. Generally, water in canals is assumed not to be in hydraulic connection with neighbouring groundwater, due to the low permeability of the canal wall. However, the section of canal north of the springs appears to have cut through sand/gravel, thus, it is possible that water may be leaking from the canal into the sand/gravel.

The water table is assumed to be a subdued reflection of the topography, thus, the groundwater flow directions are assumed to reflect the natural drainage patterns. The groundwater flow directions are expected to be from the north toward the springs.

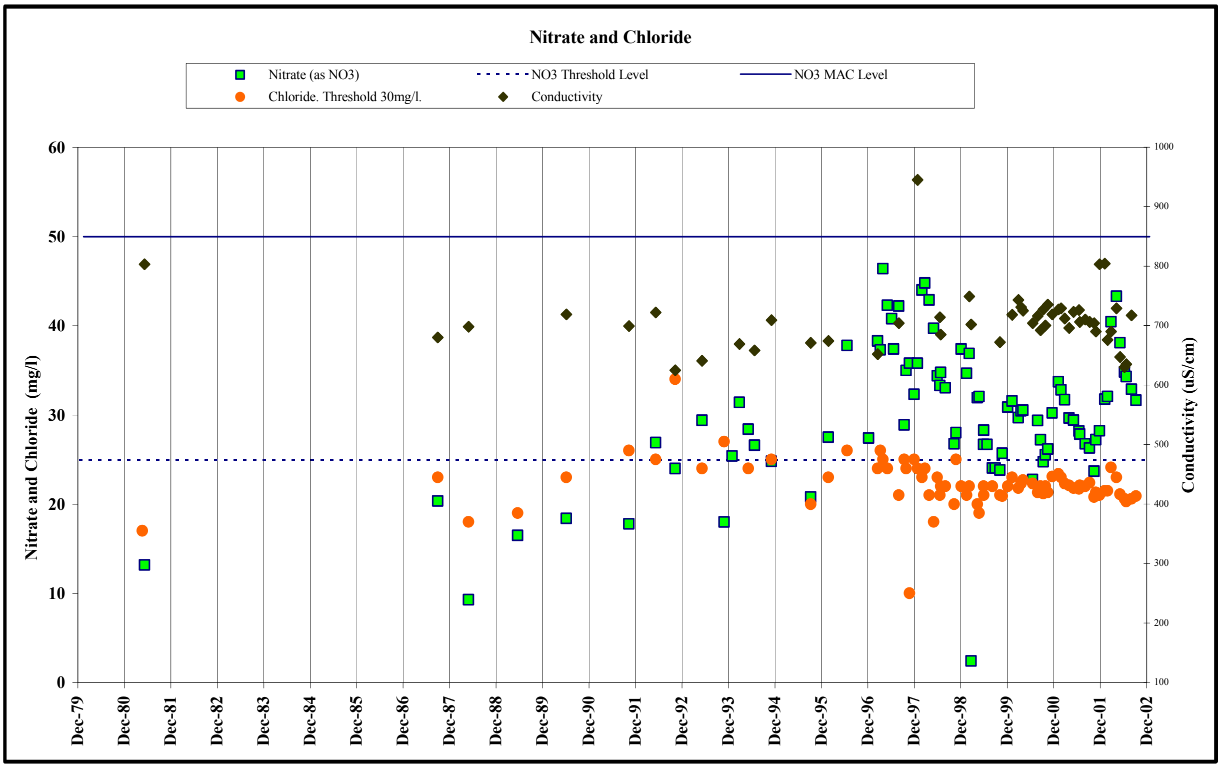
The groundwater gradients in the sand/gravel are estimated to be approximately 0.002.

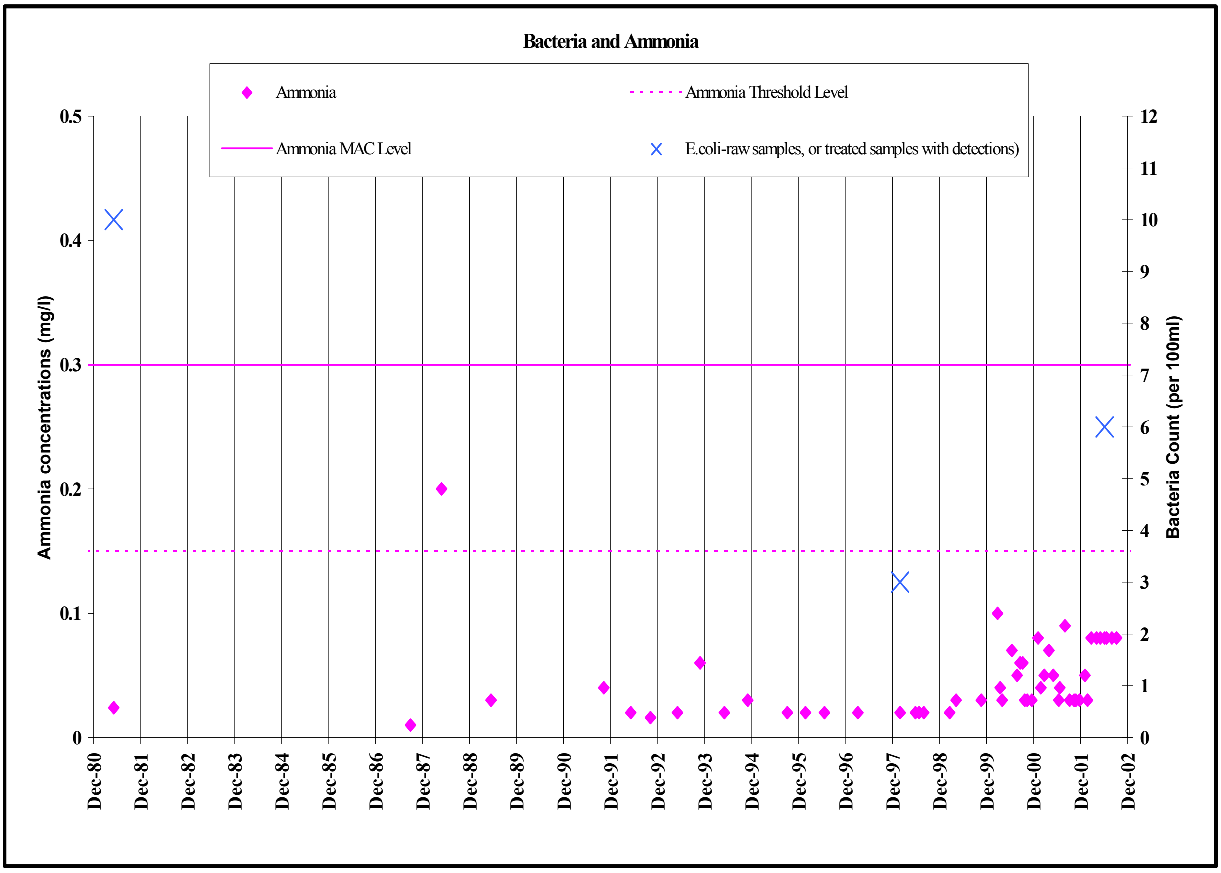
8.3 Hydrochemistry and water quality

Data on trends in water quality are summarised graphically in Figure 3. The following key points are identified from the data (all samples are from the springs).

- The water is generally "very hard" with an average total hardness of 400 mg l^{-1} (equivalent $CaCO_3$) and electrical conductivity values of 625-945 µS cm^{-1}. It is often described by the analysts as being "excessively hard". These values are typical of groundwater from limestone sand/gravel deposits.
- Nitrate concentrations in available samples (103) from the last 22 years range from 4.6-46.4 mg l^{-1} (average is 30 mg l^{-1}). There are no reported exceedances above the EU Drinking Water Directive maximum admissible concentration of 50 mg l^{-1}. However, since 1992, the data are consistently elevated above the GSI threshold value of 25 mg l^{-1}. The data over the last twenty years shows an upward trend, with the highest levels occurring in 1997 (average 38 mg l^{-1}). Since then, levels have been relatively steady. There has been an increase of housing development in Daingean, north of the springs, and the older houses are unsewered, which means that there is a relatively high density of septic tanks. In addition, most of the fields upstream of the springs are tillage, thus, there has probably been intensification in agricultural activity over the last twenty years. Therefore, the relatively high nitrate levels in Daingean, are probably due to a combination of the above factors.
- Chloride is a constituent of organic wastes and levels higher than 25 mg l^{-1} may indicate significant contamination, with levels higher than the 30 mg l^{-1} usually indicating significant contamination (Daly, 1996). Chloride data range from 18 to 34 mg l^{-1} (average 22 mg l^{-1}), suggesting that contamination from organic wastes has possibly occurred on one occasion (19/10/1992: 34 mg l^{-1}).
- There were no detections of *E. Coli* in three raw water samples available. There were three incidents of detected faecal coliforms in 98 treated water samples (22/5/1981, 9/2/1998 and 17/6/2002). On 10/5/1988 elevated ammonia (0.2 mg l^{-1}) was recorded in the analysis, which is greater than the GSI threshold value. The springs are located in the field outside the council site, used for grazing livestock, which are the most likely cause for this contamination.
- On three occasions potassium (K) was elevated above the GSI threshold value of 4 mg l^{-1}: (7/4/1997 5.7 mg l^{-1}; 16/6/1997 4.3 mg l^{-1}; 29/6/1998: 5 mg l^{-1}). The potassium:sodium (K/Na) ratio exceeds the GSI threshold of 0.35 on five occasions: 7/4/1997, 29/6/1998, 13/10/1999, 13/8/2001 and 3/12/2001. The data suggests an organic waste source, and the K/Na ratio suggests farmyard wastes rather than septic tank effluent.
- In summary, bacteriological exceedances, occasionally elevated potassium, elevated potassium:sodium (K/Na) ratio, one elevated chloride and high nitrates suggest contamination from an organic waste source. The data suggests an organic waste source, possibly farmyard

wastes, although the septic tanks and tillage areas upgradient of the springs are likely to be a significant source of nitrate.





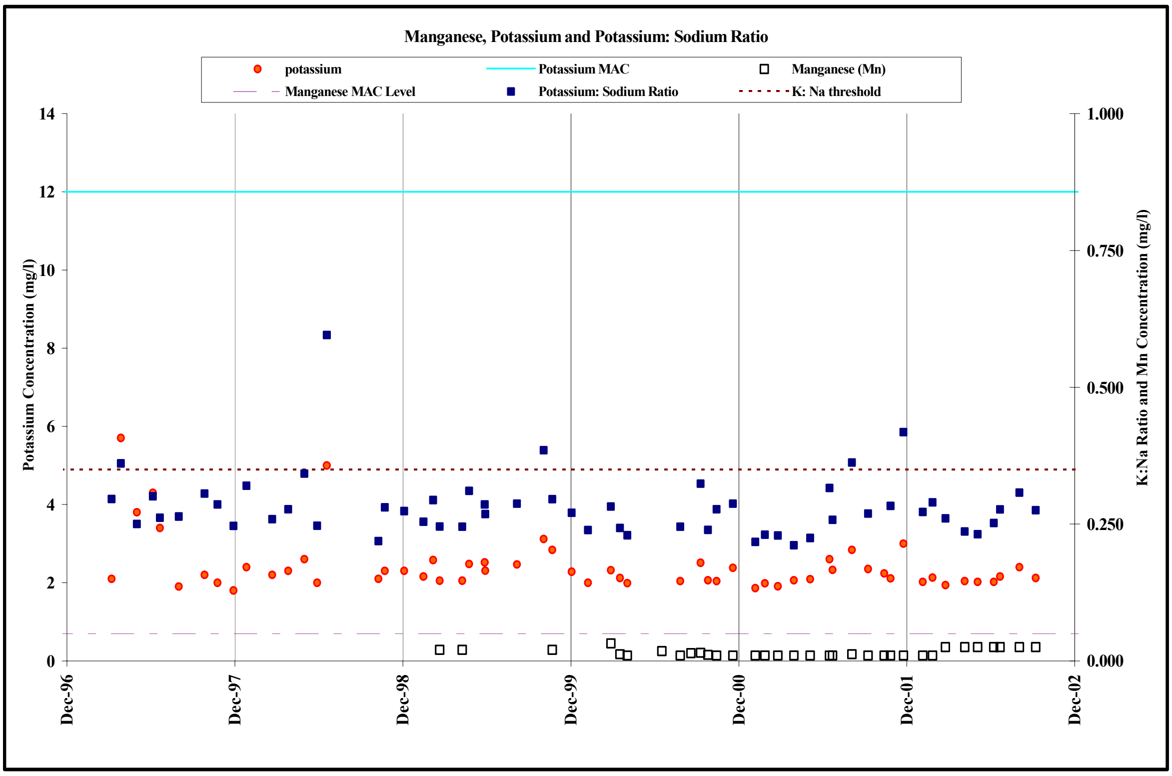


Figure 3 Key indicators of domestic and agricultural contamination at Daingean.

8.4 Spring Discharge

The total spring discharge (abstraction quantities and overflow volumes) is not well characterised. There are no records of the overflow, and the according to the caretaker the abstraction is a relatively constant, approximately 450-500 m^3d^{-1}. In dry weather periods the overflow stops and the yield drops.

8.5 Aquifer Characteristics

- Preliminary test pumping was carried out on the trial well in August 2003, and a two day test the following month. The estimated yield for the two day test was 1831 m^3d^{-1} with a reported drawdown of 0.58 m, giving a specific capacity of 3135 $m^3d^{-1}m^{-1}$. Transmissivity, estimated from the specific capacity is in the order of 3700 m^2 d^{-1}. The test pumping suggests that that the extent of the sand/gravel beneath the till and peat is significant, however, pumping was for a relatively short period, and a longer test may give more accurate estimates of the transmissivity and the sustainable yield.
- The borehole encountered approximately 6 m of saturated sand/gravel without meeting bedrock, thus permeability cannot be estimated from the test results directly, as the total saturated thickness of the sand/gravel aquifer is unknown. However, permeability must be high in view of the high transmissivity. Assuming an aquifer thickness of approximately 20 m, the permeability is in the order of 200 m d^{-1}. Porosities are estimated to be approximately 20%, given the high transmissivity.
- It is assumed that, where the sand/gravel protrudes through the peat and till, in the vicinity of the springs, groundwater is unconfined. Where the peat overlies the sand/gravel, groundwater is confined, as evidenced by the artesian conditions of the trial well. The sand/gravel pocket which protrudes through the peat and till acts as window, allowing groundwater to issue at the springs.
- The sand/gravel deposit is the main aquifer providing groundwater to the springs. In dry weather periods, the water level drops and the overflow stops. The northern extent of the deposit, which is the direction from which groundwater is assumed to flow, is limited as indicated in Section 6.3. The extent of the saturated portion is expected to be limited by the thinning of the

sand/gravel deposit upslope toward Killaderry. Thus, the area of saturated thickness upgradient of the springs is relatively small.

- To the north of the sand/gravel aquifer, the bedrock aquifer is the Upper Impure Bedded Limestone - classified in this region as a **locally Important** aquifer which is **moderately productive** only in **local zones (Ll)**. Generally, it has poor potential for water storage and abstraction. Groundwater flow tends to be concentrated in the upper fractured and weathered zone. Groundwater recharging the bedrock is expected to flow southwards and discharge into the sand/gravel aquifer.

8.6 Conceptual Model

- The springs are located in a sand/gravel aquifer.
- The abstraction is approximately 500 m^3d^{-1}.
- Transmissivity is estimated to be approximately 3700 $m^2\,d^{-1}$; permeability is estimated to be in the order of 200 m d^{-1}; and, porosity is estimated to be 20%.
- Groundwater flow directions are expected to be from the north.
- Groundwater in the bedrock, discharges to the sand/gravel aquifer, and, via a sand/gravel pocket exposed at the surface in the vicinity of the springs, which acts as a window, allows groundwater to reach the surface at the springs.
- The sand/gravel aquifer is unconfined in the immediate vicinity of the springs, but is probably confined beneath the peat. Groundwater in the trial well is artesian during the winter months.
- The northern extent of the sand/gravel aquifer is limited, thus, in dry weather the water levels of the springs drops.
- It is possible that water from the canal is recharging the groundwater in the sand/gravel aquifer beneath.
- Bacteriological exceedances, elevated potassium levels, occasionally elevated potassium:sodium (K/Na) ratio, occasionally elevated chlorides, relatively high nitrate levels suggest contamination from agricultural activities and septic tanks.
- Diffuse recharge occurs over the catchment and the annual average recharge is estimated to be 320 mm per year.

9 Delineation of Source Protection Areas

This section delineates the areas around the source that are believed to contribute groundwater to it, and that therefore require protection. The areas are delineated based on the conceptualisation of the groundwater flow pattern, and are presented in Figures 5 and 6.

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) to the springs.

9.1 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)**, which 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 subsoil and rock permeability and (d) the recharge in the area. The shape and boundaries of the ZOC were determined using hydrogeological mapping, water balance estimations, and conceptual understanding of groundwater flow. They are described as follows.

Northern boundary: The boundary is constrained by topography. In Killaderry, there is assumed to be a groundwater divide between water flowing south toward the springs and water flowing northwest and northeast draining the area of Clonearl.

Western boundary: The boundary is delineated using topography. There is assumed to be a groundwater divide to the west of Toberronan, dividing water flowing to the spring and water flowing to the stream northwest of the springs that joins the canal.
Eastern boundary: The boundary is delineated using topography. It is assumed that there is a groundwater divide, between water flowing south toward the spring and water flowing southeast and east toward the Philipstown river.
Southern boundary: The boundary is constrained by the springs themselves as it is assumed that groundwater downgradient cannot flow back up to the springs. An arbitrary buffer of 30 m is placed on the downgradient side of the springs.

The area delineated above is approximately 0.75 km^2. As a cross check, a water balance was used to estimate recharge area required to supply groundwater to the source. Assuming an annual recharge of 320 mm, a recharge area of approximately 0.5 km^2 is required to provide enough groundwater to supply 500 m^3d^{-1}. Thus, there appears to be a relatively good match between the area delineated and the area required to provide water to the springs.

9.2 Inner Protection Area

According to “Groundwater Protection Schemes” (DELG/EPA/GSI, 1999), delineation of an Inner Protection Area is required to protect the source from microbial contamination and it is based on the 100-day time of travel (ToT) to the supply.

Estimations of the extent of this area are done by using Darcy’s Law, which can be used to estimate groundwater velocities.

Velocity = (gradient x permeability) ÷ porosity

Using the estimated values for permeability, gradient and porosity (200 m d^{-1}, 0.002, 20%, respectively), the calculated velocity is 2 m d^{-1}. Accordingly, the boundary of the inner protection area (SI) is 200 m on the upgradient side of the spring.

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.

Five groundwater protection zones are present around the source as illustrated in Table 1. The final groundwater protection zones are shown in Figure 6.

Table 1 Matrix of Source Protection Zones at Daingean

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

11 Potential Pollution Sources

Land use in the area is described in Section 5. Agricultural activities and septic tanks are the principal hazards to the water quality in the area. The main potential sources of pollution within the ZOC are farmyards, septic tank systems, landspreading of organic and inorganic fertilisers and industrial byproducts/waste.

12 Conclusions and Recommendations

- The source at Daingean comprises two springs located in a sand/gravel aquifer.
- The yield of the springs is limited by the northern extent of the sand/gravel aquifer.
- The groundwater feeding the source is moderately to extremely vulnerable to contamination.
- Available data suggests that there is contamination at the source from an organic source, probably a combination of farmyards, septic tank effluent and fertilisers.
- The protection zones delineated in the report are 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. Drilling and a geophysical programme is required to delineate the extent of the sand/gravel deposit.
- It is recommended that:
  1. A sample of water from the canal and spring is taken at the same time and analysed, to help determine if the canal is providing water to the springs.
  2. The potential hazards in the ZOC should be located and assessed.
  3. A full chemical and bacteriological analysis of the **raw** water is carried out on a regular basis.
  4. Particular care should be taken when assessing the location of any activities or developments which might cause contamination at the springs.

13 References

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APPENDIX 1 LOGS OF AUGER HOLES.
Auger Drilling at Daingean, Co. Offaly.

Auger 1. Entrance to field in which springs are located.
Grid reference 2321NEW027: 246870 227760
0-7.0m: Rounded – Subrounded gravel and cobbles
water table approximately 2.0 m below ground level.
7.0 m End of Hole (refusal, boulders & cobbles)

Auger 2. Along the northern ditch of the field in which springs are located.
Grid reference 2321NEW028: 246770 227770
0-7.0m: Rounded – Subrounded gravel and cobbles
water table approximately 3.0 m below ground level.
Cobbles from 4m, no returns after 4 m.
7.0 m End of Hole (refusal, boulders & cobbles)

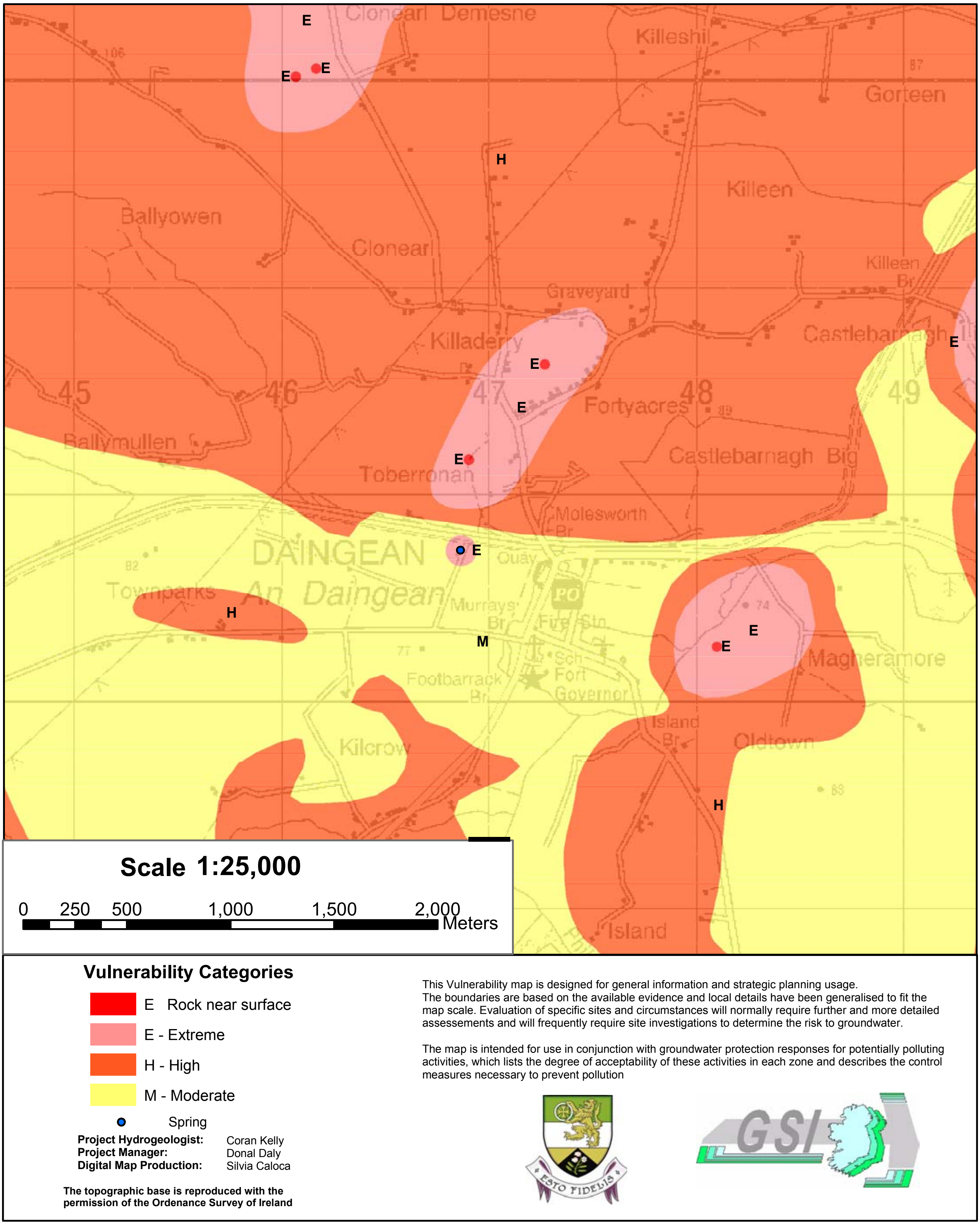

Figure 4 Groundwater Vulnerability around Daingean

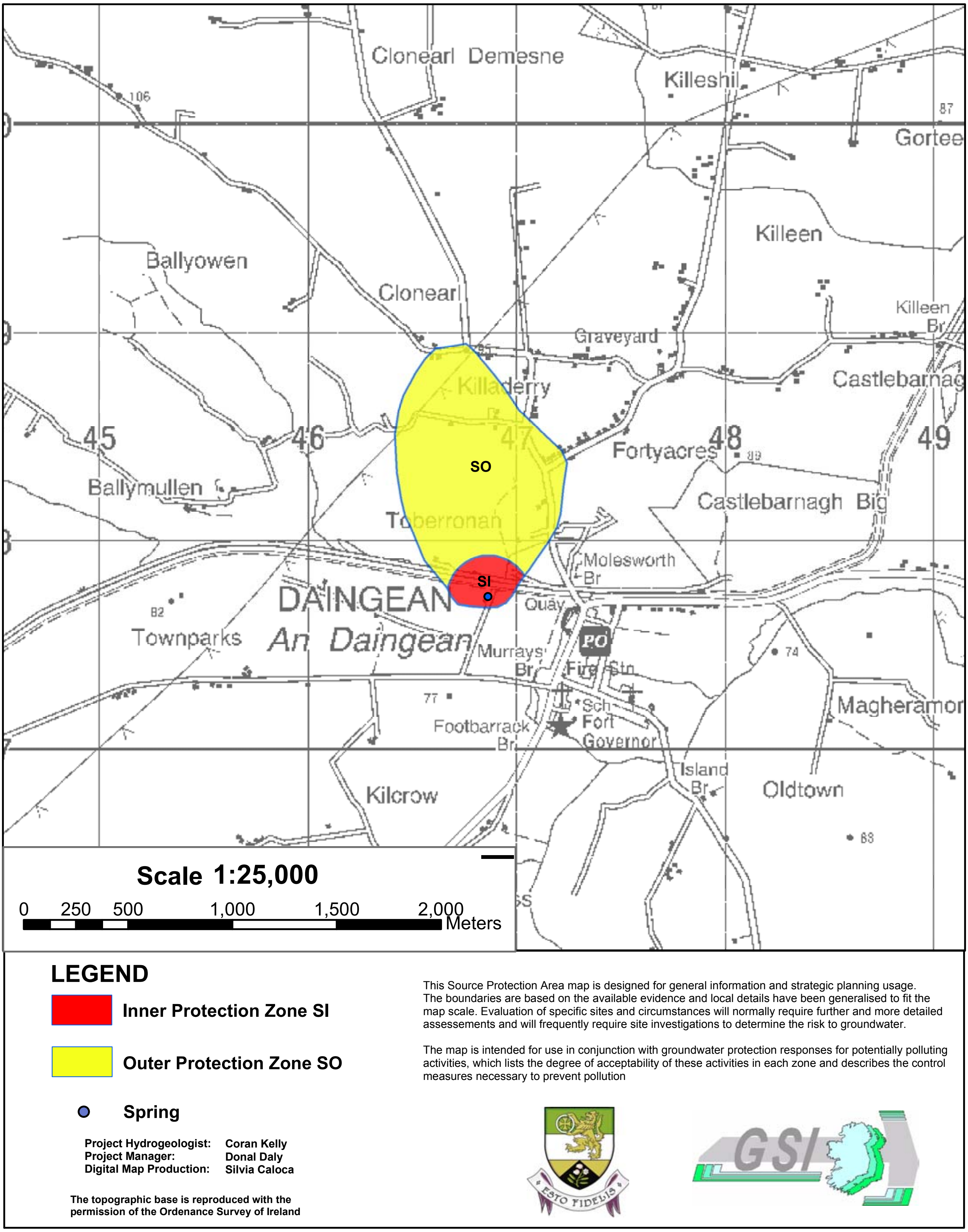

Figure 5 Source Protection Areas for Daingean springs

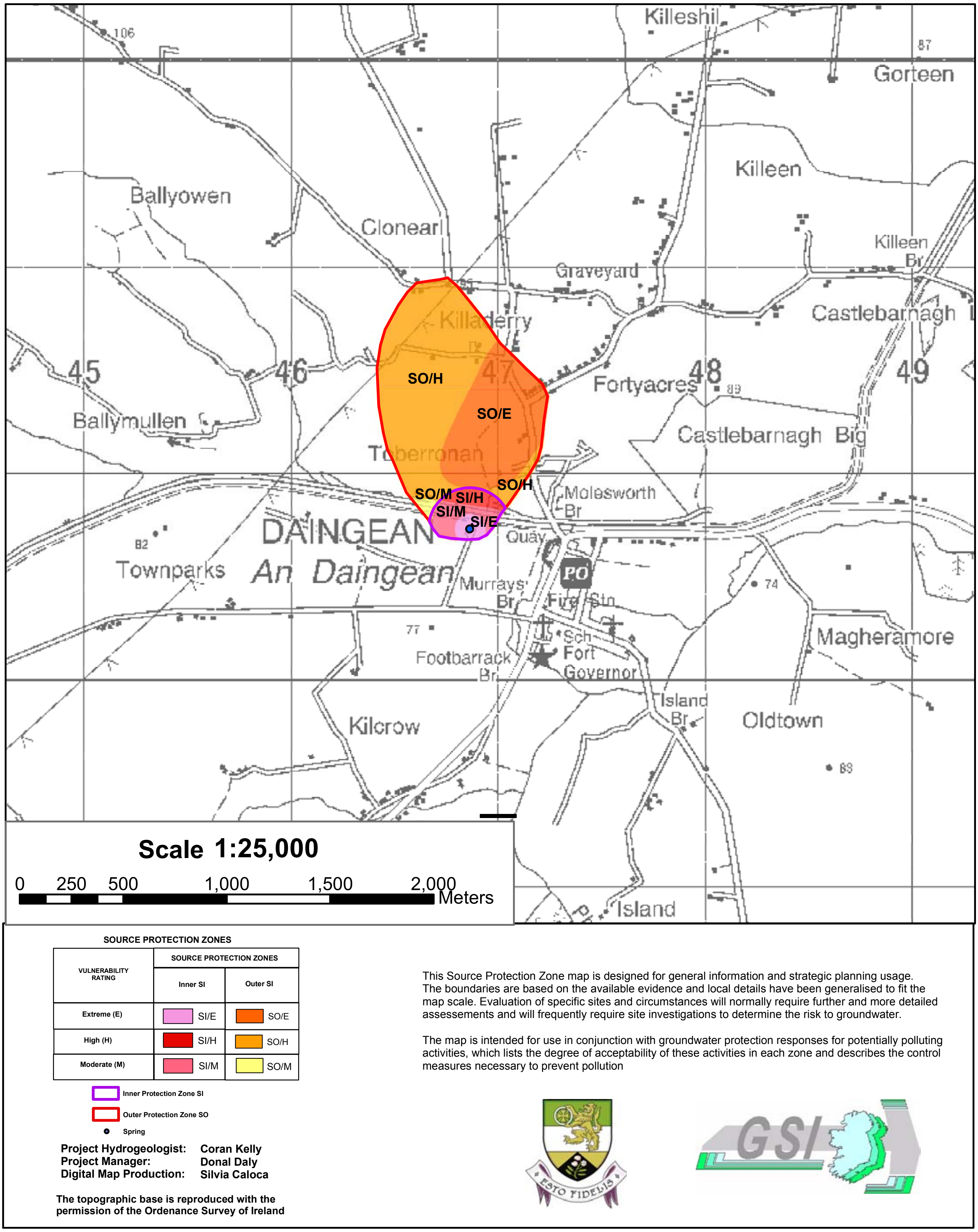

Figure 6 Source Protection Zones for Daingean springs