14 Lipstown - Narraghmore Group Water Scheme

14.1 Introduction

The objectives of the report are as follows:

- To delineate source protection zones for the spring.
- To outline the principal hydrogeological characteristics of the Narraghmore area.
- To assist Kildare 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 well. 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. The maps produced for the scheme are based largely 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 county 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.

14.2 Spring Location & Site Description

The source is located 2 km north of Ballitore village, Co. Kildare, on the boundary of two townlands, namely Narraghmore and Crookstown Lower. A sketch of the site is illustrated in Figure 14-1. The source is known locally as "Seven Springs" and comprises several springs discharging into a single zone. The source was commissioned in 1972. The discharge zone was dug out and concrete liners were installed to create an improved sump. The sump comprises 3 large concrete liners (4.5 m long) standing vertically next to each other, set down into the original natural collection point for the "seven springs". The individual springs cannot be seen. The sump is housed in a large galvanised shed next to the pump house. Both the pump house and sump area are fenced off, so it is well protected from animals and birds accessing the spring water. A rising mains runs from the pump house to a reservoir on Nine Tree Hill, which has a capacity of 85,000 gallons (386 m^3). The scheme provides water for about 1240 people comprising about 310 houses and 62 farms.

14.3 Summary of Spring Details

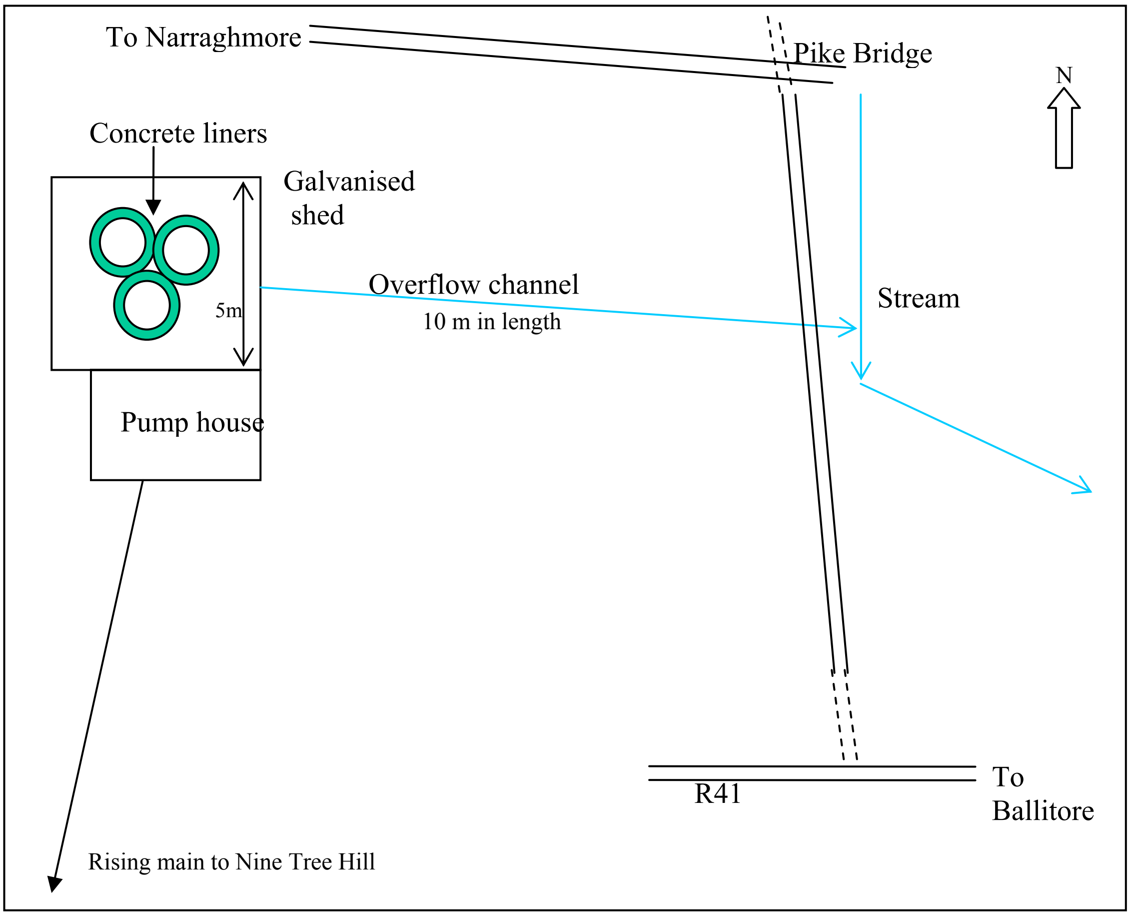
GSI No.	2619SEW239
Grid reference	S ^{2}7940 ^{1}9820
Townland	Narraghmore/Crookstown Lower
Owner	Lipstown/Narraghmore Group Scheme
Well Type	Spring
Elevation (ground level)	99.50 m OD (Malin Head). (GSI; May 2002)
Static water level	99.50 m (GSI; May 02)
Normal consumption/abstraction	383 m^3d^{-1} (Co.Co. figures 2000)
Hours Pumping	14-15 hours per day
Yield	1300 m^3d^{-1} (group scheme 1972) 1800 m^3d^{-1} (GSI measurements May 2002 of discharge and overflow)
Depth of sump	~4.5 m
Depth-to-rock	>10 m

14.4 Methodology

14.4.1 Desk Study

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

Figure 14-1Sketch of Site at Lipstown - Narraghmore



14.4.2 Site visits and fieldwork

This included the following:

- Interviews with the group scheme personnel 9/5/02.
- Estimating spring flows 13/5/2002.
- Water sampling on July 2002.
- Drilling of depth to bedrock holes during May 2002.
- Field mapping walkovers to further investigate the subsoil geology, the hydrogeology and vulnerability to contamination.

14.4.3 Assessment

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

14.5 Topography, Surface Hydrology and Land Use

The spring is located in a low-lying area surrounded by a rolling landscape. To the west of the spring the land rises to a north-south ridge in Narraghmore Demesne. This ridge stands at about 140 m O.D.

The slope down to the spring is in the order of 1:50. To the south east the highest hill in the area occurs in Boleybeg, named Nine Tree Hill (168 m O.D.). It is on this hill that the reservoir is located. The area downslope of the springs is relatively flat. Examination of the topographic maps for the Narraghmore area indicate that there are very few springs, streams and drains in the area upstream of the springs. This indicates that generally the land is free draining. In the low-lying area downstream of the spring the natural drainage appears to be much more restricted and there are some large artificial field drains. The overflow from the source joins one such drain before joining the Greese River at Crookstown Lower.

The land use around the spring is generally grassland, used for pasture and silage. There are several sand/gravel pits (both disused and in use) in the vicinity. One of the proposed routes for the new Dublin-Waterford road passes within 200 m of the source.

14.6 Geology

14.6.1 Introduction

This section briefly describes the relevant characteristics of the geological materials that underlie the Narraghmore 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:

- Bedrock Geology 1:100,000 Map Series, Sheet 16, Kildare-Wicklow. Geological Survey of Ireland. (Mc Connell *et al*, 1994).
- Information from geological mapping in the nineteenth century (on record at the GSI).
- Glanville (1997), The quaternary geology of Co. Kildare, map descriptions for relevant 1:25,000 sheets. GSI report.
- Soils of County Kildare, 1971. Conry, M. J., Hammond, R. F. and T. O'Shea. National Soil Survey of Ireland. An Foras Taluntais.

14.6.2 Bedrock Geology

The bedrock consists of one geological unit, namely the Carrighill Formation and consists of greywacke[4] sandstones, siltstone and shales.

14.6.3 Subsoil (Quaternary) Geology

The main subsoil categories in the vicinity of the source are sand/gravel and peat. The characteristics of each category are described briefly below:

- Sand/gravel is widespread in south Kildare. A locally important sand/gravel aquifer is mapped in the area around the springs. Several quarries (some disused) are mapped in the vicinity of the source, all of which are located south, east and north of the source. Several eskers are located close to the source.
- Subsoils are mapped as peat downstream of the spring.
- A depth to bedrock drilling programme was carried out to ascertain the subsoil thicknesses. Generally, depth to bedrock is greater than 10 m in the vicinity of the source. Further west the depth to bedrock decreases significantly and there are areas of shallow rock and outcrop.

14.7 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

[4] Greywacke are sandstones or siltstones that are cemented by a high proportion of mud deposited from currents loaded with sediment on subaqueous slopes.

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).

The thickness of the unsaturated zone in the sand/gravel has been estimated using the water level data and the estimated groundwater gradient. The distribution of interpreted groundwater vulnerability is presented in Map 6 and Map 8. The vulnerability in the sand/gravel areas is classed as high, except for an area of extreme vulnerability mapped in the vicinity of the spring where the depth to the saturated zone is less than 3m, the boundary of which is estimated to be approximately 60 m on the upgradient side of the spring.

In areas to the west of the source where the sand/gravel is absent, vulnerability ranges from generally extreme (in areas of rock outcrop) to generally moderate (where the subsoils are believed to be over 10m in thickness).

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 a small scale. 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 only 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).

14.8 Hydrogeology

14.8.1 Introduction

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:

- GSI files and archival Kildare County Council data.
- Kildare County Council drinking water returns.
- Group Water Scheme personnel.
- Hydrogeological mapping carried out by GSI.
- A drilling programme carried out by GSI to ascertain depth to bedrock and subsoil permeability.

14.8.2 Rainfall, Evaporation 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 to the source. 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:* 800 mm.
  Rainfall data for gauging stations around Narraghmore (from Fitzgerald, D., Forrestal., F., 1996).

Gauging Stations	Grid reference	Elevation OD (m)	Approximate distance & direction from source	Annual precipitation 1961-1990
Athy (Voc.Sh)	S656933	61	10 km south west	746 mm
Castledermot G.S.	S775848	82	12 km south	752 mm
Kilcullen G.S.	N838093	116	11 km north	860 mm

The data indicates that the rain gauges to the southern side of Narraghmore have annual precipitation values of about 750 mm annually, whereas to the north at Kilcullen there is an increase in the annual precipitation - up to 860 mm. It is likely that precipitation at Narraghmore lies within this range. The annual rainfall around Narraghmore is estimated to be 800 mm.

- *Annual evapotranspiration losses:* 430 mm. Potential evapotranspiration (P.E.) is estimated to be 450 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. This figure ('actual evapotranspiration') was calculated using an adaptation of the country-wide potential evapotranspiration data presented in the "Agroclimatic Atlas of Ireland" (Collins and Cummins, 1996). More local measurements of evapotranspiration are not available.

- *Potential recharge:* 370 mm $yr.^{-1}$. This figure is 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 runoff and is commonly referred to as "Effective Rainfall".

- *Annual runoff losses:* ~70 mm. The slopes and the nature of the deposits around the source need to be considered in order to give a representative value for the runoff during rainfall events. The subsoils are dominated by sand/gravel which have high rates of infiltration. This is supported by the free draining nature of the land. Thus a representative value for the proportion of runoff is estimated to be in the order to 20% (Wright *et al*, 1982).

These calculations are summarised as follows:

Average annual rainfall (R)	800 mm
Estimated P.E.	450 mm
Estimated A.E. (95% of P.E.)	430 mm
Potential Recharge (R – A.E.)	370 mm
Runoff losses (10% of recharge)	70 mm
Estimated Actual Recharge	**300 mm**

14.8.3 Groundwater levels, Flow Directions and Gradients

A GSI well survey was carried out in the 1960's and 1970's in County Kildare. The majority of wells around Narraghmore are recorded as being dug wells. Water levels are close to the ground surface in the low-lying area in the vicinity of the spring and at the spring itself the water level is at ground surface. Water levels elsewhere appear to be in the region of 3-7 m below ground level.

The hydrogeological data suggests that a local groundwater divide occurs in the vicinity of Narraghmore Demesne. From the data groundwater on the eastern side of the divide is thought to flow in a south easterly direction following the topographic slope towards the spring. The springs occur at a point where the ground slope becomes very gentle and where the subsoils change from sand/gravel to peat.

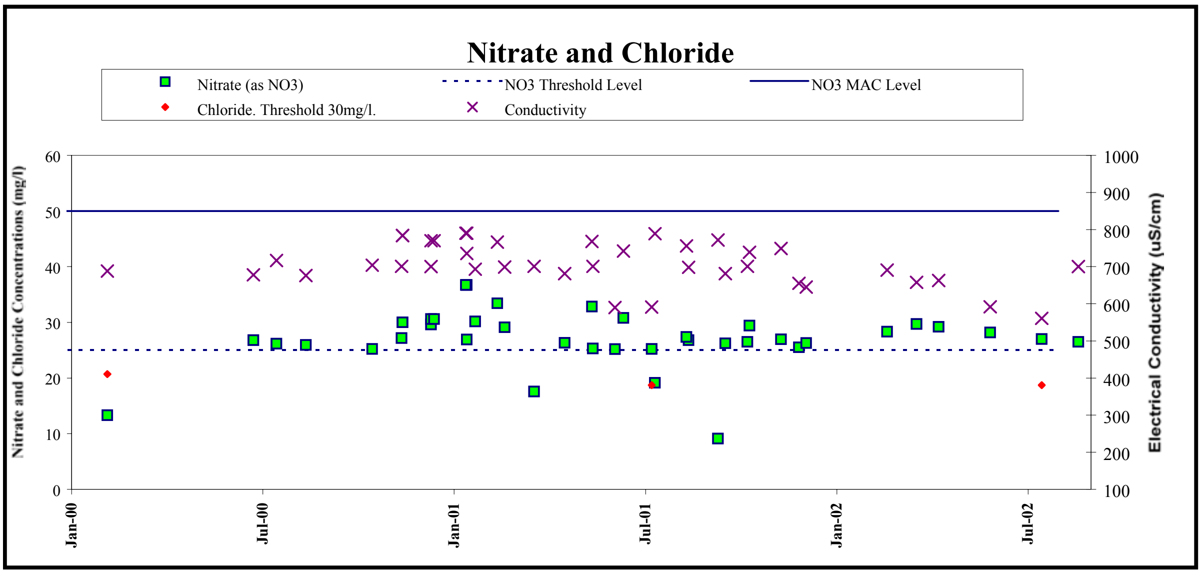
Groundwater gradients in sand/gravel are expected to be quite flat. Data from other parts of the country indicate that gradients in sand/gravel aquifers are in the order of 0.002 to 0.004. The hydrogeological data near the spring suggest local gradients are in the order of 0.02-0.002, and a value of 0.002 is used in later sections to determine the extent of the source protection zones.

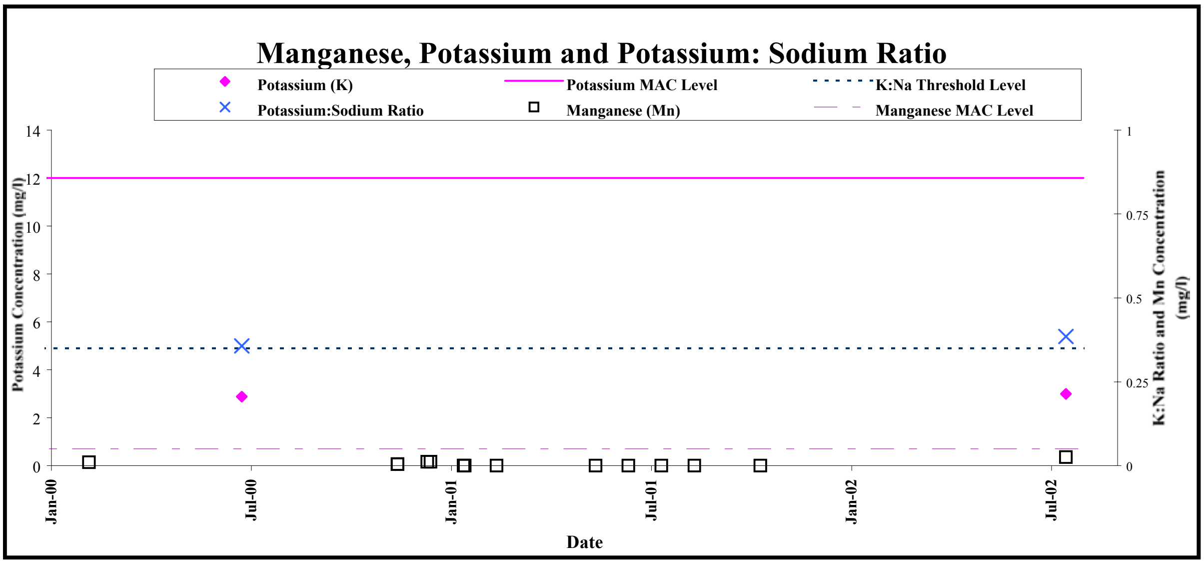
14.8.4 Hydrochemistry and Water Quality

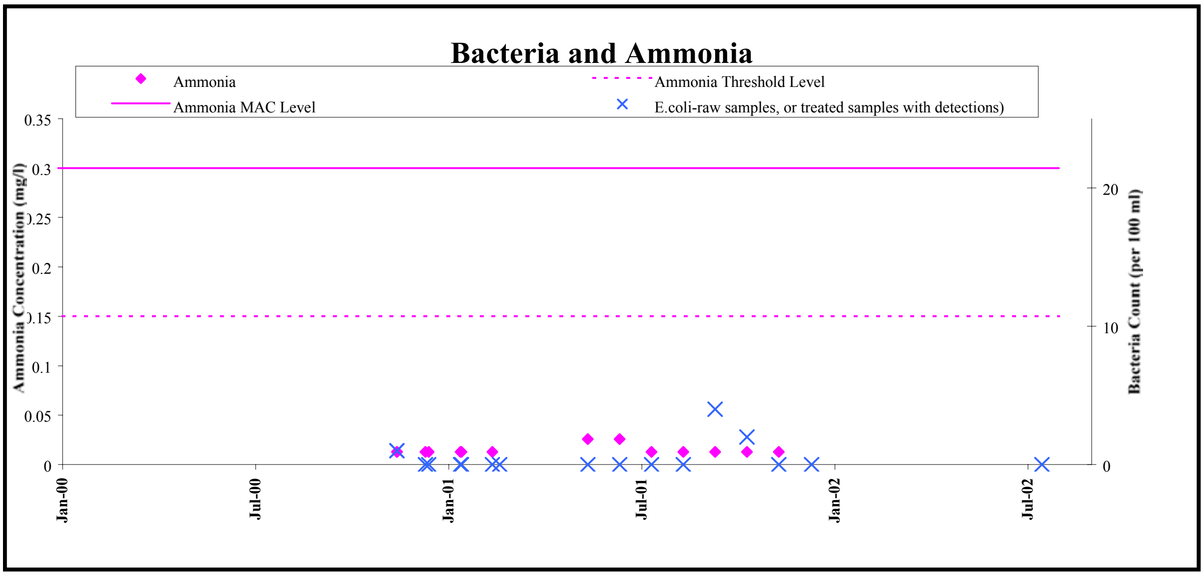
The data is summarised graphically in Figure 14-2 and the following key points are identified:

- The hydrochemical analyses show that the water is moderately hard, with total hardness values of 160 mg l^{-1} (equivalent $CaCO_3$) and electrical conductivity values of 645-720 µS cm^{-1}. These values are typical of those from limestone rock units or sand/gravel deposits. No limestone rock units occupy the area around Narraghmore, suggesting that the groundwater is mostly derived from the sand/gravel aquifer which is mapped at the source.
- Nitrate analyses available over the last two years are variable but generally lie in the range of 25-35 mg l^{-1}. Though all results are below the EU MAC, most are above GSI threshold (refer to Appendix I) and are therefore considered to be elevated.
- The potassium:sodium ratio is also slightly elevated in the 2 values available from the last 2 years. The combination of elevated nitrates and potassium:sodium ratios in a spring source with extremely vulnerable areas suggests that landspreading of inorganic fertilisers and/or farmyard wastes may be having some influence on overall groundwater quality (refer to Section 7.5.6).
- Of sixteen available raw water samples from the last 2 years, there are exceedances of *E.coli* in three samples.

Figure 14-2Narraghmore - Key indicators of agricultural and domestic groundwater contamination.







14.8.5 Aquifer Characteristics

The Narraghmore sand/gravel deposit is classed as a **Locally Important sand/gravel aquifer (Lg)** and further details are presented in Section 4 Volume I. No site specific data are available but permeability tends to be high in sand/gravel, often in the order of 20-70 m d^{-1}. For the purposes of estimating source protection areas in later sections, a permeability of 70 m d^{-1} is assumed. Conservative estimates of the porosity of sand/gravel aquifers tend to be about 0.07-0.08, based on porosity values other parts of the country.

The bedrock is not considered to be the main aquifer providing water to the spring. Groundwater that may flow in the bedrock is likely to be constrained to fractures and the upper few metres of weathered bedrock. The formation is classed as a **Poor Aquifer which is generally unproductive (Pu)**. Further details can be referred to in Section 4 Volume I.

14.8.6 Spring Discharge

The total spring discharge (abstraction and overflow volumes) is not well characterised. Group scheme personnel measured the spring discharge before the scheme was set up (1972) using a temporary V-notch weir. Since then it is understood that no reading of the overflow has been taken until the spot reading made by GSI staff 13/5/2002. It is likely that the seasonal and annual fluctuations in flow are quite narrow as springs issuing from sand/gravel aquifers tend to have a steadier, narrower range of discharge than springs found in karst areas. This is demonstrated by well hydrographs in near-by sand/gravel aquifers which show a narrow range in the fluctuation of the water levels, generally in the order of 1-2 m (refer to Section 4 of Volume I). Group scheme personnel indicate that there is a constant overflow from the springs. The measurements are as follows:

Date	Total discharge	Data source	Method
1972	1300 m^3 d	Group Scheme Personnel	v-notch weir
13/5/2002	1800 m^3 d	GSI Personnel	Flow metre/floating object

More overflow monitoring is required to provide a more reliable dataset. A spring discharge of 1300-1800 m^3 d^{-1} is considered an **Intermediate** discharge according to the GSI classification of spring discharge.

14.9 Conceptual Model

- The scheme abstracts about 380 m^3 d^{-1} (~84,000 gallons per day) from an intermediate sized spring, that is protected from surface workings inside a fenced galvanised shed.
- The spring issues from a **Locally Important sand/gravel aquifer (Lg)** at a point where the sand/gravel pinches out against peat and where the topographic gradient changes.
- Groundwater vulnerability is high to extreme.
- The groundwater gradient in the sand/gravel aquifer is low, approximately 0.002, with assumed porosities in the region of 7-8% and permeabilities in the region of 20-70 m d^{-1}. Water levels around the spring are at ground level, whilst toward the groundwater divide they are about 4-7 m below ground surface.

14.10 Delineation of Source Protection Areas

14.10.1 Introduction

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 Map 8.

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 spring.

14.10.2 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)**, 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, aerial photographs, topographic maps and the conceptual model. The ZOC is shown in Map 8 and is discussed as follows:

The **Western Boundary** is constrained by the ridge in Narraghmore Demesne that runs south to Nine Tree Hill. Water levels show that this ridge acts as groundwater divide between water flowing east to the spring and water flowing west toward the River Barrow.

The **Eastern boundary** is constrained by the location of the spring itself. Groundwater to the east of the spring cannot flow up slope to the spring. An arbitrary buffer of 50 m is placed on the downgradient side of the spring.

The **Northern** & **Southern Boundaries** are low topographic ridges delineated using aerial photographs and topographic maps. The southern boundary runs from Nine Tree Hill along a low ridge toward the spring. The northern boundary is a low ridge running about 1 km north of the spring toward Narraghmore Demesne.

A water balance was used to compare the area delineated by the above boundaries with the recharge area required to supply groundwater to the source. To try to account for lower recharge rates in summer time and to account for short term increases in abstraction, the maximum measured discharge was increased by 50% to 2000 $m^3 d^{-1}$. Assuming an annual recharge of 300 mm, a recharge area of 2.5 km^2 is required to provide enough groundwater to supply this discharge. This is slightly less than the area delineated within the above boundaries.

14.10.3 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 and viral contamination and it is based on the 100-day time of travel (ToT) to the supply. Estimations of the extent of this area are made by hydrogeological mapping and analytical modelling. It should be noted that permeability and porosity values, used to calculate the velocity, were not determined at this site, but are estimations based on our experience in other areas.
Thus; a permeability (K) value of 70 $m\ d^{-1}$, porosity (n) of 0.07 and a gradient (i) of 0.002 were used to calculate the velocity (V) as follows;

$$V = (K.i) / n$$
$$V = 2\ m\ d^{-1}$$

Thus in 100 days most groundwater will move approximately 200 m.

14.11 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 given in Table 15. The final groundwater protection zones are shown in Map 8.

Table 15 Matrix of Source Protection Zones at Narraghmore.

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

14.12 Potential Pollution Sources

Land use in the area is described in Section 14.5. The land around the source is grassland dominated, used for cattle and sheep. 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 and landspreading of organic and inorganic fertilisers. The new proposed motorway presents a future potential hazard to the source.

14.13 Conclusions and Recommendations

- The source an intermediate spring with good quality water located in a **Locally Important sand/gravel aquifer (Lg)**.

- The groundwater feeding the source is extremely to highly vulnerable to contamination.

- Available data suggests that nitrate levels are elevated and require careful management to ensure that they don't rise to significant levels.

- 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.

- It is recommended that:
  1) The potential hazards in the ZOC should be located and assessed including future potential hazards, in particular the new proposed motorway.
  2) A full chemical and bacteriological analysis of the **raw** water is carried out on a regular basis.
  3) Particular care should be taken when assessing the location of any activities or developments which might cause contamination at the well, particularly in relation to nitrates.
  4) A flow metre on the pump and a permanent v-notch weir installed in the overflow to get a proper understanding of the spring discharge, thus a better understanding of the potential groundwater resource.