

11 Usk - Gormanstown Group Water Scheme

11.1 Introduction

The objectives of the report are as follows:

- To delineate source protection zones for the source.
- To outline the principal hydrogeological characteristics of the 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.

11.2 Well/spring Location & Site Description

The source is located 2.5 km northeast of Dunlavin, Co. Wicklow and approximately 500 m from the border with Co. Kildare. The source comprises a borehole and spring located at Tober Demesne, approximately 650 m south of Tober cross roads, next to the burial ground. The borehole was commissioned in 1983 to meet the increasing demand, superseding and taking over from the spring. Caretaker staff indicate that the spring is no longer in use. The borehole pumps water to a reservoir situated at Grangebeg Park in Co. Wicklow. The scheme provides water for about 550 people; 137 houses and 80 farms, most of whom live in Co. Kildare.

11.3 Summary of Borehole & Spring Details

	Spring	Borehole
GSI No.	2619NEW013	2619NEW012
Grid reference	S 28855 20328	S 28859 20330
Townland	Tober Demesne	Tober Demesne
Owner	Gormanstown Group Water Scheme	Gormanstown Group Water Scheme
Elevation (ground level)	180.58 m OD (Malin Head) GSI survey 10/5/02.	181.88 m OD (Malin Head). GSI survey 10/5/02
Depth to rock	>10 m	>10m
Static water level	180.58 m OD. (GSI survey 10/5/02)	180 m OD. (GSI survey 10/5/02)
Normal consumption/abstraction		146 m ³ d ⁻¹ (32,000 gallons per day) (council figures 2000) 250-340 m ³ d ⁻¹ (55,000-75,000 gallons per day) (caretakers figures 2002)
Spring overflow	2900 m ³ d ⁻¹ (GSI 13/5/02)	
Depth		7.6 m; PVC slotted pipe. No casing.
Diameter		250mm
Depth-to-rock	>10 m	>10 m
Static water level	Ground level	1.2 m below ground 16/6/1983
Pumping test summary:		Carried out by Irish Geotechnical Services Ltd. 1982
(i) pumping rate		463 m ³ d ⁻¹ for 8 hours.
(ii) drawdown		4.3 m
(iii) specific capacity		107 m ³ d ⁻¹ m ⁻¹
(iv) transmissivity		Estimated from specific capacity~128 m ² d ⁻¹

11.4 Methodology

11.4.1 Desk Study

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

11.4.2 Site visits and fieldwork

This included the following;

- Water sampling in July 2002;
- Interviews with the caretakers January 2002 and June 2002;
- Levelling in the spring & borehole 10/5/02 and spring overflow measurements 13/5/02.
- Field mapping walkovers in January and May 2002 to further investigate the subsoil geology, the hydrogeology and vulnerability to contamination

11.4.3 Assessment

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

11.5 Topography, Surface Hydrology and Land Use

The source is located in west Co. Wicklow toward the bottom of a group of three small hills amongst the foothills of the Wicklow mountains. The slopes of the hills around the source are in the order of 0.04. The elevations range from about 180 m at the source to 257 m at Wards of Tober. The source is situated toward the bottom of a westerly facing slope.

According to the GSI archive 1:10560 scale maps of the area there are a series of springs occurring toward the bottom of the slopes on either side of the hills. The largest of these springs is the one that group water scheme uses and is the likely to be the historical reason for the townland name (Tober) and is also the source of the River Greese.

There is a mixture of land use type in the area. Most of the land is put to pasture for sheep and cattle. There are a number of sand/gravel pits near to the spring, with one quarry less than 300 m from the source. In addition the main road passing by the source is a busy minor road [R756].

11.6 Geology

11.6.1 Introduction

This section briefly describes the relevant characteristics of the geological materials that underlie the Tober 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).
- Wicklow County Council Groundwater Protection Scheme (Woods and Wright, 2001).
- "Report on a groundwater investigation for Gormanstown/Kildare Group Water Scheme" Irish Geotechnical Services (IGSL) Report No.571, July 1983.
- Glanville (1997) The quaternary geology of Co. Kildare, map descriptions for relevant 1:25,000 sheets. GSI report.

11.6.2 Bedrock Geology

Greywacke² sandstones, shales and slates dominate the area. They are discussed in further detail in Sections 2 and 4 of Volume I.

11.6.3 Subsoil (Quaternary) Geology

- Sand/gravel and limestone tills are the dominant subsoil in the area. The Tober source is located near the bottom of a sand/gravel deposit that has a mapped area greater than 1 km² (one of the townlands that the deposit occupies is named "Sandyhills"). The top of the hill at Manofwar is occupied by a small sand/gravel deposit mapped at roughly 200 m² in size. The logs of the boreholes drilled close to the spring indicate 6 m of "grey sand/gravel and cobbles predominantly sub angular and sub rounded, sandy at upper levels" sitting on at least 0.7 m of "boulder clay" (IGSL, 1983).
- 'Till' or 'Boulder clay' is an unsorted mixture of coarse and fine materials laid down by ice. Till deposits in County Wicklow have a widespread distribution and occupy the area surrounding the sand/gravel deposit and also underlies the sand/gravel deposit in places (IGSL 1983).
- A depth to bedrock drilling programme was carried out to ascertain the subsoil thicknesses in County Wicklow for the Wicklow Groundwater Protection Scheme (Woods, L. & Wright, G., 2001). The thicknesses vary considerably from 0 m at Friarhill (rock outcrop) to >10 m around the source. In general the subsoil thickness increases from the hill tops down to the valley floors.

11.7 Groundwater Vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater 'target'. A detailed description of the vulnerability categories can be found in the Groundwater Protection Schemes document (DELG/EPA/GSI, 1999).

The permeability of the sand/gravel is assumed to be high. As the groundwater in the sand/gravel is regarded as the "target", the depth to the saturated zone is the key element in determining the vulnerability. This was estimated using available water level data and the estimated groundwater gradient. The distribution of interpreted groundwater vulnerability is presented in Maps 6 and 8. Areas of extreme vulnerability are constrained to where the depth to the saturated zone is less than 3m (estimated to extend 100 m from the spring/borehole) and also where rock outcrop areas are present. Thus extremely vulnerable areas have been mapped close to the spring. Highly vulnerable groundwaters are mapped in the rest of the area.

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).

² Greywacke are sandstones or siltstones that are cemented by a high proportion of mud deposited from currents loaded with sediment on seafloor slopes.

11.8 Hydrogeology

11.8.1 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.
- "Report on a groundwater investigation for Gormanstown/Kildare Group Water Scheme" Irish Geotechnical Services (IGSL) Report No.571, July 1983.
- Hydrogeological mapping carried out by GSI.
- A drilling programme carried out by GSI to ascertain depth to bedrock and subsoil permeability.

11.8.2 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:* 1000 mm.
 Rainfall data for gauging stations around Tober (from Fitzgerald, D., Forrester, F., 1996).

Gauging Stations	Grid reference	Elevation OD (m)	Approximate distance away from source (km)	Annual ppt 1961-1990
Donard G.S.	S930977	183	6.5	1103
Hollywood G.S.	N937070	165	5.0	992
Ballitore G.S.	S800960	99	13.0	829
Ballymore Eustace DCWW	N933092	172	8.0	932
Kilcullen G.S.	N838093	116	6.5	860

Donard and Hollywood are the closest in terms of distance, elevation and aspect to the Tober area. From the data it would appear to be reasonable to assume an annual average precipitation of 1000 mm for the Tober area. This is supported by the interpreted contour maps of precipitation presented in the "Agroclimatic Atlas of Ireland" (Collins and Cummins, 1996).

- *Annual evapotranspiration losses:* 430 mm. Potential evapotranspiration (P.E.) is estimated to be 450 mm yr.⁻¹. Actual evapotranspiration (A.E.) is estimated as 95 % of P.E., to allow for seasonal soil moisture deficits. More local measurements of evapotranspiration are not available.
- *Potential recharge:* 570 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:* 170 mm. The slopes around the source and the nature of the deposits around the source need to be considered in order to give a representative value for the runoff that occurs in the area. Steep slopes usually suggest a high proportion of the rainfall would move down the hill sides as runoff (overland flow). However, the sand/gravel deposits that occur on the hill slopes above the Tober source are highly permeable, suggesting that a high proportion of the rainfall may infiltrate into the subsurface and down to the water table and in this instance may not allow runoff

to occur to the same degree if the slopes were not draped by sand and sand/gravel deposits, except during high intensity rainfall events. This view is supported by the number of small springs that occur at the base of the sand/gravel deposits around the hillsides. Typically the proportion of recharge that infiltrates to ground water in sand/gravel is around 80% (Wright *et al*, 1982), this figure has been reduced to 70% to take account of the steep slopes.

These calculations are summarised as follows:

Average annual rainfall (R)	1000 mm
Estimated P.E.	450 mm
Estimated A.E. (95% of P.E.)	430 mm
Potential Recharge (R – A.E.)	570 mm
Runoff losses (30% of recharge)	170 mm
Estimated Actual Recharge	400 mm

11.8.3 Groundwater levels, Flow Directions and Gradients

Water levels in the vicinity of the source are generally close to or at the ground surface. Water levels in the supply borehole are approximately 1 m below ground. The water table coincides with the ground surface where the springs emerge. Information on the water levels elsewhere is limited.

The water table in the area is generally assumed to be a subdued reflection of the topography, with groundwater flowing from the sub-catchment watersheds and discharging into the Liffey and Greese Rivers. Topography around the spring forms a horseshoe, which drives groundwater westwards to discharge at the point where the sand/gravel deposits pinch out (i.e. the spring). The borehole is located beside the spring presumably intercepting groundwater discharging at the spring.

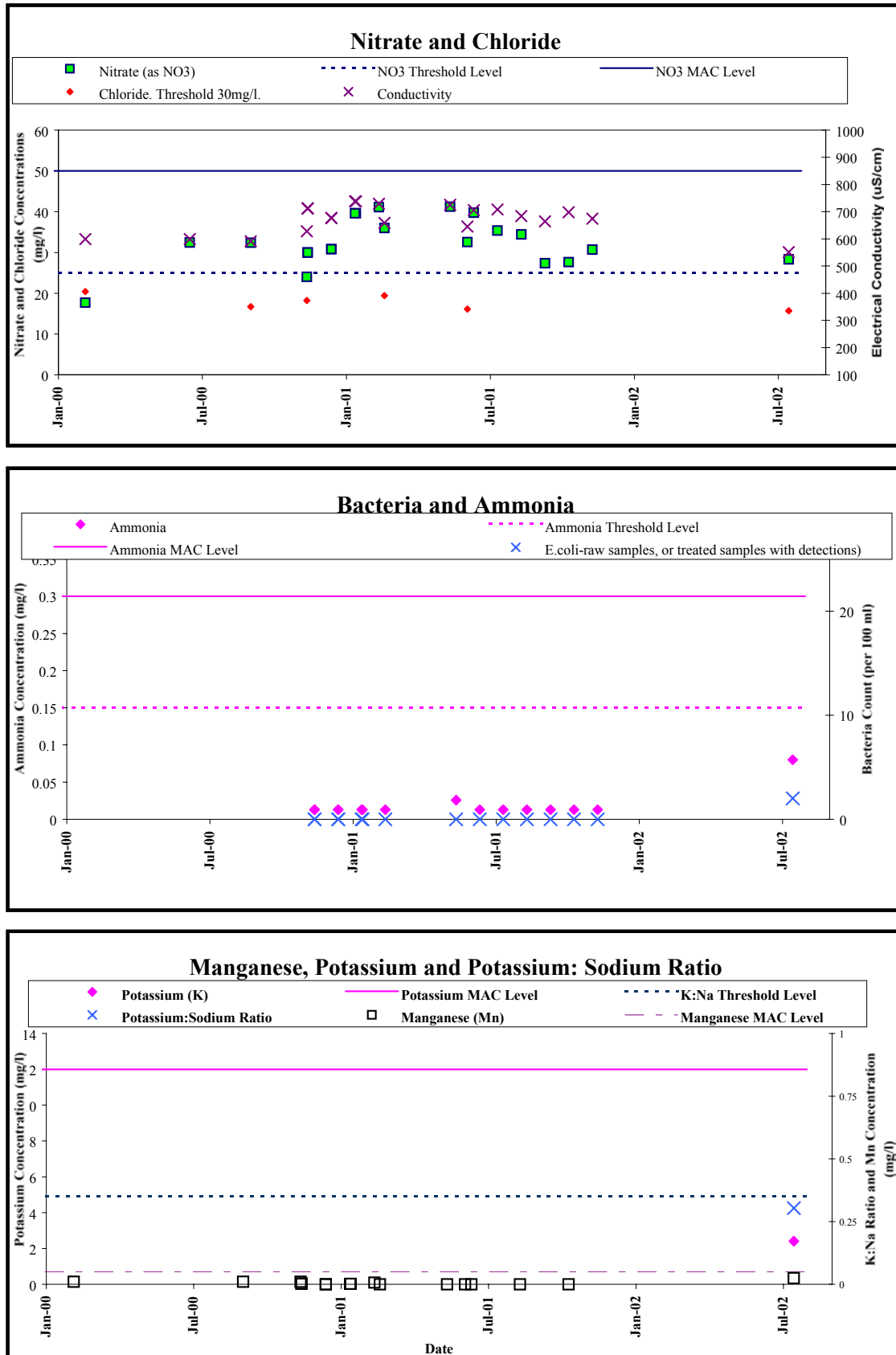
There are not enough hydrogeological data to calculate precise groundwater gradients, however low gradients are typical of sand/gravel and it is assumed to be less than the topographic gradient. For the purposes of calculations it is assumed to be 0.001.

11.8.4 Hydrochemistry and Water Quality

The data is summarised graphically in Figure 11-1 and the following key points have been identified from the data:

- The water is hard to very hard, with total hardness values of 306-405 mg l⁻¹ (as CaCO₃) and electrical conductivity values of 591-628 μS cm⁻¹. These values are indicative of groundwater from limestone or from sand/gravel deposits. The logs given by IGSL and a field examination of the sand/gravel pits show that the majority of clasts are derived from limestones. Thus the hydrochemistry suggests that the groundwater is derived from the sand/gravel deposits, with only minor amounts from the bedrock below.
- Nitrate concentrations appear to be elevated, typically 20-40 mg l⁻¹.
- On the basis of eighteen available results from the last two years, faecal bacteria are generally low with only one raw water analysis slightly exceeding the EU MAC.

Figure 11-1 Gormanstown - Key indicators of agricultural and domestic contamination



11.8.5 Aquifer Characteristics

Bedrock: The bedrock units are classed as **Poor Aquifers which are generally unproductive (Pu)** (Woods and Wright, 2001).

Subsoil: The sand/gravel deposit is termed the "Tober" sand/gravel deposit in the Wicklow Groundwater Protection Scheme and is classed as a **Locally Important sand/gravel aquifer (Lg)** (Woods and Wright, 2001).

The occurrence of springs toward the bottom of the sand/gravel deposits, the poor nature of the bedrock aquifer, and the hydrochemistry suggest that the sand/gravel deposit is the main aquifer feeding the spring and borehole. The aquifer tests carried out by IGSL are summarised in the following table.

Test	Yield (m ³ d ⁻¹)	Duration (hrs)	Drawdown (m)	Specific capacity (m ³ d ⁻¹ m ⁻¹)
27/6/1983	218	4	0.8	273
6/7/1983	273	8	2.3	119
7/7/1983	463	8	4.3	108

Transmissivities are estimated from specific capacity calculations using analytical methods by GSI giving a range of values of 130-150 m²d⁻¹. There is no site specific data on the porosity of the sand/gravel, however porosities calculated for sand/gravel in other parts of the country tend to be about 0.07-0.08. Permeability tends to be high in sand/gravel, ranging from 20-70 m d⁻¹. The borehole intercepts groundwater that is discharging to the spring. From inferences of transmissivity and aquifer thickness, the permeability is estimated to be approximately 20 m d⁻¹.

11.8.6 Spring Discharge

The spring flows were estimated by personnel from the group scheme using a V-notch weir in September 1977 to be about 1000 m³ d⁻¹ and was then estimated to be in the region of 3000 m³ d⁻¹ when measured by GSI staff in May 2002. The spring is classed as a **high** yielding spring under the GSI classifications for spring discharge.

11.9 Conceptual Model

- The Gormanstown Group Water Scheme abstracts 300 m³ d⁻¹ (66,000 gallons per day) from a borehole located beside a high yielding spring.
- A **Locally important sand/gravel aquifer (Lg)** feeds the spring and borehole.
- Groundwater levels are close to or at the ground surface in the vicinity of the spring and borehole.
- Topography around the spring forms a horseshoe, which drives groundwater westwards to discharge at the spring which is located at the point where the sand/gravel deposits pinch out.
- Groundwater is generally unconfined.
- The groundwater quality is hard to very hard.

11.10 Delineation of Source Protection Areas

11.10.1 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 and borehole.

11.10.2 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 sand/gravel permeability and (d) the recharge in the area.

The shape and boundaries of the ZOC were determined using hydrogeological mapping, water balance estimations and the conceptual model and are shown in Map 8. The ZOC catchment boundaries are discussed as follows:

The **northern, southern and eastern** boundaries are based hydrogeological mapping and the limits of the sand/gravel with an additional arbitrary buffer zone of 50 m which extends into the till.

The **western** boundary is defined by the furthest point downstream of the spring discharge area, as it is assumed that groundwater will not flow upstream to the spring. This distance is greater than the downgradient distance that the borehole is estimated to be able to draw water (50 m), thus providing an extra precaution.

The area delineated by the boundaries described is approximately 1 km². The area needed to provide water to the borehole can be estimated using a water balance. The water balance uses the average recharge and average abstraction figures to determine the area. The abstraction figure has been increased by 50% to 525 m³ d⁻¹ to allow for increases in usage and for dry periods in summer. The area required to balance is estimated to be about 0.5 km², which is less than the area delineated using the above boundaries.

11.10.3 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 semi-analytical modelling.

A permeability (K) value of 20 m d⁻¹, porosity (n) of 0.07 and a gradient (i) of 0.001 were used to calculate the velocity (V) as follows:

$$V = (K.i) / n$$

$$V = 3 \text{ m d}^{-1}$$

Thus, in 100 days most groundwater will move approximately 300 m.

11.11 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. The source protection zones as shown in Table 11 and Map 8.

Table 11 Matrix of Source Protection Zones at Gormanstown.

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

11.12 Potential Pollution Sources

Land use in the area is described in Section 11.5. The land around the source is grassland dominated, used for cattle and sheep. In addition there are a number of sand and sand/gravel pits (some disused) within the zone of contribution to the spring. The main potential sources of pollution within the ZOC are farmyards, septic tank systems, hydrocarbon wastes, runoff from the roads, leaky sewers and landspreading of organic wastes and inorganic fertilisers.

11.13 Conclusions and Recommendations

- ◆ The source comprises a small production borehole abstracting about $80 \text{ m}^3 \text{ d}^{-1}$ which is located in a **locally important sand/gravel aquifer (Lg)**.
- ◆ The vulnerability in the vicinity of the source varies from extreme to high.
- ◆ Septic tank systems, farmyards, landspreading and runoff from the roads are the main hazards in the area.
- ◆ 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.
 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.