Environmental Protection Agency

Establishment of Groundwater Source Protection Zones

Newtown Cashel Water Supply Scheme

Newtown Cashel Spring

AUGUST 2011

Prepared by:
John Dillon and Coran Kelly TOBIN

With contributions from:
Dr. Robert Meehan, Consultant Geologist; Jenny Deakin TCD;

And with assistance from:
Longford County Council

PROJECT DESCRIPTION

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

The project "Establishment of Groundwater Source Protection Zones", led by the Environmental Protection Agency (EPA), represents a continuation of the GSI's work. A CDM/TOBIN/OCM project team has been retained by the EPA to establish Groundwater Source Protection Zones at monitoring points in the EPA's National Groundwater Quality Network.

A suite of maps and digital GIS layers accompany this report and the reports and maps are hosted on the EPA and GSI websites (www.epa.ie; www.gsi.ie).

TABLE OF CONTENTS

TABLES & APPENDICES

TABLES

FIGURES

1 INTRODUCTION

Groundwater Source Protection Zones (SPZ) are delineated for the Newtown Cashel source according to the principles and methodologies set out in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999) and in the GSI/EPA/IGI Training course on Groundwater SPZ Delineation.

Newtown Cashel Spring is the main source for Newtown Cashel. The spring supplies the area surrounding Newtown Cashel, located along the eastern shore of Lough Ree.

The objectives of the report are as follows:

- To outline the principal hydrogeological characteristics of the Newtown Cashel area.
- To delineate source protection zones for the Newtown Cashel Spring.
- To assist EPA and Longford County Council in protecting the water supply from contamination.

The maps produced are based largely on the readily available information in the area, specific field work for this source 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 Newtown Cashel source is located 1 km to the southwest of Newtown Cashel in the townland of Ballagh as shown in Figure 1, and has operated as a council supply since the 1950's. Two springs have been utilized in the supply of water to the area since the 1950's namely Ballagh Spring and the Slawn Spring. The current source (Slawn Spring) comprises a spring along the eastern flank of Lough Slawn. The spring has been partially modified with a stone/concrete construction around the spring and a flat crested weir where surplus water discharges to Lough Slawn. Ballagh Spring is located 600 m to the south. The Ballagh spring source comprises a spring which has a borehole located within the spring sump.

The Slawn Spring is currently used as the abstraction area for the Newtown Cashel area. Groundwater is fed to the pump house adjacent to the Ballagh spring by the aid of a suction pump. The intake brings the water to the pump house where the untreated water is chlorinated. The sites are fenced off. The springs are uncovered. Poaching of the peat subsoil was noted adjacent to the Slawn Spring.

As the source abstracts groundwater from a karst spring issuing to Lough Slawn fen area, it is not possible to distinguish between the two source springs. Given the complexity of the geology in this area, these two springs are considered together and the Zone of Contribution delineated is for both.

According to the caretaker, the Ballagh spring was developed with the construction of a borehole in the 1950's within the spring discharge zone. Note however, that the abstraction intake is in the open spring sump area and the borehole is just 2.4 m deep. The sump has an overflow discharging to the surrounding surface drainage network/fen area. The Slawn spring was developed in the 1990's due to increasing iron concentrations in the Ballagh spring. The two springs were used simultaneously for a number of years however Slawn spring currently supplies the entire Newtown Cashel water supply scheme. Both springs are maintained by Longford County Council.

3 SUMMARY OF SPRING DETAILS

Approximately **350 m^3/day** is abstracted from the Slawn Spring. The overflow from the northern spring varies throughout the year and in summer months the overflow reduces to zero. The head difference was between the spring and Lough Slawn was 0.02m during the site visit. It was not possible to accurately measure the overflow to Lough Slawn during winter periods as the overflow comprises a broad weir constructed of rough concrete and does not allow for accurate recordings. It is possible that lake water may enter the spring during the winter flooding periods. Groundwater is seen rising within the structure through a peat/shelly marl substrate. The Slawn spring is 1.1m in depth with the abstraction point is located towards the base of the spring.

The overflow from the southern spring was measured on a number of occasions. The overflow was estimated to be approximately 900-960 m^3/day after a dry period in September 2009. The overflow was substantially reduced in August 2011 to be between 400 - 420 m^3/day.

The borehole was dipped to establish the depth of the borehole and recorded to be 2.4 m below the top of the outer casing. The top of the borehole is below the water level of the sump and the water appears to flow up through the borehole and out into the main sump area. Levels are known to drop by approximately 0.1 m during dry summers. It appears that the borehole was inserted to where the main discharge comes to the surface.

Outside of the main springs a number of smaller springs issue during the winter months and wet periods. Many of these springs issue to drainage ditches along the boundary of the fen area. These smaller springs were dry during the August 2011 site visit.

Table 3-1 provides a summary of the details as currently known.

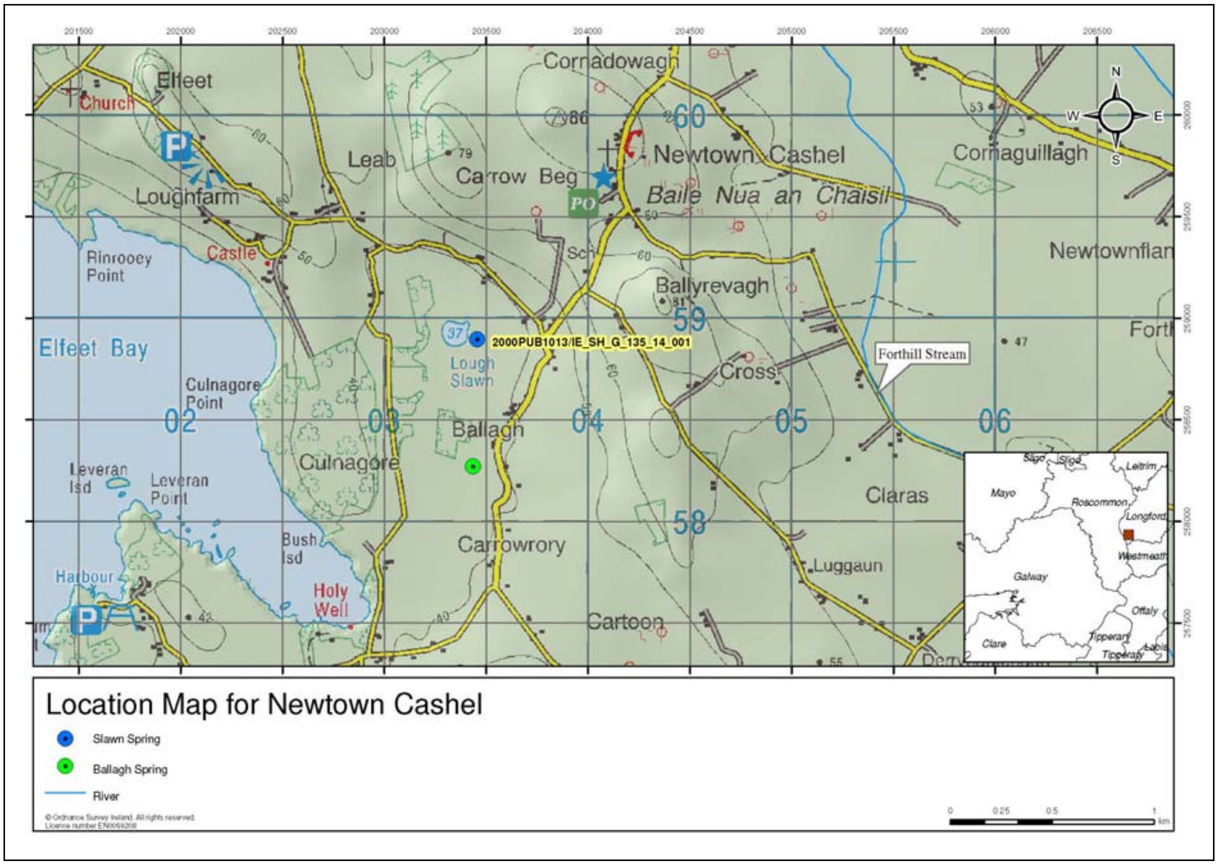
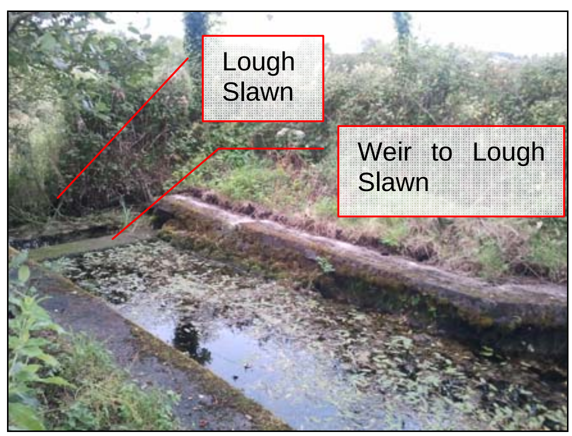


Figure 3.1 Location Map

Photograph 1 Overflow at Ballagh Spring



Photograph 2 Slawn Spring and overflow weir

Photograph 1 Ballagh Spring structure

Photograph 2 Slawn Spring

Table 3-1 Summary of Source Details

EU Reporting Code	IE_SH_G_135_14_001
Grid reference	E203440 N258900
Townland	Ballagh
Source type	Spring
Owner	Longford County Council
Elevation (Ground Level)	Less than 40m OD
Depth of spring	1.8 m
Diameter	1 m
Depth to rock	unknown
Static water level	0.2 m bgl
Consumption (Co Co records)	350 m^3/d
Overflow	400-960 m^3/d
Depth of Sump	Approximately 0.8m

4 METHODOLOGY

The methodology consisted of data collection, desk studies, site visits and field mapping. Analysis of the information collected during the studies was used to delineate the SPZ.

The initial site visit and interview with the caretaker took place on 15/09/2009. Site walk-overs and field mapping of the study area (including measuring the electrical conductivity and temperature of streams in the area) were conducted on 15/09/2009, 02/11/2009 and 12/08/2011.

5 TOPOGRAPHY, SURFACE HYDROLOGY AND LAND USE

The source is situated in a narrow low-lying depression (<40 mOD), orientated approximately North-South, surrounded to the north east and west by relatively high ground between the townlands of Lough Farm, Cornadowagh, and Ballyrevagh, in which Cornadowagh (86 mOD) forms the highest point in the surrounding area. The area to the west of the topographic depression in which the source is located is a low hill over 40mOD. This hill separates Lough Ree from the low-lying depression.

Typical topographic gradients in the study area range from between 1:20 on elevated areas and 1:100 on lower lying areas. Shallow gradients of <1:100 are located in the area around the spring. There is a high density of drainage ditches located along the edge of the peat and Lough Slawn.

The source is located within the Lough Ree watershed with few surface water features evident in the elevated areas around the source. The depression is a large discharge zone; Slawn Spring is located at the northern end and Ballagh Spring located roughly half way down the depression on the eastern flank. Outflow from Lough Slawn and surrounding springs merge to the south of the fen area and outflows to Lough Ree approximately 800m southwest of the Ballagh spring. Located close to Lough Ree is a Holy Well, also a spring.

The largest stream in the surrounding area is located over 2 km east of the source which flows in a south easterly direction to Lough Ree. The focus of this study is the region lying to the west of the Forthill Stream/Raised bog and south of Glebe Cross-roads. Within this area, surface water features are absence with the exception of a high density of drainage ditches surrounding Lough Slawn, standing water pools in the townland of Leab (1.5km north) and small drainage ditches feeding in the Forthill Stream/Raised Bog area (2km east). These surface water features were identified from existing data sources and site visits in September 2009.

The population of Newtown Cashel and the surrounding area is less than 200. Over the last 10 years, approximately twenty houses have been built in the area surrounding Newtown Cashel and the hills to the east of Newtown Cashel Spring.

Land use in the area is primarily agricultural, with lands set to pasture or used for tillage. A number of farmyards have been noted in the area. The nearest farmyard is located 150 m to the east of Slawn spring. Grazing of areas was noted in areas where bedrock is at the surface. Animal feeding was also noted in a disused quarry at Ballyrevagh.

No major industry was identified in the environs of Newtown Cashel. According to the six inch maps there are frequent drains and springs in the lowlying ground bordering Lough Slawn [proposed Natural Heritage Area (pNHA)]. Slawn Spring is located in Lough Slawn pNHA with Ballagh Spring located along the edge of the pNHA. Forestry was noted on a number of elevated sites, comprising both natural ash-hazel scrub and managed afforested sites. Forestry areas are also located adjacent to Elfeet Bay and within Lough Slawn pNHA.

6 GEOLOGY

6.1 BEDROCK GEOLOGY

This section briefly describes the relevant characteristics of the geological materials that underlie the Newtown Cashel source. The geological information is based the bedrock geological map of Longford Sheet 12, 1:100,000 Series (Geological Survey of Ireland (GSI) 1996) and the GSI Karst Database. The bedrock map (Figure 2) indicates that this area is underlain principally by pure undifferentiated Visean Limestones, which are also described as the Dinantian Pure Bedded Limestones for the purposes of the generalised rock unit map prepared for the WFD in characterising and describing the groundwater bodies by the GSI.

The mapped distribution of the pure limestones is bounded by Lower Impure Limestones, Dinantian (early) Sandstones, Shales and Limestones and Dinanatian Dolomitised Limestones to the north and north east. The Dinantian Pure Bedded limestones extend to the west and southwest.

Dinantian Pure Bedded Limestones at Newtown Cashel are composed of clean-bedded limestone and contain varying amounts of dolomite. The presence of dolomite is significant as it is generally associated with high permeability limestone and therefore has potential for high yielding wells. It is considered that the Pure Bedded Limestones are comprised of the Oakport Formation, which has been mapped in boreholes to the north and extends to the depths of 250 m (GSI, Sheet 12). Numerous surface exposures were mapped during field studies conducted in September 2009. The most significant exposures noted were disused quarries in the townlands of Cashel adjacent to Lough Ree and in Ballyrevagh located east of Newtown Cashel Village. Surface exposures extend to over 15 m of a vertical face. The bedrock exposures comprised of thickly bedded bioclastic limestones, generally dipping less than 5^0 to the west. Solutionally enhanced joints were clearly visible towards the surface.

To the north of Newtown Cashel, a 19 km NE/SW trending inlier (Keel inlier) is present extending towards Kennagh and Ardagh. The inlier is comprised of Basal Sandstones and Navan Group limestones and sandstones. A number of mapped faults are located in the area surrounding the inlier. A number of WNW-ESE faults are located towards the nose of inlier. It is likely that there are unmapped faults along this trend line present in the vicinity of the source.

Further, surrounding the nose of the inlier, extensive deposits of dolomite are present in the impure limestones. Extensive drilling by Aquitaine in the 1980's encountered extensively dolomitised, cavernous limestones.

Figure 6.1 Bedrock Geology

6.1.1 Karst Geology

Hydrogeological mapping (September 2009) included searching for karst features in the vicinity of the source. The karst features listed in Table 6-1 are both those recorded in the GSI Karst Feature Database within a 5 km radius of the source and those mapped during field mapping by TOBIN Consulting Engineers and Robert Meehan in September 2009.

The locations of these features are shown in Figure 3. The degree of karstification increases further to the north of the Keel Inlier. Turloughs are present at Fortwilliam and Cordara. A sinking stream flows into Fortwilliam Turlough during the winter period but is typically dry during summer periods. Following the heavy rainfalls of July and August, 2009, this stream was flowing in September, 2009.

The hydrogeological mapping identified seven features not recorded in the GSI Karst Features Database and include karst springs, sinking streams, swallow holes and an enclosed depression that is possibly a doline. The locations of these mapped features are shown in Figure 3.

Table 6-1 Karst features within a 5 km radius of Newtown Cashel source

Number	Feature type	Feature name	Easting	Northing	Distance to source	Townland
K1	Turlough	Fortwilliam Turlough	201500	263160	5 km north	Commons
K2	Turlough	Cordara Turlough	202520	263590	5 km north	Newpark
K3	Swallow Hole	K3	201350	263050	5 km north	Commons
K4*	Sinking stream	K4	201920	263120	5 km north	Commons
K5*	Spring	St Martins Well	199690	262930	5 km northwest	Aghakeel
K6*	Springs	Aghakeel Springs	199613	262860	5 km northwest	Aghakeel
K7*	Dolines	K7	202350	261860	3.5 km north	Carrowdunican
K8*	Dry Valley	K8	202590	259960	1.8 km north	Leab
K9*	Dry Valley	K9	202480	259930	1.6 km north	Elfeet
K10*	Spring	Lady's Well	202853	257480	1 km southwest	Derrydarragh
* are those mapped during September 2009						

Most of the distinct landforms are associated with the turloughs to the north of the Keel Inlier. It is considered that the sinkhole on the western margin of Fortwilliam acts as a sink and discharges to the springs at Aghakeel. Further possible dolines were also noted in the area surrounding the townland of Carrowdunican.

To the south of the Keel Inlier, surface expressions of Karst Features are less evident, despite the absence of surface water features on elevated areas. Two dry valleys were noted to the north within the townlands of Elfeet, Leab and Carrowmore. During the extensive dry period in September 2009, surface water ponding was recorded within the lowest parts of the valleys, with no surface outlets present.

To the south of the study area a karst spring known as 'Lady's Well' is located within 2 m of the lakeshore and is inundated by the lake on a regular basis. Water can be seen bubbling up from the base of the spring, outflowing to Lough Ree.

Solutionally enhanced karst features were noted in the top 5 m bgl within the disused quarries at Cashel and Derryrevagh and typically ranged from 100 mm to 200 mm wide. A marked decease in karstification was noted with depth, generally below 5 m bgl. Generally, the widths of the joints and karstified joints decreased to 1 mm to 30 mm respectively at 5 m bgl.

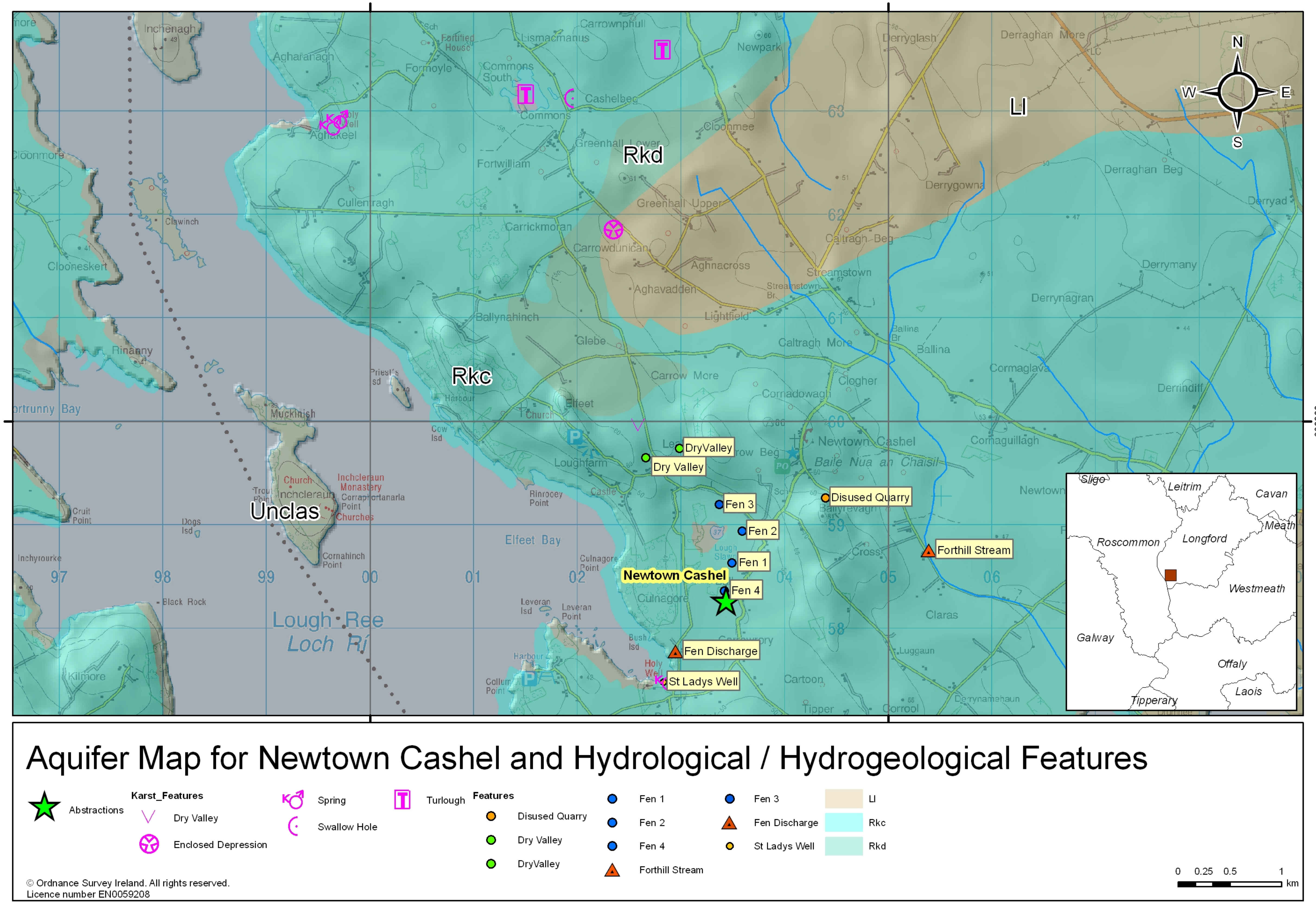


Figure 6.2 Aquifer, Karst Features and water monitoring locations map

6.2 SUBSOILS GEOLOGY

According to GSI and EPA web mapping, the study area is dominated by Limestone till (TLs) and karstified bedrock outcrop (KaRck). In the vicinity of the source there is a relatively large areal extent of 'cut over' peat (approximately 1 km^2). The areas of 'cut over' peat generally coincide with the lower most portions of the landscape. The subsoils are depicted in Figure 4. Both Slawn Spring and 2 are situated at the edge of the peat area, approximately 40 m from the glacial till. The peat area forms a sinuous boundary with the till deposits at this locality. A calcareous marl is present underlying the peat at Lough Slawn. Adjacent to Slawn Spring, the marl consisted of a cream-white calcareous marl with frequent shells at a depth of 0.8 m bgl.

The glacial till deposits are thin or absent on the elevated areas. The soils on the till areas are dominated by 'dry' soil types: typically well drained deep mineral soils (BminDW) and well drained shallow soils (BminSW) (EPA website and An Foras Talúntais, 1980).

The subsoils across County Longford have been classified according to British Standard 5930 in the preparation of the Groundwater Vulnerability map for Longford County Council, by Tobin on behalf of the Geological Survey of Ireland. The data was made available for the preparation of this report. The subsoil permeability of the till unit has been classed as '***Moderately Permeable***'.

Within the study area of the source no subsoil exposures were discovered. Based on the absence of permanent surface water features and secondary indicators of low subsoil permeability, it is considered that the till is free draining and that the subsoils are dominated by '***Moderately Permeable***' subsoil, in keeping with the overall subsoil permeability category.

6.3 DEPTH TO BEDROCK

Depth to bedrock varies greatly throughout the study area. The hydrogeological mapping indicates that the depth of subsoil is generally less than 3 m on the hilltops increasing in depth towards the source area. Due to the absence of subsoil exposures in the low lying areas and the absence of a borehole log for the source, it is not possible to accurately map the depth to bedrock at the borehole source. Soil augers and peat probes were used to assess the depth of peat surrounding the source. The depth of peat increases from 0.4 m at the edge of the peat area (100 m east of the source), to 0.9 m (20 m to the west of the source). It is estimated that the depth to bedrock in the vicinity of the source is likely to be relatively shallow, expected to be in the order of 5-10 m. No site investigation data are available to establish the depth of subsoil surrounding the source. A conceptual cross section through the subsoil/bedrock is shown in Figure 5.

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) and in the draft GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination (Fitzsimons *et al*, 2003).

The draft Groundwater Vulnerability map (2009) for the region, as mapped by Tobin on behalf of GSI, is dominated by 'extreme' and 'high' vulnerability and is shown in Figure 6.

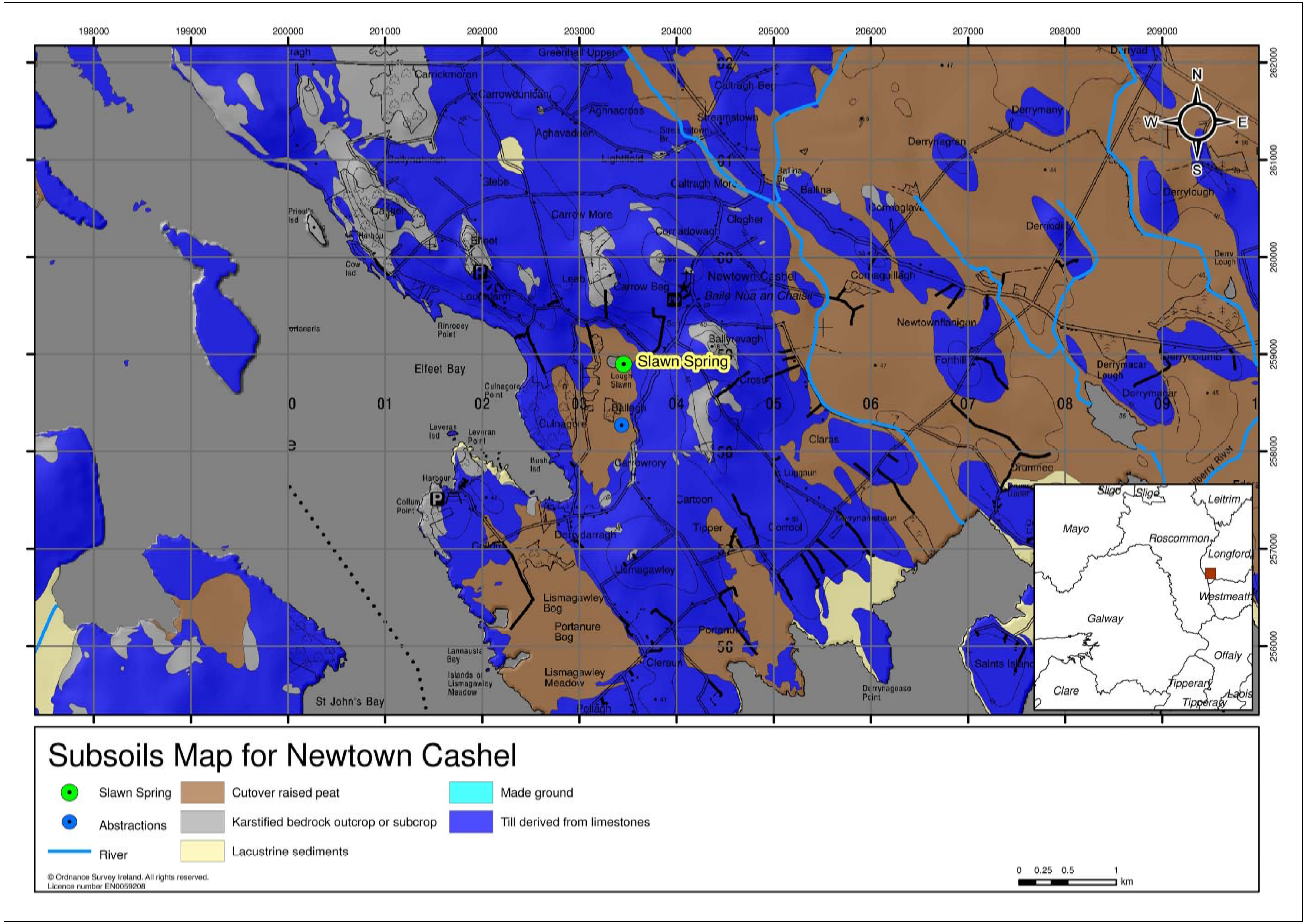


Figure 7.1 Subsoil Map

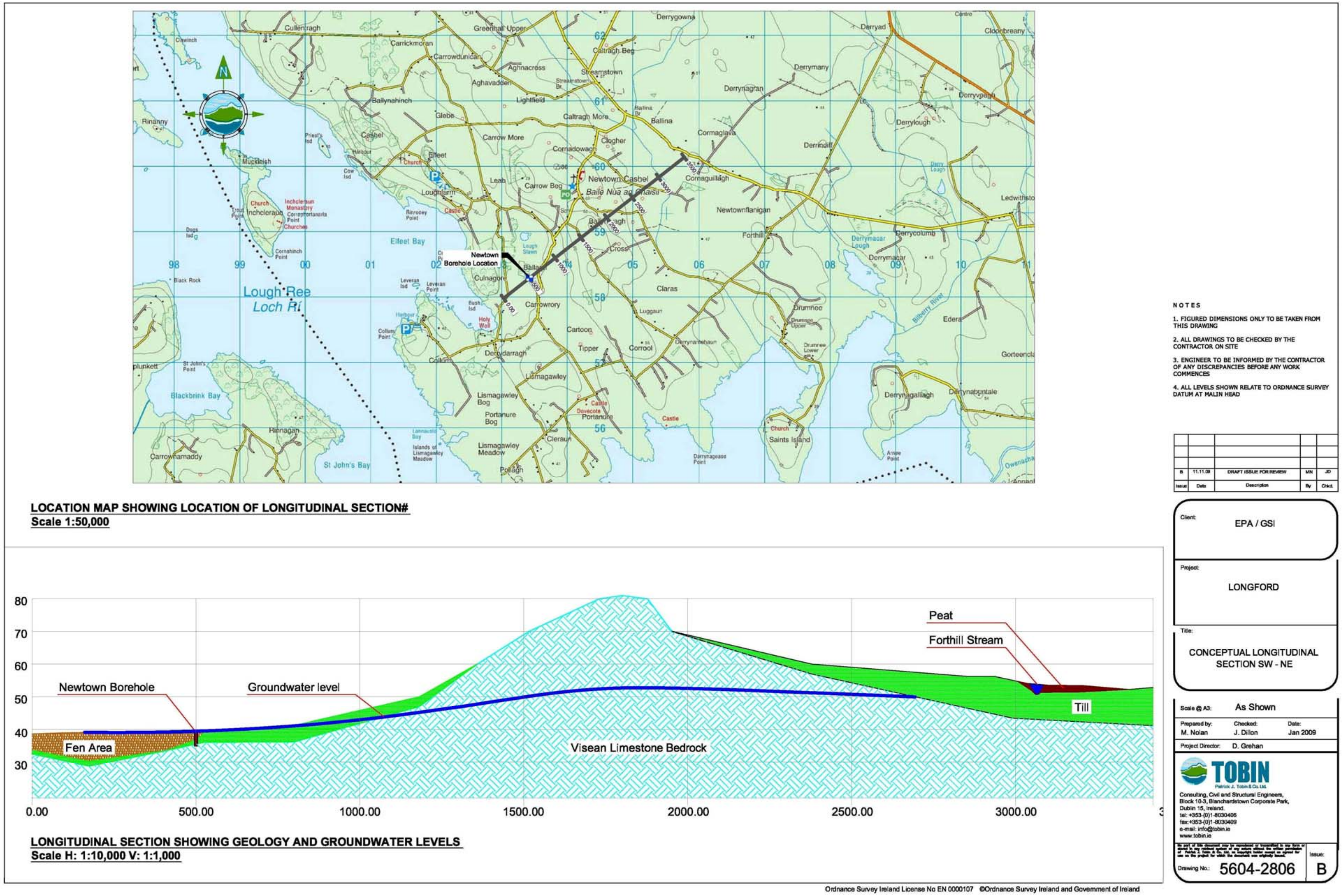


Figure 7.2 Cross Section SW to NE

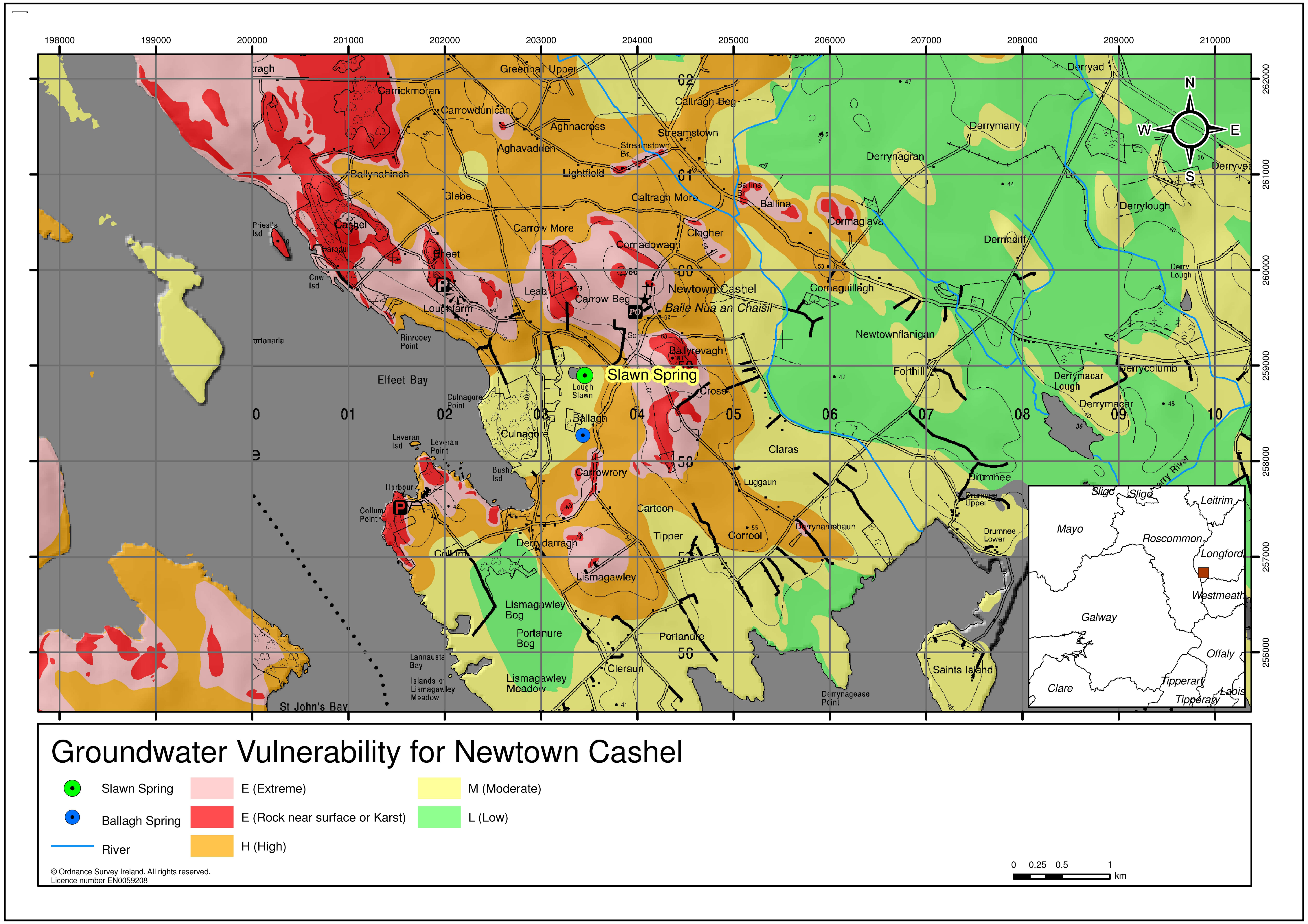


Figure 7.3 Groundwater Vulnerability Map

8 HYDROGEOLOGY

This section describes the current understanding of the hydrogeology in the vicinity of the source. Hydrogeological and hydrochemical information was obtained from the following sources:

- GSI Website and Well Database
- County Council Staff
- EPA website and Groundwater Monitoring database
- Local Authority Drinking Water returns
- Hydrogeological mapping by TOBIN Consulting Engineers and Robert Meehan in September and November 2009.

8.1 GROUNDWATER BODY AND STATUS

The area around Newtown Cashel, is included in the Lanesborough Groundwater Body which is of Good Status www.wfdireland.ie/maps.html. The groundwater body descriptions are available from the GSI website: www.gsi.ie and the 'status' is obtained from the EPA website: www.epa.ie .

8.2 METEOROLOGY

Establishing groundwater source protection zones requires an understanding of general meteorological patterns across the area of interest. The data source is Met Eiréann.

Annual rainfall: 872 mm. Met Eireann Rainfall data (Met Eireann, 1996) for the Newtown Cashel gauging station indicate that average rainfall at Newtown Cashel is 872mm/year. The contoured data map of rainfall in Ireland show that the source is located between the 800 mm and 1000 mm average annual rainfall isohyets. The closest meteorological station to the Newtown Source is at Newtown Cashel.

Annual evapotranspiration losses: 427 mm. Potential evapotranspiration (P.E.) is estimated to be 450 mm/yr (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.

Annual Effective Rainfall: 444 mm. The annual effective rainfall is calculated by subtracting actual evapotranspiration from rainfall. Potential recharge is therefore equivalent to this, or 444 mm/year. See section on Recharge which estimates the proportion of effective rainfall that enters the aquifer.

8.3 GROUNDWATER LEVELS, FLOW DIRECTIONS AND GRADIENTS

Groundwater at the source and in the surrounding area upwells at a number of spring locations along the eastern flank of Lough Slawn and fen area. Groundwater issues from the ground at the source, discharging to the local drainage network within the surrounding peat area. As water levels fall, a number of smaller spring dry up.

The overflow from Slawn Spring reduced to zero while groundwater discharges at Ballagh Spring reduced to 400 to 420 m^3/day in August 2011. It is likely that further groundwater discharges via springs/drainage ditches occur to Lough Slawn and the surrounding area however no other issuing springs were noted during the site visits. The total outflow from the Lough Slawn fen area to Lough Ree was 1,145 m^3/day. Anecdotal evidence from the caretaker indicates that the Ballagh Spring does not go dry – that there is always an overflow; and also that water level does not overtop the weir. It should be noted that the weir is leaky with water flowing around the edge of the weir plate. Based on anecdotal evidence groundwater levels within the overflow area vary by approximately 0.1 m annually.

Groundwater levels in the surrounding area are estimated to be lower than the topographical contours to account for the absence of surface water features within the surrounding area. Groundwater gradients are expected to be relatively flat and are assumed to be 0.005. Accurate level data in this area could provide more conclusive information on flow directions. Flow directions are assumed to broadly focus toward the spring discharge areas, mirroring topography.

The fen area in which the spring and L. Slawn are located forms the lowest topographical point in the Newtown Cashel area at approx 38-40mOD. The Forthill stream 2 km the east appears to be an artificial drain for Forthill Bog and is at approximately 45mOD and underlain by deep deposits of till (>10m). There are no springs to the east in the area of the Forthill Stream. It is considered that the fen area is the main groundwater discharge zone in the area, with groundwater recharge between Lough Slawn and Forthill Stream is more likely to flow towards the springs, the fen and Lough Slawn.

The Newtown Cashel Water Supply Scheme abstracts approximately 350 m^3/day of groundwater. The overflow is not well characterised. While no long term calibrated data are available in relation to the overflow, Tobin staff measured the overflow on two separate occasions in September 2009 and estimated it to be 960 m^3/day and 920 m^3/day. Flow measurements in August 2011 calculated an overflow of 400 m^3/day at Ballagh spring.

Given the complexity of the geology in this area, these two springs are considered together and the Zone of Contribution delineated is for both, this is particularly due to the uncertainty in flow directions, whilst likely to mirror topography, given the traces conducted in similar terranes by the GSI it is possible that flow within the ZOC could travel to either or spring or both at different flow conditions.

8.4 HYDROCHEMISTRY AND WATER QUALITY

Hydrogeological field mapping carried out in November 2009 and August 2011 included obtaining field measurements of electrical conductivity and temperature of surface water features which provides information on potential groundwater discharges to the springs and streams. Table 8-1 provides the field results of 12th August 2011.

Based on the measurements, the drainage ditches/springs feeding the Fen area have consistently high conductivity values indicating the springs/drainage ditches are groundwater fed. Previous monitoring of the source/Fen area/Lady's well indicated high electrical conductivity (approximately 730 µS/cm @ 25^{o}C). Based on the high conductivity values and temperature, all springs feeding the Fen area are interpreted as being groundwater fed. The lower conductivity levels and higher temperatures in Forthill Stream indicate that the stream is a combination of surface water runoff and groundwater discharge.

Table 8-1 Field measurements of electrical conductivity and temperature 12/08//2011

SW stream ID	Conductivity (µS/cm @ 25^{o}C)	pH	Dissolved Oxygen %	Temperature ^{o}C	Notes
Source - Slawn Spring	757	7.2	55	11.5	No overflow
Ballagh Spring	763	7.1	42	11.8	Overflow approximately 5 l/s
Fen 1	768	7.1	45	12.1	200m NNE of Source
Fen 2	770	7.2	60	12.5	500m NE of Source
Fen 3	774	7.3	52	12.2	300m NW of Lough Slawn
Fen 4					Dry

SW stream ID	Conductivity (µS/cm @ 25°C)	pH	Dissolved Oxygen %	Temperature °C	Notes
Fen 5	760	7.1	48	12.0	Very small outflow
Stream from Fen	750	7.3	41	12.1	Close to Lough Ree (Flow greater than 15 l/s)
Forthill stream	660	7.2	50	13.2	2 km to the east of Source (Flow approximately 3 l/s)
Lady's Well	720	7.1	43	12	3 m from lake edge
Lough Ree	403	7.2	65	15.1	4 m from Lake shore

Thirty two samples were available from the EPA Groundwater Monitoring Network, and it is assumed that the data represents Slawn spring. The water quality is hard to very hard, (280 to 460 mg/l $CaCO_3$). Alkalinity ranges from 304 to 564 mg/l as $CaCO_3$. The pH ranges between 7.0 and 7.6, which is slightly alkaline. The electrical conductivity ranges from 639 to 724 µS/cm @ 25°C. The hydrochemical signature is calcium bicarbonate and compares favorably with the signature and data given in the Lanesborough Groundwater body description.

The concentration of nitrate ranges from 1.94 mg/l to 19.66 mg/l with mean of 16.8 mg/l (as NO_3). There are no reported exceedances of the groundwater Threshold Value concentration of 37.5 mg/l. The area around the springs and Newtown Cashel village is served by septic tank systems. Some tillage is practiced around the area. Therefore, the relatively low nitrate levels at Newtown Cashel are probably due to a combination of the low population density and relatively low agriculture pressures.

Chloride concentrations range from 14.6 to 41 mg/l, with a mean of 19.1 mg/l which is considered to be below the groundwater Threshold Value since 1996 (Groundwater Regulations S.I. No. 9 of 2010)). Occasional spikes in chloride concentrations in July 1996 and July 2008 may potentially be as a result of contamination from organic fertilizer sources. A peak in iron and manganese concentrations was noted to correspond with high chloride concentrations in 1996.

Faecal coliforms were present in the water in 50% of samples, with gross contamination on three occasions (greater than 100 faecal coliforms per 100 ml). Potential sources include agriculture and septic tank systems. Although the concentrations are highly variable, the highest concentrations are generally associated with the summer months. No discernible relationship could be determined between rainfall data and faecal coliforms for 2008. The groundwater vulnerability, the rapid travel times in the karstified bedrock and landuse indicates the likelihood of faecal contamination occurring.

The concentration of sulphate, potassium, sodium, magnesium and calcium are within normal ranges. The potassium: sodium (K:Na) ratio is low, less than 0.17. The concentration of iron (3,730 µg/l) and manganese (460 µg/l) were elevated in July 1996, exceeding the drinking water standards. The concentrations of all other trace metals are low and/or are below the detection limit of the laboratory. The concentration of all organic compounds and herbicides is below the detection limit of the laboratory.

In summary, bacteriological exceedances, occasionally elevated chloride and occasional high iron suggest contamination from an organic waste source. Given the land use in the area, the most likely source is farmyard wastes and/or untreated wastewater from unsewered systems. Note the village is unsewered.

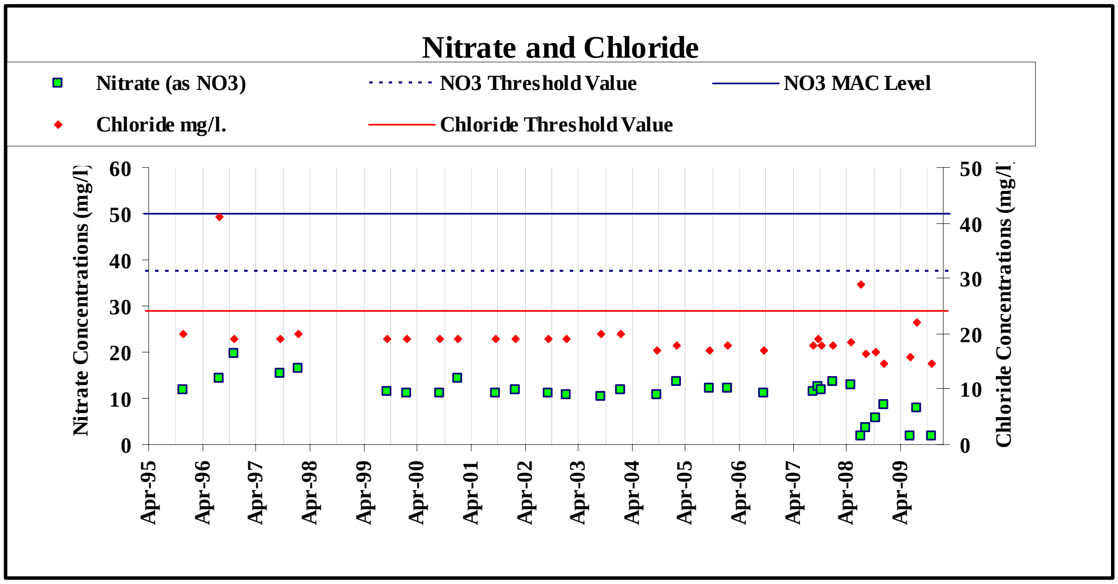


Figure 8.1 Nitrate and Chloride concentrations at Slawn Spring

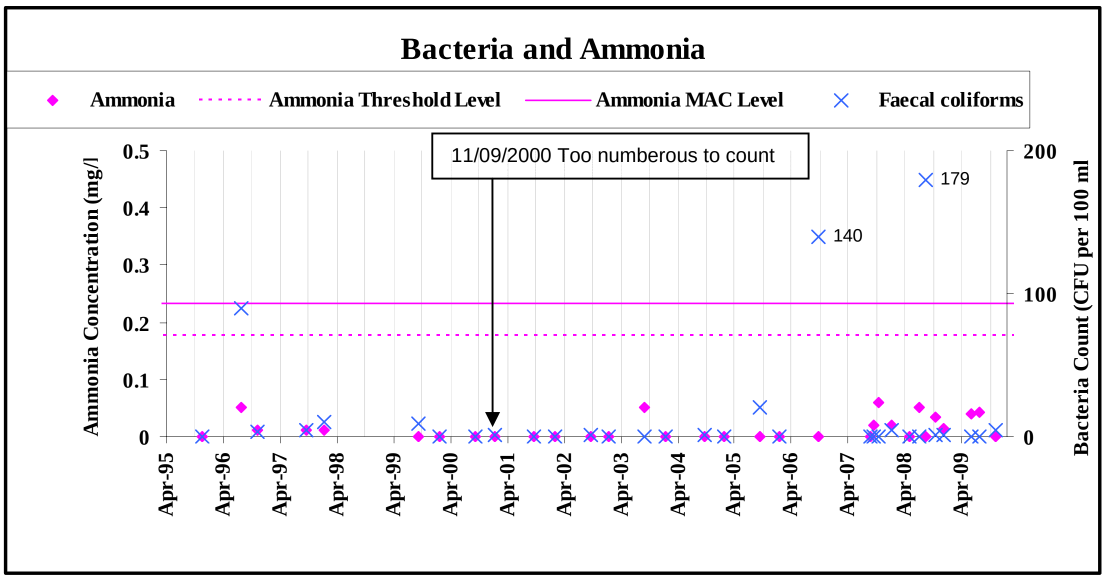


Figure 8.2 Ammonium and Bacterial Concentrations at Slawn Spring

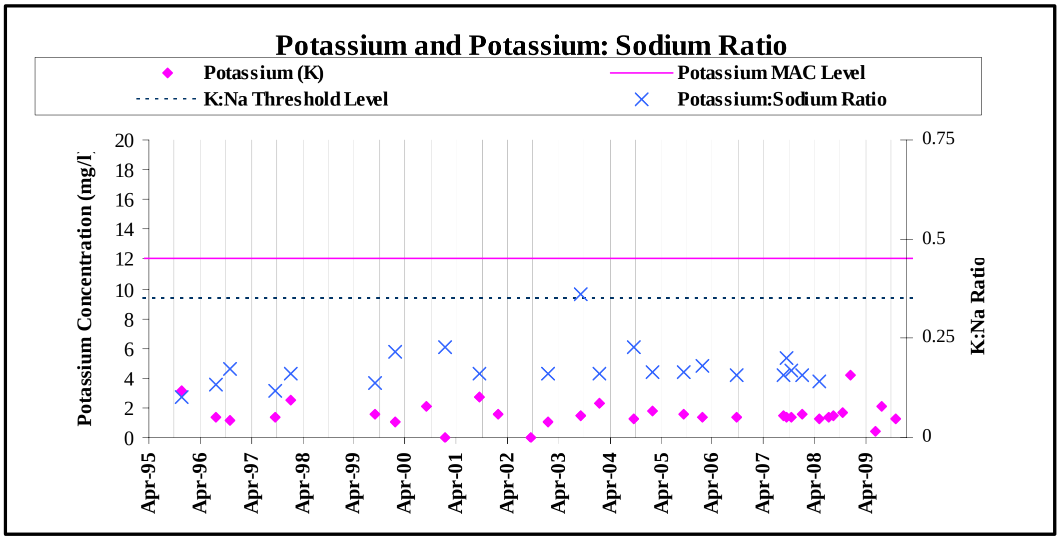


Figure 8.3 Sodium and Potassium Concentrations at Slawn Spring

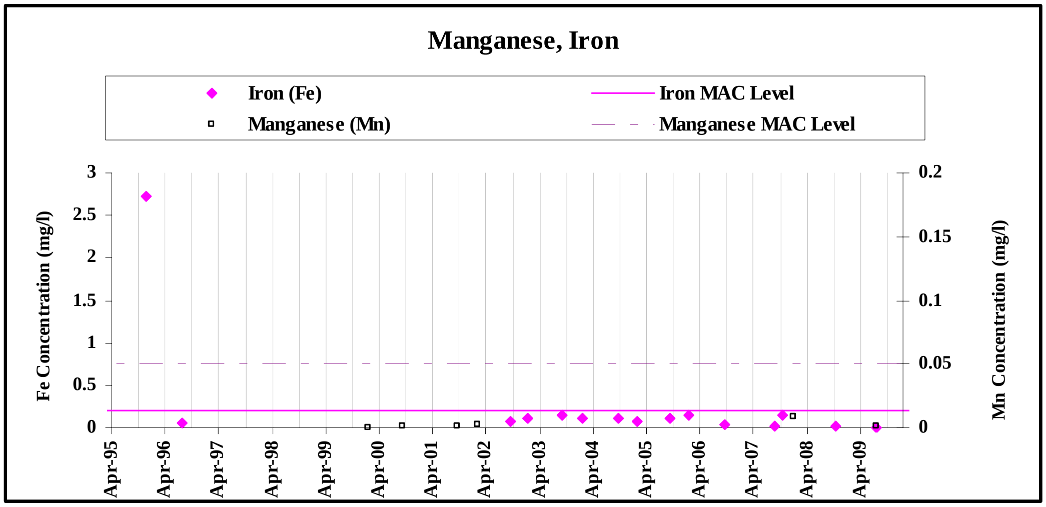


Figure 8.4 Manganese and Iron Concentrations at Slawn Spring

8.5 AQUIFER CHARACTERISTICS

The groundwater source is located in the Lanesborough Groundwater Body. The GSI bedrock aquifer map of the area indicates that the Dinantian Pure Bedded Limestone (Undifferentiated Visean Limestones), is classified as a *Regionally Important Karst Aquifer (RK*^{c}*)* dominated by conduit flow.

Flow in the aquifer is assumed to occur through the more permeable, solution-enlarged, interconnected fissure/conduit zones, which may be as much as several kilometres long. Groundwater velocities through fissures/conduits may be high and aquifer storage is frequently low. Storage and permeability within the aquifer is expected to be enhanced by the presence of dolomitised limestones. Flow through this aquifer is likely to be comprised of both diffuse and conduit flow.

Karst springs generally indicate very high transmissivities, permeabilities and velocities in the vicinity of the spring. There are no specific data for the source. However, the average discharge is estimated to be approximately 1310 m^3/day. Assuming a gradient of 0.005 and an assumed aquifer width in the vicinity of the source of 100-500m, the transmissivity is calculated to be 500-2600 m^2/day. This corresponds favorably with the regional groundwater body data, which indicates high transmissivities and rapid flow rates.

8.6 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 assumed to consist of input (*i.e.* annual rainfall) less water loss prior to entry into the groundwater system (*i.e.* annual evapotranspiration and runoff). The estimation of a realistic recharge rate is critical in source protection delineation, as it will dictate the size of the zone of contribution to the source (*i.e.* the outer Source Protection Area).

At Newtown Cashel, the main parameters involved in the estimation of recharge are: annual rainfall; annual evapotranspiration; and a recharge coefficient.

Due to the bedrock type there is no recharge cap applied in view of the karstic nature of the catchment. The recharge is estimated as follows.

This is a conservative estimate of recharge which allows for surface water outflow during periods of exceptionally heavy rainfall. However, runoff is likely to be much lower for most of the year and all of the available recharge probably infiltrates into the aquifer.

Runoff losses are assumed to be 20% of potential recharge (effective rainfall). This value is based on an assumption of *c*. 10% runoff for 65% of the area (extreme vulnerability - moderate permeability subsoils and soils, no drains or surface streams and moderate to steep slopes), and 45% runoff over 33% of the area due to high vulnerability- moderate permeability subsoil (Guidance Document GW5, Groundwater Working Group 2005).

The bulk ***recharge coefficient*** for the area is therefore estimated to be 80%.

These calculations are summarised as follows:

Average annual rainfall (R)		872 mm
estimated P.E.		450 mm
estimated A.E. (95% of P.E.)		428 mm
effective rainfall		444 mm
potential recharge		444 mm
recharge coefficient for extreme Vul rock at surface	90%	400 mm
recharge coefficient for high Vul	60%	266 mm
Averaged runoff losses	20%	111 mm
Bulk recharge coefficient	80%	
Recharge		**355 mm**

8.7 CONCEPTUAL MODEL

The current understanding of the geological and hydrogeological setting is given as follows:

- The source under consideration in this report comprises two main overflowing springs at Ballagh, Newtown Cashel, located in a karst aquifer.

- The abstraction rate from the source is 350 m^3/day with an overflow estimated to be in the order of 400 - 960 m^3/day. The overflow is not well characterised.

- The spring is located on the eastern edge of an alkaline fen area, approximately 1 km^2 surrounding Lough Slawn. It is considered that the fen area is a large discharge zone and the source forms one component of the overall discharge. The outflow from Lough Slawn and the springs discharge ultimately to L. Ree.

- There are no other permanent surface water features in the upgradient surrounding areas. A stream/river drains the partially modified Raised Bog at Forthill, 2 km to the east. Numerous small springs issue into the fen area.

- GSI maps and mineral exploration to the north of the study area indicate the presence of karstified dolomitised limestones. There are no mapped tectonic features in the Newtown Cashel area, though the regional fault set trends northeast to southwest. To the north of the Keel inlier located to the north of the source, extensive karst features including sinking streams, swallow holes, karst springs and dolines were recorded. To the south of the inlier, karst springs and dry valleys have been recorded. These features support the aquifer classification of *Regionally important karst aquifer* (Rk^c).

- In general, the depth to bedrock is shallow and the subsoils are classified as being 'moderately' permeable. The groundwater vulnerability is 'extreme' to 'moderate'.

- The natural hydraulic gradients in the aquifer are likely to be low, approximately 0.001 to 0.005, reflecting the generally high transmissivity of the limestones. Within the vicinity of the source groundwater is assumed to be unconfined within the aquifer. Rapid groundwater velocities are expected through a network of solutionally enhanced conduits, fractures and fissures.

- Groundwater flow directions are likely to be from the hills around Newtown towards the alkaline fen area and the springs. Further discharges are known along the Lough Ree shoreline. Regional groundwater flow is likely to be from east to west discharging to the River Shannon.

- Over the region, an average recharge rate of 355 mm/year is used, which is 80% of the total potential recharge. The remaining 20% of potential recharge is rejected and discharge may be via land overflow during the winter months. Some ponding of surface water is known to the north of the study area. Recharge is predominantly diffuse.

- The groundwater is of calcium bicarbonate signature and hard. Iron and manganese are elevated. Gross faecal contamination was recorded on five separate occasions. The microbial analysis of the water samples indicates that the groundwater appears to be impacted by contamination from human or agricultural sources. The variability of nitrate concentrations indicates that the groundwater appears to be impacted on occasion by contamination from human or agricultural sources. This is likely due to the extreme vulnerability over much of this highly karstified aquifer.

- Limitations to the conceptual model mainly lie with a lack of information on the following:

  ⇨ detailed aquifer properties – such as transmissivity and porosity.

⇨ Site specific depth to bedrock and localized differences in the subsoil permeability. Information on the depth to bedrock would provide greater detail and confidence in the level of protection afforded by the subsoils and also a greater understanding on the 3D visualization and interaction of the spring, peat, till and bedrock.

⇨ Discharge data. Information on this is required to be confident on the size of the area required to provide the water to the spring.

⇨ Water level data is limited in the Newtown Cashel area and therefore groundwater gradients and flow direction data is limited.

9 DELINEATION OF SOURCE PROTECTION AREAS

This section describes the delineation of 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 to the source, as described in Section 8.7 Conceptual Model.

Two source areas are delineated:

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

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. The boundaries are described below along with associated uncertainties and limitations.

Given the complexity of the geology in this area, these two springs are considered together and the Zone of Contribution delineated is for both.

The northern and northwestern boundary: It is assumed that all groundwater from the hills surrounding Newtown Cashel flows toward and discharges at the fen. The boundary is uncertain, as it is difficult to distinguish a ZOC to L. Slawn from the ZOC to the spring and there is uncertainty in the flow directions.

The Southern boundary is based on the topographic divide along the topographical high in Carrowrory townland in Cartoon. It is assumed that there is a groundwater divide based on topography between the Newtown Cashel source and the Lady's well area.

The Western boundary is based on the assumption that groundwater cannot flow to the source from the downgradient side as the source is a spring. An arbitrary 30 m distance is applied for the downgradient boundary, which allows for some drawdown in the spring sump should the overflow be exceeded or stop.

The **Eastern boundary**: it is considered likely that as there is no significant discharge east of the ridge that the majority of groundwater discharges west of the hills to the fen area and the spring. The Forthill stream appears to be an artificial drain for Forthill Bog and is at approximately 45mOD and underlain by deep deposits of till (>10m). Considering this, and the absence of springs along Forthill stream, groundwater recharge between source and Forthill stream is more likely to flow towards Lough Slawn. Thus the ZOC includes an area higher than the 50mOD contour on the other side of the ridge.

Based on a discharge of 1310 m^3/day on average from the spring alone and the estimated recharge of 355 mm/year, a zone of contribution of 1.34 km^2 in area is required. Hydrogeological field mapping and the conceptual model determined an area of 1.5 km^2. Further quantitative assessment of the spring overflow is required to validate the average discharge used within this report. Further refinement of the zone of contribution will require further investigation.

9.2 INNER PROTECTION AREA

The Inner Source Protection Area is the area defined by the horizontal 100 day time of travel from any point below the watertable to the source (DoELG, EPA, GSI, 1999). The 100-day horizontal time of travel to the source is calculated from the velocity of groundwater flow in the bedrock. The velocities are normally based on the results of the hydraulic test programme, however, in this instance, the aquifer category of Rk^c, suggests that very rapid groundwater velocities are likely in this area due to karstification of the limestones. Groundwater flow can be focused and travel very fast. Results from tracing programmes in similar rock types indicate velocities in the order of hundreds of metres/day. On this basis, all of the ZOC is designated as part of the inner protection area to the source.

10 GROUNDWATER PROTECTION ZONES

Groundwater protection zones are shown in Figure 7 and are based on an overlay of the source protection areas on the groundwater vulnerability. Therefore the groundwater protection zones are SI/E, SI/H and SI/M. The majority of the area is designated either as extreme or high all within the inner protection area.

Table 10-1 Source Protection Zones

Source Protection Zone	**% of total area (2.6 km2)**
SI/Extreme (Rock close)	**15% (0.4 km2)**
SI/Extreme	**49% (1.2 km2)**
SI/High	**30% (0.8 km2)**
SI/ Moderate	**6% (0.15 km2)**

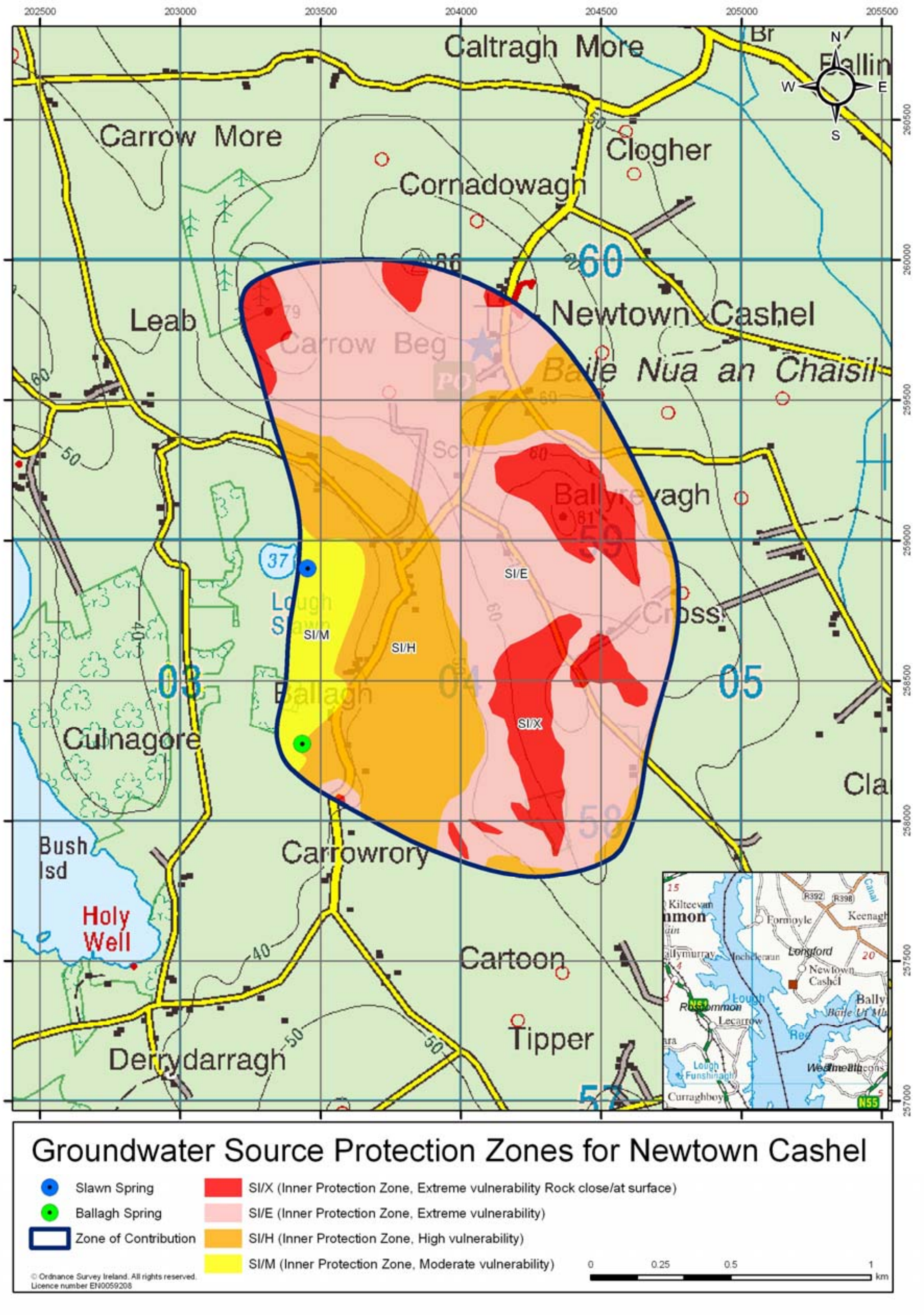


Figure 10.1 Source Protection Zones for Newtown Cashel

11 POTENTIAL POLLUTION SOURCES

The main potential sources of contamination within the ZOC are:

- Direct microbial contamination of the source by animals and birds. The main potential contaminants from these sources are faecal bacteria, viruses and cryptosporidium.
- All private residences within the ZOC are serviced by septic tank systems or similar wastewater treatment discharging percolation areas. The main potential contaminants from this source are ammonia, nitrates, phosphates, chloride, potassium, BOD, COD, TOC, faecal bacteria, viruses and cryptosporidium.
- The majority of land within the zone of contribution is agricultural land, primarily grassland with some smaller areas of tillage land. A number of farming operations are located within the source protection zone. The main potential contaminants from these sources are ammonia, nitrates, phosphates, chloride, potassium, BOD, COD, TOC, pesticides, faecal bacteria, viruses and cryptosporidium.
- Many private home heating fuel tanks are located within the catchment area. The main potential contaminants from this source are hydrocarbons.
- Roadways are present within the ZOC. The main potential contaminants from this source are hydrocarbons and metals.

12 CONCLUSIONS

- The untreated groundwater at the spring source at Newtown Cashel is currently impacted by microbial contamination. Available data suggests that there is contamination of the source occurring probably from organic waste sources; such as farmyards and/or untreated wastewater from unsewered areas.
- Due to the rapid groundwater velocities, it is considered that groundwater in any part of the ZOC could potentially reach the spring within 100 days. Therefore the entire ZOC should be classified as the Inner Protection Area.
- The SPZ delineated is based on the current understanding of groundwater conditions and bedrock geology; and on the available data. The conclusions should not be used as the sole basis for site-specific decisions. There is considerable uncertainty in flow directions and consideration of each spring in isolation is not achievable without further investigation, for example with extensive dye tracing.

13 RECOMMENDATIONS

- Continued monitoring water levels and flow data during the operation of the scheme should be carried out to develop a real-time database of hydrogeological information.
- The depth to bedrock should be investigated surrounding the source to provide greater certainty to the conceptual model.
- The ZOC of the source includes an extensive area of Extreme Vulnerability with a significant proportion of it comprising shallow rock. It is recommended therefore that an adequate barrier

to Cryptosporidium must be installed as part of the water treatment system for the supply. A hazard survey is also recommended.

- Consideration should be given to dye tracing to characterise flow to the springs.

14 REFERENCES

An Foras Talúntais and Geological Survey of Ireland (1981). Soil Map of Ireland

DELG/EPA/GSI (1999) Groundwater Protection Schemes. Department of the Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland.

Morris, J., Sumerville, E., McDermott, C., Smith ., Geraghty, M., McConnell, B., Carinbold, K., Cox, W., and Lee, M., (2003) Geology of Roscommon and Longford. Geological Survey of Ireland. *1:100,000*

Met Éireann, (1996). Fitzgerald, D., and F. Forrestal. Monthly and annual averages of rainfall for Ireland 1961–1990. Climatological Note no. 10. Dublin, Ireland.

Geological Survey of Ireland, Lanesborough GWB: Summary of Initial Characterisation. www.gsi.ie

TOBIN Consulting Engineers/ Geological Survey of Ireland. (2009). *County Longford Groundwater Protection Scheme 2009*. Draft Report to Longford County Council.

Baker, G., Crean, D. and Moran, S. (2007) Establishing Natural Background Levels for Groundwater Quality in Ireland. GSI Groundwater Newsletter No. 46.

Groundwater Working Group 2005. Guidance on the Assessment of the Impact of Groundwater Abstractions. Guidance Document No.GW5. Intergovernmental Working Group on Groundwater.

www.wfdireland.ie/maps.html (2008) Lanesborough GWB status