Walsh Island Water Supply Scheme

Coolagarry Borehole

Groundwater Source Protection Zones

(March 2001)

Prepared by:
Coran Kelly
Geological Survey of Ireland

In collaboration with:
Offaly County Council

TABLE OF CONTENTS

List of Figures (maps are enclosed at the back of the report)

List of Tables

1 Introduction

The objectives of the report are as follows:

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

2 Location, Site Description and Well Head Protection

Coolagarry borehole is on the outskirts of Walsh Island village, close to the reservoir. The borehole is situated inside a small pumphouse. There is no cover on top of the borehole. Due to the narrow casing and the rising main inside the borehole it is impossible to place a dipping tube inside the borehole.

3 Summary of Spring Details

G.S.I. No:	:	2321NEW004
Grid reference	:	25217 22108
Townland	:	Coolagarrybeg
Well type	:	Borehole
Owner	:	Offaly County Council
Elevation (ground level)	:	~100 m (330 feet) OD.
Depth of Borehole	:	~49 m
Diameter of Casing	:	15 cm (6″)
Diameter of Rising Main	:	7.6 cm (3″)
Depth to rock	:	3 m
Static water level	:	~70 m OD.
Normal Abstraction	:	410 $m^3 d^{-1}$

4 Methodology

4.1 Desk Study

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

4.2 Site visits and fieldwork

This included carrying out depth to rock drilling and subsoil sampling. Field walkovers were also carried out to investigate the subsoil geology, the hydrogeology and vulnerability to contamination.

4.3 Assessment

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

5 Topography, Surface Hydrology and Land Use

Two hills occupy the area around Walsh Island, that stand above the rest of land around Walsh Island (hence, the name). There are no streams or drains on the hills. Draining the low-lying boggy area around Walsh Island there are numerous streams and drains. The most significant of these are the Cushina River that flows south-eastwards, the Wouge River that drains the area to the north of Walsh Island flowing to the Philipstown River. The primary land use is agricultural (both pasture and tillage) on the hill slopes along with Walsh Island village. Off the hill slopes there is some pasture land and forestry. A great deal of this area is peatland, with large tracts devoted to bog-cutting.

6 Geology

6.1 Introduction

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

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

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

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

6.2 Bedrock Geology

Limestones occupy the whole area and a brief description of the individual rock units in the vicinity of the source is given in Table 1.

Table 1 The Bedrock Geology of the Walsh Island area.

Name of Rock Formation	*Rock Material*	*Occurrence*
Waulsortian Limestone Formation (Dolomitized*)	Fossiliferous, pale-grey, poorly bedded fine grained LIMESTONE.	Occupies the area to the west of the borehole.
Edenderry Limestone Formation	Pale-grey, poorly bedded oolithic LIMESTONE.	Underlies the source. Occupies the area to the east of the borehole.

*Dolomitized – calcium is replaced by magnesium, often resulting in an increase in porosity and permeability.

Movements in the earth's crust have caused the rocks to be folded, faulted and jointed. A large fault cross cuts the area in a northwest-southeast line within 500 m of the borehole.

6.3 Subsoil (Quaternary) Geology

The subsoils comprise a mixture of coarse and fine-grained materials, namely: alluvium, till, sand & gravel. They are directly influenced by the underlying bedrock, which is made up of limestones. The geological logs of the auger holes drilled are given in Appendix 1. The characteristics of each category are described briefly below:

6.3.1 Peat

Peat occupies the low-lying area surrounding Walsh Island.

6.3.2 Till with Gravel

The borehole is located within till with gravel deposits. In many places it is not possible to map out separately the sand/gravel units and the till units during a reconnaissance mapping project. This has led to the term "till with gravel" being employed to categorise the sediments over relatively large areas (Daly *et al*, 1997). The matrix comprises silty SAND with frequent angular gravels and sandy CLAY with frequent angular imestone gravels.

6.3.3 Depth to Bedrock

The depth to rock is known in certain localities from a drilling programme carried out by the GSI to ascertain the thickness and permeability of the subsoils. The locations of the auger holes are given in Figure 1 and the logs are given in Appendix 1. The depth to bedrock varies from 0-11 m

7 Hydrogeology

7.1 Introduction

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

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

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

7.2 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 is assumed to consist of 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 for the Agall area are estimated as follows:

- Annual rainfall: 825 mm. (Met Éireann)
- Annual evapotranspiration losses: 431 mm. Potential evapotranspiration (P.E.) is estimated to be 454 mm $yr.^{-1}$ (based on data from Met Éireann). Actual evapotranspiration (A.E.) is then estimated as 95 % of P.E.
- Potential recharge: 394 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 vertical downward flow to groundwater or for runoff.
- Annual runoff losses: 20 mm. This estimation assumes that 5% of the potential recharge may be lost to overland flow and shallow soil quickflow without reaching the main groundwater system.

These calculations are summarised as follows:

Average annual rainfall (R)	825 mm
Estimated A.E.	431 mm
Potential Recharge (R – A.E.)	394 mm
Runoff losses	20 mm
Estimated Actual Recharge	374 mm

7.3 Groundwater levels, Flow Directions and Gradients

Water level data are poor for the area. The level of the water in the borehole was impossible to measure as there is no room within the casing to put a dipper down. Archival data on the level is used to approximate the level within the borehole. Water levels in the Wouge, Philipstown, Cushina Rivers and Ballaghassaan Spring are assumed to represent true groundwater levels. Archival data on the water level in the borehole suggests that the static water level is deep, indicating that the 'hill' is largely unsaturated and the water level is only slightly higher than the groundwater in the rivers and Ballaghassaan Spring. As a result the gradient is low and is estimated to be approximately 0.002.

7.4 Aquifer Characteristics

The borehole is located within the Edenderry Limestone Formation, but is close to the geological contact with the Waulsortian (dolomitised) Limestone Formation. These rock types may be considered together as they are likely to have similar aquifer characteristics (Daly *et al*, 1998). The aquifers are classed as "**locally important aquifers that are generally moderately productive (Lm)"**. The dolomitised Waulsortian Limestone is likely to be more permeable than the Waulsortian Limestone due the effect of dolomitisation increasing the porosity and permeability. Table 2 presents the aquifer characteristics for Walsh Island. Unfortunately test pumping of the aquifer in which this borehole is located was impossible. The land around Walsh Island is free draining indicating the relatively high permeabilities of the bedrock.

Table 2 Estimated Aquifer parameters for the rock units in Walsh Island.

Parameter	*Source of data*	*Edenderry and Waulsortian*
Permeability (m d^{-1})	Regional*	10-20
Porosity	Regional	0.02
Velocity (m d^{-1})		1-2
Hydraulic Gradient	Local**	0.002

* Regional data: based on information for the Offaly (Mountlucas) area.
** Local data: based on information for Walsh Island.

7.5 Hydrochemistry and Water Quality

The hydrochemical analyses (two C3 samples) show that the water is very hard with total hardness values in excess of 350 mg l^{-1} (equivalent $CaCO_3$) and electrical conductivity values ranging 590-634 µS cm^{-1}, indicating that the groundwater has a hydrochemical signature of calcium bicarbonate type water. These values are typical of groundwater from limestone rocks.

Nitrate concentrations are in the range of 22-33 mg l^{-1} (average 29 mg l^{-1}) from 37 samples taken between 1994 and December 1999. The results are representative of general nitrate contamination by both diffuse (spreading of inorganic fertiliser and slurry) and point sources (septic tank systems and farmyards) in this relatively intensive farming area in mid-Offaly (Daly *et al*, 1997). There is no apparent trend in the data.

Chloride concentrations range from 17-35 mg l^{-1}, with an average of 21 mg l^{-1} (14 samples). Chloride is a constituent of organic wastes and levels higher than 25 mg l^{-1} may indicate significant contamination. Concentrations higher than the 30 mg l^{-1} usually indicates significant contamination. There have been two occasions (February 1998 and February 1999) where the concentrations have been 35 and 33 mg l^{-1} respectively.

Sodium concentrations are noticeably higher on the dates of high chlorides (Feb. 1998: Na = 22 mg l^{-1} and Feb. 1999: Na = 15 mg l^{-1}), supporting evidence of organic contamination on these dates. It is possible that high sodium may result from application of road salt, however road salt is not used in this area (Spain, R., 2000).

Bacteriological sampling of the raw water indicate faecal contamination on three occasions between 1994-1998 (20 samples).

The faecal bacteria count is the only parameter to exceed EU Drinking Water Directive maximum admissible concentrations (MAC). Overall the water quality appears to be good - all major cations and anions are within the E.U. limits, however there is occasional significant organic contamination. There is a sewage treatment works situated close by, that is in good working order. It is possible however, that underground pipes bringing sewage from the houses to the treatment works are in poor repair, thus leaks from these pipes are likely to be the source of any contamination at the borehole.

7.6 Conceptual Model

- Walsh Island borehole is located in the dolomitised Waulsortian and Edenderry Limestone Formations.
- The permeability of the aquifer depends on the development of faults, fissures and fractures.
- These rock units are largely overlain by permeable till with gravel. Therefore the groundwater can be considered as unconfined.
- The water table is assumed to be flow in all directions outward from the hills, discharging to the streams at the bottom of the hills. Walsh Island acts as a recharge mound to the area around it.
- The groundwater gradient is relatively flat.

8 Delineation of Source Protection Areas

8.1 Introduction

This section delineates the area around the borehole that is believed to contribute groundwater to the borehole, and that therefore requires protection. The area is delineated based on the conceptualisation of the groundwater flow pattern, and is presented in Figures 1 and 2.

Two source protection areas are delineated:

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

8.2 Outer Protection Area

The Outer Protection Area (SO) is bounded by the complete catchment area to the source, i.e. the zone of contribution (ZOC), 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 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 the conceptual model. The ZOC boundaries are shown in Figures 1 and 2. The boundaries drawn are estimates, based on information on the limestones in the area, experience and judgement. More definitive boundaries would require test pumping.

The borehole lies very close to a surface water divide and it is generally assumed the water table is a subdued reflection of topography. However in this instance the water table is comparably flat, thus the topography is not used to delineate boundaries for the borehole. The water balance shows that to provide an abstraction rate 50% greater (615 $m^3 d^{-1}$)than the current abstraction rate an area of about 0.6 km^2 is required. An area of 0.6 km^2 is drawn around the well to cover the zone of contribution.

8.3 Inner Protection Area

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 to the supply. Estimations of the extent of this area cannot be made by hydrogeological mapping and conceptualisation methods alone. Analytical modelling using the aquifer parameters in Section 7.4 assists in estimating the 100-day ToT boundary. The inner protection area is shown in Figure 2. It is estimated that groundwater velocities range 1-2 m d^{-1}. The 100-day ToT boundary is estimated using an assumed velocity of 2 m d^{-1}. It gives a distance of 200 m for the inner protection area.

9 Groundwater Vulnerability

Vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities and depends on the thickness, type and permeability of the subsoils. A detailed description of the vulnerability categories can be found in the Groundwater Protection Schemes document (DELG/EPA/GSI, 1999).

There are areas of outcrop, areas of rock close to surface and areas with a depth to rock <3 m. These areas are designated an 'Extreme' vulnerability rating. The subsoils that comprise highly permeable till with gravel that have a depth greater than 5 m across the entire area are designated a 'High' vulnerability rating. Further details of the groundwater vulnerability in the area may be referred to in the Offaly Groundwater Protection Scheme (Daly *et al*, 1998).

10 Groundwater Protection Zones

The groundwater protection zones are obtained by integrating the two elements of land surface zoning (source protection areas and vulnerability categories) – a possible total of 8 source protection zones. In practice, the source protection zones are obtained by superimposing the vulnerability map on the source protection area map. Each zone is represented by a code e.g. **SI/H**, which represents an Inner Protection area where the groundwater is highly vulnerable to contamination. Three groundwater protection zones are present around the spring source as shown in Table 3. The final groundwater protection map is presented in Figure 2.

Table 3 Matrix of Source Protection Zones for Walsh Island borehole.

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

11 Potential Pollution Sources

Land use in the area is described in Section 5. The land around the source is largely grassland-dominated and is primarily used for grazing. Agricultural activities and septic tanks are the principal hazards in the area. The main potential pollutants are faecal bacteria and viruses.

12 Conclusions and Recommendations

- The borehole is located in "**locally important limestone aquifers that are generally moderately productive (Lm)"**.

- The groundwater around the borehole is extremely or highly vulnerable to contamination.

- The sewage works, underground sewage pipes, landspreading, and runoff from the roads pose a threat to the water quality at the borehole.

- The available information is not adequate to allow the delineation of definitive groundwater protection zone boundaries. The protection zones delineated in the report are based on our current understanding of groundwater conditions, on the available data and our judgement. Additional data obtained in the future may indicate that amendments to the boundaries are necessary. A more definitive understanding of the hydrogeology would require an extensive site investigation that would include drilling, geophysics and test pumping.

- It is recommended that:

1) Chemical and bacteriological sampling is carried out of the **raw** water on a regular basis.
2) particular care should be taken when assessing the location of any activities or developments that might cause contamination at the well.
3) the potential hazards in the ZOC should be located and assessed.

13 References

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

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

Department of the Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland (1999) *A Scheme for the Protection of Groundwater*. DELG/EPA/GSI report.

Spain, R.P, 2000. *"An examination of water quality on eleven selected public water supply sources in county Offaly with particular emphasis on nitrate"* unpublished MSc thesis. Sligo Institute of Technology.

Appendix 1 Geological Logs of the Auger Boreholes.

Borehole No.	Grid Ref.	Depth	BS5930	Permeability
Walsh Island 1	25217 22106	0-6.0	Silty SAND with frequent angular gravel.	High
Walsh Island 2	25223 22093	0-3.0	Sandy CLAY with few angular gravel and cobble size stones.	Low

Appendix 2 Hydrochemical Analyses

Current Monitoring (C4) from Offaly County Council.

Date	Nitrate	Chloride	Na	K
16-Jun-97	29.4	20.00	14.8	2.7
8-Dec-97	22.0	21.00	7.1	1.1
26-Jan-98	31.2	17	6.9	1.2
26-Jan-98	31.2	17	6.9	1.2
23-Feb-98	29.0	35	22.2	1.5
18-May-98	32.6	18	7.1	1.3
15-Jun-98	29.6	17	8.2	1.3
20-Jul-98	28.86	18	7.5	1.3
24-Aug-98	27.58	19	11.1	1.2
13-Oct-98	29.24	19	7.9	1.2
9-Nov-98	29.56	19	8.54	1.21
8-Dec-98	28.69	19	8.1	1.1
18-Jan-99	29.08	20	8.4	1.1
15-Feb-99	29.37	33	14.49	1.23
19-Apr-99	28.71	19.2	8.81	1.16

Current Monitoring (C1) Raw water analyses.

Date	Total Bacteria -22	Total Bacteria-37	Total Coliforms	Faecal Coliforms
15/06/1998	2	<1	0	0
20/07/1998	1	<1	0	0
24/08/1998	16	40	0	0
04/07/1994	1	4	Nil	1
13/05/1996	<1	<1	0	0
04/07/1995	innum	<1	0	0
17/06/1996	<1	<1	0	0
01/04/1996	<1	<1	0	0
20/06/1994	<1	<1	0	0
09/05/1994	1	1	0	0
22/05/1995	1	Innum	Nil	Nil
19/02/1996	<1	<1	0	0
04/03/1996	<1	<1	0	0
26/04/1995	<1	<1	Nil	Nil
04/07/1994	1	4	0	1
04/07/1994	1	4	0	1
08/05/1995	1	1	Nil	Nil
07/06/1994	1	1	0	0
06/06/1995	1	1	0	0
26/04/1994	<1	<1	0	0
23/05/1994	1	2	0	0

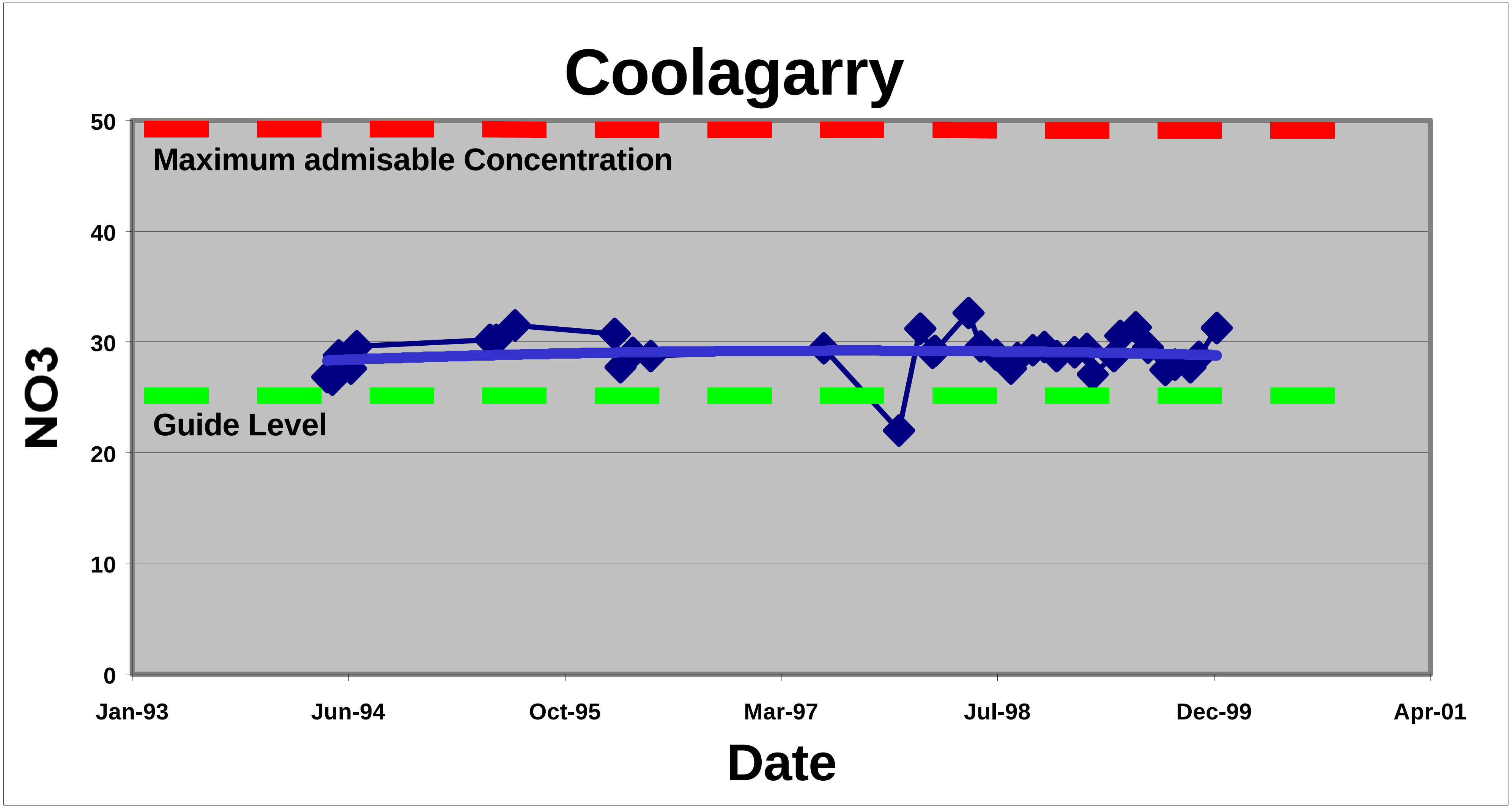
Appendix 3 Nitrate concentrations

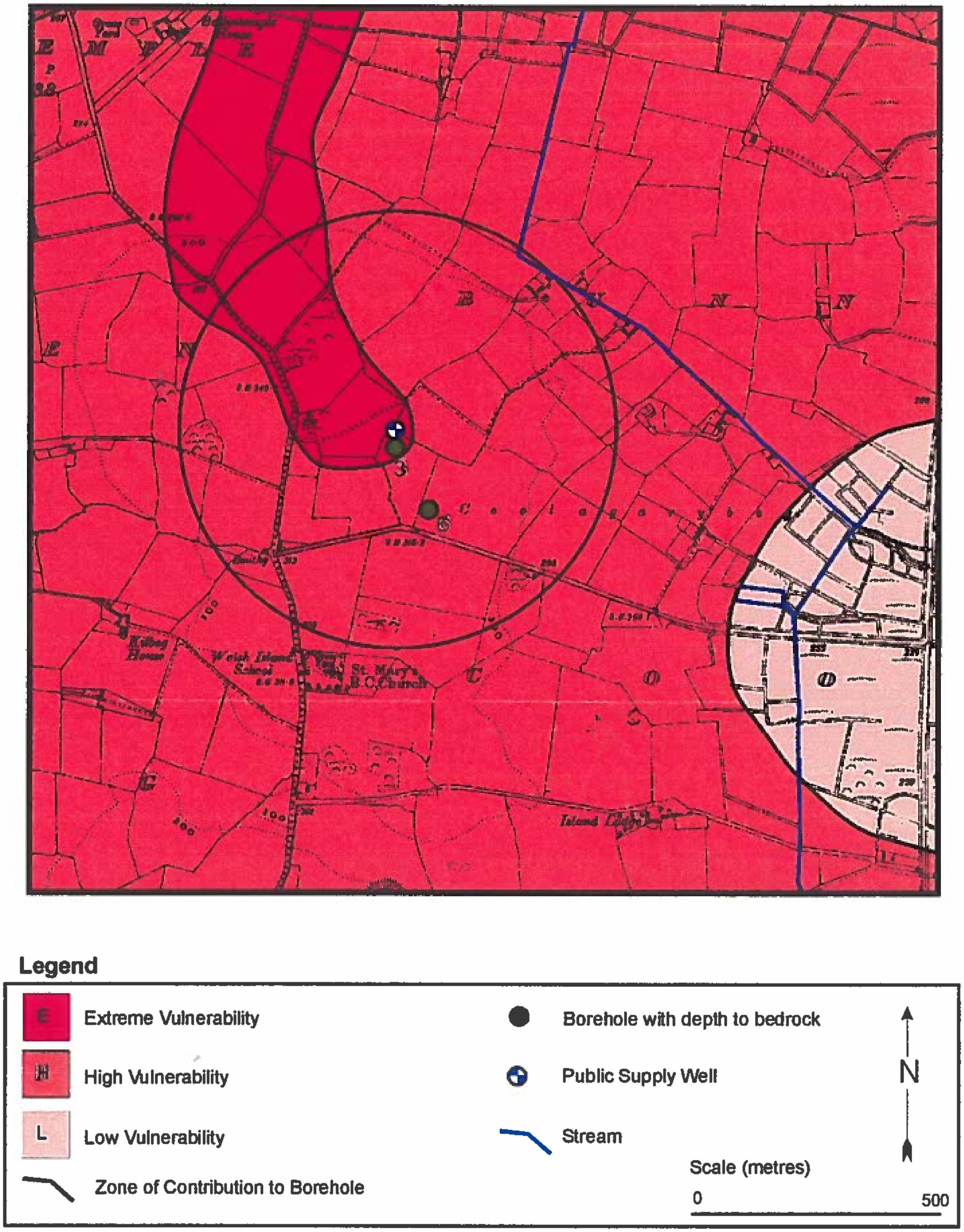
26-Apr-94	26.8
9-May-94	26.6
23-May-94	28.8
7-Jun-94	27.9
20-Jun-94	27.6
4-Jul-94	29.6
8-May-95	30.2
22-May-95	30.2
4-Jul-95	31.5
20-Feb-96	30.7
4-Mar-96	27.7
1-Apr-96	29.0
13-May-96	28.7

17-Jun-97	29.4
8-Dec-97	22.0
26-Jan-98	31.2
23-Feb-98	29.0
2-Mar-98	29.2
18-May-98	32.6
15-Jun-98	29.6
20-Jul-98	28.9
24-Aug-98	27.6
7-Sep-98	28.6
13-Oct-98	29.2
9-Nov-98	29.6
8-Dec-98	28.7

18-Jan-99	29.1
15-Feb-99	29.4
1-Mar-99	27.1
19-Apr-99	28.7
4-May-99	30.5
8-Jun-99	31.3
6-Jul-99	29.5
16-Aug-99	27.5
7-Sep-99	27.9
12-Oct-99	27.7
1-Nov-99	28.6
13-Dec-99	31.3

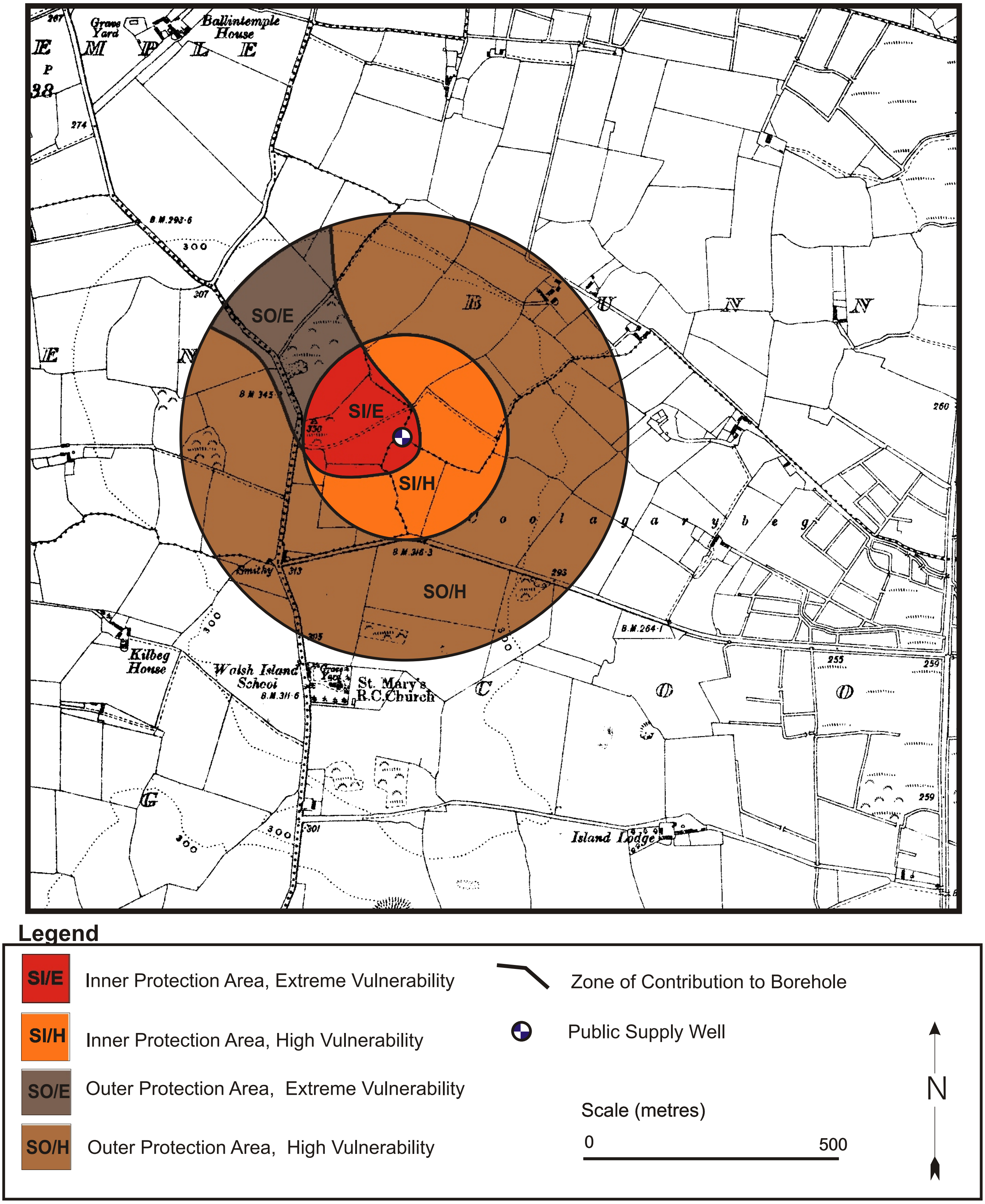
Appendix 4 Graph of Nitrate levels at the borehole, 1993-1994; taken from Spain, R., 2000.





Groundwater Vulnerability Zones for Walsh Island Water Supply Scheme (Coolagarry Borehole)

Figure 4



Groundwater Source Protection Zones for Walsh Island Water Supply Scheme (Coolagarry borehole)

Figure 2.

The boundaries are based on the available evidence and the resulting conceptualisation of groundwater flow, which is described in the accompanying report. Evaluation of specific sites and circumstances will normally require further and more detailed assessments and will frequently require site investigations to determine the risk to groundwater.

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

Compilation: Coran Kelly
Digital Map: David Chew