Kilteel Group Water Scheme

Extracted from:
County Kildare Groundwater Protection Scheme,
Volume II: Source Protection Zones

County Kildare
Groundwater Protection Scheme

Volume II: Source Protection Zones

May 2004

John Lahart
Director of Services
Housing and Water Services
Kildare County Council
St. Mary's, Naas,
County Kildare

Coran Kelly and Vincent Fitzsimons
Groundwater Section
Geological Survey of Ireland
Beggars Bush
Haddington Road
Dublin 4

Authors

Coran Kelly, Groundwater Section, Geological Survey of Ireland

Vincent Fitzsimons, Groundwater Section, Geological Survey of Ireland

in partnership with:

Kildare County Council

Table of Contents – Volume II

Sections 1 to 6 are contained within Volume I. They comprise an Executive Summary, an overall introduction, classifications of aquifers and vulnerability, and overall conclusions.

LIST OF FIGURES

LIST OF TABLES

APPENDIX IV: Discussion of the key indicators of domestic and agricultural contamination of groundwater
APPENDIX V: Laboratory analytical results
APPENDIX VI: Summary of trends in water quality over time for selected supply sources in Kildare
APPENDIX VII: KT Cullen & Company. Source Protection Reports for Monasterevin, Rathangan, Johnstown Bridge and Robertstown.

- Overall conclusions are contained within Volume I -

13 Kilteel Group Water Scheme

13.1 Introduction

The objectives of the report are as follows:

- To delineate source protection zones for the groundwater supply at Kilteel.
- To outline the principal hydrogeological characteristics of Kilteel 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.

13.2 Location & Site Description

The source is located 2 km east of Kilteel village, Co. Kildare, on the north west facing slopes of Cupidstownhill. The source comprises a spring & sump located in the townland of Cromwellstown. The source was commissioned in 1963. A sump 2.5 m deep and 2 m wide was built over the spring. The sump is covered with a concrete cap. Water flows from the sump via gravity to an 18,000 gallon reservoir situated 400 m directly downslope of the spring. According to the group scheme administrators the scheme provides water for about 220 people. At present there is no chlorination of the water at the source.

13.3 Summary of Source Details

GSI No.	2921NWW157
Grid reference	O $^{3}00513$ $^{2}21703$
Townland	Cromwellstown
Owner	Kilteel Group Water Scheme
Source Type	Spring
Elevation (ground level)	285 m OD (Malin Head).
Static water level	Ground level
Normal consumption (Co.Co. figures 2000)	13,000 gals/day (60 m^3d^{-1})
Yield (estimates from group scheme administrators)	160 m^3 d^{-1}
Depth of sump	2.55 m
Depth-to-rock	~5 m

13.4 Methodology

13.4.1 Desk Study

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

13.4.2 Site visits and fieldwork

This included the following;

- Interview with the group scheme personnel 9/5/02;
- Water sampling October 2002;
- Field mapping walkovers on 14/3/02 and 9/5/02 to further investigate the subsoil geology, the hydrogeology and vulnerability to contamination.

13.4.3 Assessment

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

13.5 Topography, Surface Hydrology and Land Use

The spring is located on the leading north western slopes of the Wicklow hills. It occurs at a break of slope at about 250 m O.D. To the east of the spring the slopes continue upwards to the highest point in the vicinity of the spring - Cupidstown Hill (379 m O.D.) in the order of 1 in 11. The topography to the west of the spring as far as Kilteel village become less steep, with slopes in the order of 1 in 18. Beyond Kilteel village the topography is relatively flat.

There are frequent springs and streams in the area. Approximately 470 m south of the source spring another spring of similar magnitude occurs at the same topographic contour. Cupidstown Hill and Cromwellstown Hill form the watersheds in the area and the spring lies in the catchment of the Kill, Slane and Liffey rivers.

The land use around the spring is predominately sheep and cattle grazing and some forestry. One large quarry sits just on the watershed at Cromwellstown Hill.

13.6 Geology

13.6.1 Introduction

This section briefly describes the relevant characteristics of the geological materials that underlie the Kilteel 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 (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, L., Wright, G., 2001).
- Soils of County Kildare (Conry, M. J., Hammond, R. F. and T. O'Shea, 1971).

13.6.2 Bedrock Geology

Greywacke[3] sandstones, shales and slates dominate the area. Further details are given in Section 2 Volume I. These rocks are exposed in the large quarry at Cromwellstown Hill where they dip steeply (80^{o}) to the east.

---

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

13.6.3 Subsoil (Quaternary) Geology

13.6.4 Till (Boulder Clay)

'Till' or 'Boulder clay' is an unsorted mixture of coarse and fine materials laid down by ice. Till is mapped around the source, except in the uppermost reaches of the hillsides, where due to elevation and steep slope rock is very close to surface.

13.6.5 Sand/gravel

Isolated sand/gravel pockets are mapped in the area and there are numerous small sand/gravel pits. Note no sand/gravel is mapped in the vicinity of the source. However, group scheme administrators indicate that sand/gravel was found during excavation of the spring supply and it is likely that small sand/gravel pockets do occur in the area of the source.

13.6.6 Depth to Bedrock

The area around the hill tops is mostly outcrop and shallow rock. Moving down slope toward Kilteel the depth to bedrock deepens to >5 m.

13.7 Groundwater Vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater 'target'. No sand/gravel aquifers are mapped at the source and considerations of groundwater vulnerability concern the permeability of the whole subsoil profile and the depth to bedrock. A detailed description of the vulnerability categories can be found in the Groundwater Protection Schemes document (DELG/EPA/GSI, 1999).

Mapped depth to bedrock varies from 3-5 m near the source to less than 3 m closer to the watershed. Consequently, vulnerability ranges from high at the source to extreme at the watershed (refer to Maps 6 and 8).

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).

13.8 Hydrogeology

13.8.1 Introduction

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

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

- GSI files and archival Kildare County Council data.
- Kildare County Council drinking water returns.
- Group Water Scheme personnel.
- Hydrogeological mapping carried out by GSI.

13.8.2 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 Kilteel (from Fitzgerald, D., Forrestal., F., 1996).

Gauging Stations	**Grid reference**	**Elevation OD (m)**	**Approximate distance& direction from source**	**Annual ppt 1961-1990**
Brittas G.S (Dublin)	O034235	244	2.5 km east	1048
Blessington G.S.	N980142	206	8.0 km south	948
Rathcoole-Saggart G.S.	O032273	107	5.0 km north east	810
Kill G.S.	N970226	101	7.0 km west	794

  Brittas (Glenaraneen) G.S. is the closest in terms of distance and elevation to the Kilteel source. Contour maps produced by Fitzgerald, D., Forrestal., F., 1996 suggest that annual rainfall near Kilteel is in the range of 1000-1200 mm rainfall. It would therefore appear to be reasonable to assume an annual average precipitation of 1000 mm for the Kilteel area.
- *Annual evapotranspiration losses:* 430 mm. Potential evapotranspiration (P.E.) is estimated to be 450 mm yr.$^{-1}$ (based on data from Met Éireann). Actual evapotranspiration (A.E.) is then estimated as 95 % of P.E., to allow for seasonal soil moisture deficits. This figure ('actual evapotranspiration') was calculated using an adaptation of the country-wide potential evapotranspiration data presented in the "Agroclimatic Atlas of Ireland" (Collins and Cummins, 1996). More local measurements of evapotranspiration are not available.
- *Potential recharge:* 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:* 460 mm. Given the nature of the slopes, till cover and iron pans in the soil it is considered that most potential recharge will runoff to surface water and only a small proportion will infiltrate to bedrock or to the pockets of sand/gravel subsoil. The lowest infiltration factor used by (Wright *et al*, 1982). Thus a representative value for the runoff is estimated to be in the order to 80%.

These estimations 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 (80% of recharge)	460 mm
Estimated Actual Recharge	**110 mm**

13.8.3 Groundwater levels, Flow Directions and Gradients

No water level data are available in the vicinity of the spring, but at the sump water levels are at ground level.

The water table in the area is generally assumed to be a subdued reflection of the topography, with groundwater flowing from the watersheds at Cupidstown Hill and discharging into the Slane River. Groundwater is assumed to flow in a westerly direction following the topographic downslope direction. The water is caused to focus at the spring mainly due to topography. Several other springs are noted at the same topographic contour where there is a break in slope.

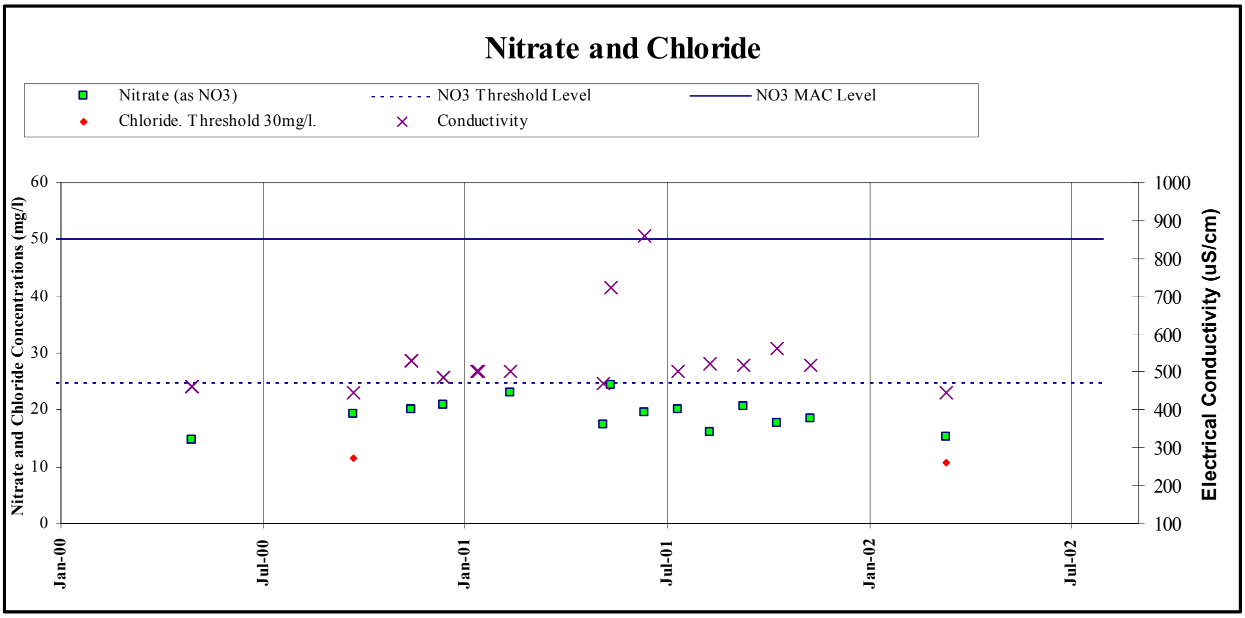
The topographic gradient is estimated to be about 0.09. Groundwater gradients in the bedrock are assumed to be similar to the topographic gradient due to the low permeability and steep slopes. For the purposes of calculations it is assumed to be 0.05.

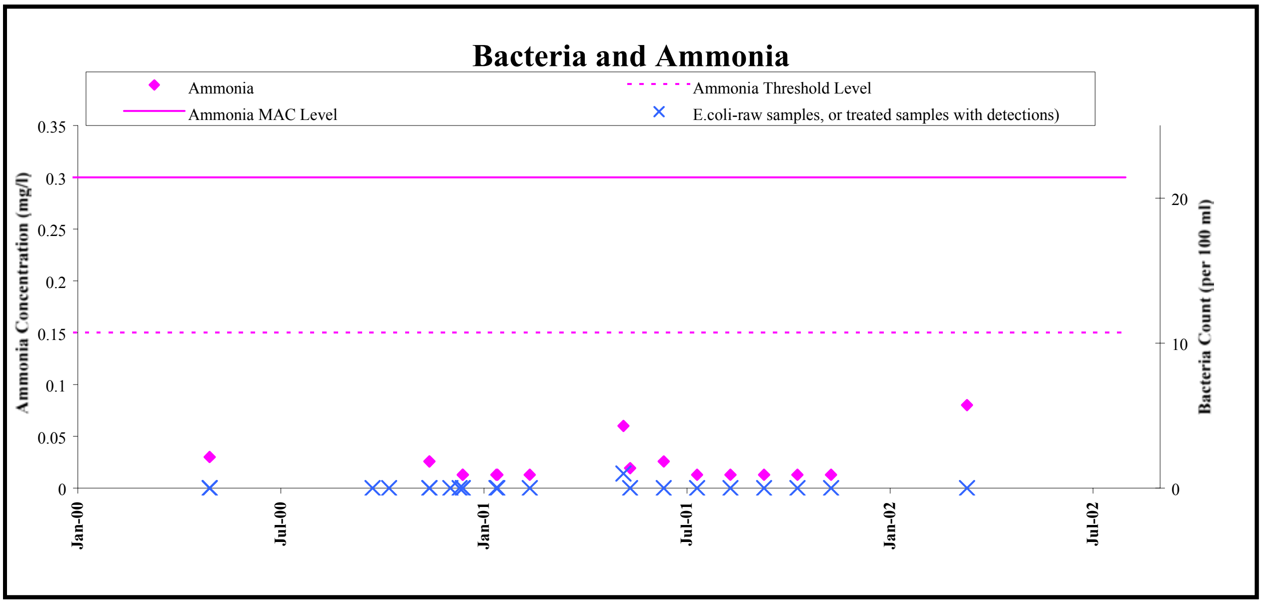
13.8.4 Hydrochemistry and Water Quality

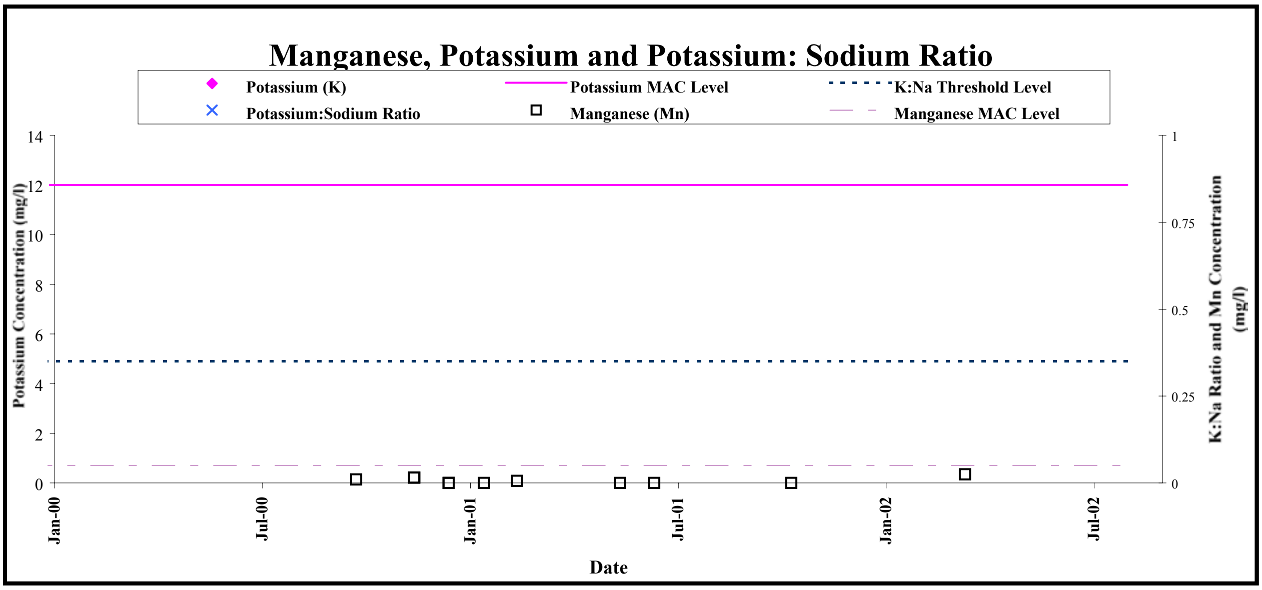
The data is summarised graphically in Figure 13-1 and the following key points are identified:

- The hydrochemical analyses show that the water is slightly hard, with total hardness values of 108-150 mg l^{-1} (equivalent $CaCO_3$) and electrical conductivity values of 305-490 µS cm^{-1}. These values are not typical of those from limestone rock units or sand/gravel deposits. This suggests that, though groundwater may be reaching the surface through a small sand/gravel pocket, the spring is mainly fed by the bedrock aquifer.
- Nitrate concentrations from fifteen available samples over the last two years are only slightly above background levels.
- Only one slight exceedance of faecal coliforms is recorded from the eight available raw water samples taken over the last two years.

Figure 13-1Kilteel - Key indicators of agricultural and domestic groundwater contamination







13.8.5 Aquifer Characteristics

The bedrock formations at the source are classed as **Poor Aquifers which are generally unproductive (Pu)**. Further details can be found in Section 4 of Volume I. Groundwater is assumed to flow through the upper few metres of weathered bedrock.

Sand/gravel was reported to be present during excavation of the spring sump, and small sand/gravel pockets are present on the hillsides of north east Kildare (refer to Map 2). It is likely that the sand/gravel at the source comprises a small pocket perhaps only a few tens of square metres in size. This sand/gravel deposit would be too small to be mapped as an aquifer, but sand/gravel of even this small size could provide significant extra storage for groundwater in a poor bedrock aquifer, and the pocket may be significant in allowing this spring to supply demand throughout the summer.

Given the expected small size of the sand/gravel pocket at the source and given the inferences derived from the water quality data (Section 13.8.4), the sand/gravel is not thought to be significant in terms of overall recharge to the source. As such, the aquifer parameters of the bedrock are taken as the main influence on the source protection zones around the source. Permeabilities are considered to be low in the bedrock, estimated to be in the order of 1-2 m d^{-1}. Porosities are assumed to be 0.01. These are conservative estimates based on values used for the slightly more productive bedrock aquifer at the Kilkea source (refer to Section 12.8.5).

13.9 Conceptual Model

- The Kilteel scheme abstracts 60 m^3 d^{-1} from a mountainside spring. The aquifer is mapped as 'generally unproductive'. Note that it is not unusual for springs of this size to occur in mountainside settings in even the most unproductive aquifers.
- Most of the flow to the spring occurs through the top few metres of weathered bedrock, with some additional flow and storage provided by a small sand/gravel pocket located at the spring.
- Groundwater discharges at the spring as a result of topography and the presence of a sand/gravel pocket.

13.10 Delineation of Source Protection Areas

13.10.1 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.

13.10.2 Outer Protection Area

The Outer Protection Area (SO) is bounded by the complete catchment area to the source, i.e. **the zone of contribution (ZOC)**, which is defined as the area required to support an abstraction from long-term recharge. The ZOC is controlled primarily by (a) the total discharge, (b) the groundwater flow direction and gradient, (c) the subsoil and rock permeability and (d) the recharge in the area. The ZOC is delineated using both analytical modelling and the results of hydrogeological mapping and conceptualisation. Given the limited amount of calibration data available, a full groundwater numerical model was not undertaken. The resulting boundaries are presented in Map 8 and are described as follows:

The **Eastern Boundary** is defined using topography. A ridge runs from Cupidstown Hill through Cromwellstown Hill and then onto Saggart Hill/Slievethoul, creating a watershed between water flowing east to the Brittas river and water flowing toward the springs and the Slane river.

The **Western boundary** is constrained by the location of the springs itself. Groundwater to the west of the spring cannot flow to the spring as the groundwater is downgradient on the western side of the spring. An arbitrary buffer of 50 m is placed on the downgradient side of the spring.

The **Northern** and **Southern** boundaries were delineated to link the spring to the watershed at Cupidstown Hill, using topographic ridges, ensuring that;

- The final width of the ZOC at the watershed was no less than the width predicted by the uniform flow equation (100 m).
- The total area of the ZOC was no less than that predicted by the water balance. Assuming an average annual recharge of 110 mm/year, the recharge area required to balance the spring flow is estimated to be 0.3 km^2. The spring flow used in this calculation was derived by increasing measured flows by 50% to allow for an expansion of the ZOC during dry weather.
- The limits of the ZOC equated to or exceeded a distance of 50 m in all directions from the spring.

13.10.3 Inner Protection Area

According to “Groundwater Protection Schemes” (DELG/EPA/GSI, 1999), delineation of an Inner Protection Area is required to protect the source from microbial and viral contamination and it is based on the 100-day time of travel (ToT) to the supply. Estimations of the extent of this area are made by hydrogeological mapping and analytical modelling. A permeability (K) value of 1 m d^{-1}, porosity (n) of 0.015 and a gradient (i) of 0.05 were used to estimate the velocity (V) as follows;

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

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

Thus the 100-day time of travel is estimated to be 300 m.

13.11 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. Four groundwater protection zones are present around the source. The final groundwater protection zones are shown in Map 8.

Table 14 Matrix of Source Protection Zones around the Kilteel source.

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

13.12 Potential Pollution Sources

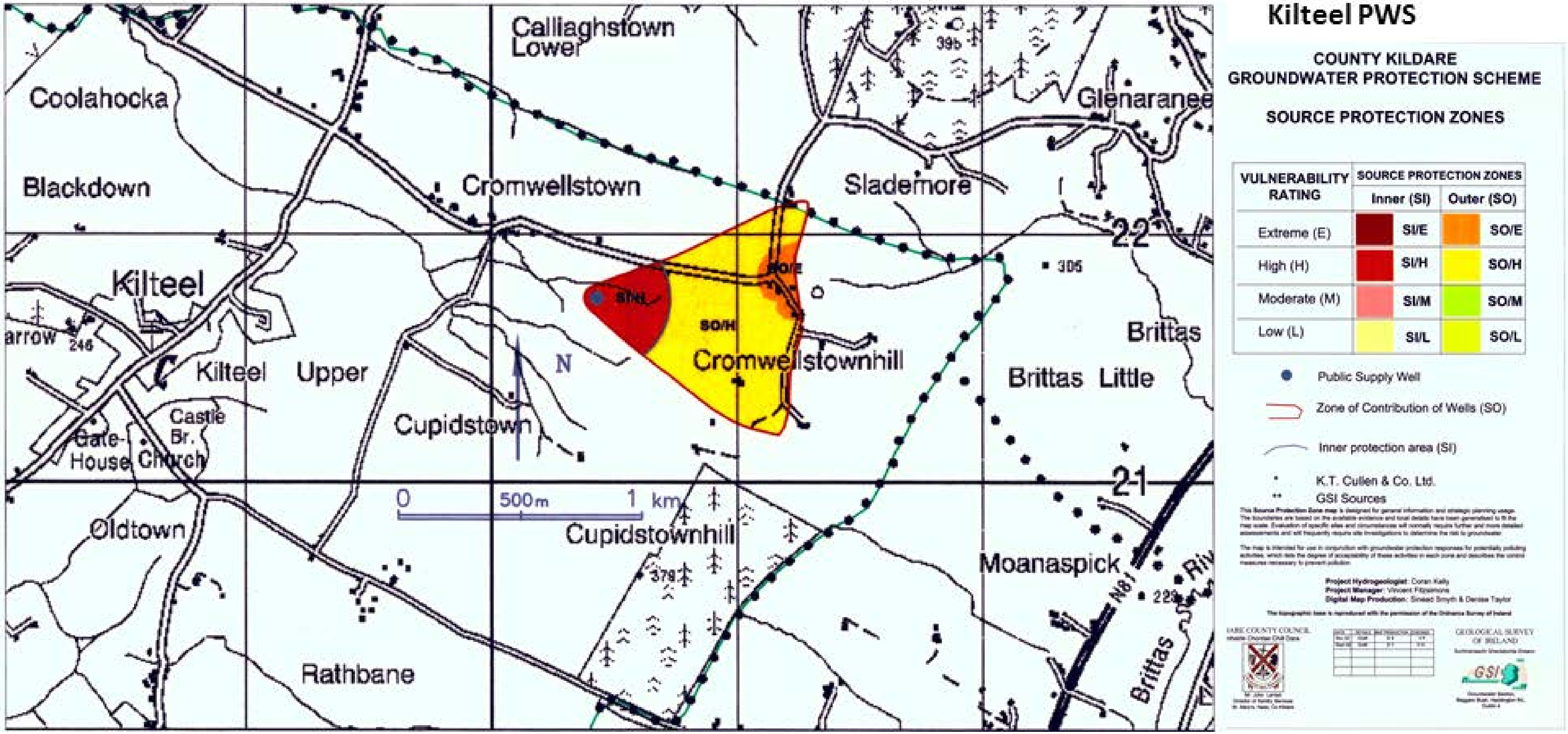
Land use in the area is described in Section 13.5. The land around the source is grassland dominated, used for cattle and sheep. Agricultural activities, septic tanks, road spillages and waste petroleum products from the quarry are the principal potential hazards to the water quality in the area. As discussed in Section 13.8.4, available water quality data provide no evidence of significant domestic and agricultural impacts on water quality at the source at present. However, nitrate levels are slightly elevated. Given the small discharge at the spring, the potential for dilution is low and these nitrate levels would rise rapidly to significant levels with only a slight increase in, for example, landspreading loading rates or the number of domestic wastewater treatment systems in the source protection areas.

13.13 Conclusions and Recommendations

- The source is a small supply and is extremely to highly vulnerable to contamination.

- 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. A full chemical and bacteriological analysis of the **raw** water is carried out on a regular basis. The range of analytes should be expanded to include possible contaminants from quarrying and associated activities.
    2. particular care should be taken when assessing the location of any activities or developments which might cause contamination at the well, particularly with relation to nitrates and microbial pathogens.
    3. Well head protection is improved with fencing and proper capping.
    4. The supply is chlorinated.



Map 8 Kilteel Source Protection Zones

16 References

Ball, D. (1995). Pump tests and pump selection, Hare Park Pumping Station, The Curragh Camp, Co. Kildare.

British Standards Institution. 1999. BS 5930:1999, Code of practice for site investigations. British Standards Institution, London.

Buckley, R., Fitzsimons, V., Hegarty, S., Gately, C. (2002). County Kilkenny Groundwater Protection Scheme. GSI report for Kilkenny Council, 167pp.

Burdon, D. (1983). Irish Geothermal Project. Phase I (June 1981 – March 1983). Minerex Ltd report for the Geological Survey of Ireland.

Collins, J.F. and Cummins, T. (1996). Agroclimatic Atlas of Ireland. AGMET – Joint working group on Applied Agricultural Meteorology, Dublin.

Conry, M. J., Hammond, R. F. and T. O'Shea, 1970. *Soils of County Kildare.* National Soil Survey of Ireland, An Foras Taluntais, 92pp.

Cullen K.T., 2001. Environmental Impact Statement for Groundwater Abstraction from North Kildare Aquifer, Robertstown, Co. Kildare. Kildare County Council Report.

Cullen K.T., 2002. Environmental Report for Groundwater Abstraction from Allenwood Limestone Aquifer at Rathangan, Co. Kildare. Kildare County Council Report.

Daly, D., 1981. Pollardstown Fen. Hydrogeological Assessment of the Effects of Drainage on the Water Supply to the Grand Canal. Internal Report, Geological Survey of Ireland, 40pp.

Daly, D., Cronin, C., Coxon, C., Burns, S.J. 1998. *Offaly Groundwater Protection Scheme*. Geological Survey of Ireland. 78pp.

Daly, D. (1994). Chemical Pollutants in Groundwater: a Review of the Situation in Ireland. Paper presented at *Conference "Chemicals – a Cause for Concern?"* in Cork, 3-4 November 1994.

Daly, D., Moore, B., Meehan, R., Murphy, G., Fitzsimons, V., Clenaghan, C., Beirne, M., Carty, G., O'Leary, G., O'Dwyer, R. 2000. *Site Suitability Assessments for On-site Wastewater Treatment Systems: Course Manual*. FÁS and Geological Survey of Ireland.

Daly, E.P., (1981). Nitrate Levels in the aquifers of the Barrow River Valley. Internal Groundwater Section Report. Geological Survey of Ireland.

Daly, E.P., (1983). Water in the Landscape: Groundwater Resources in Laois. In: "Laois, an environmental history". Ed. Feehan, J. Ballykilcavan Press.

Daly, E.P., (1985). Hydrogeology. In : "The Quaternary History of Ireland". Ed. Edwards, K.J. and Warren, W.P. Academic Press. 382pp.

Daly, E.P., (1987). Water Sources for Athy, Co. Kildare: Possible contamination by a pollution incident in the River Barrow, August 1987. GSI report for Athy TC.

Daly, E.P. (1995). The Principal Characteristics of the Flow Regime in Irish Aquifers. Paper presented at the 15th Annual Groundwater Seminar held in Portlaoise, on: The Role of Groundwater in Sustainable Development. Published by: IAH (Irish Group).

Daly, E.P., (2002). Draft Report on: Trial & Production Wells, Athy TC.

Deakin, J., Fitzsimons, V., Gately, C., Wright, G. 2002. *Laois Groundwater Protection Scheme.* Geological Survey of Ireland.

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

EOLAS (1992). Bottled Water. National Standards Authority of Ireland, **IS 432:1992.**

Glanville, C., (1997) The quaternary geology of Co. Kildare, map descriptions for relevant 1:25,000 sheets. GSI report.

Fitzgerald, D. and Forrestal, F. (1996). Monthly and Annual Averages of Rainfall for Ireland 1961-1990. Meteorological Service, Climatological Note No. 10, TC 551.577.2(415).

Fitzsimons, V. And Wright G.R.W (2000). Durrow (Convent) Water Supply Scheme. Groundwater Source Protection Zones. Draft Unpublished GSI Report Produced For Laois County Council.

Flanagan, P.J. (1992). Parameters of Water Quality: Interpretation and Standards. Second Edition. Environmental Research Unit, **ISBN 1 85053 095 5**

Hayes, T., Sutton, S., Cullen, K. and Faherty, J. (2001). The Curragh Aquifer. Current Conceptual Understanding & Numerical Modelling. Paper presented at the Proceedings of the Annual Groundwater Seminar, IAH (Irish Group) 16th-17th October 2001 Tullamore.

Irish Geotechnical Services (IGSL) 1983 *"Report on a groundwater investigation for Gormanstown/Kildare Group Water Scheme"* Report No.571.

K. T. Cullen - White Young Green Ltd, 2000. Groundwater Abstraction at Kilkea Lodge Farm.

Lee, M., 1999. Surface indicators and land use as secondary indicators of groundwater recharge and vulnerability. Unpublished (Research) MSc thesis. Department of Civil, Structural and Environmental Engineering, Trinity College Dublin.

Long, M. and Mc Cullen, P. (1999) *Arthurstown Landfill Facility: Geotechnical Site Characterisation.* A paper presented to a joint meeting of the Water & Environment Section and The Geotechnical Society of the Institution of Engineers of Ireland on March 9th 1999.

Mc Connell, B., Philcox, M., A.G. Sleeman, G. Stanley, A.M. Flegg, E. P. Daly and W.P. Warren. 1994. *A Geological description to accompany the Bedrock Geology 1:100,000 Scale Map Series, Sheet 16, Kildare-Wicklow*, Geological Survey of Ireland, 70 pp.

O Suilleabhain C. (2000). Assessing the Boundary Between High and Moderately Permeable Subsoils. Unpublished MSc thesis. Department of Civil, Structural and Environmental Engineering, Trinity College Dublin.

Swartz, M. (1999). Assessing the Permeability of Irish Subsoils. Unpublished (Research) MSc thesis. Department of Civil, Structural, and Environmental Engineering, Trinity College Dublin.

Tietzsch-Tyler, D. and Sleeman, A.G. (1994a). Geology of Carlow - Wexford. A geological description to accompany the Bedrock Geology 1:100,000 map series, Sheet 19, Carlow - Wexford. With contributions by B.J. McConnell, E.P. Daly, A.M. Flegg, P.J. O'Connor and W.P. Warren. Edited by B. McConnell. Geological Survey of Ireland.

Wright *et al*, 1982. *Groundwater Resources in the Republic of Ireland.* Geological Survey of Ireland.

Woods, L., Meehan, R., Wright, G. (1998). *County Meath Groundwater Protection Scheme.* GSI report for Meath County Council, 54pp.

Wright, G.R., (1988). *The Mid-Kildare sand/gravel Aquifer*. Paper presented to the IAH Irish Group, 8th annual seminar, Portlaoise, 10pp.

Wright, G.R. (2000). *QSC Graphs: and Aid to Classification of Data-poor Aquifers in Ireland*. From: Robins, N.S. and Misstear, B.D.R. (eds.) Groundwater in the Celtic Regions: Studies in Hard Rock and Quaternary Hydrogeology. Geological Society, London, Special Publications, **182**. The Geological Society of London 2000.

Wright, G.R. and Woods, L. (2001). *County Wicklow Groundwater Protection Scheme* (Draft). Unpublished GSI report produced for Wicklow County Council.

Appendix IV: Discussion Of the Key Indicators of Domestic and Agricultural Contamination of Groundwater

A.1 Introduction

This appendix is adapted from Daly, 1996.

There has been a tendency in analysing groundwater samples to test for a limited number of constituents. A "full" or "complete" analysis, which includes all the major anions and cations, is generally recommended for routine monitoring and for assessing pollution incidents. This enables (i) a check on the reliability of the analysis (by doing an ionic balance), (ii) a proper assessment of the water chemistry and quality and (iii) a possible indication of the source of contamination. A listing of recommended and optional parameters are given in Table A1. It is also important that the water samples taken for analysis have not been chlorinated - this is a difficulty in some local authority areas where water take-off points prior to chlorination have not been installed.

The following parameters are good contamination indicators: E.coli, nitrate, ammonia, potassium, chloride, iron, manganese and trace organics.

TABLE A1

Recommended Parameters

Appearance
Sediment
pH (lab)
Electrical Conductivity (EC)*
Total Hardness
General coliform
E. coli *

Calcium (Ca)
Magnesium (Mg)
Sodium (Na)
Potassium (K)*
Chloride Cl)*
Sulphate ($S0_4$)*
Alkalinity

Nitrate ($N0_3$)*
Ammonia ($NH_4$and NH_3)*
Iron (Fe)*
Manganese (Mn)*

Optional Parameters (depending on local circumstances or reasons for sampling)

Fluoride (F)
Orthophosphate
Nitrite ($N0_2$)*
B.O.D.*
Dissolved Oxygen *

Fatty acids *
Trace organics *
TOC *
Boron (B) *
Cadmium (Cd)

Zinc (Zn)
Copper (Cu)
Lead (Pb)
Other metals

*** good indicators of contamination**

A.2 Faecal Bacteria and Viruses

E. coli is the parameter tested as an indicator of the presence of faecal bacteria and perhaps viruses; constituents which pose a significant risk to human health. The most common health problem arising from the presence of faecal bacteria in groundwater is diarrhoea, but typhoid fever, infectious hepatitis and gastrointestinal infections can also occur. Although E. coli bacteria are an excellent indicator of pollution, they can come from different sources - septic tank effluent, farmyard waste, landfill sites, birds. The faecal coliform : faecal streptococci ratio has been suggested as a tentative indicator to distinguish between animal and human waste sources (Henry *et al.*, 1987). However, researchers in Virginia Tech (Reneau, 1996) cautioned against the use of this technique.

Viruses are a particular cause for concern as they survive longer in groundwater than indicator bacteria (Gerba and Bitton, 1984).

The published data on elimination of bacteria and viruses in groundwater has been compiled by Pekdeger and Matthess (1983), who show that in different investigations 99.9% elimination of *E. coli* occurred after 10-15 days. The mean of the evaluated investigations was 25 days. They show that 99.9% elimination of various viruses occurred after 16-120 days, with a mean of 35 days for Polio-, Hepatitis, and Enteroviruses. According to Armon and Kott (1994), pathogenic bacteria can survive for more than ten days under adverse conditions and up to 100 days under favourable conditions; entertoviruses can survive from about 25 days up to 170 days in soils.

Bacteria can move considerable distances in the subsurface, given the right conditions. In a sand and gravel aquifer, coliform bacteria were isolated 100 ft from the source 35 hours after the sewage was introduced (as reported in Hagedorn et al., 1981). They can travel several kilometres in karstic aquifers. In Ireland, research at Sligo RTC involved examining in detail the impact of septic tank systems at three locations with different site conditions (Henry, 1990; summarised in Daly, Thorn and Henry, 1993). Piezometers were installed down-gradient; the distances of the furthest piezometers were 8 m,10 m and 9.5 m, respectively. Unsurprisingly, high faecal bacteria counts were obtained in the piezometers at the two sites with soakage pits, one with limestone bedrock at a shallow depth where the highest count (max. 14 000 cfu's per 1000 ml) and the second where sand/gravel over limestone was present (max 3 000 cfu's per 100 ml). At the third site, a percolation area was installed at 1.0 m b.g.l; the subsoils between the percolation pipes and the fractured bedrock consisted of 1.5 m sandy loam over 3.5 m of poorly sorted gravel; the water table was 3.5 b.g.l. (So this site would satisfy the water table and depth to rock requirements of S.R.6:1991, and most likely the percolation test requirement.) Yet, the maximum faecal coliform bacteria count was 300 cfus per 100 ml. Faecal streptocci were present in all three piezometers. It is highly likely that wells located 30 m down gradient of the drainage fields would be polluted by faecal bacteria.

As viruses are smaller than bacteria, they are not readily filtered out as effluent moves through the ground. The main means of attenuation is by adsorption on clay particles. Viruses can travel considerable distances underground, depths as great as 67 m and horizontal migrations as far as 400 m have been reported (as reported in US EPA, 1987). The possible presence of viruses in groundwater as a result of pollution by septic tank systems is a matter of concern because of their mobility and the fact that indicator bacteria such faecal coliforms have been found not to correlate with the presence of viruses in groundwater samples (US EPA, 1987).

The natural environment, in particular the soils and subsoils, can be effective in removing bacteria and viruses by predation, filtration and absorption. There are two high risk situations: (i) where permeable sands and gravels with a shallow water table are present; and (ii) where fractured rock, particularly limestone, is present close to the ground surface. The presence of clayey gravels, tills, and peat will, in many instances, hinder the vertical migration of microbes, although preferential flow paths, such as cracks in clayey materials, can allow rapid movement and bypassing of the subsoil.

A.3 Nitrate

Nitrate is one of the most common contaminants identified in groundwater and increasing concentrations have been recorded in many developed countries. The consumption of nitrate rich water by young children may give rise to a condition known as methaemoglobinaemia (blue baby syndrome). The formation of carcinogenic nitrosamines is also a possible health hazard and epidemiological studies have indicated a positive correlation between nitrate consumption in drinking water and the incidence of gastric cancer. However, the correlation is not proven according to some experts (Wild and Cameron, 1980). The EC MAC for drinking water is 50mg/l.

The nitrate ion is not adsorbed on clay or organic matter. It is highly mobile and under wet conditions is easily leached out of the rooting zone and through soil and permeable subsoil. As the normal concentrations in uncontaminated groundwater is low (less than 5 mg/l), nitrate can be a good indicator of contamination by fertilisers and waste organic matter.

In the past there has been a tendency in Ireland to assume that the presence of high nitrates in well water indicated an impact by inorganic fertilisers. This assumption has frequently been wrong, as examination of other constituents in the water showed that organic wastes - usually farmyard waste, probably soiled water - were the source. The nitrate concentrations in wells with a low abstraction rate - domestic and farm wells - can readily be influenced by soiled water seeping underground in the vicinity of the farmyard or from the spraying of soiled water on adjoining land. Even septic tank effluent can raise the nitrate levels; if a septic tank system is in the zone of contribution of a well, a four-fold dilution of the nitrogen in the effluent is needed to bring the concentration of nitrate below the EU MAC (as the EU limit is 50 mg/l as NO_3 or 11.3 mg/l as N and assuming that the N concentration in septic tank effluent is 45 mg/l).

The recently produced draft county reports by the EPA on nitrate in groundwater show high levels of nitrate in a significant number of public and group scheme supplies, particularly in south and southern counties and in counties with intensive agriculture, such as Carlow and Louth. This suggest that diffuse sources – landspreading of fertilisers – is having an impact on groundwater.

In assessing regional groundwater quality and, in particular the nitrate levels in groundwater, it is important that:

(i) conclusions should not be drawn using data only from private wells, which are frequently located near potential point pollution sources and from which only a small quantity of groundwater is abstracted;

(ii) account should be taken of the complete chemistry of the sample and not just nitrate, as well as the presence of *E. coli.*;

(iii) account should be taken of not only the land-use in the area but also the location of point pollution sources;

(iv) account should be taken of the regional hydrogeology and the relationship of this to the well itself. For instance, shallow wells generally show higher nitrate concentrations than deeper wells, low permeability sediments can cause denitrification, knowledge on the groundwater flow direction is needed to assess the influence of land-use.

A.4 Ammonia

Ammonia has a low mobility in soil and subsoil and its presence at concentrations greater than 0.1 mg/l in groundwater indicates a nearby waste source and/or vulnerable conditions. The EU MAC is 0.3 mg/l.

A.5 Potassium

Potassium (K) is relatively immobile in soil and subsoil. Consequently the spreading of manure, slurry and inorganic fertilisers is unlikely to significantly increase the potassium concentrations in groundwater. In most areas in Ireland, the background potassium levels in groundwater are less than 3.0 mg/l. Higher concentrations are found occasionally where the rock contains potassium e.g. certain granites and sandstones. The background potassium:sodium ratio in most Irish groundwaters is less than 0.4 and often 0.3. The K:Na ratio of soiled water and other wastes derived from plant organic matter is considerably greater than 0.4, whereas the ratio in septic tank effluent is less than 0.2. Consequently a K:Na ratio greater than 0.4 can be used to indicate contamination by plant organic matter - usually in farmyards, occasionally landfill sites (from the breakdown of paper). However, a K:Na ratio lower than 0.4 does not indicate that farmyard wastes are **not** the source of contamination (or that a septic tank is the cause), as K is less mobile than Na. (Phosphorus is increasingly a significant pollutant and cause of eutrophication in surface water. It is not a problem in groundwater as it usually is not mobile in soil and subsoil).

A.6 Chloride

The principle source of chloride in uncontaminated groundwater is rainfall and so in any region, depending on the distance from the sea and evapotranspiration, chloride levels in groundwater will be fairly constant. Chloride, like nitrate, is a mobile cation. Also, it is a constituent of organic wastes. Consequently, levels appreciably above background levels (12-15 mg/l in Co. Offaly, for instance) have been taken to indicate contamination by organic wastes such as septic tank systems. While this is probably broadly correct, Sherwood (1991) has pointed out that chloride can also be derived from potassium fertilisers.

A.7 Iron and manganese

Although they are present under natural conditions in groundwater in some areas, they can also be good indicators of contamination by organic wastes. Effluent from the wastes cause deoxygenation in the ground which results in dissolution of iron (Fe) and manganese (Mn) from the soil, subsoil and bedrock into groundwater. With reoxygenation in the well or water supply system the Fe and Mn precipitate. High Mn concentrations can be a good indicator of pollution by silage effluent. However, it can also be caused by other high BOD wastes such as milk, landfill leachate and perhaps soiled water and septic tank effluent.

Box A1 Warning/trigger Levels for Certain Contaminants

As human activities have had some impact on a high proportion of the groundwater in Ireland, there are few areas where the groundwater is in a pristine, completely natural condition. Consequently, most groundwater is contaminated to some degree although it is usually not polluted. In the view of the GSI, assessments of the degree of contamination of groundwater can be beneficial as an addition to examining whether the water is polluted or not. This type of assessment can indicate where appreciable impacts are occurring. It can act as a warning that either the situation could worsen and so needs regular monitoring and careful land-use planning, or that there may be periods when the source is polluted and poses a risk to human health and as a consequence needs regular monitoring. Consequently, thresholds for certain parameters can be used to help indicate situations where additional monitoring and/or source protection studies and/or hazard surveys may be appropriate to identify or prevent more significant water quality problems.

Parameter	**Threshold** mg/l	**EU MAC** mg/l
Nitrate	25	50
Potassium	4	12
Chloride	30 (except near sea)	250
Ammonia	0.15	0.3
K/Na ratio	0.3-0.4	
Faecal bacteria	0	0

Box A2 Summary : Assessing a Problem Area

Let us assume that you are examining an area with potential groundwater contamination problems and that you have taken samples in nearby wells. How can the analyses be assessed?

E. coli present ⇨ organic waste source nearby (except in karst areas), usually either a septic tank system or farmyard.
E. coli absent ⇨ either not polluted by organic waste or bacteria have not survived due to attenuation or time of travel to well greater than 100 days.
Nitrate > 25 mg/l ⇨ either inorganic fertiliser or organic waste source; check other parameters.
Ammonia > 0.15 mg/l ⇨ source is nearby organic waste; fertiliser is not an issue.
Potassium (K) > 5.0 mg/l ⇨ source is probably organic waste.
K/Na ratio > 0.4 (0.3, in many areas) ⇨ Farmyard waste rather than septic tank effluent is the source. If < 0.3, no conclusion is possible.
Chloride > 30 mg/l ⇨ organic waste source. However this does not apply in the vicinity of the coast (within 20 km at least).

In conclusion, faecal bacteria, nitrate, ammonia, high K/Na ratio and chloride indicate contamination by organic waste. However, only the high K/Na helps distinguish between septic tank effluent and farmyard wastes. So in many instances, while the analyses can show potential problems, other information is needed to complete the assessment.

A.8 References

Armon, R. and Kott, Y., 1994. The health dimension of groundwater contamination. In: Zoller, U. (Editor), Groundwater Contamination and Control. Published by Marcel, Dekker, Inc., pp71-86.

Daly, D. 1996. Groundwater in Ireland. Course notes for Higher Diploma in Environmental Engineering, UCC.

Daly, D., Thorn, R. and Henry, H., 1993. Septic tank systems and groundwater in Ireland. Geological Survey Report Series RS 93/1, 30pp.

Gerba, C.P. and Bitton, G., 1984. Microbial pollutants : their survival and transport pattern to groundwater. In : G.Bitton and C.P. Gerba (Editors), Groundwater Pollution Microbiology, Wiley - Intersciences Publishers, pp 65-88.

Hagedorn, C., McCoy, E.L. and Rahe, T. M. 1981. The potential for ground water contamination form septic tank effluents. Journal of Environmental Quality, volume 10, no. 1, p1-8.

Henry, H. (1990). An Evaluation of Septic Tank Effluent Movement in Soil and Groundwater Systems. Ph.D. Thesis. Sligo Regional Technical College. National Council for Education Awards - Dublin.

Reneau, R.B. 1996. Personal communication. Virginia Polytechnic Institute and State University.

Sherwood, M., 1991. Personal communication, Environmental Protection Agency.

US EPA. 1987. Guidelines for delineation of wellhead protection areas. Office of Ground-water Protection, U.S. Environmental Protection Agency.

Wild, A. and Cameron, K.C., 1980. Nitrate leaching through soil and environmental considerations with special reference to recent work in the United Kingdom. Soil Nitrogen - Fertilizer or Pollutant, IAEA Publishers, Vienna, pp 289-306.

APPENDIX V: Laboratory analytical results

Location	County	Plot_no	location	Scheme	details	NGR	Easting	Northing	type	LAB	LAB_REF	date	pH	pH_field	Temp(O c)	Temp_Field (O c	Odour	Dslvd oxgen %sat	DO_field (mg/l)	DO_field (%sat)	BOD(mg/l O2)	Conduct (us/cm)	conduct_field_u	Location	Ammonia (mg/l N)	O-Phosphate (mg)	TON (mg/l N)	Nitrate (mg/l N	Nitrate (mg/l NO)	Nitrite (mg/l N	alkalinity(mg/l	Chloride (mg/lCl)	Flouride (mg/lF)	TOTL_HARD(mg/l)	Faecal_ Coliform	lab2_bact	Sulphate (mg/l S)	Sulphide (mg/l S)	Sodium (mg/l Na)	Potassium (mg/l)	Magnesium (mg/l)	Copper (mg/l Cu)	Calcium (mg/l Ca)	Iron (mg/l Fe)	Manganese (mg/l
Castledermot WS	KID	6	Castledermot WS	Castledermot @ Plunketstown		S805860	280527	186017	Bore	DUB	3718	11/21/95	7.29		nda		nda	nda			nda	718		Castledermot WS	<0.005	0.015	6.704	7.34	32.50152	nda	318	17.38	nda	nda	nda		16.2	nda	7.67	1.93	13.84	nda	110.53	0.0113	0.0025
Castledermot WS	KID	6	Castledermot WS	Castledermot @ Plunketstown		S805860	280527	186017	Bore	DUB	2988	08/21/96	7.12		nda		nda	nda			nda	683		Castledermot WS	<0.01	0.012	7.621	nda	33.74*	nda	302	17.87	nda	nda	nda		12.7	nda	8.04	1.68	13.1	nda	113.54	0.236	<0.0005
Castledermot WS	KID	6	Castledermot WS	Castledermot @ Plunketstown		S805860	280527	186017	Bore	DUB	4095	11/20/96	7.36		nda		nda	nda			nda	712		Castledermot WS	<0.01	0.0215	8.609	nda	38.13*	nda	316	18.1	nda	nda	nda		14.12	nda	7.09	2.17	9.2	nda	120.6	0.0633	0.002
Castledermot WS	KID	6	Castledermot WS	Castledermot @ Plunketstown		S805860	280527	186017	Bore	DUB	4342	11/05/97	7.24		nda		nda	nda			nda	652		Castledermot WS	0.018	0.018	8.107	nda	35.91*	nda	314	18.429	nda	nda	nda		16.089	nda	7.739	0.496	14.016	nda	127.451	0.067	0.007
Castledermot WS	KID	6	Castledermot WS	Castledermot @ Plunketstown		S805860	280527	186017	Bore	DUB	666	02/11/98	7.32		nda		nda	nda			nda	583		Castledermot WS	<0.01	0.00929	8.195	nda	36.31*	nda	289	17	nda	nda	nda		11.9	nda	9.5	1.4	15.2	nda	117	0.0165	<0.0005
Castledermot WS	KID	6	Castledermot WS	Castledermot @ Plunketstown		S805860	280527	186017	Bore	DUB	3184	09/10/98	7.51		nda		nda	nda			nda	599		Castledermot WS	2.589	0.0901	9.329	nda	41.31*	nda	273	18.9	nda	nda	nda		13.2	nda	10.4	11.7	13.8	nda	101.8	0.0513	0.009
Castledermot WS	KID	6	Castledermot WS			S805860	280527	186017	Bore	DUB	116	01/14/99	7.4	nda	9.3	9.3	nda	nda		9.48	85.3	nda	609	nda	Castledermot WS	<0.01	0.01127	9.49	nda	42.02*	nda	296	nda	nda	nda	nda		nda	nda	nda	nda	nda	nda	nda	0.0281	<0.0005
Castledermot WS	KID	6	Castledermot WS			S805860	280527	186017	Bore	DUB	3211	10/12/99	7.89	nda	10.1	10.1	nda	nda	nda			nda	356	430	Castledermot WS	0.016	1.32639	2.74	nda	12.13*	nda	156	13.8	nda	nda	nda		10.18	nda	13.67	2.81	6.39	nda	62.6	0.0535	0.0105
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	3014	08/22/96	7.39		nda		nda	nda			nda	799		Kilberry Area WS	<0.01	0.009	10.559	nda	46.76*	nda	308	38.63	nda	nda	nda		38.28	nda	12.19	1.61	12.23	nda	135.54	0.128	0.0058
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	4079	11/19/96	7.54		nda		nda	nda			nda	820		Kilberry Area WS	<0.01	0.009	9.934	nda	43.97*	nda	310	35.86	nda	nda	nda		40.56	nda	12.37	2.51	9.72	nda	147	0.182	0.0058
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	4329	11/04/97	7.21		nda		nda	nda			nda	700		Kilberry Area WS	<0.01	0.008	10.756	nda	47.64*	nda	294	54.646	nda	nda	nda		42.341	nda	20.458	3.92	15.154	nda	146.189	<0.001	0.0028
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	695	02/12/98	7.25		nda		nda	nda			nda	750		Kilberry Area WS	<0.01	0.007	14.407	nda	63.81*	nda	308	42.8	nda	nda	nda		30.7	nda	13.1	1.7	14.7	nda	148.1	0.0067	0.0014
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	3152	09/08/98	7.12		nda		nda	nda			nda	742		Kilberry Area WS	<0.01	0.0096	10.84	nda	48.0*	nda	311	35.1	nda	nda	nda		33.8	nda	14.8	1.8	14.7	nda	140.4	<0.01	0.0021
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	57	01/12/99	7.29	nda	10.9	10.9	nda	nda		6.97	64	nda	742	nda	Kilberry Area WS	<0.01	0.009	12.294	nda	54.42*	nda	303	54.8	nda	nda	nda		37.5	nda	15.8	2.3	16.8	nda	171.2	0.0115	0.0025
Kilberry Area WS	KID	9	Kilberry Area WS			N662000	266200	200000	Bore	DUB	2775	09/20/99	7.13	nda	12.4	12.4	nda	nda		6.1		nda	749	936	Kilberry Area WS	<0.01	0.006	9.174	nda	40.60*	nda	314	35	nda	nda	nda		37.1	nda	15.4	2.07	15.03	nda	144.1	0.0081	0.0037
Kilberry area WS	KID	9	Kilberry area WS			N662000	266200	200000	Bore	DUB	726	02/09/00	7.25	nda	10.4	10.4	nda	nda		8.45		nda	751	849	Kilberry area WS	<0.01	0.01	9.44	nda	41.80*	nda	276	33.6	nda	nda	nda		30.4	nda	14.62	1.61	14.24	nda	140.4	<0.02	0.0042
Kilberry area WS	KID	9	Kilberry area WS			N662000	266200	200000	Bore	DUB	5809	11/21/00	7.443	nda	11.7	11.7	nda	6.24	6.24		nda	833	862	Kilberry area WS	0.02	0.005558	6.745	nda	29.87*	nda	241	34.4	nda	nda	<1	DCORP	31.7	nda	11.6	<1	14.5	nda	126.5	<0.05	0.0024
Kilberry area WS	KID	9	Kilberry area WS			N662000	266200	200000	Bore	DUB	1467	04/04/01	7.161	nda	9	9	nda	7.11	7.11		nda	856	893	Kilberry area WS	<0.01	0.023987	10.801	nda	47.83*	nda	305	43.1	nda	nda	<1	DCORP	31	nda	14.87	0.55	13.86	nda	136.6	<0.05	0.0024
Monasterevin WS(spring@Hybla)	KID	14	Monasterevin WS(spring@Hybla)			N642125	264230	212502	Spring	DUB	3167	09/09/98	7.38		nda		nda	nda			nda	611		Monasterevin WS(spring@Hybla)	<0.01	0.009	3.247	nda	14.38*	nda	303	13.4	nda	nda	nda		18.7	nda	8.9	1.3	26.4	nda	103.3	0.0149	<0.0005
Monasterevin WS(spring@Hybla)	KID	14	Monasterevin WS(spring@Hybla)			N642125	264230	212502	Spring	DUB	92	01/13/99	7.54	nda	9.5	11.2	nda	nda		2.42	23	nda	597	nda	Monasterevin WS(spring@Hybla)	<0.01	0.011	3.134	nda	13.88*	nda	315	18.3	nda	nda	nda		25.3	nda	10.2	1.4	31.2	nda	131.4	0.0458	0.0025
Monasterevin WS(spring@Hybla)	KID	14	Monasterevin WS(spring@Hybla)			N642125	264230	212502	Spring	DUB	3202	10/11/99	7.45	nda	11.2	11.2	nda	nda	nda			nda	614	758	Monasterevin WS(spring@Hybla)	<0.01	0.006	3.42	nda	15.14*	nda	334	16.34	nda	nda	nda		19.7	nda	8.47	1.19	27.6	nda	111.2	0.0097	0.0025
Monasterevin WS(spring@Hybla)	KID	14	Monasterevin WS(spring@Hybla)			N642125	264230	212502	Spring	DUB	724	02/09/00	7.36	nda	9.9	9.9	nda	nda		5.35		nda	651	728	Monasterevin WS(spring@Hybla)	<0.01	<0.005	3.11	nda	13.77*	nda	299	17.4	nda	nda	nda		20.5	nda	8.84	1.18	26.8	nda	109.8	0.0201	0.0032
Monasterevin WS(spring@Hybla)	KID	14	Monasterevin WS(spring@Hybla)			N642125	264230	212502	Spring	DUB	5811	11/21/00	7.467	nda	9.9	9.9	nda	4.15	4.15		nda	693	717	Monasterevin WS(spring@Hybla)	<0.01	<0.005	2.226	nda	9.86*	nda	240	13.9	nda	nda	<1	DCORP	19.5	nda	6.9	<1	26.2	nda	96.5	<0.05	0.0046
Monasterevin WS(spring@Hybla)	KID	14	Monasterevin WS(spring@Hybla)			N642125	264230	212502	Spring	DUB	1469	04/04/01	7.33	nda	9.3	9.3	nda	4.92	4.92		nda	695	723	Monasterevin WS(spring@Hybla)	0.04	0.018274	3.27	nda	14.48*	nda	310	11.08	nda	nda	<1	DCORP	20.2	nda	9.3	0.2	28.8	nda	103.1	0.0698	0.0019
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		N642125	264354	203229	Bore	DUB	3716	11/21/95	7.25		nda		nda	nda			nda	804		Monastrevin WS (BH No.1(Ballykelly))	<0.005	0.009	6.012	6.27	27.76356	nda	320	19.52	nda	nda	nda		57.66	nda	9.36	2.14	31.88	nda	109.29	0.0066	0.0494
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		N642125	264230	212502	Bore	DUB	3012	08/22/96	7.2		nda		nda	nda			nda	837		Monastrevin WS (BH No.1(Ballykelly))	<0.01	0.006	8.175	nda	36.22*	nda	348	21.28	nda	nda	nda		61.05	nda	7.88	1.71	30.18	nda	127.13	0.0926	0.0149
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		N642125	264230	212502	Bore	DUB	4081	11/19/96	7.2		nda		nda	nda			nda	857		Monastrevin WS (BH No.1(Ballykelly))	<0.01	0.007	8.154	nda	36.09*	nda	356	21.24	nda	nda	nda		64.18	nda	8.59	1.96	32.55	nda	143.8	0.0081	0.0143
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		S642125	264230	212502	Bore	DUB	3166	09/09/98	7.19		nda		nda	nda			nda	759		Monastrevin WS (BH No.1(Ballykelly))	<0.01	0.009	8.437	nda	37.37*	nda	341	20.9	nda	nda	nda		61.7	nda	10.4	2.3	31.3	nda	130.1	0.0142	0.0173
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		S642125	264230	212502	Bore	DUB	91	01/13/99	7.28	nda	11.2	10.8	nda	nda		7.28	67.7	nda	753	nda	Monastrevin WS (BH No.1(Ballykelly))	<0.01	0.009	7.779	nda	34.45*	nda	337	24.8	nda	nda	nda		77.6	nda	11.4	2.9	35.8	nda	162	0.0063	0.0225
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		S642125	264230	212502	Bore	DUB	5812	11/21/00	7.319	nda	10.8	10.8	nda	nda	nda			nda	880	911	Monastrevin WS (BH No.1(Ballykelly))	0.059	<0.005	4.077	nda	18.05*	nda	257	19.2	nda	nda	<1	DCORP	74.3	nda	8.2	1.4	31.4	nda	130.2	<0.05	0.0629
Monastrevin WS (BH No.1(Ballykelly))	KID	15	Monastrevin WS (BH No.1(Ballykelly))	Ballykelly		S642125	264230	212502	Bore	DUB	1470	04/04/01	7.202	nda	10.7	10.7	nda	5.36	5.36		nda	871	911	Monastrevin WS (BH No.1(Ballykelly))	<0.01	0.014014	6.722	nda	29.77*	nda	350	14.12	nda	nda	<1	DCORP	59.9	nda	10.03	1.86	33.9	nda	126	<0.05	0.0231
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	3015	08/22/96	7.3		nda		nda	nda			nda	728		Churchtown WS	<0.01	0.016	12.548	nda	55.57*	nda	276	33.22	nda	nda	nda		24.2	nda	10.55	1.95	12.4	nda	118.36	0.287	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	4078	11/19/96	7.34		nda		nda	nda			nda	696		Churchtown WS	<0.01	0.014	9.784	nda	43.31*	nda	288	29.13	nda	nda	nda		21.55	nda	10.57	1.32	13.04	nda	116	0.185	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	4328	11/04/97	7.32		nda		nda	nda			nda	647		Churchtown WS	<0.01	0.016	12.147	nda	53.80*	nda	272	37.466	nda	nda	nda		21.072	nda	11.4	0.731	13.834	nda	124.626	0.021	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	4714	12/09/97	7.46		nda		nda	nda			nda	666		Churchtown WS	0.014	0.016	12.76	nda	56.50*	nda	274	nda	nda	nda	nda		nda	nda	nda	nda	nda	nda	nda	0.015	0.0017
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	696	02/12/98	7.37		nda		nda	nda			nda	607		Churchtown WS	<0.01	0.013	13.136	nda	58.18*	nda	268	33	nda	nda	nda		21.6	nda	11.3	1.6	13.3	nda	127.1	0.003	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	3153	09/08/98	7.44		nda		nda	nda			nda	667		Churchtown WS	<0.01	0.0143	13.008	nda	57.61*	nda	262	31.9	nda	nda	nda		22.8	nda	14.6	2	14.5	nda	119.1	<0.01	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	58	01/12/99	7.36	nda	10.4	10.4	nda	nda		8.73	80.6	nda	637	nda	Churchtown WS	<0.01	0.014	10.982	nda	48.62*	nda	267	37.2	nda	nda	nda		26	nda	14.3	2.1	16.1	nda	144.7	<0.0005	0.0006
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	2774	09/20/99	7.25	nda	10.8	10.6	nda	nda		7.8		nda	637	767	Churchtown WS	<0.01	0.013	10	nda	44.28*	nda	270	29	nda	nda	nda		20.9	nda	11.79	1.53	16.87	nda	115.8	<0.02	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	727	02/09/00	7.33	nda	10.8	10.8	nda	nda		8.85		nda	693	775	Churchtown WS	<0.01	0.011	9.99	nda	44.24*	nda	325	28.4	nda	nda	nda		21.4	nda	12.7	1.69	14.6	nda	126.2	<0.02	<0.0005
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	5808	11/21/00	7.395	nda	10	10	nda	8.1	8.1		nda	735	759	Churchtown WS	<0.01	0.006101	10.554	nda	46.73*	nda	263	30.6	nda	nda	<1	DCORP	21.4	nda	10.5	<1	15.5	nda	112.6	<0.05	<0.001
Churchtown WS	KID	18	Churchtown WS	Churchtown		S640955	264000	195500	Bore	DUB	1466	04/04/01	7.242	nda	10.8	10.8	nda	8.63	8.63		nda	734	753	Churchtown WS	<0.01	0.026112	10.057	nda	44.53*	nda	275	20.83	nda	nda	<1	DCORP	24.9	nda	13.49	1.78	14.18	nda	107	<0.05	<0.001
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. S	DUB	3717	11/21/95	7.27		nda		nda	nda			nda	725		Monasterevin WS (Lughill)	<0.005	0.016	6.243	6.67	29.53476	nda	273.798	23.45	nda	nda	nda		25.94	nda	11.45	1.89	14.66	nda	108.28	0.0389	0.0051
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. S	DUB	3013	08/22/96	7.18		nda		nda	nda			nda	732		Monasterevin WS (Lughill)	<0.01	0.01	7.736	nda	34.27*	nda	316	25.85	nda	nda	nda		25.73	nda	10.44	1.83	12.94	nda	123.76	0.5	0.0051
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. S	DUB	4080	11/19/96	7.18		nda		nda	nda			nda	747		Monasterevin WS (Lughill)	<0.01	0.009	8.132	nda	36.0*	nda	318	25.8	nda	nda	nda		25.35	nda	10.57	1.86	9.17	nda	134.9	0.0194	<0.0005
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. S	DUB	4330	11/04/97	7.17		nda		nda	nda			nda	665		Monasterevin WS (Lughill)	<0.01	0.009	7.72	nda	34.18*	nda	318	25.731	nda	nda	nda		20.232	nda	10.109	0.775	11.337	nda	136.664	0.076	0.0006
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. S	DUB	652	02/11/98	7.21		nda		nda	nda			nda	653		Monasterevin WS (Lughill)	<0.01	0.009	8.327	nda	36.89*	nda	318	32.523	nda	nda	nda		22.805	nda	10.965	1.812	12.085	nda	132.3	0.0248	<0.0005
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. S	DUB	3165	09/09/98	7.23		nda		nda	nda			nda	644		Monasterevin WS (Lughill)	<0.01	0.011	8.332	nda	36.89*	nda	302	23.4	nda	nda	nda		23.5	nda	13.9	1.7	14.3	nda	123.3	0.0526	0.0031
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. S	DUB	90	01/13/99	7.17		10.8		nda	nda			nda	663		Monasterevin WS (Lughill)	<0.01	0.011	9.154	nda	40.52*	nda	308	24.8	nda	nda	nda		21.8	nda	12.7	2.3	12.2	nda	161.7	<0.0005	0.001
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. S	DUB	2794	09/21/99	7.19	nda	11.2	11.2	nda	nda		5.6		nda	659	804	Monasterevin WS (Lughill)	<0.01	0.007	7.696	nda	34.10*	nda	291	24.7	nda	nda	nda		25.4	nda	12.72	1.63	15.42	nda	128.3	0.0022	<0.0005
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. S	DUB	725	02/09/00	7.22	nda	10.9	10.9	nda	nda		6.83		nda	701	789	Monasterevin WS (Lughill)	<0.01	0.007	7.41	nda	32.81*	nda	287	21	nda	nda	nda		20	nda	12.03	1.84	13.07	nda	133.8	<0.02	<0.0005
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. S	DUB	5810	11/21/00	7.262	nda	10.7	10.7	nda	6.36	6.36		nda	773	800	Monasterevin WS (Lughill)	0.018	<0.005	8.45	nda	37.42*	nda	279	23.1	nda	nda	<1	DCORP	20.7	nda	9.3	<1	12	nda	126.3	<0.05	<0.001
Monasterevin WS (Lughill)	KID	20	Monasterevin WS (Lughill)			N635064	263507	206482	3 No. S	DUB	1468	04/04/01	7.075	nda	10.8	10.8	nda	6.56	6.56		nda	753	785	Monasterevin WS (Lughill)	0.02	0.016167	8.159	nda	36.13*	nda	300	15.96	nda	nda	<1	DCORP	23.1	nda	11.88	0.84	12.08	nda	127.2	0.1549	0.0034
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	3715	11/21/95	7.31		nda		nda	nda			nda	574		Newtown / Kilcock WS	0.14	0.013	0.06	0.13	0.57564	nda	210.665	13.69	nda	nda	nda		41.3	nda	7.5	2.51	6.05	nda	95.96	1.952	0.113
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	2954	08/20/96	7.16		nda		nda	nda			nda	624		Newtown / Kilcock WS	0.078	0.009	0.084	nda	0.35*	nda	248	14.4	nda	nda	nda		70	nda	7.28	2.74	5.91	nda	124.9	5.046	0.398
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	4101	11/21/96	7.26		nda		nda	nda			nda	576		Newtown / Kilcock WS	0.137	0.015	0.062	nda	0.27*	nda	252	10.51	nda	nda	nda		41.38	nda	8.31	2.41	2.09	nda	94.41	1.468	0.135
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	4710	12/09/97	7.23		nda		nda	nda			nda	557		Newtown / Kilcock WS	0.134	0.012	0.1	nda	0.44*	nda	254	nda	nda	nda	nda		nda	nda	nda	nda	nda	nda	nda	4.585	0.144
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	649	02/11/98	7.24		nda		nda	nda			nda	539		Newtown / Kilcock WS	0.163	0.013	0.027	nda	0.13*	nda	322	16.772	nda	nda	nda		100.161	nda	7.226	2.209	6.794	nda	124.6	4.072	0.157
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	3169	09/09/98	7.25		nda		nda	nda			nda	542		Newtown / Kilcock WS	0.197	0.017	<0.01	nda	<0.04*	nda	220	11.8	nda	nda	nda		61.7	nda	9.1	2.8	6.6	nda	114.7	2.134	0.147
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	94	01/13/99	7.3	nda	11.8	9.5	nda	nda		7.2	64.5	nda	543	nda	Newtown / Kilcock WS	0.17	0.015	0.021	nda	0.9*	nda	258	14.8	nda	nda	nda		75	nda	8.3	2.5	7.5	nda	140.6	3.065	0.211
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	2792	09/21/99	7.3	nda	13.9	13.9	nda	nda		3		nda	535	648	Newtown / Kilcock WS	0.068	0.011	0.127	nda	0.56*	nda	245	13.77	nda	nda	nda		50.6	nda	7.67	2.22	6.58	nda	108.5	1.135	0.1041
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	692	02/07/00	7.19	nda	11.3	11.3	nda	nda		3.52		nda	589	633	Newtown / Kilcock WS	0.14	0.015	0.07	nda	0.31*	nda	252	13.45	nda	nda	nda		73.6	nda	7.82	2.26	6.57	nda	121.8	1.0674	0.1286
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	5793	11/20/00	7.16	nda	12.7	12.7	nda	0.41	0.41		nda	611	624	Newtown / Kilcock WS	0.172	0.103611	0.042	nda	0.19*	nda	244	11.5	nda	nda	<1	DCORP	52.4	nda	6.6	1.3	6.6	nda	107.4	1.6531	0.1539
Newtown / Kilcock WS	KID	22	Newtown / Kilcock WS			N818394	281850	239447	Bore	DUB	1377	04/03/01	7.183	nda	12.7	12.7	nda	3.63	3.63		nda	622	645	Newtown / Kilcock WS	0.08	0.007104	0.142	nda	0.63*	nda	238	9.92	nda	nda	<1	DCORP	70	nda	8.07	1.17	5.94	nda	104.85	1.0454	0.2133
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	3714	11/21/95	7.34		nda		nda	nda			nda	672		Pollardstown Fen	<0.005	0.012	2.84	2.92	12.92976	nda	302.489	13.69	nda	nda	nda		18.97	nda	10.01	1.45	19.08	nda	98.48	0.144	0.0152
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	2957	08/20/96	7.24		nda		nda	nda			nda	679		Pollardstown Fen	<0.01	0.011	2.933	nda	12.97*	nda	338	14.7	nda	nda	nda		18.6	nda	11.59	1.51	19.07	nda	119.2	0.239	0.0197
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	4105	11/21/96	7.3		nda		nda	nda			nda	681		Pollardstown Fen	<0.01	0.004	2.932	nda	12.97*	nda	318	12.84	nda	nda	nda		17.9	nda	10.14	0.52	18.5	nda	129.7	0.0223	0.0047
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	4332	11/04/97	7.28		nda		nda	nda			nda	595		Pollardstown Fen	<0.01	0.01	2.87	nda	12.71*	nda	330	12.511	nda	nda	nda		16.687	nda	8.762	<0.01	18.875	nda	112.923	0.194	0.0138
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	692	02/12/98	7.36		nda		nda	nda			nda	597		Pollardstown Fen	<0.01	0.007	2.855	nda	12.66*	nda	322	13.8	nda	nda	nda		18.3	nda	10.8	0.7	19.6	nda	112.7	0.223	0.006
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	3151	09/08/98	7.33		nda		nda	nda			nda	602		Pollardstown Fen	<0.01	0.0109	3.095	nda	13.73*	nda	319	12.8	nda	nda	nda		18	nda	11.6	0.7	19.6	nda	109.2	0.1	0.0097
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	3151	09/08/98	7.33		nda		nda	nda			nda	602		Pollardstown Fen	<0.01	0.011	3.1	nda	13.73*	nda	319	12.8	nda	nda	nda		18	nda	11.6	0.7	19.6	nda	109.2	0.1	0.0097
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	89	01/13/99	7.33	nda	9.6	9.6	nda	nda		6.17	56	nda	568	nda	Pollardstown Fen	<0.01	0.014	2.846	nda	12.62*	nda	302	16.4	nda	nda	nda		20.8	nda	11.8	0.9	21.4	nda	130	0.111	0.0077
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	2795	09/21/99	7.43	nda	11.3	11.3	nda	nda		7.3		nda	607	723	Pollardstown Fen	<0.01	0.011	2.963	nda	13.12*	nda	290	15.85	nda	nda	nda		19.78	nda	11.19	0.66	19.95	nda	111.7	0.0998	0.0153
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	722	02/09/00	7.42	nda	9.9	9.9	nda	nda		8.72		nda	632	710	Pollardstown Fen	<0.01	0.007	2.85	nda	12.62*	nda	257	15.9	nda	nda	nda		19.4	nda	10.92	0.63	19.69	nda	116.8	<0.02	0.0014
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	5796	11/20/00	7.198	nda	9.9	9.9	nda	3.68	3.68		nda	681	697	Pollardstown Fen	<0.01	0.075726	2.757	nda	12.21*	nda	290	12.5	nda	nda	23	DCORP	17.8	nda	6.9	<1	14.4	nda	95.1	<0.05	0.0272
Pollardstown Fen	KID	23	Pollardstown Fen	Pollardstown Fen		N773154	277282	215459	Spring	DUB	1380	04/03/01	7.319	nda	10.2	10.2	nda	7.25	7.25		nda	677	703	Pollardstown Fen	<0.01	0.005654	2.974	nda	13.17*	nda	318	10.89	nda	nda	10	DCORP	20.05	nda	10.36	<1	17.65	nda	98.85	<0.05	0.0032
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	2955	08/20/96	7.36		nda		nda	nda			nda	608		Clogherinkoe WS	<0.01	0.059	1.333	nda	5.89*	nda	300	11.4	nda	nda	nda		20.7	nda	8.71	0.93	12.6	nda	111	0.201	0.0736
Clogherinkoe WS	KID	40	Clogherinkoe WS		Clogheri	N658387	265500	239000	Bore	DUB	4102	11/21/96	7.38		nda		nda	nda			nda	615		Clogherinkoe WS	<0.01	0.047	2.302	nda	10.18*	nda	298	10.55	nda	nda	nda		24.49	nda	10.24	2.14	8.25	nda	119.1	0.0186	0.0256
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	4367	11/06/97	7.41		nda		nda	nda			nda	524		Clogherinkoe WS	0.012	0.048	2.133	nda	9.43*	nda	282	17.708	nda	nda	nda		25.367	nda	14.3	1.097	12.757	nda	110.966	<0.001	0.017
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	4711	12/09/97	7.4		nda		nda	nda			nda	552		Clogherinkoe WS	0.028	0.047	2.483	nda	10.98*	nda	298	nda	nda	nda	nda		nda	nda	nda	nda	nda	nda	nda	0.024	0.0185
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	650	02/11/98	7.37		nda		nda	nda			nda	534		Clogherinkoe WS	<0.01	0.05268	2.306	nda	10.23*	nda	340	13.384	nda	nda	nda		24.659	nda	9.45	0.67	12.625	nda	106.1	0.0083	0.0134
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	3168	09/09/98	7.37		nda		nda	nda			nda	541		Clogherinkoe WS	<0.01	0.049	2.1	nda	9.30*	nda	269	10.3	nda	nda	nda		22.9	nda	12.8	2	13.1	nda	106.6	<0.01	0.0153
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	93	01/13/99	7.39		10.8		nda	nda			nda	547		Clogherinkoe WS	<0.01	0.045	3.592	nda	15.90*	nda	291	12.8	nda	nda	nda		28.6	nda	11.9	1.1	14	nda	131.8	0.0097	0.0141
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	2793	09/21/99	7.29	nda	11	11	nda	nda		3.8		nda	548	663	Clogherinkoe WS	<0.01	0.058	1.939	nda	8.59*	nda	288	11.85	nda	nda	nda		22.6	nda	10.7	0.82	13.44	nda	108.1	0.1462	0.1351
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	693	02/07/00	7.28	nda	10.8	10.8	nda	nda		6.41		nda	580	653	Clogherinkoe WS	0.02	0.049	2.43	nda	10.76*	nda	265	11.96	nda	nda	nda		23.8	nda	10.53	0.75	12.44	nda	110.2	0.0316	0.0414
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	5794	11/20/00	7.426	nda	10.4	10.4	nda	nda		3.91		nda	620	637	Clogherinkoe WS	0.01	0.119055	2.185	nda	9.68*	nda	285	9.6	nda	nda	<1	DCORP	21.6	nda	9.5	<1	11.6	nda	95.5	<0.05	0.0095
Clogherinkoe WS	KID	40	Clogherinkoe WS			N658387	265500	239000	Bore	DUB	1378	04/03/01	7.292	nda	10.8	10.8	nda	2.97	2.97		nda	619	646	Clogherinkoe WS	<0.01	0.046382	2.235	nda	9.90*	nda	272	9.13	nda	nda	<1	DCORP	24.35	nda	10.3	<1	11.6	nda	94.75	<0.05	0.0387
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	3046	08/27/96	6.92		nda		nda	nda			nda	788		Hare Park (Curragh Camp)	<0.01	0.018	4.461	nda	19.75*	nda	322	26.24	nda	nda	nda		3.58	nda	33.92	2.21	13.49	nda	145.62	0.293	0.0015
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)		HarePar	N770115	277011	211522	Bore	DUB	4103	11/21/96	7.24		nda		nda	nda			nda	790		Hare Park (Curragh Camp)	<0.01	0.01	4.327	nda	19.17*	nda	352	20.33	nda	nda	nda		42.67	nda	17.39	2.51	11.92	nda	161.2	0.0315	<0.0005
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	4369	11/06/97	7.25		nda		nda	nda			nda	694		Hare Park (Curragh Camp)	<0.01	0.008	3.972	nda	17.58*	nda	352	23.415	nda	nda	nda		34.382	nda	17.501	1.389	14.61	nda	137.181	0.05	0.0011
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	694	02/12/98	7.25		nda		nda	nda			nda	719		Hare Park (Curragh Camp)	<0.01	0.01	4.298	nda	19.04*	nda	338	33	nda	nda	nda		27.7	nda	23.3	2.1	13.6	nda	136.3	0.012	<0.0005
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	3164	09/09/98	7.21		nda		nda	nda			nda	707		Hare Park (Curragh Camp)	<0.01	0.022	5.693	nda	25.20*	nda	325	27.1	nda	nda	nda		28.5	nda	22.6	2.2	12.7	nda	133	0.0371	0.0069
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	55	01/12/99	7.375	nda	10.4	10.4	nda	nda		8.33	76.7	nda	675	nda	Hare Park (Curragh Camp)	<0.01	0.018115	4.404	nda	19.48*	nda	322	40.6	nda	nda	nda		29.3	nda	26.6	2.5	13.7	nda	150.3	0.0088	0.001
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	2772	09/20/99	7.14	nda	11.1	11.1	nda	nda		8.7		nda	708	876	Hare Park (Curragh Camp)	<0.01	0.015	4.918	nda	21.78*	nda	325	27.5	nda	nda	nda		24.8	nda	20.1	2.08	13.47	nda	133.8	<0.02	<0.0005
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	694	02/07/00	7.21	nda	10.6	10.6	nda	nda		8.9		nda	736	831	Hare Park (Curragh Camp)	<0.01	0.005	4.43	nda	19.62*	nda	341	30.73	nda	nda	nda		23.7	nda	21.53	2.09	12.59	nda	133.33	<0.02	<0.0005
Hare Park (Curragh Camp)	KID	42	Hare Park (Curragh Camp)			N770115	277011	211522	Bore	DUB	1471	04/04/01	7.266	nda	10.7	10.7	nda	9.26	9.26		nda	838	876	Hare Park (Curragh Camp)	0.02	0.011823	5.085	nda	22.52*	nda	330	36.5	nda	nda	<1	DCORP	30.2	nda	23.6	0.82	15.65	nda	130	<0.05	<0.001
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	3047	08/27/96	7.16		nda		nda	nda			nda	744		McDonagh(Curragh Camp)	<0.01	0.127	5.638	nda	24.97*	nda	293	18.31	nda	nda	nda		5.27	nda	21.32	1.66	12.96	nda	147.09	0.146	0.0015
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	4104	11/21/96	7.84		nda		nda	nda			nda	687		McDonagh(Curragh Camp)	<0.01	0.282	4.835	nda	21.43*	nda	332	11.5	nda	nda	nda		19.43	nda	11.82	0.78	12.7	nda	138.8	0.155	0.001
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	4712	12/09/97	7.83		nda		nda	nda			nda	595		McDonagh(Curragh Camp)	0.015	0.012	4.597	nda	20.37*	nda	332	nda	nda	nda	nda		nda	nda	nda	nda	nda	nda	nda	0.011	0.0018
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	693	02/12/98	7.76		nda		nda	nda			nda	601		McDonagh(Curragh Camp)	<0.01	0.012	4.596	nda	20.37*	nda	320	11.1	nda	nda	nda		18.9	nda	8.2	0.5	15.9	nda	121.2	0.0015	<0.0005
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	3150	09/08/98	7.69		nda		nda	nda			nda	624		McDonagh(Curragh Camp)	<0.01	0.0133	5.218	nda	23.11*	nda	344	11	nda	nda	nda		19.2	nda	9.1	1	16	nda	117.5	<0.01	<0.0005
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	56	01/12/99	7.87	nda	9.8	9.8	nda	nda		12.31	113	nda	597	nda	McDonagh(Curragh Camp)	<0.01	0.011822	4.825	nda	21.39*	nda	310	14.7	nda	nda	nda		22	nda	9.8	0.8	16.9	nda	140.8	0.0125	0.0006
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	2773	09/20/99	7.61	nda	10.6	10.6	nda	nda		11.8		nda	621	730	McDonagh(Curragh Camp)	<0.01	0.011	5.248	nda	23.24*	nda	289	14.14	nda	nda	nda		19.3	nda	8.28	0.58	15.88	nda	118.4	<0.02	<0.0005
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	695	02/07/00	7.76	nda	10.4	0.4	nda	nda		12.1		nda	640	720	McDonagh(Curragh Camp)	<0.01	0.01	4.84	nda	21.43*	nda	322	13.37	nda	nda	nda		19.78	nda	8.34	0.58	15.67	nda	118.8	<0.02	<0.0005
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	5795	11/20/00	7.785	nda	9.9	9.9	nda	nda		11.98		nda	688	707	McDonagh(Curragh Camp)	<0.01	0.08722	4.875	nda	21.59*	nda	313	10.9	nda	nda	<1	DCORP	19.6	nda	7.4	0.5	14.7	nda	96	<0.05	<0.001
McDonagh(Curragh Camp)	KID	50	McDonagh(Curragh Camp)	McDonagh Pump Stn		N788117	278814	211736	Bore	DUB	1379	04/03/01	7.695	nda	10.4	10.4	nda	12.22	12.22		nda	687	717	McDonagh(Curragh Camp)	0.02	0.011522	5.369	nda	23.77*	nda	320	9.72	nda	nda	<1	DCORP	18.7	nda	8.56	<1	14.85	nda	102.35	<0.05	<0.001
Martinstown	KID	72	Martinstown			N773064	277283	206406		DUB	4713	12/09/97	7.24		nda		nda	nda			nda	730		Martinstown	0.023	0.018	10.528	nda	46.63*	nda	352	nda	nda	nda	nda		nda	nda	nda	nda	nda	nda	nda	0.028	0.0029
Osborne Lodge	KID	74	Osborne Lodge			N756147	275579	214671		DUB	2956	08/20/96	7.15		nda		nda	nda			nda	641		Osborne Lodge	<0.01	0.007	1.412	nda	6.25*	nda	338	9	nda	nda	nda		9.3	nda	6.24	0.71	9.8	nda	128.6	0.939	0.0209
Monasterevin WS BH No.1 & Spring)	KID	80	Monasterevin WS BH No.1 & Spring)	Ballykelly		N641126	264100	212600		DUB	4331	11/04/97	7.28		nda		nda	nda			nda	707		Monasterevin WS BH No.1 & Spring)	<0.01	0.007	5.845	nda	25.90*	nda	330	18.378	nda	nda	nda		46.514	nda	8.133	0.664	28.372	nda	125.432	<0.001	0.0111
Monasterevin WS BH No.1 & Spring)	KID	80	Monasterevin WS BH No.1 & Spring)	Ballykelly		N641126	264100	212600		DUB	651	02/11/98	7.29		nda		nda	nda			nda	689		Monasterevin WS BH No.1 & Spring)	<0.01	<0.005	5.979	nda	26.48*	nda	328	23.975	nda	nda	nda		52.301	nda	8.576	1.671	28.33	nda	121	0.0413	0.0099
Monasterevin WS(sprng+Bore1+2)	KID	80	Monasterevin WS(sprng+Bore1+2)			S642125	264230	212502		DUB	3201	10/11/99	7.22	nda	11.2	11.2	nda	nda	nda			nda	740	954	Monasterevin WS(sprng+Bore1+2)	<0.01	0.006	8.05	nda	35.65*	nda	332	21.9	nda	nda	nda		75.4	nda	10.36	2.81	32.5	nda	150.6	<0.02	0.0156
Monasterevin WS(sprng+Bore1+2)	KID	80	Monasterevin WS(sprng+Bore1+2)			S642125	264230	212502		DUB	723	02/09/00	7.19	nda	10.9	10.9	nda	nda		5.11		nda	878	986	Monasterevin WS(sprng+Bore1+2)	<0.01	0.007	7.23	nda	32.01*	nda	308	20.4	nda	nda	nda		83.6	nda	11.07	3.63	30	nda	151.4	<0.02	0.0146