Athy TC Water Supply

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

County Kildare
Groundwater Protection Scheme

Volume II: Source Protection Zones

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8 ATHY TC WATER SUPPLY

8.1 Introduction

The objectives of the report are as follows:

- To delineate source protection zones for the Athy Town Council Water Supply; namely the Infiltration Gallery, "Woodstock" Borehole and the new Barrack Lane Borehole.
- To outline the principal hydrogeological characteristics of the surrounding 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 abstraction points. 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.

8.2 Summary of Supply Details

	"Woodstock"	**Barrack Lane**	**Infiltration Gallery**
GSI no.	2619SWW388	2619SWW520	2619SWW541
Grid ref. (1:25,000)	S ^{2}6790 ^{1}9450	S ^{2}6793 ^{1}9446	S^{2}6809 ^{1}9436
Townland	Townparks	Townparks	Townparks
Source type	Borehole	Borehole	Infiltration Gallery
Drilled	23/6/1977	6/3/2001	Unknown
Owner	Athy Town Council	Athy Town Council	Athy Town Council
Elevation (ground level)	~ 56.0 m O.D. (Malin Head)	~ 57 m OD (Malin Head)	~56.8 m O.D. (Malin Head)
Depth (Daly, 2002)	38.4 m	50.3 m	4.7 m
Depth of casing	13 m	12.2 m	N/a
Diameter	305 mm (12")	250 mm (10")	N/a
Depth to rock	8.0 m	12.2 m	Unknown
Static water level	Ground level	0.67m	0.8 m
Depth of pump	12.0 m below ground	40.0 m below ground	4.0 m below ground
Pumping water level	7-8.5 m (Daly, 1987)	7.41 m below ground (Daly, 2002)	
Consumption (from CoCo records)	700-900 $m^3 d^{-1}$	500-700 $m^3 d^{-1}$	900-1200 $m^3 d^{-1}$
Pumping test summary:			
(i) abstraction rate $m^3 d^{-1}$	1496 (16-21/6/1977 GSI files)	1010 (26/3/2001 Daly, 2002)	
(ii) specific capacity	107	150	
(iii) transmissivity	150	200	

8.3 Methodology

8.3.1 Desk Study

Details about the boreholes such as depth, date commissioned and abstraction figures were obtained from County Council personnel and reports written by E. P. Daly (1981, 1987, 2001, 2002). Additional geological and hydrogeological information was provided by the GSI mapping programmes (Glanville (1997), Mc Connell et al. (1994)).

8.3.2 Site visits and fieldwork

This included the following:

- Meetings with Athy Town Council Staff 31/1/2002 and 30/10/02.
- Water sampling by South Western Area Health Board staff in July 2002.
- Drilling of one depth to bedrock hole and field mapping walkover on 27th May 2002 to further investigate the subsoil geology, the hydrogeology and vulnerability to contamination.

8.3.3 Assessment

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

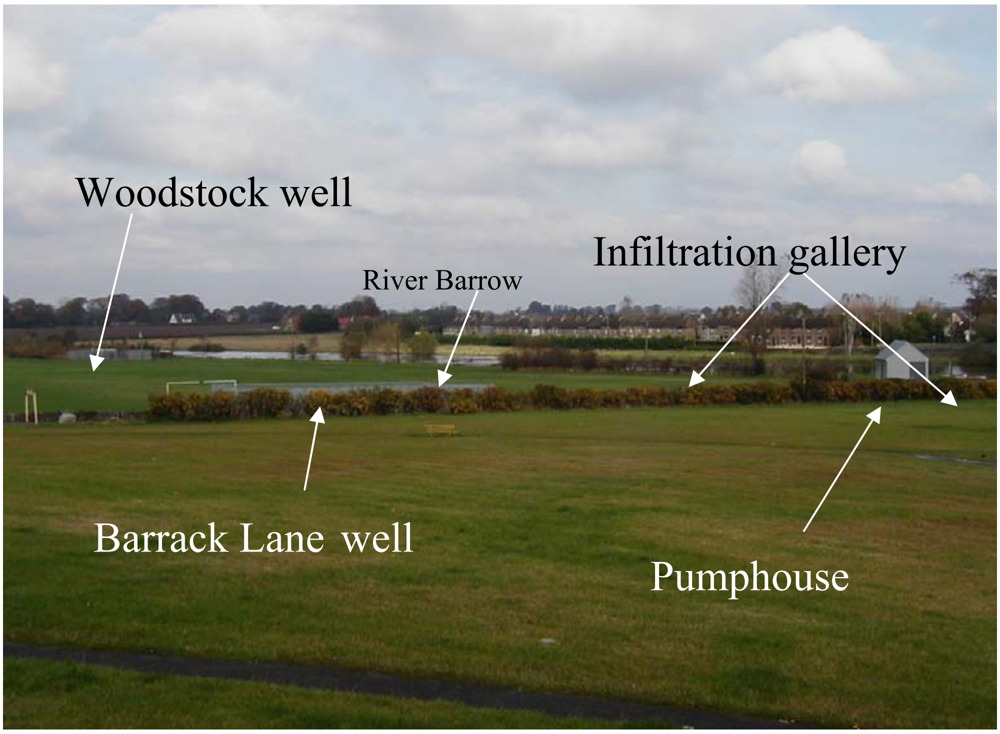
8.4 Location & Site Description

The well field is located in the townland of Townparks, Athy, Co. Kildare. The site is situated at Barrack Lane, which is on the north side of Athy, off the Stradbally Road, on the western side of the River Barrow. Figure 8-1 provides an overview of the site. The main pump house is located at the end of Barrack Lane, The Barrack Lane supply borehole is located alongside Barrack Lane. The infiltration gallery is located between the pump house and the River Barrow. The “Woodstock” borehole is approximately 200 m north of the main pump house close to Woodstock Castle.

Each well site (“Woodstock” and Barrack Lane wells) is located inside an area that is secured by a 2 m high galvanised fence. Each well head and access point for the infiltration gallery is secured by a galvanised cover that is either padlocked or bolted fast. The “Woodstock” well head is raised to approximately 0.5 m above ground level, presumably for added protection against possible flooding from the River Barrow. In times of extreme flooding the water level in the river has been reported by Co. Co. staff to be above the top of the sump.

Each of the abstraction points pumps water directly into the main distribution system which covers the main Athy urban area, supplying water to approximately six thousand people. From the caretakers records consumption in 1995 was approximately 1800 $m^3 d^{-1}$, in October 2002 the consumption was approximately 2700 $m^3 d^{-1}$, which is an approximate increase of 50% over a seven year period. To meet the increase in demand the new production well (Barrack Lane) was installed. According to council staff each of the abstraction points pumps continuously over the entire day and there is chlorination treatment at each point.

Figure 8-1 Photograph showing Athy Well Field



8.5 Topography, Surface Hydrology and Land Use

The topography in the vicinity of the source is flat or undulating with an altitude of approximately 50 to 60 m O.D. The general lie of the landscape is a very gentle dip toward the River Barrow. There is a series of hills approximately 10 km to the west in county Laois. The highest points in this range of hills are approximately 260 m O.D.

The River Barrow is the largest surface water feature in the area and can be seen in Figure 8-1. The land appears to be free draining with only occasional ditches.

Land use in the vicinity of the well field is generally urban: housing estates, streets, the canal and some parkland. Approximately 1 km north and west of the site the land use becomes agricultural - dominated primarily by tillage and grassland. There are also a few sand/gravel pits in the locality (some disused) and there is a large limestone quarry at Ballyadams, Co. Laois.

8.6 Geology

8.6.1 Introduction

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

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

- Bedrock Geology 1:100,000 Map Series, Geological Survey of Ireland. (Mc Connell et al., 1994).
- Information from geological mapping in the nineteenth century (on record at the GSI).
- Reports by GSI on the well drilling and a pollution incident in the 1980's. (Daly, 1981, 1987) Geological Survey of Ireland.
- Subsoil mapping by the GSI, Glanville (1997).

8.6.2 Bedrock Geology

The Milford Limestone Formation occupies the area around the source. It is generally regarded as being a clean, often karstified and dolomitised shelf (shallow water) limestone (refer to Section 3 of Volume I).

8.6.3 Subsoil (Quaternary) Geology

The main subsoil categories in the vicinity of the source are till (‘boulder clay’) and sand/gravel. The characteristics of each category are described briefly below:

- ‘Till’ or ‘Boulder clay’ is an unsorted mixture of coarse and fine materials laid down by ice. Till is at the surface to the north of the sources, but also occurs at varying depths below the sand/gravel. At the “Woodstock” and Barrack Lane boreholes, till occurs in a layer approximately 2 m thick at the surface and in a layer approximately 4 m thick at the top of the rock. It is not classed as an aquifer in the area and its significance is mainly in relation to groundwater vulnerability and the protection of the sand/gravel and rock aquifers from surface contaminants.
- Sand/gravel is widespread in south Kildare and is the dominant subsoil around Athy and the River Barrow. It occurs in all three sources and is mapped as a **regionally important sand/gravel aquifer (Rg)** in the Barrow valley. Section 4 of Volume I provides further details.
- Alluvium occupies a narrow floodplain (250-400 m) along the River Barrow. The alluvium is thin - in the order of 0.25-0.42 m (E.P. Daly 1987). Its main significance is in vulnerability classification.
- A depth to bedrock drilling programme was carried out to ascertain the subsoil thicknesses in Kildare. In Athy there is good depth to bedrock information available from previous

investigations. The depth to bedrock varies from 5-20 m in Athy. At the source the depth to bedrock is reported to be 12-13 m (E. P. Daly, 1987).

8.7 Groundwater Vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater 'target'. In areas where the sand/gravel aquifer is exposed or covered by less than three metres of till this will be the main target and vulnerability will be dictated by the mapped thickness of the unsaturated zone.

Generally the depth to the water table in the sand/gravel in the vicinity of the infiltration gallery is less than 2 m below ground. The water table is estimated to be within 3 m of the ground surface up to 400 m west of the gallery. Therefore, the groundwater vulnerability in the area closest to the gallery is classed as 'extreme'. Thus the vulnerability to contamination of groundwater feeding the infiltration gallery is extreme but becomes less vulnerable moving upslope away from the gallery.

In areas away from the sand/gravel aquifer (i.e., to the west of the sources) bedrock is the main target and the vulnerability will be dictated by the mapped depth to rock and the permeability of the subsoil. In the vicinity of the source, the permeability of the subsoil is mapped as moderate and the mapped depth to bedrock varies from 10 m at the edge of the sand/gravel aquifer to less than 1 m 2 km west of the source. Thus, the vulnerability ranges from moderate to extreme moving westwards from the sand/gravel aquifer towards higher ground. The distribution of the vulnerability is presented in Maps 6 and 8. Note that, though the vulnerability of groundwater at the source is mapped as extreme, this refers to the uppermost groundwater "target" in the sand/gravel. The gallery draws from the sand/gravel but the boreholes draw from the rock, which is confined by a deeper layer of till (see section 8.8). As such, the vulnerability of groundwater supplying the boreholes will be lower than that represented in Map 6 and 8.

Depth to rock interpretations are based on the available data cited here. However, depth to rock can vary over a small scale. As such, the vulnerability mapping provided will not be able to anticipate all the natural variation that occurs in an area. The mapping is intended only as a guide to land use planning and hazard surveys, and is not a substitute for site investigation for specific developments. Classifications may change as a result of investigations such as trial hole assessments for on-site domestic wastewater treatment systems. The potential for discrepancies between large scale vulnerability mapping and site-specific data has been anticipated and addressed in the development of groundwater protection responses (site suitability guidelines) for specific hazards. More detail can be found in 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999).

8.8 Hydrogeology

8.8.1 Introduction

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

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

- GSI files and archival Kildare County Council data.
- Athy U.D.C. Trial & Production Wells. Eugene Daly Associates (2002).
- E.P. Daly (1981, 1982, 1987) Geological Survey of Ireland.
- Kildare County Council drinking water returns for 2002 and 2001.
- Hydrogeological mapping carried out by GSI on 9th, 10th, 27th & 28th May 2002 and 30th October 2002.
- A drilling programme carried out by GSI to ascertain depth to bedrock and subsoil permeability (1 hole within 2 km of the source).
- A Groundwater Protection Scheme for Co. Laois (Deakin, 2002).

8.8.2 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; along with the rate of abstraction at the source 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:* 750 mm.
  Rainfall data for gauging stations around Athy (from Fitzgerald, D., Forrestal., F., 1996) are as follows:

Gauging Stations	Grid reference	Elevation OD (m)	Approximate distance & direction from source	Annual precipitation 1961-1990
Athy (Voc.Sh)	S656933	61	2.5 km west	746 mm
Kilberry	S663999	61	5 km north west	745 mm

  As the borehole is closest (in terms of distance and altitude) to the Athy and Kilberry gauging stations the precipitation is assumed to be about 750 mm annually. This is supported by the interpreted contour maps of precipitation presented in the "Agroclimatic Atlas of Ireland" (Collins and Cummins, 1996).

- *Annual evapotranspiration losses:* 400 mm. Potential evapotranspiration (P.E.) is estimated to be 425 mm $yr.^{-1}$. Actual evapotranspiration (A.E.) is estimated as 95 % of P.E., to allow for seasonal soil moisture deficits. More local measurements of evapotranspiration are not available.

- *Potential recharge:* 350 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:* ~35 mm. The slopes and the nature of the deposits around the source need to be considered in order to give a representative value for the runoff during rainfall events. The subsoils are thought to be free draining (refer to Section 8.6.3) with very little surface drainage and a representative value for the runoff is estimated to be in the order to 10%.

These calculations are summarised as follows:

Average annual rainfall (R)	750 mm
Estimated P.E.	425 mm
Estimated A.E. (95% of P.E.)	400 mm
Potential Recharge (R – A.E.)	350 mm
Runoff losses (10% of recharge)	35 mm
Estimated Actual Recharge	**315 mm**

8.8.3 Groundwater Levels

A GSI well survey was carried out in the 1970's in County Kildare, from which broad estimates of the groundwater levels & directions and gradients can be made. Detailed hydrogeological work was carried out on the "Woodstock" borehole and the Infiltration Gallery by the GSI in 1987, in response to an enquiry by Kildare County Council due to a potential pollution incident in the River Barrow (Daly, E.P., 1987). In 1999, 2000 and 2001 further work on the area was carried out by E.P. Daly Associates in helping Athy TC to locate a new supply borehole (Barrack Lane) to augment the supply to the town.

Barrack Lane Well: on 21/3/2001 static water levels were less than 1 m below ground for the Barrack Lane well and a trial well (40 m away). The pumping water level for the supply borehole is approximately 7 m below ground. During test pumping in March 2001 the pumping water levels never went below 8.5 m below ground (Daly, E.P., 2000). Both the static and pumping water levels are above the top of the rock (11 m and 3.5 m respectively) suggesting that the groundwater in the vicinity of the supply borehole is confined.

Woodstock Well: Daly (1987) states that the piezometric surface of the bedrock is close to the ground level in the area around the Townparks borehole and suggests groundwater in the vicinity is confined. During the initial pumping test in 1977 it is reported that the water level rose during the five day constant rate test and that the static water level was above ground level. Daly (1987) suggests that the groundwater becomes unconfined approximately 3 km further to the south and toward the river.

Infiltration Gallery: It is assumed that the main sump and the three legs that make up the gallery are entirely excavated in sand/gravel. Static water levels are reported to be less than 2 m below ground (approximately 56 m O.D.) in the main sump which is two metres higher than the water level in the River Barrow (Daly, 1987). The water level in the sand/gravel is estimated to be less than 3 m from ground surface up to approximately 400 m west of the gallery. It is assumed that there is a hydraulic connection between the water in the sump and the water in the river despite a thin layer of alluvium present between the two. The maximum pumping water level in the sump is approximately 52.5 m O.D. which is approximately 1 m below the water level in the river.

8.8.4 Groundwater Flow Directions:

Static water levels in the Barrack Lane borehole are slightly less than the static water level in the "Woodstock" well, while levels in both wells are above the level of the river. At a local scale, this suggests that groundwater in the bedrock aquifer is moving in a southerly direction to discharge into the river where the groundwater is unconfined. At a more regional scale, groundwater flow is in an easterly/south easterly direction toward the River Barrow. The topographic highs that occur to the west in the townlands of Oughaval, Ballaghmore, Ballintlea and Crannagh are assumed to be surface water and groundwater divides.

Pumping water levels in the gallery and boreholes are lower than those in the river and, in a restricted area near the source, some river recharge to the deep boreholes is likely to occur during pumping. However Daly (1987) estimates amounts will be small.

TC staff carried out an experiment at the infiltration gallery to determine the relationship of the gallery with the river (Daly, 1987). They dug two pits on either side of the gallery and measured how long it took for a salt tracer to appear in the gallery discharge. After one week the tracer from the river bank didn't appear in the gallery. However, tracer from the west side of the gallery appeared in the discharge after only three days. Daly (1987) uses these data to suggest that only a small proportion of water supplying the gallery comes from the river.

8.8.5 Groundwater Gradients:

Gradients are estimated for the piezometric surface in the bedrock aquifer and for the water table in the sand/gravel for both static and pumping conditions.

The static water gradient in the bedrock aquifer is estimated from the reported piezometric levels in "Woodstock" borehole and the Barrack Lane borehole to be in the order of 0.002-0.004. Pumping water gradients are much steeper close to the wells. These are estimated to be in the order of 0.14-0.16.

Static groundwater gradients in the sand/gravel close to the gallery are in the order of 0.05. Moving away from the gallery and the river the gradient decreases becoming similar to the topographic gradient; being in the order of 0.002. During pumping the gradient is reversed and the maximum pumping gradient is about 0.03 (Daly, 1987).

8.9 Hydrochemistry and Water Quality

The following key points have been identified from the data. See Appendix VI for graphs.

- Analysis of hardness indicates a very hard (>350 mg l^{-1} $CaCO_3$) calcium bicarbonate hydrochemical signature. Magnesium levels in the "Woodstock" and Barrack Lane boreholes are above 20 mg l^{-1} in all but one analysis suggesting that the groundwater to the boreholes is coming from the magnesium rich dolomite aquifer.
- Reported nitrate concentrations are in the order of 15-30 mg l^{-1} for the three abstraction points. The average nitrate levels are as follows: Infiltration Gallery (approximately 27 mg l^{-1}); "Woodstock" borehole (approximately 17 mg l^{-1}); and, Barrack Lane (approximately 23 mg l^{-1}). Levels in the infiltration gallery appear to be higher than in either of the two wells, and are generally above the GSI threshold of 25 mg l^{-1}. The nitrate data for the "Woodstock" well is the most extensive, with occasional data covering the last 30 years and it can be seen that overall the nitrate level appear to relatively steady and there appears to be no overall trend in the data.
- Chloride is a constituent of organic wastes and levels higher than 25 mg l^{-1} may indicate significant contamination, and levels higher than the 30 mg l^{-1} usually indicates significant contamination. Chloride data range from 30 to 44 mg l^{-1} (average (35 mg l^{-1}) in the available samples for the "Woodstock" borehole, suggesting that contamination from organic wastes is occurring on a regular basis. Data range from 23 to 25 mg l^{-1} in the Barrack Lane well and from 21 to 38 mg l^{-1} in the infiltration gallery. The data for the infiltration gallery suggests that contamination from organic wastes has also occurred.
- Of the contaminant indicators examined, only chloride was at significant levels in available samples. There is only reported incident of bacteria in the analyses, occurring at the "Woodstock" borehole in 1987. However Daly (1987) concluded that the result was anomalous and is not representative of the groundwater quality at the boreholes and the gallery. Nitrate and chloride in the infiltration gallery and chlorides in the "Woodstock" borehole may reflect localised hazards (perhaps from leaking sewers).

8.10 Aquifer Characteristics

The bedrock (Milford Limestone Formation) is the main aquifer feeding the Woodstock and Barrack Lane boreholes. The bedrock is described in Sections 3 & 4 of Volume 1 of the main report. The Milford Limestone Formation is classed as a **Regionally Important Karstified Aquifer (Rk)** (refer to Section 4.12 of Volume I). The bedrock in the vicinity of the boreholes is dolomitised (Daly, E.P., 1987). Daly (1987, 2002) suggests that the bedrock is fissured and/or karstified up to 56 m below ground. The fissures are frequently filled with sand & clay near the surface (E. P. Daly 1982). Daly (2001) also reports cavernous rock at the bottom of the Barrack Lane borehole. There are five "Excellent" and two "good" yielding wells in the Athy area, all abstracting water from the dolomitised bedrock. Table 4 presents the available range of aquifer parameters for the Milford Formation based primarily on locally derived data. The high productivity of the bedrock in this locality is attributed to the possible presence of a fault or fracture zone along the River Barrow (Daly, 1987, 2000). Faults and fractures are likely to be the focus of groundwater movement and dolomitisation and dissolution of the clean limestone is likely to have occurred preferentially along them. Eugene Daly Associates calculated the transmissivities from the trial well test data to be approximately 140 m^2 d^{-1} which compares favourably with estimates of the transmissivity from specific capacity data.

The infiltration gallery is excavated in a sand/gravel deposit that is classed as a **Regionally Important Sand/gravel aquifer (Rg)**. Further details of this aquifer can referred to in Section 4 of Volume I. The permeability was estimated from salt tracer experiments that were carried out by TC staff (Daly, 1987). Transmissivities were estimated from test pumping of the Graysland Borehole (located in the same aquifer on the southern side of Athy) to be in the order of 200 m^2 d^{-1}.

Table 4 Estimated Aquifer parameters for the Milford Limestone.

Parameter	*Source of data*	*Milford fmn.*
Transmissivity (m^2 d^{-1}) (Daly 1987)	Local	140
Specific Capacities (Daly 1987)	Local	50-150
Permeability (m d^{-1})	Local	5
Porosity	Assumed	0.015

Table 5 Estimated Aquifer parameters for Barrow sand/gravel aquifer.

Parameter	*Source of data*	*Barrow sand/gravel Aquifer.*
Transmissivity (m^2 d^{-1}) (Daly, 1987)	Local	200
Specific Capacities (Daly, 1987)	Local	70
Permeability (m d^{-1})	Local	8
Porosity	Assumed	0.07

8.11 Conceptual Model

- The Athy TC water supply consists of two boreholes and an infiltration gallery.
- The "Woodstock" and Barrack Lane supply boreholes are fed by the Milford Limestone Formation which is classed a **Regionally Important Karst aquifer** (**Rk**). The infiltration gallery is fed by the sand/gravel which is classed a **Regionally Important Sand/gravel aquifer (Rg)**.
- The bedrock aquifer parameters are variable but the permeability is thought to be generally high in the area of the "Woodstock" and Barrack Lane borehole.
- The bedrock aquifer is confined in the vicinity of the two supply boreholes. The piezometric surface for the confined bedrock aquifer is approximately at ground surface. Groundwater flow in the bedrock aquifer is probably via dolomitised and karstified fractures, fissures, joints, bedding planes and the uppermost part of the bedrock.
- The sand/gravel deposit is unconfined. Water levels are estimated to be less than 3 m below ground level up to 400 m west of the infiltration gallery.
- There are few drains and surface streams and the subsoils are moderately-highly permeable.
- It is expected that the regional groundwater flows to the east and discharges to the River Barrow. It is assumed that the gallery is almost entirely groundwater fed and that very little river water is induced into the gallery by pumping.
- Diffuse recharge occurs over most of the land surface through the permeable till. Estimates are in the order of 315 mm yr^{-1}.
- The hydrochemical chemical signature of the groundwater in the boreholes indicates that the groundwater is fed by the bedrock dolomitised aquifer.
- Elevated chloride in the "Woodstock" borehole suggest that there is contamination occurring from organic wastes. Whilst nitrates and chloride levels in the infiltration gallery also suggest that contamination from organic wastes is occurring.

8.12 Delineation of Source Protection Areas

8.12.1 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.

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 each of the boreholes and the infiltration gallery.

8.12.2 Outer Protection Area

The Outer Protection Area (SO) is bounded by the complete catchment area to the well field, 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 pumping rate, (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. The boundaries are shown in Map 8 and are described as follows:

The **western boundary** is delineated using the regional topographic divides that lie to the west in County Laois. It is thought that all shallow groundwater could potentially make its way to the source along an east-west line drawn eastwards from the source to meet the watershed at right angles. This represents maximum flow distances of 9 km. Flow paths of this length are possible, given the karstified and dolomitised nature of the bedrock and the high permeability of the sand/gravel aquifer. Given flat topography and the generally high permeability of the aquifers, it is difficult to justify drawing the western boundary any closer to the well.

The **eastern boundary** is on the down gradient side of the borehole. The test pumping data of the Barrack Lane borehole indicates that it can draw water down by 0.2-0.3 m at a distance of 40 m toward the river. As the river is 110 m to the east of the supply borehole, the boundary is taken as far as the river to allow for errors and variability in the aquifer parameters.

The **northern** and **southern boundaries** are complicated by the presence of the three Castlemitchell supply sources, two of which lie directly upgradient of the Athy source. They are also difficult to determine given the flat topography and the karstified and dolomitised nature of the bedrock. In other words, the ZOC needs to be big enough to incorporate the catchments of several sources and significant safety margins are required to allow for the unpredictability of groundwater flow within karstic bedrock aquifers in areas of flat topography. The proposed boundaries have therefore been extended to incorporate the most significant topographic hills in the plains area whilst allowing for a significant safety margin.

Note that the area delineated by these boundaries is significantly greater than the area required to supply sufficient diffuse recharge to meet the abstraction demand at the various supply sources. However, given the uncertainties outlined above, it is difficult to justify boundaries which delineate a smaller area.

8.12.3 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 cannot be made by hydrogeological mapping and conceptualisation methods alone. Estimations of the extent of this area are made using Darcy's Law as follows:

Sand/gravel: with a permeability (K) value of 40 m d^{-1}, porosity (n) of 0.07 and a gradient (i) of 0.05 the velocity (V) can be estimated as follows;

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

$$V = 8 \text{ m } d^{-1}$$

This means that in 100 days groundwater will move approximately 800 m in the sand/gravel.

Bedrock Aquifer: with a permeability value of 5 m d^{-1}, porosity of 0.015 and gradients estimated using the Theim equation, the 100 day ToT is estimated be approximately 225 m for the Townparks borehole and approximately 165 m for the Barrack Lane borehole.

As the 100 day ToT for the infiltration gallery is greater than for the boreholes, a distance of 800 m has been used to delineate the 100 day ToT for the source as a whole.

8.13 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. The matrix of source protection zones is given in Table 6. The vulnerability ratings for County Laois are take directly from the Laois Groundwater Protection Scheme (Deakin, J. *et al*, 2002). Due to shallow rock and outcrop in the western part of the source protection area these areas are extremely and highly vulnerable to contamination.

Table 6 Matrix of Source Protection Zones for Athy Well field.

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

8.14 Potential Pollution Sources

Agriculture is the principal activity in the ZOC. Most of the land is used for tillage, although a small proportion is used for pasture. The well field (Barrack Lane, Townparks and the infiltration gallery) is located in an urban environment, close the river Barrow. Potential hazards include farmyards, septic tank systems, application of fertilisers (organic and inorganic), pesticides, possible spillages along the roads and leaky underground sewers. Potentially the infiltration gallery is under threat from the River Barrow when it is in high flood stage. Of the contaminant indicators examined, none were at significant levels in available samples. Nitrate and chloride in the infiltration gallery are elevated and may reflect localised hazards (perhaps from leaking sewers). Levels in the deeper boreholes are above background levels but lower than those in the gallery. They may reflect releases from point and diffuse hazards such as septic tank systems and landspreading of organic wastes in rural areas upslope of the wells, along with a component of vertical leakage from those more local hazards affecting the infiltration gallery.

8.15 Conclusions and Recommendations

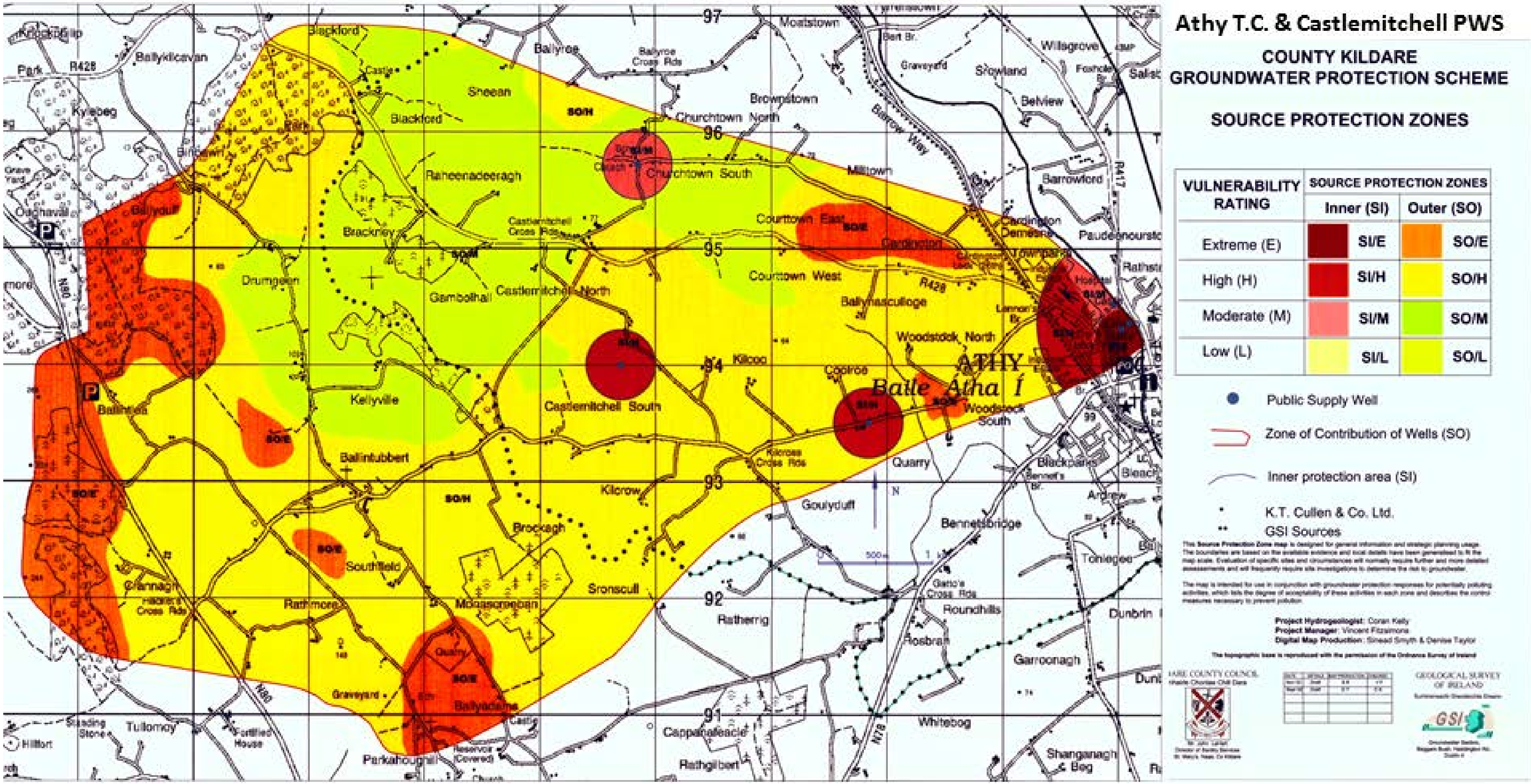
- Athy TC water supply consists of two boreholes located in a regionally important karstified aquifer (Rk) and an infiltration gallery located in a **regionally important** sand/gravel aquifer (**Rg**).

- The vulnerability of the groundwater in the ZOC varies from moderate to extreme moving west to east.

- Septic tanks, farmyards, landspreading, diesel/oil spills, runoff from the roads, leaky underground sewers and high flood stage of the River Barrow pose a threat to the water quality at the well field.

- 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 at each abstraction point is carried out on a regular basis. The elevated E.coli were found during an incident in 1987. Though these results are believed to be erroneous, there are very few raw water results available since that time to examine this issue further.
  2. particular care should be taken when assessing the location of any activities or developments which might cause contamination at the well field; particularly in relation to underground sewers and waste pipes.
  3. the potential hazards in the ZOC should be located and assessed.
  4. site security is checked to be adequate.
  5. well head protection is checked and improved where necessary.



Map 8 Athy T.C. & Castlemitchell Source Protection Zones

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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	Calcium (Ca)	Nitrate ($N0_3$)*
Sediment	Magnesium (Mg)	Ammonia ($NH_4$and NH_3)*
pH (lab)	Sodium (Na)	Iron (Fe)*
Electrical Conductivity (EC)*	Potassium (K)*	Manganese (Mn)*
Total Hardness	Chloride Cl)*	
General coliform	Sulphate ($S0_4$)*	
E. coli *	Alkalinity	
Optional Parameters (depending on local circumstances or reasons for sampling)		
Fluoride (F)	Fatty acids *	Zinc (Zn)
Orthophosphate	Trace organics *	Copper (Cu)
Nitrite ($N0_2$)*	TOC *	Lead (Pb)
B.O.D.*	Boron (B) *	Other metals
Dissolved Oxygen *	Cadmium (Cd)	
*** 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.

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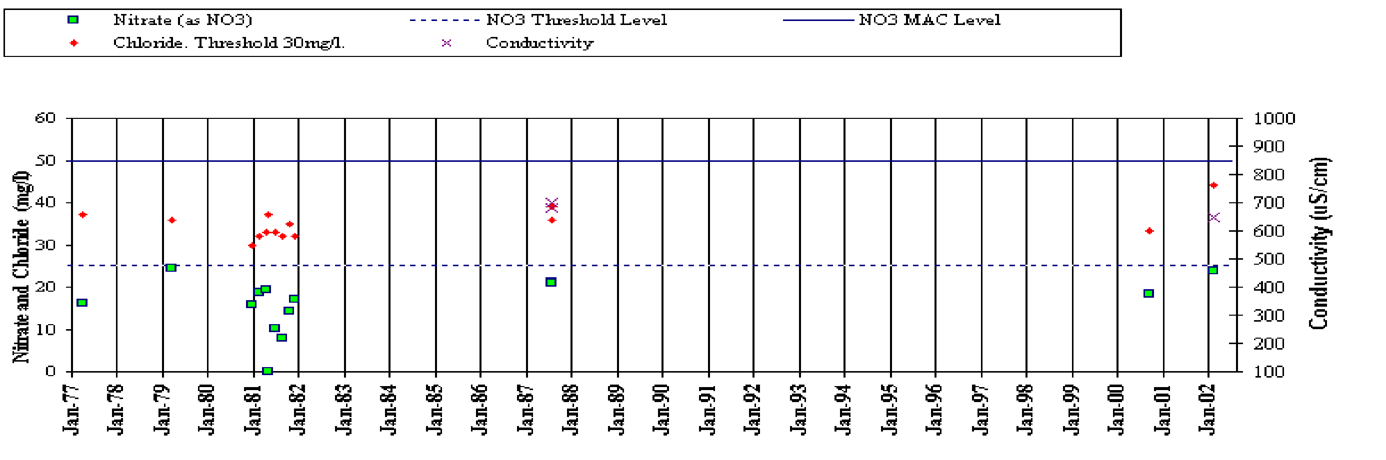
APPENDIX V: Laboratory analytical results

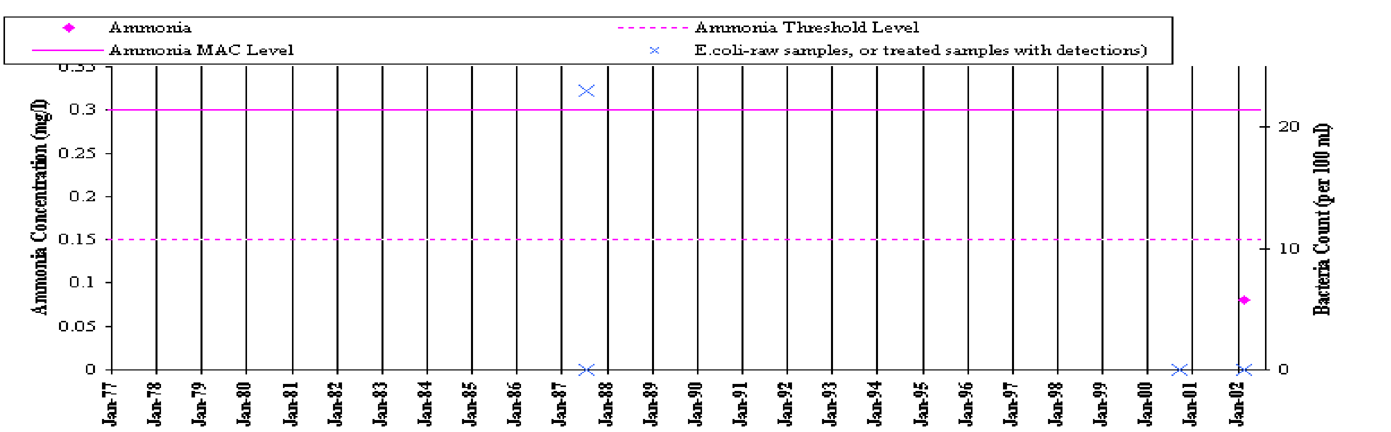
Location	County	Plot_no	location	Scheme	details	NGR	Easting	Northing	type	LAB	LAB_REF	date	pH	pH_field	Temp(O c)	Temp_Field (O c	Odour	Dslvd oxgen %sat	DO_field (mg/l)	DO_field (%sat)	BOD(mg/l O2)	Conduct (us/cm)	conduct_field_u	Location	Ammonia (mg/l N)	O-Phosphate (mg)	TON (mg/l N)	Nitrate (mg/l N	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

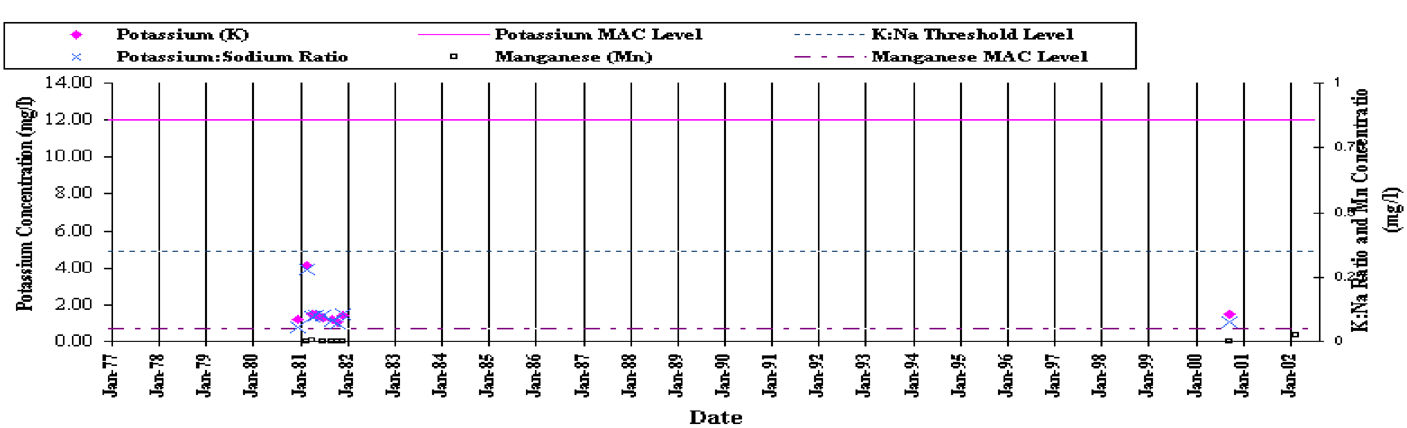
APPENDIX VI: Summary of trends in water quality over time for selected supply sources in Kildare

Athy_Townparks PWS
Key Indicators of Agricultural and Domestic Groundwater Contamination.

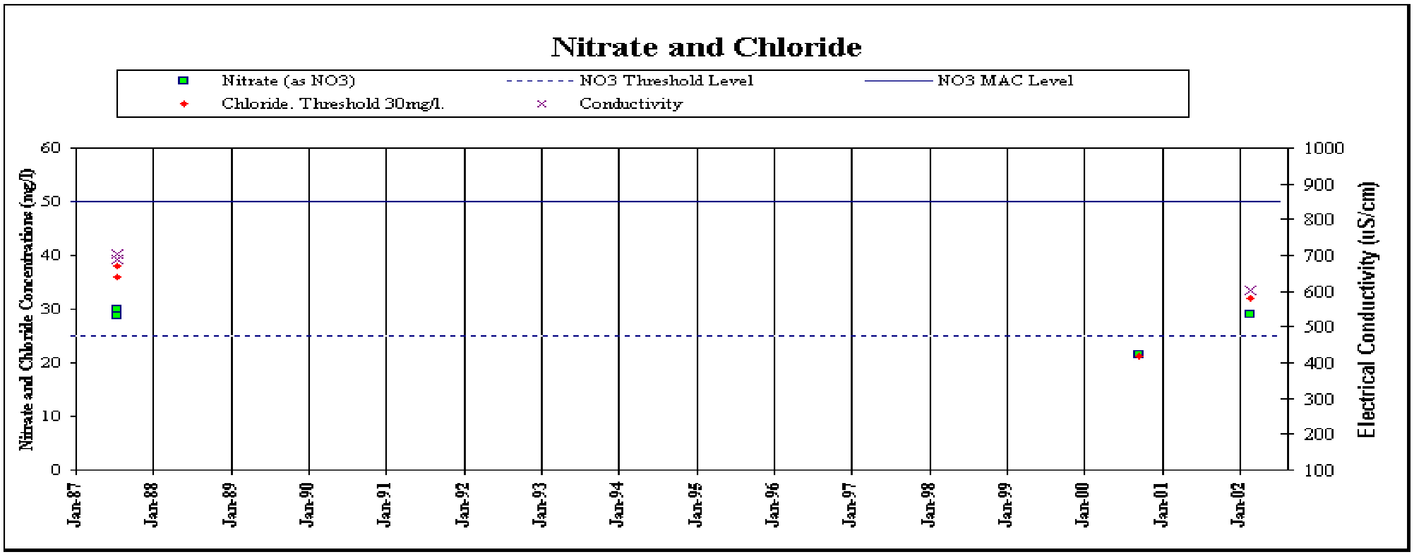
Nitrate and Chloride

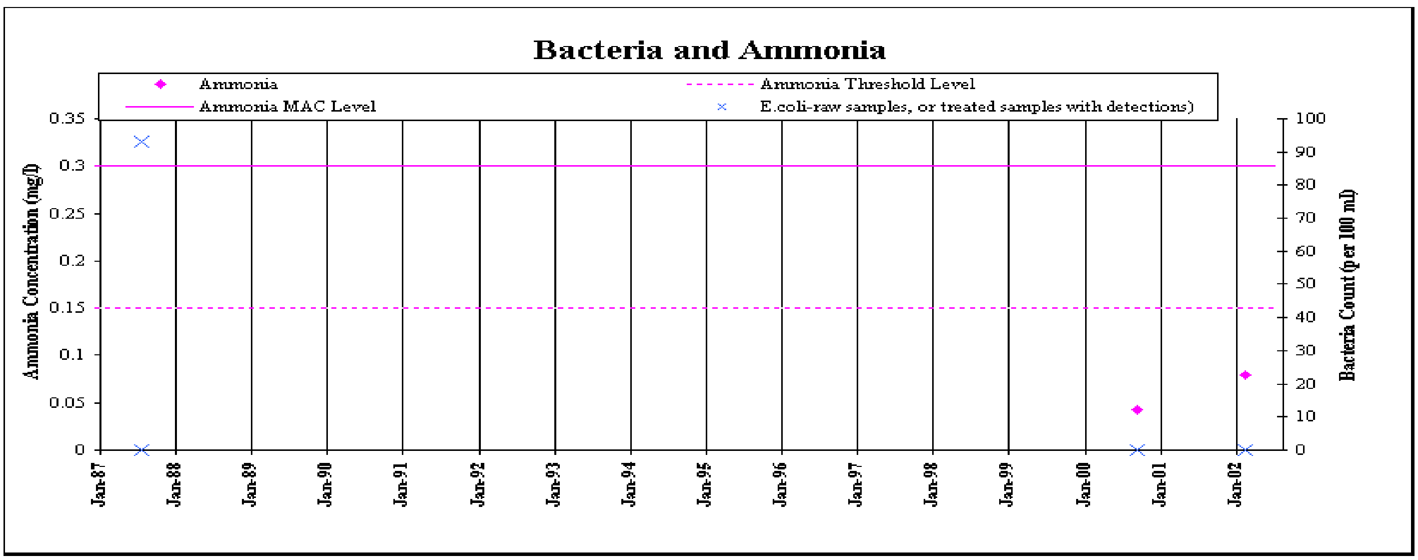


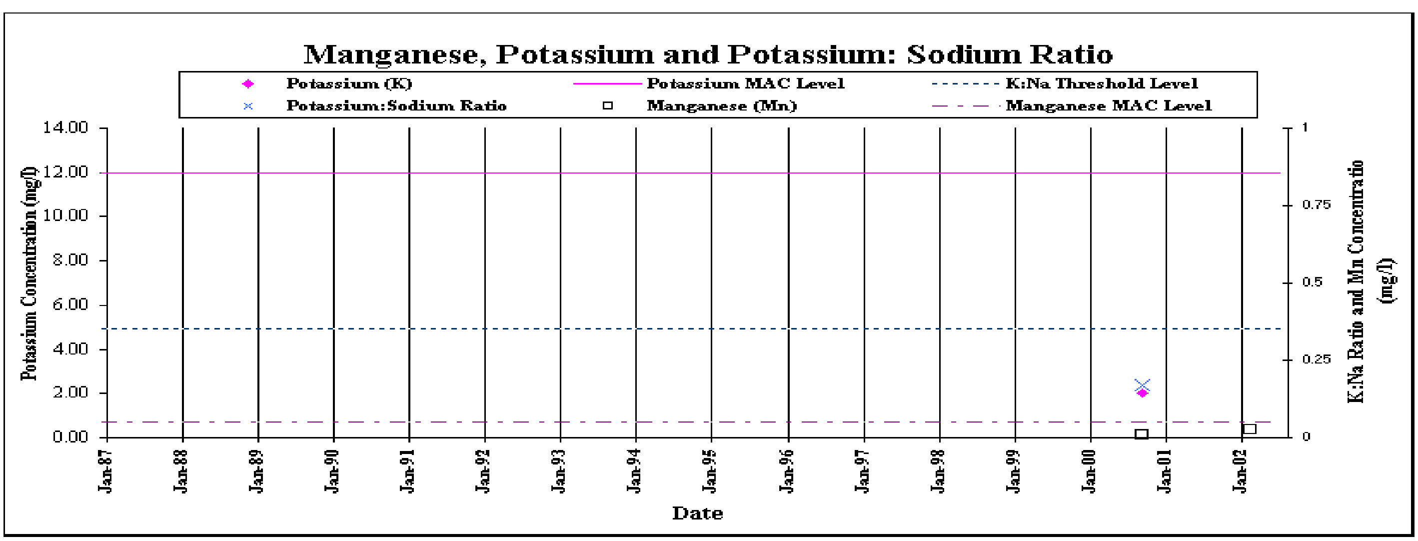




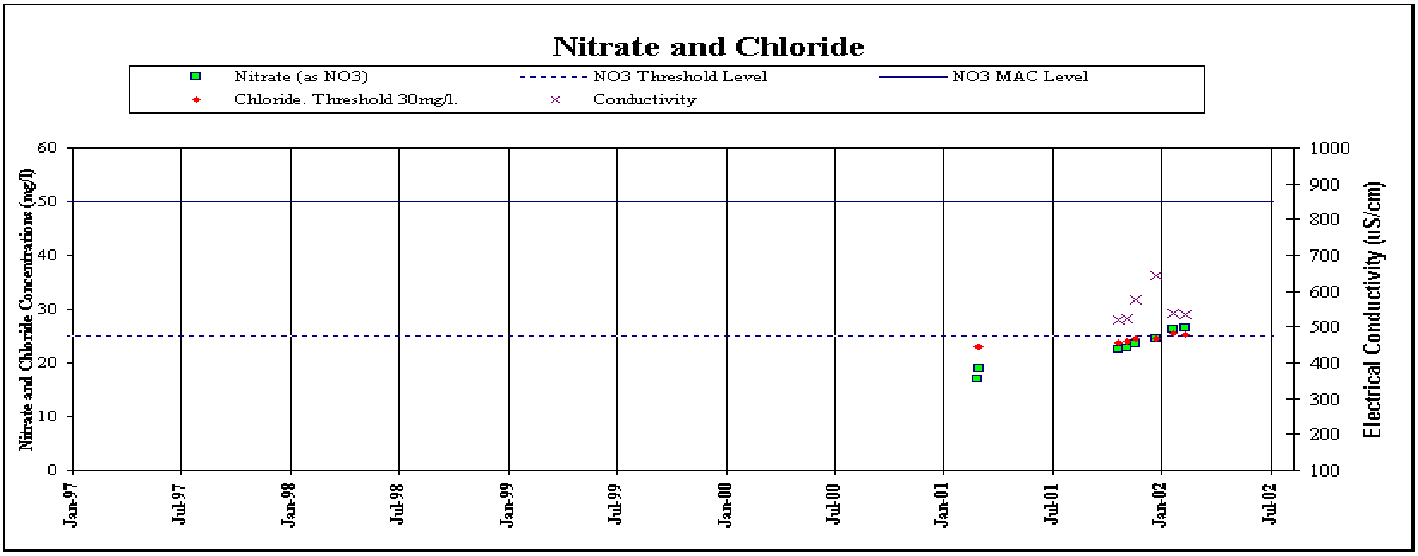
Athy PWS – Infiltration Gallery
Key Indicators of Agricultural and Domestic Groundwater

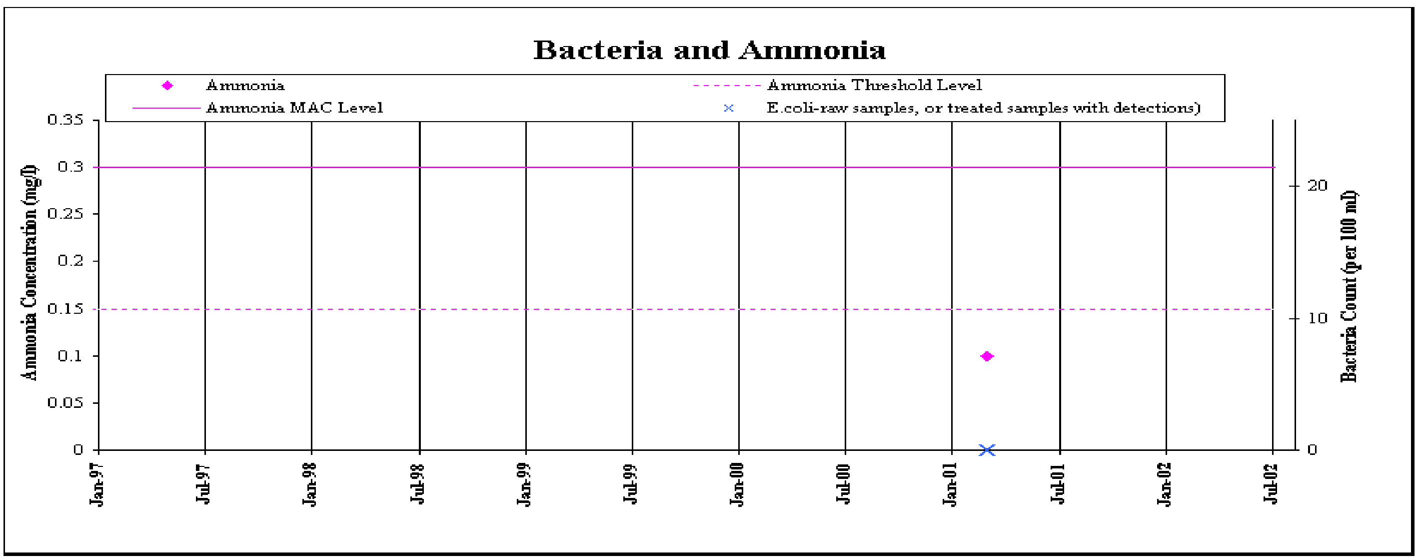


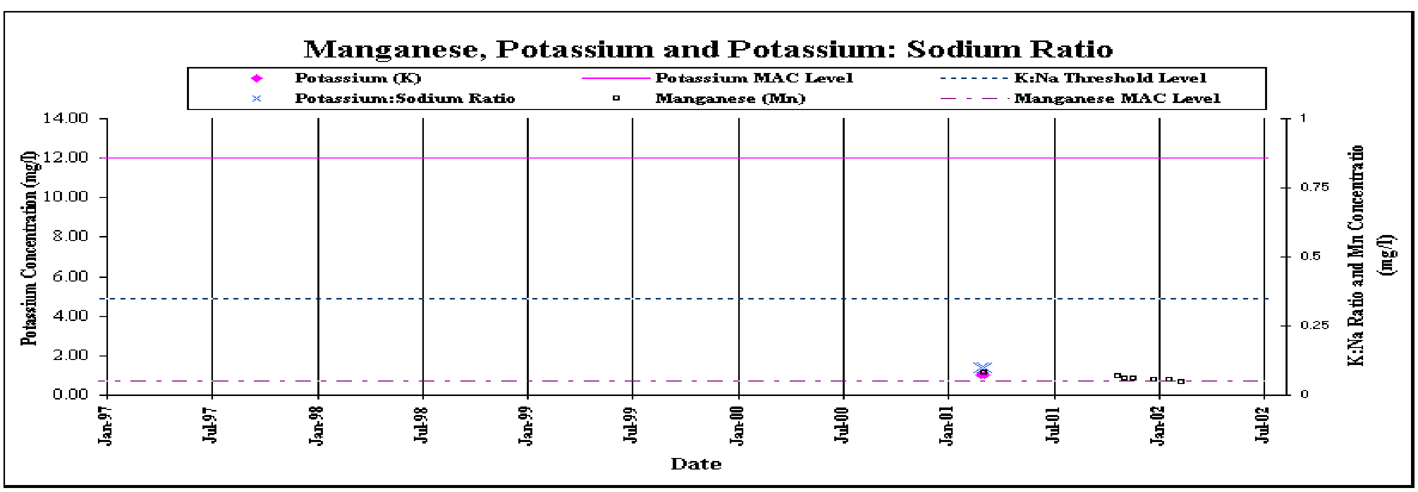




Athy PWS – Barrack Lane Bore.
Key Indicators of Agricultural and Domestic Groundwater Contamination.







Bullock Park PWS.
Key Indicators of Agricultural and Domestic Groundwater Contamination.