FERMOY WATER SUPPLY SCHEME

Coolroe Infiltration Gallery and Borehole

GROUNDWATER SOURCE PROTECTION ZONES

Draft

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October 2000

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1. Introduction

The objectives of this report are:

- To delineate source protection zones for the Fermoy Water Supply sources at Coolroe.
- To outline the principal hydrogeological characteristics of the Coolroe area.
- To assist Cork County Council (Northern Division) in protecting the water supply from contamination.

2. Location and site description

The Fermoy Water Supply is situated in the townland of Coolroe, about 3 km west of Fermoy town in North Cork. The water supply comes from an infiltration gallery constructed in 1968. The gallery is 350 metres long and is aligned approximately east-west, some 15 to 30 metres south of the bank of the Blackwater River (see sketch, Figure 1). The gallery, about 4.5 m deep, is accessible through six manholes, numbered MH1 – MH6 in Figure 1.The gallery drains from both ends towards MH2, from where the water flows by gravity to the pumphouse, some 60 metres south.

There is also a Production Borehole (PW 1) drilled in December 1999, and an observation borehole (trial well, TW 4) drilled in March 1996. PW1 is now inside the new pumphouse, while TW4 is in a fenced-off compound just outside the pumphouse.

The water is chlorinated and fluoridated, and pumped to a service reservoir.

3. Summary of well details

GSI no.	1709SW
Grid ref. (1:25,000)	17720 09820
Townland	Coolroe
Owner	Cork County Council (Northern Division)
Well type	Infiltration Gallery
Elevation	c. 27 m OD
Depth	approx. 4.5 m
Diameter	460 mm (pipe)
Depth-to-rock	approx. 9 m (maximum drilled, at TW#2)
Static water level	2.7 m b.g.l. (22/1/99). m b.g.l. before pumping test.
Current Abstraction	approx. 4500 m^3/d (1 million gallons per day)
Pumping test summary	*('combined test', 16-25/4/96)*
Abstraction rate	5472 m^3/d (gallery only, after 9 days); 5616 m^3/d after 4 days
Drawdown	1.03 m (maximum, after 4 days)
Specific Capacity	5450 m^3/d/m (after 4 days)

GSI no.	1709SW
Grid ref. (1:25,000)	17785 09845
Townland	Coolroe
Owner	Cork County Council (Northern Division)
Well type	Borehole (PW1)
Elevation (top of casing)	c. 27 m OD
Depth	39 m
Diameter	250 mm
Depth-to-rock	5.5 m
Pump depth	m approx.
Static water level	2.23 m b.g.l. (14/12/99). m b.g.l. before pumping test.
Current Abstraction	*(none)*
Pumping test summary	*(72 hour test, 14-17/12/99)*
Abstraction rate	1982 m^3/d (after 72 hours)
Drawdown	4.48 m (after 72 hours); 4.8 (extrapolated to 7 days)
Specific Capacity	442 m^3/d/m (after 72 hours); 413 m^3/d/m (extrapolated to 7 days)
Transmissivity	417 m^2/d

GSI no.	1709SW
Grid ref. (1:25,000)	17725 09830
Townland	Coolroe
Owner	Cork County Council (Northern Division)
Well type	Borehole TW4
Elevation (top of casing)	c. 27 m OD
Depth	26 m
Diameter	150 mm
Depth-to-rock	7.5 m
Static water level	4.1 m b.g.l. (11/3/96) before pumping test; 4.38 m (14/12/99)
Pumping test: (1)	*(test on TW4, 11/3/96)*
Abstraction rate	1050 m3/d
Drawdown	2.01 m (maximum, after 20 hours)
Specific Capacity	522 m^3/d/m (after 20 hours);
Pumping test: (2)	*(test on PW1, 14/12/99)*
Drawdown	3.32 m (after 72 hours)
Transmissivity	361 m^2/d

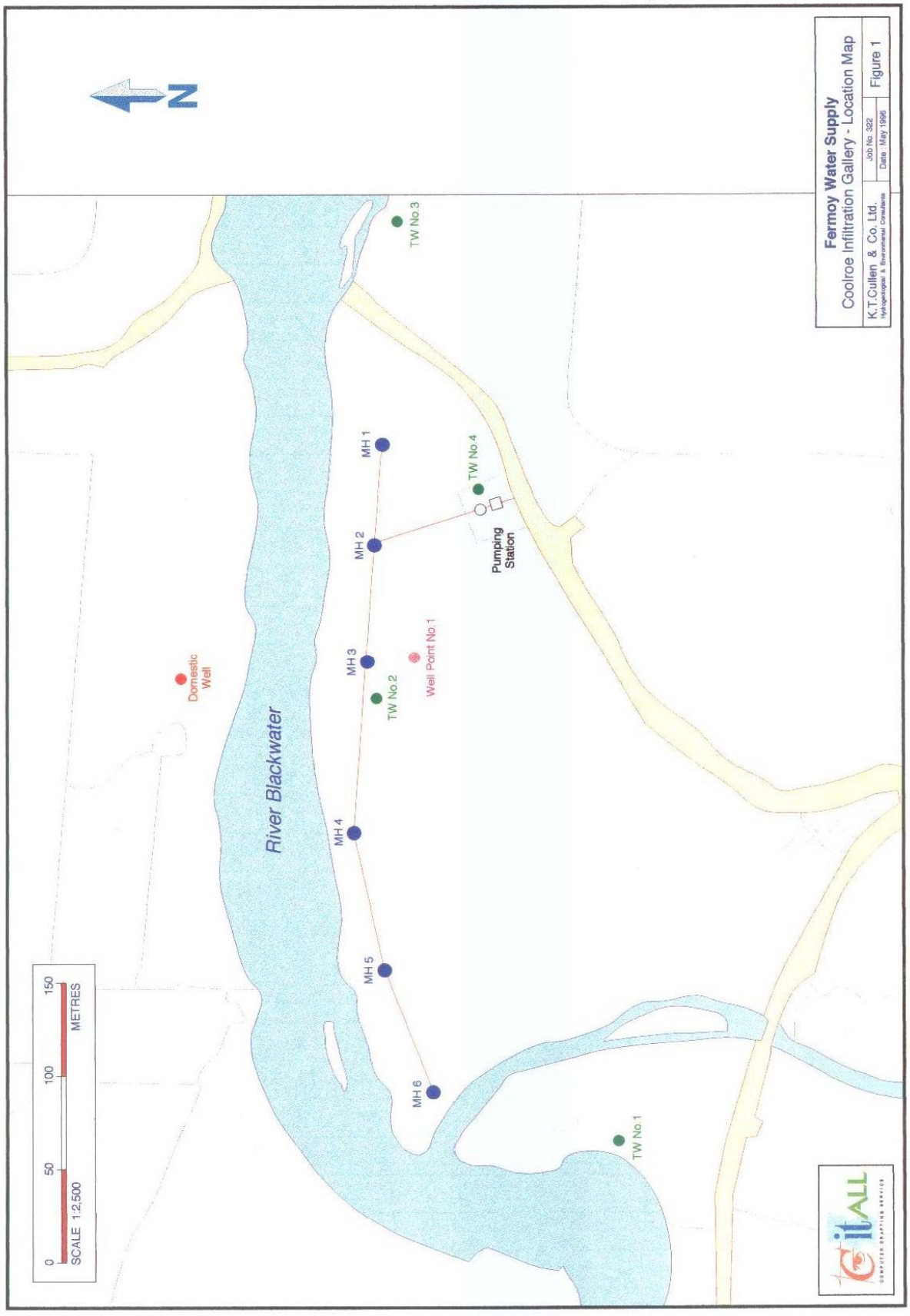

Figure 1 Location map of the area around the gallery and borehole at Coolroe

(from K.T. Cullen & Co. Ltd., 1996)

4. Methodology

Desk Study

Bedrock geology information was compiled from the published Geological Survey of Ireland 1:100,000 Bedrock Series (Sheet 22), (Sleeman & Pracht, 1994) and subsoils were compiled from consultants' reports. Basic source details were obtained from County Council personnel and consultants' reports (K.T. Cullen & Co. Ltd., 1996, 2000, and Geoex 1985).

Site Visits and Fieldwork

This included a walkover survey, to aid in the conceptualisation of the hydrogeology. Vulnerability to contamination and the current pollutant loading in the area were also considered.

Analysis

Field studies, data from consultants' reports, and assumptions about the flow regime in the area were used to delineate protection zones around the sources.

5. Topography and surface hydrology

The infiltration gallery and pumphouse at Coolroe are located in a field (c. 6 hectares, or 16 acres) on the flood plain on the south (right) bank of the Blackwater River. The elevation at the gallery is approximately 27 m O.D.

The field slopes slightly away from the river bank, i.e. there is a small levee. The are above the gallery is subject to flooding in winter, to a depth of one to two metres.

At the western end of the field, just north of Millquarter Bridge, the Blackwater is joined by the Cregg Stream, draining the hillside to the south, which rises to an elevation of about 225 m O.D.

6. Geology

6.1 Bedrock geology

6.1.1 Geological Succession

Geological Unit	Code	Description	Occurrence
Carboniferous Limestones (various formations)	LLS, BT, BA, WA		*(not found by drilling in 1996 or 1999, but reported from a private well on the northern bank of the river)*
(Devonian) Gyleen Formation ***or*** Kiltorcan Formation	 GY KT	 Sandstone with mudstone and siltstone Yellow and red sandstone & green mudstone	Beneath the Coolroe site as shown on GSI Sheet 22 Occurs north and east of Fermoy (GSI Sheet 22)
(Devonian) Ballytrasna Formation	BS	Purple mudstone with some sandstone	Underlies the hillside to the south of the Coolroe site, above about 60 metres O.D.

The geological succession as depicted on GSI Bedrock Sheet 22 (Sleeman & Pracht, 1994) shows the site to be underlain by Devonian sandstones of the Gyleen Formation. However, K.T. Cullen & Co. (1996) refer the sandstone aquifer to the Kiltorcan Formation (KT), which conforms better with the well yield and transmissivity as inferred from the pumping test data.

On the 19th century geological sheets, the rocks beneath the site are described variously as being red, grey and yellow in colour, and as sandstone or slate in lithology.

The finer grained sandstones and mudstones of the Ballytrasna formation underlie the upper slopes of the hillside south of the Coolroe site. On the 19th century geological sheets, these rocks are described as red, yellow and greenish, and as sandstone or slate.

6.1.2 Geological Structure

The geological formations all dip northwards at varying angles. In the nearest exposures (near Millquarter Bridge) angles of 25 to 45 degrees from horizontal are recorded. Elsewhere, steeper dips are indicated.

The Ballytrasna Formation dips northwards beneath the overlying Gyleen or Kiltorcan Formation.

There is some evidence for a north-south fault along the valley of the Cregg Stream, although this is not shown on any geological maps. The presence of such a fault would help to explain the high yields and transmissivities shown in the Coolroe boreholes.

6.2 Subsoil Geology

6.2.1 Subsoil types

Two subsoil types can be identified in the area, namely till and alluvium.

Till

The till was examined at two locations: (a) immediately behind the pumphouse, in an excavation (now obscured by landscaping); (b) in a cliff beside the stream at Millquarter Bridge. In both places it appeared to be a free-draining sandy till, essentially a sandy silt with cobbles (BSI, 1981).

Notes on the 19th century geological sheets describe the till as "sandy clay drift"

Alluvium

The alluvial gravel is the aquifer feeding the infiltration gallery. Information is available from the consultants' reports. Geoex (1985) describes the sediments as interbedded clays, gravels and silts, with a probable maximum thickness of 15 feet (4.5 m) and a width of about 500 feet (150 m). Trial pits dug for the gallery were reported to have met 3 feet (0.9 m) of clay overlying 7-8 feet (2.1-2.4 m) of gravel.

6.3.1 Depth to bedrock

Depth to bedrock information is available only from the trial boreholes and production borehole, which indicate a depth of 1.5 to 9 metres. Rock outcrop is visible to the west of Millquarter Bridge, on the upstream side only. On the downstream right bank, only till is found, even in the stream bed, and the high cliff appears to be entirely composed of till.

Geoex (1985) suggested the till might be 10-15 feet thick (3-4.6 m) over the Devonian rocks, but may be thicker above the Carboniferous Limestone.

K.T. Cullen & Co. Ltd. (1996, 2000) supervised trial drilling and found:

- 2 m of clay above 5 m of coarse gravel and sand in Trial Well #1
- 3 m of clay above 6 m of sandy gravel in Trial Well #2
- 3 m of clay above 3 m of sandy gravel in Trial Well #3

- 1.5 m of boulder clay (till) above bedrock in Trial Well #4
- 5.5 m of brown boulder clay (till) above bedrock in Production Well Well #1

7. Rainfall, Evapotranspiration and Recharge

Long term average annual rainfall (P) is estimated at 1100 mm (Met Eireann).

Long term average annual actual evapotranspiration (Ae) is estimated at 486 mm (EPA).

Long term average annual potential recharge is (1100 - 486) 614 mm.

Actual recharge will be a proportion of this, depending on the local runoff coefficient. Considering that the bedrock is covered with free-draining till, and that topographic slopes are fairly steep, actual recharge is estimated at 75% of the potential, i.e. about 460 mm/year.

8. Water Quality

8.1 Data availability

Nitrate data are available for the Coolroe source from 1989 to date (EPA and County Council data), with some additional data from 1968. Data from the consultants' reports are collated in Appendix 1.

No other data were examined for this report.

8.2 Nitrate

Nitrate has been a problem in the Coolroe source for several years. Figure X presents the available nitrate data for the source. Before 1994 the data appear to relate to mixed samples (groundwater from the gallery mixed with surface water from an impoundment on the Cregg Stream). Since 1994 there has been a general increasing trend. There is some evidence that summer levels are lower than winter levels.

8.3 Bacteria

Bacterial quality of the water from the various boreholes, from the limited sampling recorded in the consultants' reports, is quite good, with small coliform counts recorded in some samples and zero counts in others.

8.3 Other parameters

The analyses show that the water in the gallery and in the gravel wells is considerably softer (less mineralised) than the water from the sandstone (TW4 & PW1). This confirms the connection with the river water, which is softer than groundwater.

No significant water quality concerns (apart from nitrate) are evident from the analyses seen.

9 Hydrogeology

9.1 Pumping tests

Several pumping tests have been carried out at the site and are recorded in the reports by K.T. Cullen & Co. Ltd. (1996, 2000). The data are summarised in Table 2.

The tests demonstrated that the alluvial gravel aquifer tapped by the gallery is in intimate hydraulic connection with the river water, as shown by a parallel responses by the river and well water levels, following heavy rainfall. This is at variance with the statement by Geoex (1985) that "The water which enters the infiltration gallery is groundwater and not river water." In fact, it is clear that water is likely to flow either way, depending on the hydrological situation: when the river is high, water may flow from the river into the aquifer, and when the river is low, water will flow the other way. This has obvious implications for water quality in both the river and the aquifer.

Table 2: Summary of Pumping Test Data

Borehole	TW1	TW2	TW3	TW4	PW1
Aquifer	Gravel (5 m)	Gravel (6 m)	Gravel (3 m)	Sandstone	Sandstone
Date of test	23-26/1/96		11-12/4/96	11-14/3/96	14/12/1999
Duration (hours)	72		24	72	72
Pumping well	*		*	*	*
Observation wells				TW2, TW3, WP1	TW4
Pumping rate, m3/d	1604 / 1000		720 / 674	1050	2033 / 1982
Maximum drawdown, m	1.95 / 1.42		1.93 / 1.67	2.01	4.48
Time of maximum drawdown (hrs)	1 / 72		7 / 20	20	72
Specific capacity, m3/d/m	823 / 704		373 / 404	522	442
Transmissivity, m2/d	1175		225		417
	TW1	**TW2**	**TW3**	**TW4**	**Gallery**
Date of test (Combined Test)	16-25/4/96	16-25/4/96	16-25/4/96	16-25/4/96	16-25/4/96
Duration (days)	9	9	9	9	9
Pumping well	*		*	*	*
Observation wells		*	(also WP1 and 'Domestic Well')		
Pumping rate, m3/d	1490 / 1267		687 / 511	1898 / 1767	5616 / 5472
Maximum drawdown, m	2.08	0.89	3.32	4.65	1.03
Time of maximum drawdown (hrs)	8	108	48	108	102
Specific capacity, m3/d/m	702		185	372	
Transmissivity, m2/d					

9.2 Aquifer properties

The pumping tests indicate an aquifer transmissivity in the sandstone of approximately 420 m^2/d. TW4 is 39 m deep, with a total sandstone thickness of 33.5 m. Major water inflows were recorded at 26.5-27 m and 30.5-31 m below ground. For estimating purposes, the active aquifer thickness is taken as 30 m. Hence the aquifer permeability (Transmissivity/thickness is estimated at 14 m^2/day.

The transmissivity of the gravel aquifer as indicated by the pumping tests varies from over 200 to over 1000 m^2/d. The transmissivity is much higher in TW1 than in TW3. This is only partially explained by the greater thickness of gravel in TW1 (5 as compared with 3 m) and the greater degree of dewatering of the gravel at TW3. It also appears that the gravel at TW1(described as “coarse gravel and some sand”), near the mouth of the Cregg Stream is coarser and perhaps cleaner than the gravel at TW3 (described as “sandy gravel”). Geoex (1985) noted that inflow to the gallery trench was said to have been greater at the western end than the eastern end, which supports the test results above.

9.3 Groundwater levels, gradients and flow directions

Beside the water levels recorded during the drilling and pumping tests, the only water level data is from the Geoex (1985) report, which sketched in some water table contours and flow directions in the sandstone aquifers. The relevant Geoex map (85/W/136) suggests a hydraulic gradient in the Balytrasna Formation of approximately 0.12 (30 m in 250 m). For the main sandstone aquifer (Gyleen

or Kiltorcan Formation) a maximum gradient of 0.066 (30 m in 450 m) is indicated, but the interval over which this is measured includes much of the Ballytrasna Formation. The actual gradient in the main sandstone is unlikely to be greater than 0.025, and for estimating purposes a value of 0.02 is taken.

9.4 Aquifer throughput

If the transmissivity of the main sandstone aquifer is around 420 m^2/d, and the hydraulic gradient is 0.02, then the average rate of groundwater movement through the aquifer (aquifer throughput) can be estimated as 420 x 0.02 x 1000 = 8,400 m^3/d per kilometre of aquifer width.

If the Coolroe Production Well can develop a catchment width of approximately 500 m, then the likely maximum output of the well should be in the region of 4,200 m^3/d. (However, an alternative approach (section 12.2) suggests that this is probably an overestimate.)

9.5 Aquifer classification

The Gyleen Formation in Cork is generally classified as a Locally Important Aquifer, moderately productive only in local zones (Ll).

The Kiltorcan Formation in Cork is classified as a Regionally Important Fissured Aquifer (Rf). The aquifer transmissivity (= permeability x thickness) of the aquifer at Coolroe, as demonstrated by the pumping tests, is higher than found to date anywhere else in County Cork in the Gyleen Formation (from available data). This suggests that the aquifer is, in fact, Kiltorcan Formation. In any event, in the local context, the main sandstone aquifer at Coolroe is best envisaged as a Regionally Important (Rf) Aquifer.

The Ballytrasna Formation is classified as a Locally Important Aquifer, moderately productive only in local zones (Ll), based on data from many areas of counties Cork, Waterford and South Tipperary.

10. Groundwater Vulnerability

Subsoil Thicknesses

Subsoil thicknesses are discussed in Section 6.2.2. Insufficient data are available to allow 5 or 10 m contours to be drawn.

Subsoil Permeability

The sandy till seen beside the pump house and in the cliffs at the bridge is assessed as ‘moderately permeable’.

Vulnerability Assessment

Groundwater in the alluvial gravel is considered “extremely vulnerable” *(E)* to contamination, because the aquifer is a sand/gravel with a water table depth of less than 3 metres. Groundwater in the Gyleen Formation is assessed as “highly to extremely vulnerable” *(H – E)* since it is overlain by sandy till of moderate permeability and less than 10 m deep.

11. Conceptual Model

The groundwater flow system in and around the Coolroe site is best envisaged in the form of a south-north transect from the upland ridge to the south, down the hillside to the river. In succession, this transect crosses:

- The Ballytrasna locally important aquifer
- The main sandstone (?Gyleen/?Kiltorcan) regionally important aquifer
- The gravel aquifer

Recharge from rainfall infiltrates all parts of the three aquifers. On the gravel aquifer the recharge is substantially augmented by recharge from river floodwater which seasonally inundates the flood plain.

Groundwater in the Ballytrasna aquifer flows northwards into the main sandstone aquifer, where the transmissivity increases and, consequently, the hydraulic gradient decreases. Groundwater in the main sandstone aquifer continues to flow northwards towards the river. Pumping from PW1 will intercept a substantial volume of the flow in a strip of the aquifer perhaps 500 metres wide (east-west). In the absence of such pumping, this groundwater will continue to flow north, through the alluvial gravels and into the river. However, the gallery will intercept much of this flow towards the river through a strip some 400-500 metres wide.

The gallery also draws on groundwater stored in the alluvial gravels, and will induce flow from the river into the gravels, except when the water level in the gravel is significantly higher than in the river.

12. Delineation of Source Protection Areas

12.1 Introduction

This section describes the delineation of the areas around the gallery that are believed to contribute groundwater to the public water supply and that therefore require protection. The areas are delineated on the basis of the conceptualisation of the groundwater flow pattern, as described in Section 11. Two source protection areas are delineated:

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

12.2 Outer Source Protection Area (SO)

The Outer Protection Area (SO) includes the complete catchment area to a source, i.e. the zone of contribution (ZOC), and is delineated 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 aquifer permeability, and (d) the recharge. The ZOC is delineated as follows:

i) An estimate of the area size is obtained by using the average recharge and the abstraction rate.

ii) The shape of the area is then derived by both analytical modelling and hydrogeological mapping techniques.

iii) To allow for errors in estimating the groundwater flow direction and to allow for an increase in the ZOC in dry weather, a safety margin may be incorporated by assuming a higher abstraction rate, and/or allowing for a +/-20° variation in the flow direction.

In the case of the Coolroe site, the topographic catchment to the source is essentially the hillside immediately to the south, which extends approximately 1500 metres north-south and perhaps 500 metres east-west, totalling no more than 0.75 km^2, and probably less. Assuming an annual recharge of 460 mm, this would provide no more than 345,000 m^3/year, or 945 m^3/day, approximately 20% of the current abstraction. This indicates that the gallery must receive substantial additional recharge. A small amount could be contributed by the Cregg Stream, but by far the greatest contribution must come from the Backwater River, partly by direct lateral infiltration from the river channel, and partly from seasonal flooding of the gravel aquifer.

Hence the water quality at this site can be affected by the quality of the river water, and in a sense the ZOC of the gallery is the entire Blackwater catchment upstream of this point.

Note that the above estimate of catchment yield (945 m^3/day) is at variance with the earlier estimate of aquifer throughput (section 9.4) of 4,200 m^3/day. The truth probably lies somewhere between the two figures, but is likely to be closer to 1,000 m^3/day than 4,200 m^3/day, since the catchment yield is more closely constrained by climatological and topographic factors. A more reliable estimate may be obtainable by numerical modelling. The most probable reason for overestimating groundwater

throughput is that the transmissivity inferred from the pumping tests is not representative of the aquifer as a whole.

12.3 Inner Source Protection Area (SI)

The Inner Protection Area (SI) is normally the area defined by a 100 day time of travel (TOT) to the source and is delineated to protect against the effects of potentially contaminating activities which may have an immediate influence on water quality at the source, in particular microbial contamination.

Given that the gallery is subject to seasonal flooding, this source is exceptional.

It is proposed that, for the Coolroe gallery source, the SI area is defined as the 16 acre field, bounded as follows:

To the west, by the Cregg Stream

To the east, by the Coolroe Townland boundary

To the north, by the Blackwater channel

To the south, by the road to the pumphouse.

For the Coolroe borehole source, a much larger area needs to be defined as the Inner Protection Area. Assuming a permeability of 14 m/day, a hydraulic gradient of 0.02 (from Geoex water table contour maps, 1985) and a porosity of 4%, the 100 day travel time gives a radius of 700 metres, i.e. just beyond Stack's Cross Roads (Figure X).

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), i.e. by superimposing the vulnerability map on the source protection area map – a possible total of 8 source protection zones (see the matrix in the table below). 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. There are 4 groundwater protection zones present around the gallery and borehole as shown in the matrix below.

Matrix of Source Protection Zones

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

Response measures imposing restrictions on certain developments and activities within these zones are included in the "Groundwater Protection Schemes" publication by the DELG, EPA and the GSI in 1999. These measures indicate the degree of restriction recommended in each protection zone. Further documents listing groundwater protection responses to other developments will be published from time to time.

14. Land Use and Potential Pollution Sources

Land use in the area is predominantly dairy farming. The field above the gallery is grazed by a dairy herd. There are a number of farms in the area.

The main hazards within the Zones of Contribution are considered to be landspreading and the application of fertilisers immediately above and around the gallery. Other hazards include farmyards, septic tank systems, and possible spillages along the roads upgradient of the wells. No detailed assessment of hazards was carried out for this report.

15. Conclusions and Recommendations

- The Coolroe Water Supply consists of an infiltration gallery and a borehole.
- Water quality at both the sources is generally quite good, apart from the elevated nitrate levels. The inner and outer 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:

- Spreading of slurry and fertiliser within the gallery's Inner Protection Area (i.e the 16-acre field) should cease. This alone should bring the nitrate concentrations in the gallery water down to a satisfactory level. The borehole water quality would probably be slower to respond to this change than the gallery, since the nitrate in the bedrock aquifer will be slower to flush out.
- Chemical and bacteriological analyses of raw water rather than treated water should be carried out on a regular basis (every 6 months). The chemical analyses should include all major ions: calcium, magnesium, sodium, potassium, ammonium, bicarbonate, sulphate, chloride, and nitrate.
- The potential hazards in both ZOCs should be located and assessed; in particular, activities in and around the main farms. Checks should be carried out to see that fertiliser applications and landspreading are carried out at appropriate times and rates.
- Contingency plans should be drawn up for dealing with spillages along roads in the area.
- When landspreading around the gallery has been halted, water from the Production Well should be tested periodically until the nitrate concentration reaches a satisfactory level and the well can be brought into service. An extended period of pumping water to waste should expedite the normalisation of the nitrate level.

- An extended pumping test (at least 15 days) should be carried out on the Production Well under summer conditions, to confirm the aquifer properties and the sustainable yield of the well.
- It is suggested that an automatic water level recorder is installed on the observation well (TW4) to monitor groundwater level fluctuations.

16. References

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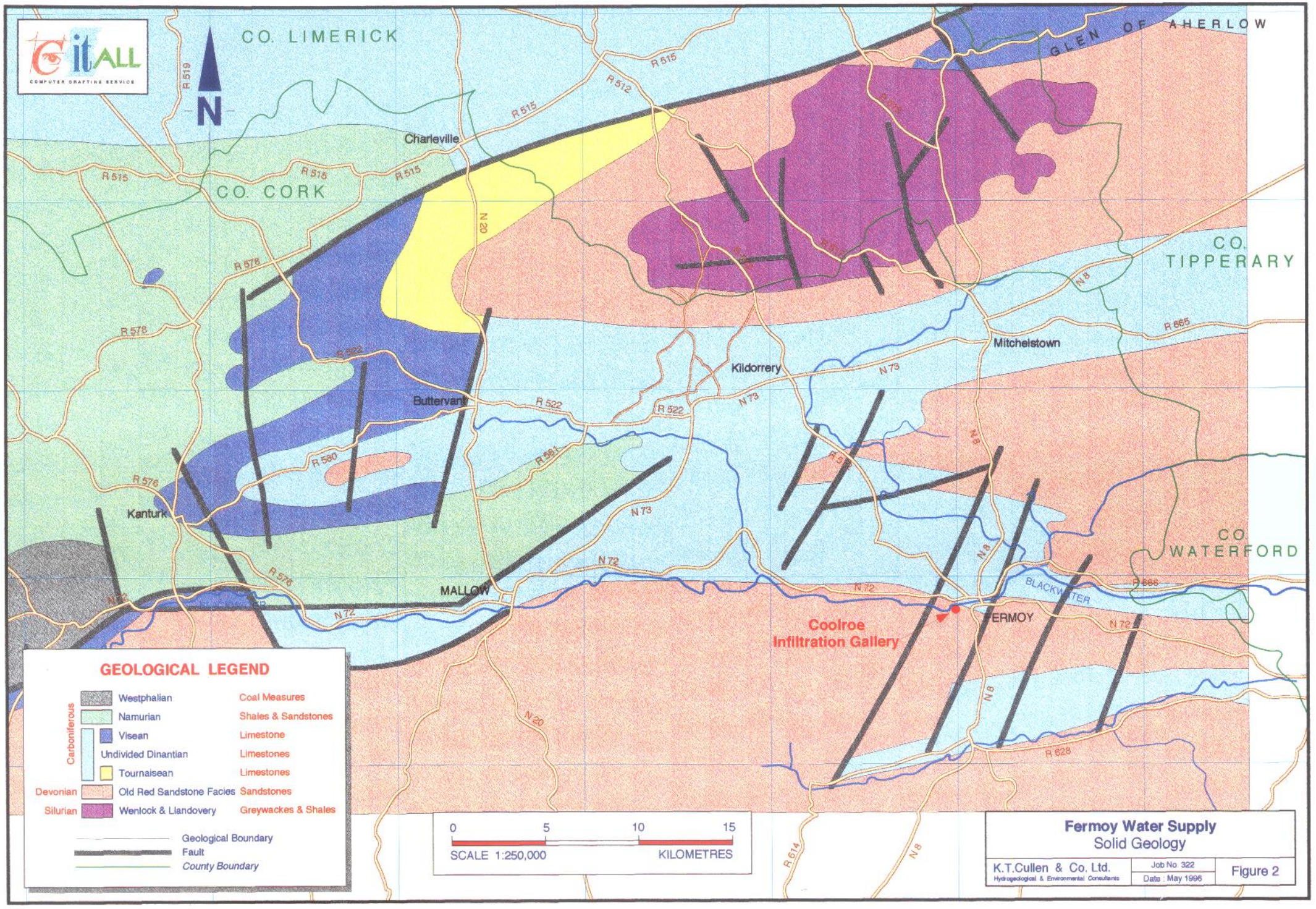
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Charleville
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Kanturk
MALLOW
FERMOY
BLACKWATER
Coolroe
Infiltration Gallery
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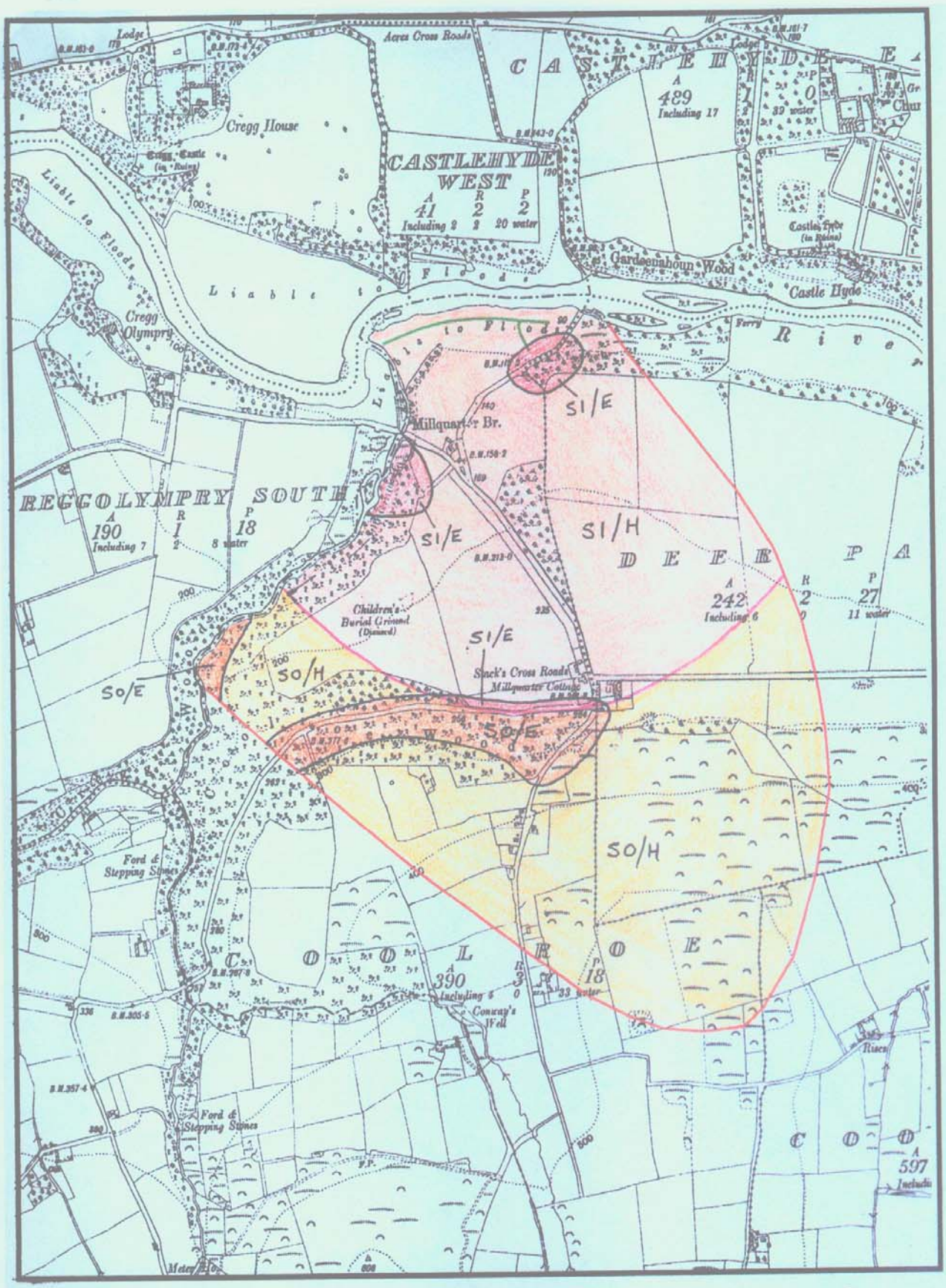
Figure 2



Map 1 : SOURCE PROTECTION ZONES FOR COOLROE BOREHOLE.

Appendix 1

Water Quality Data

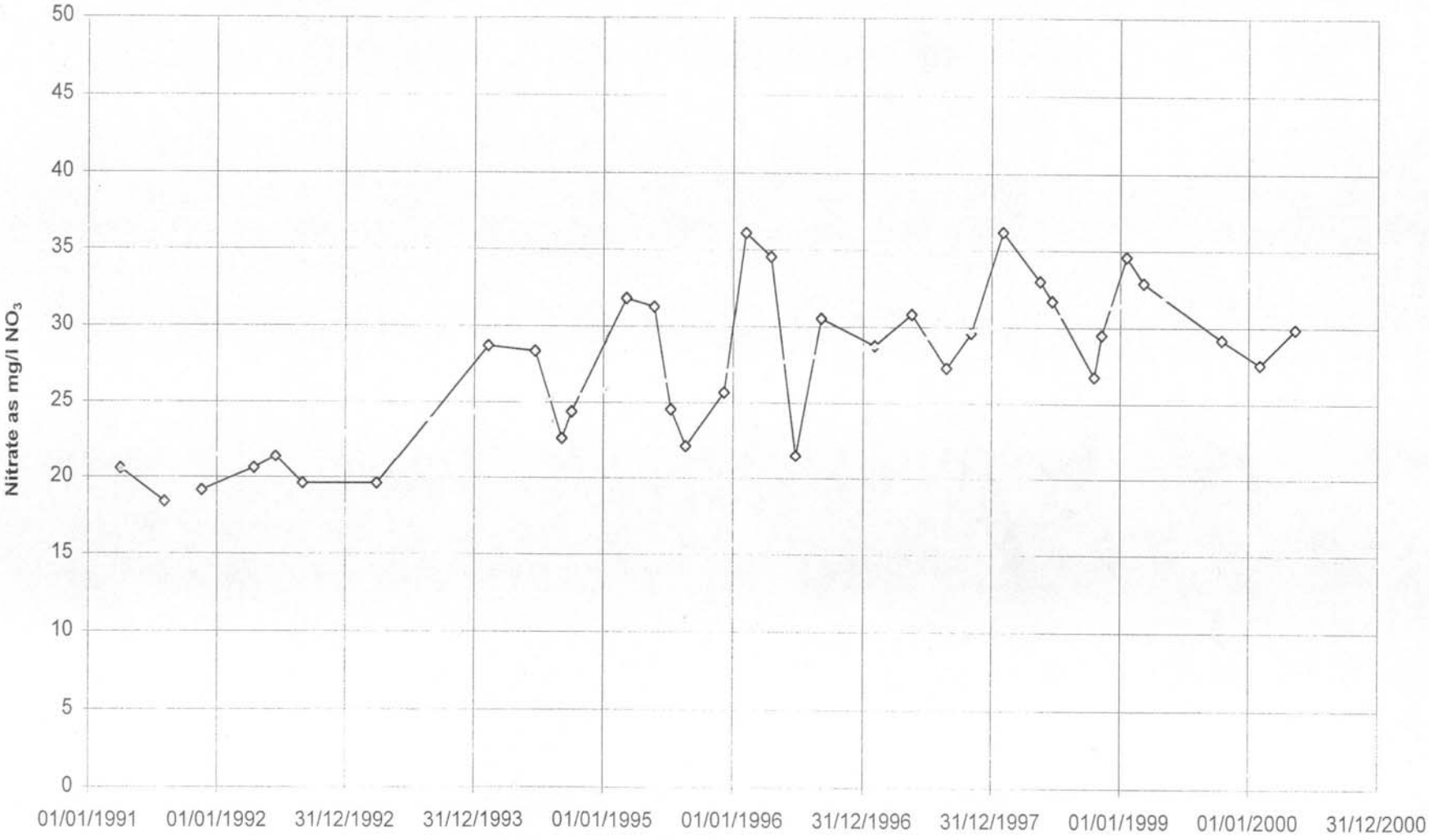
Water Quality Parameters at Coolroe, Fermoy

Parameter	Unit	PW#1 15/12/1999	TW#4 25/04/1996	TW#4 15/03/1996	TW#3 25/04/1996	TW#1 25/04/1996	TW#1 26/01/1996	Gallery 22/10/1968	Gallery 18/10/1968	Gallery 03/10/1968
pH	pH units	7.6	7.1	7.3	6.8	6.9	6.7	7.3	7.4	7.5
Colour	Hazen units	<5	<5	<5	<5	5	<5	<5	<5	<5
Conductivity	(mS/cm)	460	465	463	390	250	253			
Total Hardness	mg/l as CaCO3	252	230	235	197	106	118	168	164	196
Total Alkalinity	mg/l as CaCO3	185	176	176	150	77	78	160	160	36
Calcium	mg/l	87	79	81	68	34	38			
Magnesium	mg/l	8.5	8	8	6.5	5	5.6			
Sodium	mg/l	12	13	12	10	11	11			
Potassium	mg/l	1.9	1.7	1.4	1.2	1.8	1.6			
Iron	mg/l	<0.01	<0.01	0.01	0.01	0.01	0.01		0.08	0.1
Manganese	mg/l	<0.01	<0.01	<0.01	<0.01	<0.05	0.03			
Copper	mg/l	0.03	<0.05	<0.01	<0.05	<0.05	<0.01	n.d.	n.d.	n.d.
Aluminium	mg/l	<0.05								
Chloride	mg/l	24	23	24	23	21	19	20	22	20
Sulphate	mg/l	12	13	13	12	9	8.8	11	10	10
Nitrate	mg/l as NO_3	51	49	47	37	24	30	5.54	4.43	1.77
Nitrite	mg/l as NO_2	<0.01	<0.01	<0.01	0.01	0.01	<0.01	absent	trace	absent
Total Ammonia	mg/l	<0.01	<0.05	<0.05	<0.01	<0.05	<0.01	0.044 (N)	0.02 (N)	0.036 (N)
Non-Purg. Org. C	mg/l	<0.5	0.6	0.71	0.8	1.7	1.1			
Total Coliforms	count/100 ml	0	0	10	0	3	0			
E. coli	count/100 ml	0	1	3	0	1	0			
Plate count @ 22°C	Col/ml	46	63	284	69	114	>100			
Plate count @ 37°C	Col/ml	5	0	10	0	13	12			

Data sources: Reports by Geoex (1985) and K.T. Cullen & Co. Ltd. (1996, 2000)

Nitrate levels at Coolroe Water Source, Fermoy				
date	mg/l NO_3	EC	data source	
03/10/1968	1.77		Geoex report	
18/10/1968	4.43		Geoex report	
22/10/1968	5.53		Geoex report	
12/04/1989	23.47		EPA	
02/08/1989	32.01		EPA	
09/10/1989	20.81		EPA	
09/08/1990	2		EPA	?N
11/12/1990	5.2		EPA	?N
20/12/1990	5.2		EPA	?N
02/04/1991	20.58	430	CCC	
05/08/1991	18.4	410	CCC	
04/09/1991		390	CCC	
19/11/1991	19.14	429	CCC	
15/04/1992	20.61	450	CCC	
16/06/1992	21.4	425	CCC	
01/09/1992	19.6	442	CCC	
30/03/1993	19.6	463	CCC	
09/02/1994	28.7	518	CCC	
22/06/1994	28.36	522	CCC	
06/09/1994	22.66	466	CCC	
04/10/1994	24.4	493	CCC	
07/03/1995	31.83	480	CCC	
24/05/1995	31.28	491	CCC	
10/07/1995	24.58	464	CCC	
21/08/1995	22.17	469	CCC	
07/12/1995	25.68		EPA	
05/02/1996	36.1	473	CCC	
15/04/1996	34.55	491	CCC	
24/06/1996	21.54	467	CCC	
04/09/1996	30.55	452	CCC	
03/02/1997	28.77	468	CCC	
19/05/1997	30.84	470	CCC	
26/08/1997	27.33	451	CCC	
04/11/1997	29.6	440	CCC	
02/02/1998	36.2	496	CCC	
19/05/1998	33	492	CCC	
22/06/1998	31.73	465	CCC	
20/10/1998	26.78	446	CCC	
10/11/1998	29.5	446	CCC	
19/01/1999	34.6	480	CCC	
08/03/1999	32.9	470	CCC	
18/10/1999	29.2	456	CCC	
03/02/2000	27.6		CCC	
12/05/2000	29.9		CCC	

Nitrate levels at Coolroe WSS, Fermoy since 1991



Coolroe WSS, Nitrate and Electrical Conductivity