COACHFORD WATER SUPPLY SCHEME

GROUNDWATER SOURCE PROTECTION ZONES

Draft

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1. Introduction

The objectives of this report are as follows:

- To delineate source protection zones for the Coachford Water Supply Scheme(WSS).
- To outline the principal hydrogeological characteristics of the Coachford area.
- To assist Cork County Council (Southern Division) in protecting the water supply from contamination.

2. Location and site description

The Coachford Water Supply is situated in Glebe townland just northwest of Coachford village. The water supply comprises 2 bored wells just outside the village. One lies at the edge of a green field area beside the council houses (Borehole 1, by Fr. Sheehan Place) while the other is situated at the side of a small road just north of the village, near the old railway terminus (Borehole 2). Both boreholes are well protected. Borehole 1 is just outside the pumphouse in a chamber at ground level. It is covered by a padlocked steel cover. Borehole 2 is also located outside its pumphouse and protected by a covered chamber. There is also an abandoned well approximately 0.5 km north of the village (close to the reservoir) which is no longer used by the Council but which was capable of 55 m^3/d when in use.

3. Summary of well details

GSI no.	1407SWW121 (Borehole 1)
Grid ref. (1:25,000)	14550 07365
Townland	Glebe
Owner	Cork County Council (Southern Division)
Well type	Bored well
Elevation (top of casing)	approx. 85 m O.D. (from 6" map)
Depth	approx. 85 m
Diameter	0.2 m (8")
Depth-to-rock	approx. 4.5 m
Static water level	7 m b.g.l. from a yield test. 13.64 m b.g.l. before test on 9/7/99.
Drawdown	16.59 m
Current Abstraction	approx. 164 m^3/d (18 - 24 hours during summer) (Not reliable info)
Pumping test summary	(i) Abstraction rate: 158 m^3/d (ii) Transmissivity: approx. 6 m^2/d
Yield test summary	(I) 14/05/96 average 170m^3/d over 5 days.

GSI no.	1407SWW122 (Borehole 2)
Grid ref. (1:25,000)	14572 07346
Townland	Glebe
Owner	Cork County Council (Southern Division)
Well type	Bored well
Elevation (top of casing)	approximately 75 m OD
Depth	approx. 30 m
Diameter	0.15 m (6")
Depth-to-rock	>8 m from depth to rock augering nearby
Static water level	Pumping water level in mid cycle is 3.23 m b.g.l. (25/1/99)
Drawdown	n/a
Current Abstraction	131 m^3/d (16 hrs a day from caretaker); also noted as 60 m^3/d.
Pumping test summary	(i) Abstraction rate: n/a (ii) Transmissivity: n/a
Yield test summary	(i) 120 m^3/d in Aug 1952

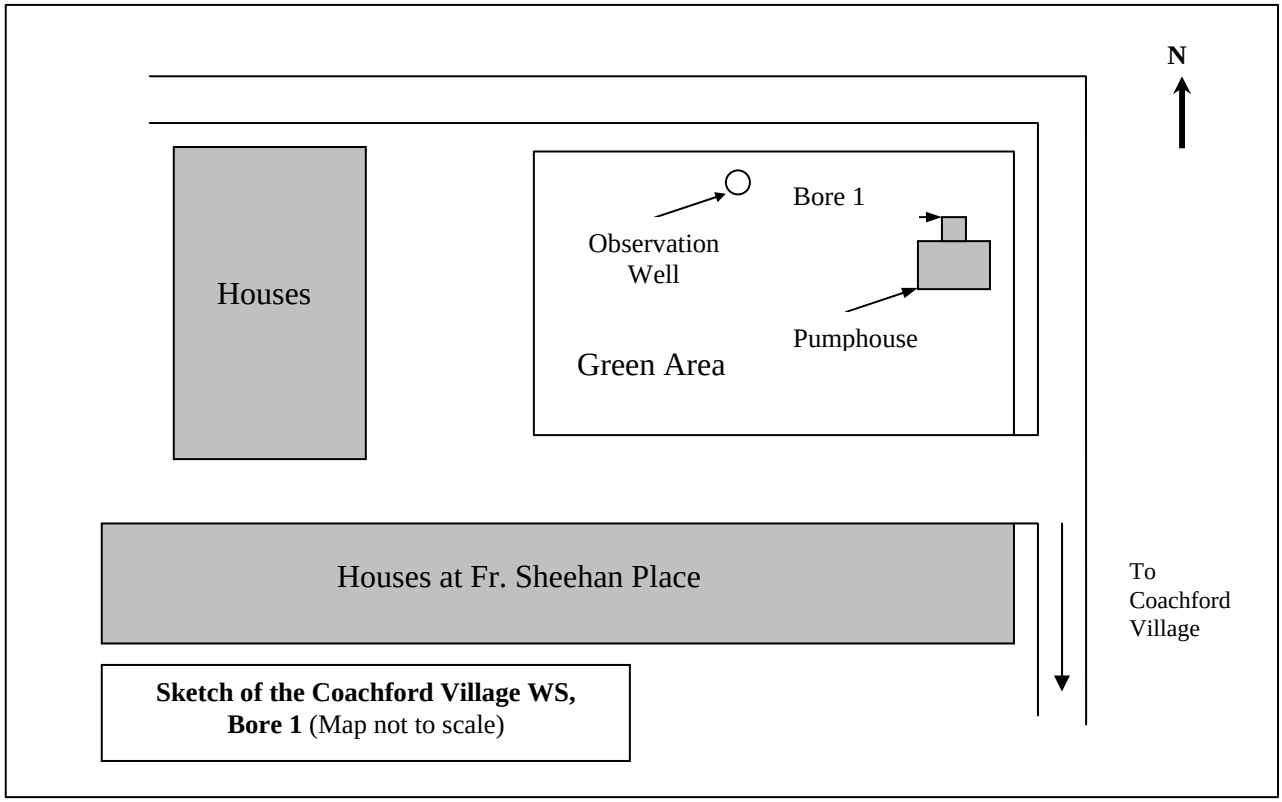

Figure 1 Sketch map of the area around Borehole 1 at Fr. Sheehan Place, Coachford

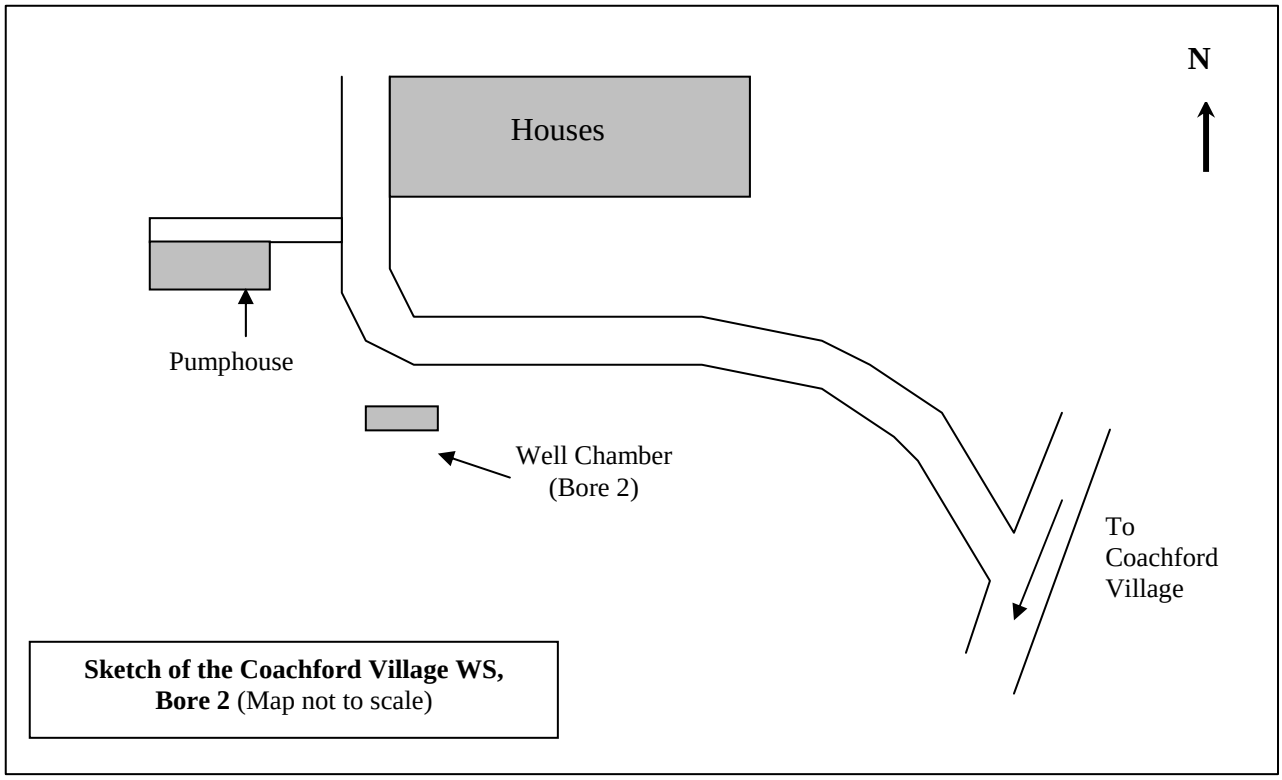

Figure 2 Sketch map of the area around Borehole 2 near the Old Railway Terminus, Coachford

4. Methodology

4.1 Desk Study

Bedrock geology information was compiled from the GSI report and 1:100,000 scale map of Sheet 25 (Sleeman & Pracht, 1994). Subsoils/soils were compiled from information available from Teagasc's mapping of soils & subsoils in County Cork (Teagasc, 2000). Basic well details such as borehole depth, elevation, abstraction and yield test data were obtained from GSI records and County Council personnel.

4.2 Site visits and fieldwork

Site visits and fieldwork in the area included a walkover survey to look at the geology and subsoils of the catchments in order to further investigate the hydrogeology and groundwater vulnerability. Augering of some depth to bedrock holes also helped in collecting subsoil samples for later analysis, and in obtaining better knowledge of the thickness of subsoils in the area. Well surveys, water quality sampling and a pumping test were also carried out to aid in the conceptualisation of the hydrogeology.

4.3 Data analysis

Analytical equations and hydrogeological mapping were utilised to delineate protection zones around the public supply wells. The subsoils samples taken during fieldwork were analysed using a geotechnical engineering method, BS 5930 (Daly & Swartz, 1999). This aided in the determination of the groundwater vulnerability of the area.

5. Topography & surface hydrology

The area around both public supplies in Coachford is quite low-lying. Both wells are in a slight valley and are situated at heights of ~76m to just under 91m. Borehole 1, situated on a green area at the council houses, is at a height of approximately 85m. Borehole 2, the more easterly well, is actually situated close to what used to be the terminus of an old railway line, and as such is probably in one of the lower parts of the area, at around 75 m.

There are no surface streams in evidence in the immediate area around Borehole 1. It is thought that subsoils in the area are relatively free draining (as evidenced during drilling) and this may account for the lack of surface hydrology. There is one stream flowing north to south, just east of Borehole 2, which may indicate that the land around this well is not as free draining as the area around Borehole 1. This stream drains the small valley around it and turns eastwards after Coachford village and flows into the Lee Reservoir.

6. Geology

6.1 Bedrock Geology

The bedrock geology of the Coachford area consists of rocks deposited during the Upper Devonian (approximately 375 - 355 million years ago), and comprise sandstones and mudstones. In the Coachford area, there is evidence for two main rock formations; the Ballytrasna Formation and the Gyleen Formation, which are shown on Map 1, and summarised below.

Age	Formation	Member
Upper Devonian 375 - 355 Ma	Gyleen	Ardmore
		Ballyquinn
		Ballyknock
	Ballytrasna	

6.1.1 Ballytrasna Formation

The older of the two geological formations in the area, the Ballytrasna Formation, consists of dusky-red mudstones with subordinate pale red fine to medium grained sandstones, which may be cross-bedded (Sleeman & Pracht, 1994). It occurs very widely throughout the area, and to the north of the village.

6.1.2 Gyleen Formation

This unit mainly comprises 80% mudstones and 20% medium-grained red sandstones with large and small scale cross laminations and a fining upwards sequence. There is also evidence of thinly bedded alterations of green and red sandstones, siltstones and mudstones towards the top of the sequence. It occurs in the Coachford area, mainly in a band running NE/SW, south of the village. This band is part of the Blarney syncline which formed as part of the Variscan Orogeny.

6.1.3 Structure

The rocks in the area have been subjected to some folding and some local faulting in the past. The band of sandstones and mudstones, which makes up the Gyleen Formation, has been folded, from north to south, into a fairly steep syncline, with two anticlines on either side, in the Ballytrasna Formation. Subsequently, the rocks dip quite steeply, ranging from approximately 45^{o}-70^{o}. There is also evidence that the area around Borehole 2, may be situated on a small, fairly localised fault, but still within the Ballytrasna Formation.

6.2 Subsoil Geology

The subsoil geology of the area has been mapped by Teagasc. Augering of depth to bedrock holes was carried out in the area by the G.S.I. and subsoil samples taken to identify the nature of the deposits. These were analysed and described using a British Standards Protocol (BS 5930) widely used by Geotechnical Engineers to describe subsoil samples with regard to permeability. The subsoils in this area have also been looked at by Teagasc, using digital aerial photography.

6.2.1 Tills

Subsoil deposits around Coachford consist of a very uniform blanket of sandstone tills of Devonian age, thought to have been derived from the underlying sandstone and siltstone rocks (based on the work by Teagasc). An cored observation well was drilled close to Borehole 1 for use in the pumping test at this site. This drilling proved a depth to bedrock of between 4.5 and 5 m. No hand samples of the subsoil were taken due to the nature of the drilling, but it was noted to be a silty deposit. Two depth-to-bedrock holes were augered around the Coachford area, one about 1 km north of the village at Coolacullig and another very close to Borehole 2 at the old railway terminus. According to the Teagasc maps, both these holes are in the sandstone till. The texture of these subsoils has been established to be a sandy clay (with silt) at Coolacullig and a silty sand with some gravels at Coachford Borehole 2, by analysis of hand samples (by BS 5930 method).

6.2.2 Gravels

Gravelly deposits occur south of Coachford village near the Lee Valley. These deposits have not been mapped in detail but were looked at by Farrington in the 1950s, who found that gravel and alluvium occur in terraces along the River Lee (Farrington, 1959).

6.3 Depth to Bedrock

Accurate information on depth to bedrock is based on outcrop information, well records, subsoil sections and drilling. Subsoil depths for the Coachford area are fairly shallow although there are pockets of deeper till cover. The area around Borehole 1 has a fairly shallow covering of subsoil although rock is definitely >3 m below surface. An observation well, drilled for use in a pumping test at this well near the council houses, indicates that rock is approximately 4.5-5.0 m below ground surface. Two depth to bedrock holes augered in this area have revealed depth to rock of between 4 and 8 m. The hole augered near Borehole 2 found subsoils at least 8 m deep. Very little information is

available from any accurately located wells in the area, but those that do exist seem to confirm subsoil depths between 3 and 8 m. The Teagasc maps also show that depth to rock in the Coachford area is generally shallow although an area of depth to bedrock greater than 5 m has been identified.

7. Hydrogeology

7.1 Data availability

Data for this report was compiled from a number of different sources.

- Well records and outcrop data were obtained from the G.S.I. archives and databases.
- Water levels taken from well surveys carried out in the area in July 1999.
- A yield test carried out by South Cork County Council in May 1996.
- A pumping test carried out by the G.S.I. on 9th July 1999.
- Drilling and augering of depth to bedrock holes in the area, and subsequent analyses of subsoil samples using BS 5930.
- The South Cork Groundwater Protection Scheme.

7.2 Meteorology and Recharge

Average annual rainfall for the area is taken from Met Éireann data. Mean annual rainfall (R) for the area was 1134 mm (1961-1990), using the station at Coachford (which closed in 1993). Potential evaporation (P.E.) is estimated to be 525 mm/yr. (from Met Éireann data). Actual evapotranspiration (A.E) is then calculated as 95 % of P.E. i.e. 499 mm/yr. Runoff is taken to be only 10% of available recharge in the Coachford area (because of the high permeability subsoils and low gradients) and is estimated to be 64 mm. These calculations are summarised below:

Average annual rainfall	1134 mm
Estimated P.E.	525 mm
Estimated A.E. (95 % P.E.)	499 mm
Available recharge	635 mm
Surface Runoff (10%)	64 mm
Actual Recharge	571 mm

This is a conservative estimate of recharge which allows for surface water outflow during periods of exceptionally heavy rainfall.

7.3 Groundwater levels

Groundwater levels in the area are variable, depending largely on elevation. The “static” water level in Borehole 1 on 9/7/99, just before the start of the pumping test, was 13.64 m b.g.l. (approx. 71.5 m O.D.). The well had a full 12 hours recovery beforehand and as can be seen from the recovery test, the water level rebounds fairly fast. It is therefore thought that this static water level is representative for this time of year, even though a yield test in 1996 recorded a static water level of 7 m b.g.l. The static water level in the nearby observation well was found to be somewhat higher at 10.92 m b.g.l. although it is only approximately 27.5 m away from the pumping well. Only one pumping water level is available for Borehole 2, which was 3.23 m b.g.l. (in winter), or approximately 76 m O.D.

Water levels were also measured in some private wells in the area during a well survey in July 1999. These indicate that the water table varies from between approximately 86 m O.D. in the slightly higher areas to the north-west of Borehole 1 to 76 m O.D. in the valley around the Borehole 2. All these data come from wells in the Ballytrasna Formation, although Borehole 2 seems to lie along a fault between the Ballytrasna and Gyleen Formations. The water table seems to be, as expected, a subdued reflection of the topography of the area.

7.4 Groundwater flow directions and gradients

The water table in the area is generally assumed to reflect topography but is also influenced by the local permeability of the rock. Around the Coachford area, groundwater flows generally south-eastwards around Borehole 1 and has a generally low to moderate gradient of between 0.055 - 0.073 (although these gradients were calculated using water levels in the pumping well, which may not have fully recovered from pumping at the time). Groundwater around Borehole 2 also seems to be flowing to the south-east to the small stream valley nearby. Gradients from around this borehole are thought to be in the order of 0.04 to 0.05 although these had to be taken from topography because of the lack of water levels available from wells in the vicinity.

7.5 Aquifer Characteristics

A pumping test carried out by the G.S.I. on 9th July 1999 at Coachford Borehole 1 helped to obtain some values for aquifer characteristics for the Coachford area and the Ballytrasna Formation. Unfortunately no pumping test could be carried out on Borehole 2 near the old railway terminus due to operational reasons, but the data from Borehole 1 can be extrapolated, taking into account the different geological conditions at this site (a more permeable fault zone) and the similarities in groundwater flow direction and gradient.

Drawdown after ten hours pumping was 16.59 m. With a final pumping rate of 157 m^3/d, this gives a specific capacity of 9.52 m^3/d/m. However it is apparent from the drawdown graph that drawdown had not stabilised after 10 hours of pumping. Analysis of the pumping test data using appropriate software provided transmissivity values in the range 5.13 to 10.3 m^2/d (values of transmissivity from the very earliest data have been excluded due to their inaccuracies). The value of 5.13 m^2/d is from the later data and as such is more reliable. An acceptable estimate of a value of T for the aquifer is about 6 m^2/d.

Conductivity measurements of water samples taken during the pumping test do not seem to show any variation throughout the 10 hour pumping cycle, remaining at 455 - 460 μS/cm. There are no surface streams in the immediate vicinity of the well which are being influenced by pumping and this is supported by the conductivity measurements.

The pumping test also indicates that one element of groundwater flow to the well, is happening in the upper few metres of more permeable bedrock. This idea seems to be supported by the drawdown curves for this well, which shows a permeable area close to the well and a drop off in permeability as the drawdown curve expands further away from the well.

7.6 Aquifer Category

The Ballytrasna Formation is part of the Old Red Sandstone succession in the south of Ireland. As such, permeability is thought to be mostly secondary in nature with water moving through fractures and weathered zones. Using QSC graphs (which plot discharge (Q) against Specific Capacity (SC), see Wright (2000)), it can be seen that this well falls into one of the higher well productivity categories and the formation is classed as a **locally important aquifer which is moderately productive only in local zones** (**Ll)**. (For more information refer to the South Cork Groundwater Protection Scheme (Kelly *et al*, 2002).)

7.7 Hydrochemistry and Water Quality

Results of laboratory analysis of water samples taken in April and September 1999 suggest that water in the public supplies in Coachford is characteristic of a typical calcium-bicarbonate type water. The water in Borehole 1 is a little harder than that in Borehole 2. Using the analyses of samples taken in April and September 1999, hardness values for Borehole 1 range from 187-212 mg/l $CaCO_3$. The values for Borehole 2 range from 168-175 mg/l $CaCO_3$. The groundwater abstracted from both boreholes can therefore be classified as “moderately hard”, while that from Borehole 2 is just a little softer.

Other parameters measured (Table 1) show that this area has high levels of nitrate. Borehole 1 has NO_3 levels that are close to (and in September 1999, above) the EU MAC of 50 mg/l. Borehole 2 has levels just below the EU Guide level of 25 mg/l. The water from these wells is at present being mixed to bring the nitrate levels down to acceptable levels, and it is this water which is being put into supply. Historical water quality data are available from Cork County Council going back to 1991, but these records do not indicate which source was sampled or if it was a mixed sample from the two boreholes. It is therefore difficult to pick out any trends in the data, although it is clear that these levels are high.

Raw water samples from April and September 1999 also showed that E.U. MACs were exceeded at Borehole 2 with regard to total coliforms and *E.coli*. In April, a total coliform count of 1 per 100 ml was recorded. In September the breach was more serious, with a total count of 19 per 100 ml and an *E.coli* count of 1 per 100 ml. Bacteriological water quality at Borehole 1 seems to be quite good with no coliforms recorded in either sampling round. Potassium/Sodium ratios, usually an indication of organic pollution, are not above 0.4. in either borehole, although this does not prove the *absence* of a farmyard source of contamination.

Iron and Manganese levels in both wells are normal and from the sampling and historical records, there seem to be no other water quality problems.

	Results of Laboratory Analyses			
Location & Date / **Parameter**	**Borehole 1 (Fr. Sheehan Pl)**		**Borehole 2 (near railway terminus)**	
	13/04/99	14/09/99	13/04/99	14/09/99
Conductivity (μS/cm)	397	420	341	346
Temperature (°C)	11.5	11.6	11.7	11.9
pH	6.8	7.1	7.0	6.9
Total Hardness	187	212.23	168	175.17
Total Alkalinity (mg/l)		133		125
Calcium	47.6	53.6	39.7	41.4
Magnesium	16.5	19.2	16.8	17.6
Chloride	28.2	27.2	24	22.6
Sulphate	15.6	18.3	11.7	15.4
Sodium	14.3	16.23	14.5	15.29
Potassium	1.7	1.8	1.2	1.3
Nitrate (as NO_3)	48.4	50.4	23.5	23.7
Iron	<0.05	<0.1	<0.05	<0.1
Manganese	<0.05	<0.05	<0.05	<0.05
Total Coliforms per 100 ml	0	0	1	19
E. coli count per 100 ml.	0	0	0	1

Table 1 Hydrochemical parameters obtained from sampling at Coachford

Water samples were also taken by Cork County Council (at G.S.I's request) at the farm just north of Borehole 1 on 17/12/99. Bacteriological and nitrate levels were compared with samples taken at Borehole 1 at the same time. The nitrate levels in the farmyard well are very similar to those at the public supply well with 50 mg/l NO_3 being recorded in each well on this particular day. Bacteriological levels in the farmyard well are very high as indicated by the total coliform count of 200 per 100 ml. Borehole 1 did not seem to have any coliforms.

7.8 Conceptual Model

- The groundwater catchments in the area are assumed to coincide with the surface water catchments. As such there is a groundwater divide approximately 250 m north of Borehole 1. Water north of this divide, which runs roughly east/west along a slight ridge, will flow northwards, while water to the south of it will flow south/south-east towards both Borehole 1 and Borehole 2.

- The groundwater divide is only about 250 m away from Borehole 1. Therefore the catchment for this well is relatively small. Groundwater flow direction around this well is from north-west to south east, although because of the gentle topography and in order to take account of the heterogeneity of flow, possibly in the upper few metres of the aquifer, a variation in the flow direction of ± 20^{o} was included as a safety margin. Therefore there may be a strong element of groundwater flow coming from the west. Around Borehole 2 the groundwater is also thought to be flowing from the north/north-west to the south/south-east. It has a stronger element of groundwater coming from the *north* because of its position in a small valley, close to the nearby stream. Its catchment is also relatively small.
- The stream to the east of Borehole 2 which flows to the south (towards the Lee) does not seem to be within the ZOC of this well, as it lies outside the 20^{o} variation in groundwater flow direction. Due to a lack of pumping test data or electrical conductivity values, no information is available on whether the nearby river affects the groundwater being abstracted from this borehole.
- Groundwater flow gradients in the area around Borehole 1 are in the order of 0.055 to 0.07. These figures come from water levels taken in the wells in the nearby farmyard (Moynihan's wells) and Borehole 1 at Fr. Sheehan Place and its observation well. Topographic gradients are in the order of 0.08 which is comparable. Gradients in the vicinity of Borehole 2 are approximately 0.045, which is taken from topography due to the lack of wells in the area.
- Both sources are thought to be abstracting from the same geological formation, the Ballytrasna mudstones and sandstones. These rocks are dipping both north (towards a very small local syncline) and south (towards the centre of the Blarney syncline, with the Gyleen formation in the centre of this syncline). Dip angles range between 60^{o} north and 53^{o} south. This reflects the folding which these rocks have been subjected to during the Variscan Orogeny (mountain building period) (Kelly *et al*, 2002). These mudstones and subsidiary sandstones are thought to have a fairly low permeability as the aquifer parameters around Borehole 1 show (as outlined in Section 7.5), and as such flow in these rocks is likely to occur in the upper weathered, fissured zones as well as in the areas affected by the folding and faulting. The lower levels of the aquifer are thought to be less permeable. Borehole 2 is also abstracting from the Ballytrasna Formation, but as can be seen from the geological map, it is in an area of local faulting. As such the rocks around this local area are thought to be more permeable than those at Borehole 1. The Ballytrasna Formation is a **locally important aquifer which is moderately productive only in local zones** (**Ll**), according to the South Cork Groundwater Protection Scheme (Kelly *et al*, 2002).
- Recharge to the groundwater system is thought to be mainly through the shallow subsoils in the area. Detailed mapping of the subsoils in this area has yet to be carried out, but they appear to be sandstone tills (from aerial photography, see Section 6.2.1). As explained in Section 7.2, surface runoff in this area is about 10% of available recharge. The subsoils around the well at Fr. Sheehan Place (Borehole 1) seem to be quite shallow and well drained as explained in Sections 6.2.1 and 6.3. However around Borehole 2, at the Old Railway, subsoils are though to be much deeper and a hole augered near there found subsoils with thicknesses greater than 8m.
- The subsoils in the areas are thought to be quite free-draining, with permeabilities estimated to be moderate. The water level in the public supply well was about 13.64 m b.g.l on 9 July 1999, (although this level may be a little lower than normal as the well may not have fully recovered at this point). In the observation well close by, it is a little higher, about 10.9 m b.g.l. The aquifer, namely the Ballytrasna Formation, is thought to be unconfined.

8. Delineation of Source Protection Areas

8.1 Introduction

This section describes the delineation of the areas around the wells that are believed to contribute groundwater to both public water supply wells in Coachford, and that therefore require protection. The areas are delineated on the basis of the conceptualisation of the groundwater flow pattern, as described

in Section 7.8. Given the limited amount of calibration data available, a full groundwater numerical model is not believed to add significant useful information to the conceptualisation.

Two source protection areas are delineated:

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

8.2 Outer Protection Area (ZOC)

The Outer Protection Area (SO) includes the complete catchment area to the source, i.e. the zone of contribution (ZOC), and it 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 rock permeability and d) the recharge in the area. 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 the estimation of groundwater flow direction and to allow for an increase in the ZOC in dry weather, a safety margin is incorporated by assuming a higher abstraction rate than the current rate.

8.2.1 Borehole 1 (Fr. Sheehan Place)

The average abstraction rate for Borehole 1 was calculated using the rate noted during the pumping test in July. This rate of 158 m^3/d is thought to match fairly well with the average pumping rate over longer periods of time. Usually during calculation of the ZOC, a factor of safety is built into the average discharge, and it is increased (typically by 50%) to allow for possible future increases in abstraction and for expansion of the ZOC in dry periods. However in the case of this borehole it is unlikely that the present yield could be increased by 50% and sustained over long periods of time. In analysing the pumping test data it is clear that drawdown had not stabilised after 10 hours of pumping at 158 m^3/d. At this point in time the water level is actually 30.25 m below ground level. The well itself is 85 m deep, so it could be expected that at a higher yield, such as 236 m^3/d (a 50% increase) the well could dry up. Therefore, for the purposes of calculation of this ZOC the discharge used is kept at 158 m^3/d. The recharge for the area is thought to be approximately 571.7 mm/yr, so the required area needed to provide the increased discharge above is 0.1 km^2, or 10 ha.

Hydrogeological mapping of the area around this source was used to delineate the ZOC to the well. The northern boundary of the ZOC is thought to be coincident with the surface water catchment. The distance to the southern boundary of the ZOC (i.e. the downgradient distance) was calculated as 60.1 m. The main flow direction of groundwater in the area is towards the south-east and from this flow direction, the eastern and western boundaries of the ZOC can be drawn, as is shown in Map 3. The mapped ZOC has an area of approximately 0.1 km^2 (10 ha), which is comparable with the calculated area outlined above.

8.2.2 Borehole 2 (Old Railway Terminus)

Long term discharges for this well are not available. Data from a yield test in 1952 showed that this well is capable of 120 m^3/d. According to County Council staff, the well is typically pumping 16 hours a day at about 1200 gals/hr. This converts to a yield of approximately 90 m^3/d. In order to calculate the area of the ZOC for these wells, the discharge of the well was increased by 50% to a discharge of 135 m^3/d, to allow for an increase in discharge from the well. However it must be noted here, as with Borehole 1, that with a small catchment such as this, it may not be possible to increase the yield by 50% of the present abstraction. If the discharge of 135 m^3/d is used and recharge is taken to be 570 mm/yr, as above, the calculated catchment would be in the order of 0.08 km^2. This figure is comparable with the mapped catchment described below.

The mapped catchment for the well has an area of approximately 0.078 km^2, as seen from Map 3. The northern boundary is once again taken as the surface water catchment divide. Using a hydraulic conductivity (K) value of 0.25 m/d (taken from a value for sandstones, which also corresponds with the T value at Borehole 1 and the aquifer depth at this borehole, namely 22 m), a downgradient distance of approximately 78 m was calculated. The main flow direction of groundwater in this area is towards the south/south-east. A variation in the flow direction of ± 10^o or 20^o can be included as a safety margin when predicting groundwater flow to a well. However there is quite a strong element of flow from the north, so this safety margin was not included here. This may be revised after subsequent pumping tests. As explained in Section 7.8, no information is available on whether the nearby river affects the groundwater being abstracted from Borehole 2. Values of electrical conductivity measured during sampling in April and September 1999 average around 350 μS/cm, which is only slightly below the values at Borehole 1. The river is not included in the ZOC.

8.3 Inner Protection Area

The Inner Protection Area (SI) is the area defined by a 100 day time of travel (TOT) to the source and it 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.

8.3.1 Borehole 1 (Fr. Sheehan Place)

Permeability values for the aquifer around this source were derived from pumping test data (see Appendix 1). However this estimate of permeability (0.09 m/d) is an average over the assumed 66.4 m depth of the aquifer. It is also assumed that a lot of the flow would be occurring in the upper few metres, in the upper weathered, fissured zones (as outlined in Section 7.8). Therefore actual permeability for these levels of the aquifer are possibly a lot higher. If the transmissivity of 6 m^2/d is taken with a depth of 15 m (the approximate upper weathered zone) a higher permeability of 0.4 m/d is derived. In the context of creating an inner protection zone based on the time it would take pollutants to reach the well, the higher permeability must be taken into account to give maximum protection to the borehole. Therefore, a permeability of 0.4 m/d was used to estimate the 100 day time of travel zone distance to the well. Using an effective porosity value of 0.02 and a groundwater gradient of 0.07, the 100 day time of travel distance to the well is estimated at 140 m (see Map 3).

8.3.2 Borehole 2 (Old Railway Terminus

The geology of the area around this well is very similar to that at Borehole 1. However the well itself may be situated very close to a fault zone as can be seen from the geology map. In the absence of any pumping or yield test data, the permeability for the area around Borehole 1 was taken as 0.25 m/d because of a presumed higher permeability in this area due to the fault zone and its position in a valley. However it is also assumed that the permeability of the upper aquifer could be much higher again and a ‘k’ value of 0.4 m/d is used for calculation of an inner protection zone as explained above in Section 8.3.1. Using the same porosity and a gradient of 0.05, the 100 day time of travel distance to the wells is estimated at 100 m (see Map 3).

9. Groundwater Vulnerability

9.1 Subsoil Thicknesses

Subsoil thicknesses are discussed in Section 6.3. Depth to Bedrock in this area is fairly shallow. The areas where subsoil thickness is known to be less than 3 m were used to delineate areas of extreme vulnerability. Very little well or borehole information is available for the rest of the area on which to base a 5 m contour. However work by Teagasc succeeded in delineating an area south of Coachford village where rock is greater than 5 m below the ground surface. Without further borehole data no more 5 or 10 m contours can be reliably drawn. Areas of shallow subsoil can be found within both ZOC’s. The higher part of the ZOC for Borehole 1 has quite shallow subsoils (<3 m). In these areas of shallow subsoil, groundwater is considered “extremely vulnerable” *(E)* to contamination. This may account for the water quality problems at this borehole. Borehole 2 at the Old Railway further to the

south-east seems to have deeper subsoils overlying the sandstone rock. A depth-to-rock hole augered nearby suggested thicknesses of at least 8 m.

9.2 Subsoil permeabilities

The rest of the area around Coachford (which doesn't have rock close to surface) is covered by a Sandstone till, believed to be derived from the underlying sandstone rocks (Teagasc, 2000). Samples of this till were taken during the depth-to-bedrock augering. The texture of these subsoils were analysed by the BS 5930 method.

A hole augered at Coolacullig (grid ref: 14548, 07455) found sandy CLAY with silt down to about 1.5 m, but it is very close to an area of rock within 3 m. Another hole was augered (grid ref: 14575, 07359) very close to Borehole 2 near the Old Railway and found a number of different subsoil textures. Sandy SILT, some clay and about 30% gravels was found down to 1 m depth. This was underlain by silty SAND with gravels from 5 to 6 m below surface, followed by sandy CLAY with silt from 6 to 8 m. The top few metres consist of quite high to moderate permeability material. This was confirmed during the drilling of an observation well near Borehole 1 in March 1999 when the water used during the drilling process was seen to infiltrate into the ground quite quickly. Field observations of drainage and vegetation, such as arable farming, large field sizes and the lack of any surface drains or water courses near Borehole 1 confirm a moderate permeability.

The groundwater vulnerability of these deposits is therefore noted as High (**H**) even around the area of depth to bedrock greater than 5 m (DELG/EPA/GSI (1999)).

10. Groundwater Protection Zones

The groundwater protection zones are obtained by integrating the two elements of land surface zoning (source protection areas and vulnerability categories) – a possible total of 8 source protection zones (see matrix below). 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. There are 3 groundwater protection zones present around Borehole 1 public supply well at Fr. Sheehan Place and 3 around Borehole 2 near the Old Railway Terminus (Map 3), as shown in the matrix below.

Matrix of Source Protection Zones

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

The response measures imposing restrictions or conditions on certain developments and activities within these zones have been published as 'Groundwater Protection Responses' by the DELG, EPA and GSI. These measures indicate the degree of restriction recommended in each protection zone.

11. Land use and potential pollution sources

A farm survey by Cork County Council in October 1998 found only one farm in the vicinity of Borehole 1. This farm mainly cultivates vegetables and other tillage crops and has no livestock of any kind. It is assumed that fertilisers are being used on this farm and this may be a cause for the elevated nitrate levels in Borehole 1, as at least part of the farm is within the catchment of the borehole. Poor bacteriological water quality was found during sampling in December 1999 at the wells on this farm (see Section 7.7). However the water quality in Borehole 1 did not seem to be affected, which tends to confirm the fact that most of this farm is outside the 100 day time of travel zone (SI).

The nearby council houses are assumed to be on main drainage and do not pose a major threat to groundwater quality at this well. However it should be ensured that the well chamber and its pumphouse are secure at all times.

There are a number of houses quite close to Borehole 2, as well as some agriculture (mainly pasture) to the west of it. The group of houses could pose a bacteriological threat to the well via septic tanks. Bacteriological levels at this well have been recorded (sampling in April and September 1999).

Activities at the GAA pitch and any septic tanks around the area should also be considered as potential threats to water quality at Borehole 1 and 2.

12. Conclusions and Recommendations

- The Public Water Supply at Coachford consists of 2 boreholes. One is located on a green area on front of a number of Council houses just north of the village of Coachford. The other is located near the Old Railway terminus to the north of the village and east of Borehole 1.
- The well at Fr. Sheehan Place (Borehole 1) is considered to be a 'good' well, yielding in the order of 158 m^3/d at present. It is a deep well (85 m) and is abstracting from the Ballytrasna Formation (mudstones and subsidiary sandstones). Borehole 2 at the Old Railway is a 'moderate' well capable of 131 m^3/d, 16 hours a day at present (equivalent to 87 m^3/d). A yield test was carried out in 1952, but very little other more recent reliable data exists on the sustainability of the yield in this well. This well also abstracts from the Ballytrasna Formation, but is located in a local fault zone.
- The Ballytrasna Formation is classified as a **locally important aquifer which is moderately productive only in local zones** (**Ll**) (Kelly *et al*, 2000).
- Borehole 1 lies in an area where depth to bedrock is between 3 and 5 m. Borehole 2 lies in an area of deeper subsoil cover, with an augered hole in the area not encountering bedrock at a level of 8 m below ground level. Both wells lies in an area of high vulnerability as shown on the Vulnerability Map. Their catchments and Groundwater Source Protection Zones are shown on Map 3.

- Water quality in Coachford is generally quite good apart from the high levels of nitrate found in Borehole 1. Borehole 2 seems to have less of a problem with nitrate although the levels of around 25 mg/l should be monitored closely in the future to pick out a possible increasing trend. At present Cork County Council mixes the water from both boreholes to bring the nitrate level down, which is a good interim measure until NO_3 levels in Borehole 1 can be reduced after changes in the agricultural practices in the ZOC. Bacteriological water quality at both these supplies is also generally good, although there have been a few breaches of the EU levels in Borehole 2.
- 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:
  - chemical and bacteriological analyses of raw 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.
  - particular care should be taken in allowing any activities or developments which might significantly increase nitrate levels or cause contamination at any of the wells in the WSS.
  - the potential hazards in the ZOC should be located and assessed;
  - interim codes of practice should be drawn up for dealing with underground petroleum storage/transfer, and spillages along the roads in the area.

13. References

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Appendix 1

Pumping Test Data

SITE Coachford Borehole 1 **DATE** 9/7/1999

Project Title Sth Cork GWPS

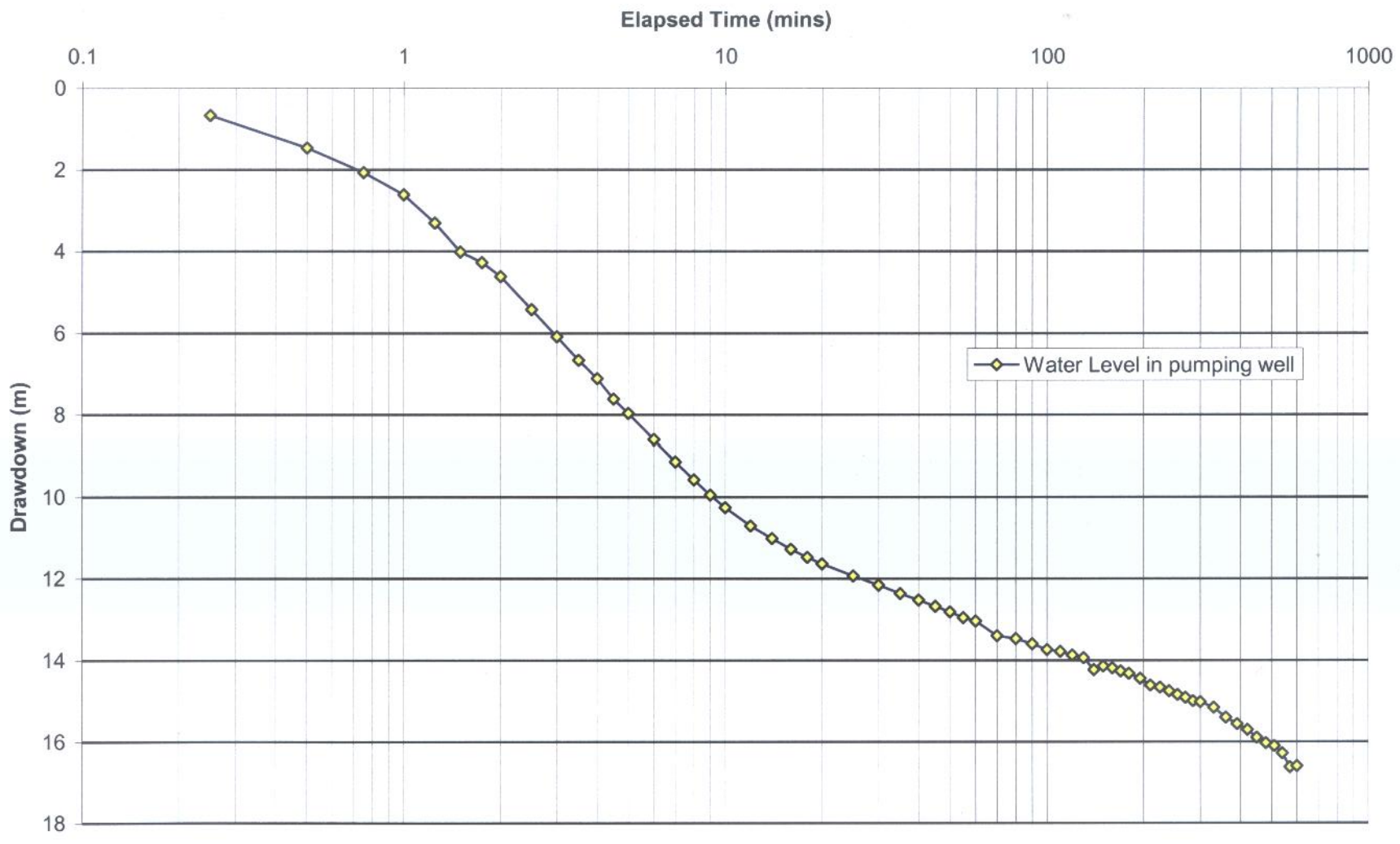
PUMPING TEST **PUMPING WELL** **Page No.** 1

Borehole Name	Coachford Borehole 1	**Well Depth**	~85.3 m	**Datum Point**	top of dipping pipe installed recently
Borehole No.	1407SW W121	**Well Diameter**	200 mm	**Height of Datum**	0.23 m above g.l
Well Owner	Cork Co Co	**Pump Depth**		**Ground Elevation**	
Location	Green at Fr. Sheehan Place	**Aquifer**	Ballytrasna Formation.	**Datum Elevation**	
Grid ref.				**Weather**	Dull but dry. Sunny and hot later
6" Sheet No.	CORK 72			**Observer**	D. Kelly

Date	Time	Elapsed Time	Water level below datum	Drawdown	Discharge		Discharge	Remarks
		Mins	(m)	(m)	Meter	Spot	(m3/d)	
9/7/1999	07:00	0	13.64	0				Pump on just about 2 seconds after 07:00
		0.25	14.3	0.66				as pump also needed green button to start
		0.5	15.1	1.46				
		0.75	15.7	2.06				
		1	16.25	2.61				
		1.25	16.94	3.3				
		1.5	17.65	4.01				
		1.75	17.91	4.27				
		2	18.25	4.61				
		2.5	19.06	5.42				
		3	19.72	6.08				
		3.5	20.3	6.66				
		4	20.75	7.11				
		4.5	21.25	7.61				
	07:05	5	21.6	7.96				
		6	22.24	8.6				
		7	22.77	9.13				
		8	23.21	9.57				
		9	23.58	9.94				
	07:10	10	23.89	10.25				
		12	24.34	10.7			160.23	(24.5 gals/min)
		14	24.65	11.01				
		16	24.91	11.27				
		18	25.11	11.47				
	07:20	20	25.27	11.63				
		25	25.57	11.93				
	07:30	30	25.79	12.15				
		35	26	12.36			160.23	
		40	26.16	12.52				
	07:45	45	26.31	12.67				
		50	26.45	12.81				
		55	26.59	12.95				
	08:00	60	26.67	13.03				463 uS/cm at 20oC. Temp = 11.7 oC
		70	27.03	13.39				pH = 6.92
		80	27.1	13.46				
	08:30	90	27.23	13.59				
		100	27.37	13.73				
		110	27.42	13.78				
	09:00	120	27.51	13.87				
		130	27.57	13.93			160.23	459 uS/cm @20 oC. Temp = 11.8 oC
		140	27.87	14.23			??	pH = 6.89
	09:30	150	27.78	14.14				
		160	27.82	14.18				
		170	27.9	14.26				
	10:00	180	27.96	14.32				
		195	28.08	14.44			156.96	456 uS/cm @ 20 oC. Temp = 11.8 oC
		210	28.25	14.61				pH = 6.89
		225	28.3	14.66				
	11:00	240	28.39	14.75				
		255	28.48	14.84				
		270	28.55	14.91				
		285	28.63	14.99				
	12:00	300	28.66	15.02				
		330	28.79	15.15			156.96	455 uS/cm @ 20 oC. Temp = 12.0 oC
	13:00	360	29.04	15.4				pH = 6.93
		390	29.2	15.56				
	14:00	420	29.34	15.7			153.69	455 uS/cm @ 20 oC. Temp = 12.2 oC
		450	29.53	15.89				pH = 6.95
	15:00	480	29.67	16.03				
		510	29.74	16.1				
	16:00	540	29.92	16.28				
		570	30.26	16.62			156.96	455 uS/cm @20 oC. Temp = 12.2 o C
	17:00	600	30.23	16.59				pH = 6.88

Date	Time	Elapsed Time	Water level below datum	Drawdown	Discharge		Discharge	Remarks	
		Mins	(m)	(m)	Meter	Spot	(m3/d)		
		600.25	29.25	15.61				PUMP OFF at 17:00	
		600.5	28.65	15.01					
		600.75	27.85	14.21					
		601	27.1	13.46					
		601.25	26.35	12.71					
		601.5	25.75	12.11					
		601.75	25.15	11.51					
		602	24.5	10.86					
		602.5	23.55	9.91					
		603	22.62	8.98					
		603.5	21.82	8.18					
		604	21.13	7.49					
		604.5	20.55	6.91					
		605	20.05	6.41					
		606	19.33	5.69					
		607	18.8	5.16					
		608	18.43	4.79					
		609	18.16	4.52					
		610	17.95	4.31					
		612	17.67	4.03					
		614	17.47	3.83					
		616	17.34	3.7					
		618	17.2	3.56					
		620	17.06	3.42					
		625	16.8	3.16					
		630	16.61	2.97					
		635	16.44	2.8					
		640	16.31	2.67					
		645	16.18	2.54					
		650	16.03	2.39					
		655	15.91	2.27					
		660	15.8	2.16					
		670	15.57	1.93					
		680	15.37	1.73					
		690	15.22	1.58					
		700	15.09	1.45					
		710	14.97	1.33					
		720	14.87	1.23					
		735	14.75	1.11					
		750	14.62	0.98					
		765	14.5	0.86					
		780	14.4	0.76					
		795	14.31	0.67					
		810	14.23	0.59					
		825	14.16	0.52					
	20:52	832	14.12	0.48					

Drawdown in Pumping Well (Borehole 1), Coachford, 9/7/99



7/8/2009

Coachford Borehole 1
Recovery Test

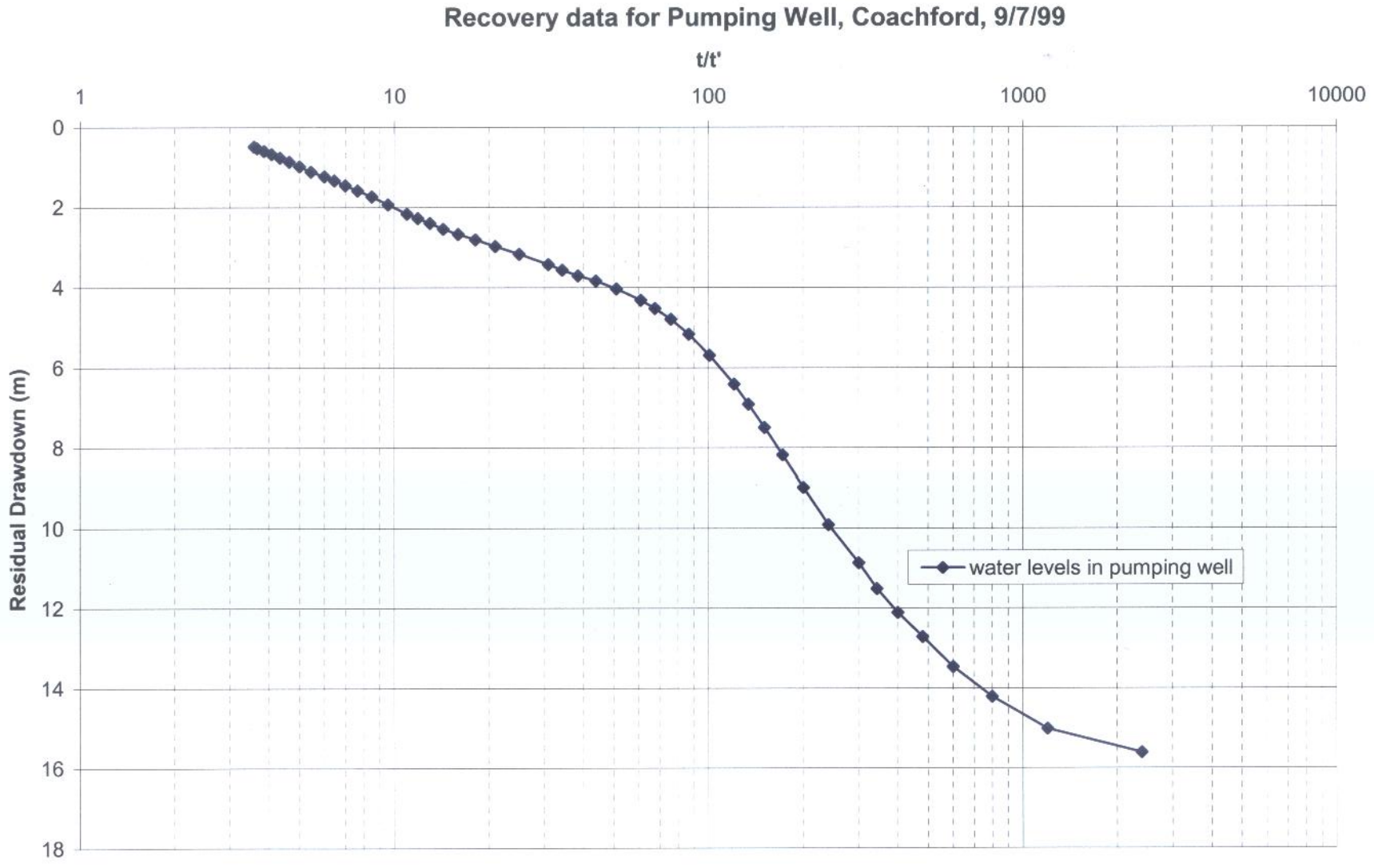
SITE Coachford Borehole 1 **DATE** 9/7/1999

Project Title Sth Cork GWPS
Page No. 1

RECOVERY TEST **PUMPING WELL**

Borehole Name	Coachford Borehole 1	**Well Depth**	~85.3 m	**Datum Point**	Top of dipping pipe recently installed
Borehole No.	1407SW W121	**Well Diameter**	200 mm	**Height of Datum**	0.23 m above g.l.
Well Owner	Cork Co Co	**Pump Depth**		**Ground Elev.**	
Location	Green at Fr. Sheehan Place	**Duration of Pumping**		**Datum Elev.**	
Grid ref.		**Average Discharge**	157.9 m3/d	**Weather**	Sunny and dry
6" Sheet No.	CORK 72	**Aquifer**	Ballytrasna Formation	**Observer**	D. Kelly

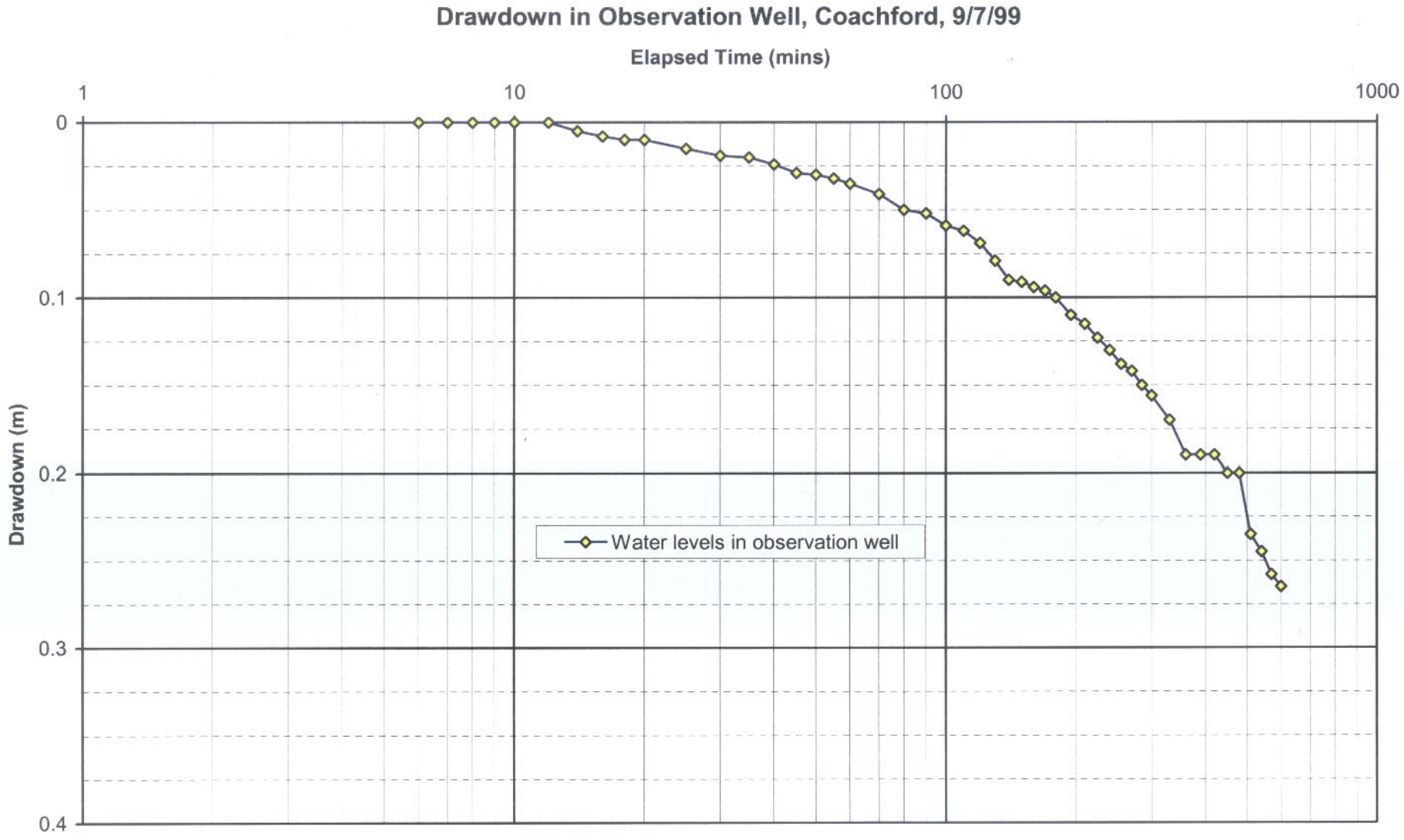
Date	Time	Time since Pumping Began (t)	Time since Pumping Ended (t')	Water level below datum	t/t'	Residual Drawdown	Recovery	Remarks
		Mins	Mins		(m)	(m)	(m)	
9/7/1999	17:00	600	0	30.23		16.59	0	
		600.25	0.25	29.25	2401.00	15.61	0.98	
		600.5	0.5	28.65	1201.00	15.01	1.58	
		600.75	0.75	27.85	801.00	14.21	2.38	
		601	1	27.1	601.00	13.46	3.13	
		601.25	1.25	26.35	481.00	12.71	3.88	
		601.5	1.5	25.75	401.00	12.11	4.48	
		601.75	1.75	25.15	343.86	11.51	5.08	
		602	2	24.5	301.00	10.86	5.73	
		602.5	2.5	23.55	241.00	9.91	6.68	
		603	3	22.62	201.00	8.98	7.61	
		603.5	3.5	21.82	172.43	8.18	8.41	
		604	4	21.13	151.00	7.49	9.1	
		604.5	4.5	20.55	134.33	6.91	9.68	
	17:05	605	5	20.05	121.00	6.41	10.18	
		606	6	19.33	101.00	5.69	10.9	
		607	7	18.8	86.71	5.16	11.43	
		608	8	18.43	76.00	4.79	11.8	
		609	9	18.16	67.67	4.52	12.07	
	17:10	610	10	17.95	61.00	4.31	12.28	
		612	12	17.67	51.00	4.03	12.56	
		614	14	17.47	43.86	3.83	12.76	
		616	16	17.34	38.50	3.7	12.89	
		618	18	17.2	34.33	3.56	13.03	
	17:20	620	20	17.06	31.00	3.42	13.17	
		625	25	16.8	25.00	3.16	13.43	
	17:30	630	30	16.61	21.00	2.97	13.62	
		635	35	16.44	18.14	2.8	13.79	
		640	40	16.31	16.00	2.67	13.92	
	17:45	645	45	16.18	14.33	2.54	14.05	
		650	50	16.03	13.00	2.39	14.2	
		655	55	15.91	11.91	2.27	14.32	
	18:00	660	60	15.8	11.00	2.16	14.43	
		670	70	15.57	9.57	1.93	14.66	
		680	80	15.37	8.50	1.73	14.86	
	18:30	690	90	15.22	7.67	1.58	15.01	
		700	100	15.09	7.00	1.45	15.14	
		710	110	14.97	6.45	1.33	15.26	
	19:00	720	120	14.87	6.00	1.23	15.36	
		735	135	14.75	5.44	1.11	15.48	
	19:30	750	150	14.62	5.00	0.98	15.61	
		765	165	14.5	4.64	0.86	15.73	
	20:00	780	180	14.4	4.33	0.76	15.83	
		795	195	14.31	4.08	0.67	15.92	
	20:30	810	210	14.23	3.86	0.59	16	
		825	225	14.16	3.67	0.52	16.07	
	20:52	832	232	14.12	3.59	0.48	16.11	


Recovery data for Pumping Well, Coachford, 9/7/99
t/t'
1
10
100
1000
10000
Residual Drawdown (m)
0
2
4
6
8
10
12
14
16
18
water levels in pumping well

SITE	Coachford Borehole 1	PUMPING TEST	OBSERVATION WELL	DATE	9/7/1999
				Project Title	Sth Cork GWPS
				Page No.	1

Borehole Name	Coachford Observation Borehole	**Well Depth**	~ 60 m	**Datum Point**	Top of lining
Borehole No.		**Well Diameter**	~ 60 mm	**Height of Datum**	ground level
Well Owner	Cork Co Co / GSI	**Pump Depth**	n/a	**Datum Elevation**	
Location	20 m approx from pumping well	**Aquifer**	Ballytrasna Formation	**Weather**	Sunny and dry for most of day
6" Sheet No.	CORK 72			**Observer**	O. Craig

Date	Time	Elapsed Time, minutes	Water level below datum, m	Drawdown (m)	Discharge meter	Discharge spot	Discharge (m3/d)	Remarks	
9/7/1999	07:00	0	10.92	0					
		6	10.92	0					
		7	10.92	0					
		8	10.92	0					
		9	10.92	0					
	07:10	10	10.92	0					
		12	10.92	0					
		14	10.925	0.005					
		16	10.928	0.008					
		18	10.93	0.01					
	07:20	20	10.93	0.01					
		25	10.935	0.015					
	07:30	30	10.939	0.019					
		35	10.94	0.02					
		40	10.944	0.024					
	07:45	45	10.949	0.029					
		50	10.95	0.03					
		55	10.952	0.032					
	08:00	60	10.955	0.035					
		70	10.961	0.041					
		80	10.97	0.05					
	08:30	90	10.972	0.052					
		100	10.979	0.059					
		110	10.982	0.062					
	09:00	120	10.989	0.069					
		130	10.999	0.079					
		140	11.01	0.09					
	09:30	150	11.011	0.091					
		160	11.014	0.094					
		170	11.016	0.096					
	10:00	180	11.02	0.1					
		195	11.03	0.11					
		210	11.035	0.115					
		225	11.043	0.123					
	11:00	240	11.05	0.13					
		255	11.058	0.138					
		270	11.062	0.142					
		285	11.07	0.15					
	12:00	300	11.076	0.156					
		330	11.09	0.17					
	13:00	360	11.11	0.19					
		390	11.11	0.19					
	14:00	420	11.11	0.19					
		450	11.12	0.2					
	15:00	480	11.12	0.2					
		510	11.155	0.235					
	16:00	540	11.165	0.245					
		570	11.178	0.258					
	17:00	600	11.185	0.265					
		606	11.185	0.265					
		607	11.185	0.265					
		608	11.185	0.265					
		609	11.182	0.262					
	17:10	610	11.181	0.261					
		612	11.181	0.261					
		614	11.18	0.26					
		616	11.178	0.258					
		618	11.175	0.255					
	17:20	620	11.173	0.253					
		625	11.17	0.25					
	17:30	630	11.165	0.245					
		635	11.161	0.241					
		640	11.159	0.239					
	17:45	645	11.155	0.235					
		650	11.151	0.231					
		655	11.148	0.228					
	18:00	660	11.141	0.221					
		670	11.133	0.213					
		680	11.127	0.207					
	18:30	690	11.118	0.198					
		700	11.105	0.185					
		710	11.091	0.171					
	19:00	720	11.082	0.162					
		735	11.062	0.142					
	19:30	750	11.032	0.112					
		765	11.02	0.1					
	20:00	780	11.019	0.099					
		795	10.999	0.079					
	20:30	810	10.997	0.077					
	20:45	825	10.997	0.077					


Drawdown in Observation Well, Coachford, 9/7/99
Elapsed Time (mins)
1
10
100
1000
0
0.1
0.2
0.3
0.4
Drawdown (m)
Water levels in observation well

Appendix 2

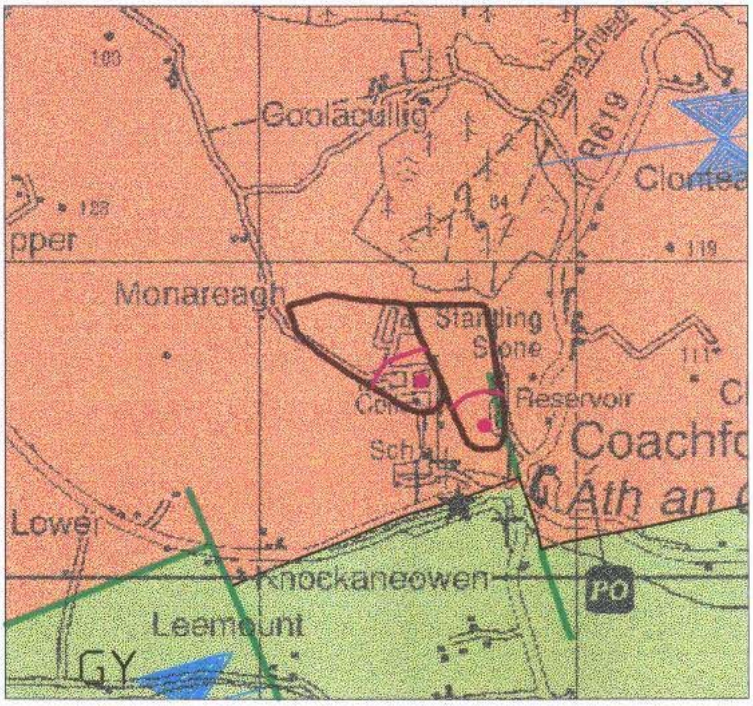
Water Quality Data

Coachford WSS Water Quality

Greater than Guide levels
Greater than MAC levels

Groundwater Section, Geological Survey of Ireland.

					Other Commonly Analysed Parameters									Bacteria		pH	Temp	EC	
	Lab	Date	SO4	Cl	Alk.	TH	Fe	Mn	Nitrite		Nitrate	NH4	Al	E-Coli	TC	Lab	Lab	Lab	Zn
Units			mg/l	mg/l	mg/l CaCo3		mg/l	mg/l	mg/l N	NO2	mg/l N	mg/l	mg/l	no/100l	no/100l		oC	uS/cm	mg/l
MAC			250	250			0.2	0.05	0.03	0.1	50	0.23	0.2	0	0			1500	1
	Inniscarra	9/4/1991												0	0				
	Inniscarra	25/6/1991												0	0				
	Inniscarra	7/10/1991												0	0			395	
	Inniscarra	11/12/1991							0.006		18.44	0.049		0	0	7.3	3	549	
	Inniscarra	27/1/1992							0.004		32.34	0.013		0	0	7.1	7.5	419	
	Inniscarra	31/3/1992												0	0		8	438	
	Inniscarra	18/8/1992												0	0		16	387	
	Inniscarra	12/10/1992												0	35		12	378	
	Inniscarra	18/1/1993												0	0			400	
	Inniscarra	1/2/1993							0		25.17	0.081		0	0	6.8		403	
	Inniscarra	8/3/1993												0	0			353	
	Inniscarra	20/4/1993												0	0		10	372	
	Inniscarra	4/5/1993												0	0			384	
	Inniscarra	5/7/1993												0	0			379	
	Inniscarra	13/7/1993							0.003		23.05			0	2	7	13	368	
	Inniscarra	9/8/1993												0	2			397	
	Inniscarra	21/9/1993												0	0			179	
	Inniscarra	12/10/1993												0	1			369	
	Inniscarra	30/11/1993												5	6			389	
	Inniscarra	7/12/1993												0	37			390	
	Inniscarra	14/12/1993												0	14			384	
	Inniscarra	11/1/1994												2	42			322	
	Inniscarra	8/2/1994			128	197	0.03	0.044	0.003		25.49	0.001		0	0	6.8		393	
	Inniscarra	26/4/1994												0	0			344	
	Inniscarra	30/8/1994												0	0			362	
	Inniscarra	29/11/1994												0	0			393	
	Inniscarra	10/1/1995												0	0			312	
	Inniscarra	14/3/1995	15	24	46	149	0.1	0.025	0.003		25.37	0.01	0.03	0	1	6.9	9.5	351	0.05
	Inniscarra	17/10/1995												1	2			257	
	Inniscarra	7/11/1995					0	0	0.002		38.37	0.001		0	0	7.7	14	170	
	Inniscarra	12/3/1996												0	0			350	
	Inniscarra	9/7/1996					0	0	0.01		28.84	0.01		0	0	6.9	16	354	
	Inniscarra	30/9/1996												0	1			358	
	Inniscarra	9/12/1996												0	0			363	
	Inniscarra	14/1/1997												0	0			417	
	Inniscarra	17/2/1997												0	0			402	
	Inniscarra	13/3/1997									53			0	0			390	
	Inniscarra	8/4/1997									43			0	0			401	
	Inniscarra	23/4/1997									49			0	0			404	
	Inniscarra	3/9/1997												7	12			418	
	Inniscarra	18/11/1997									51								
	Inniscarra	5/1/1998									42								
	Inniscarra	15/4/1998									54								
	Inniscarra	11/11/1998								0.013	48.7	0.039		0	0	6.8	11	386	
	Inniscarra																		
	Inniscarra																		



Coachford Water Supply Scheme

Map 1. Geology

0 500m 1 km

GY Gyleen Formation

BS Ballytrasna Formation

Fault

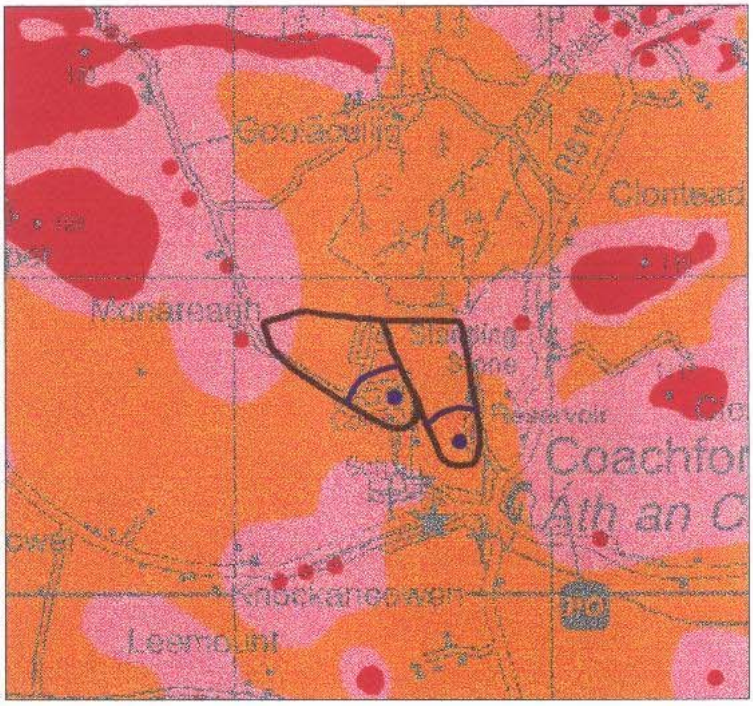
Synclinal Axis

Public Supply Well

Inner Protection Zone

Zone of Contribution

This Bedrock Map is designed for general information and stragegic planning usage. The boundaries are based on the available evidence and local details have been generalised to fit the map scale.
Evaluation of specific sites and circumstances will normally require further and more detailed assessments, and will frequently require site investigations.



0 500m 1km

Coachford Water Supply Scheme

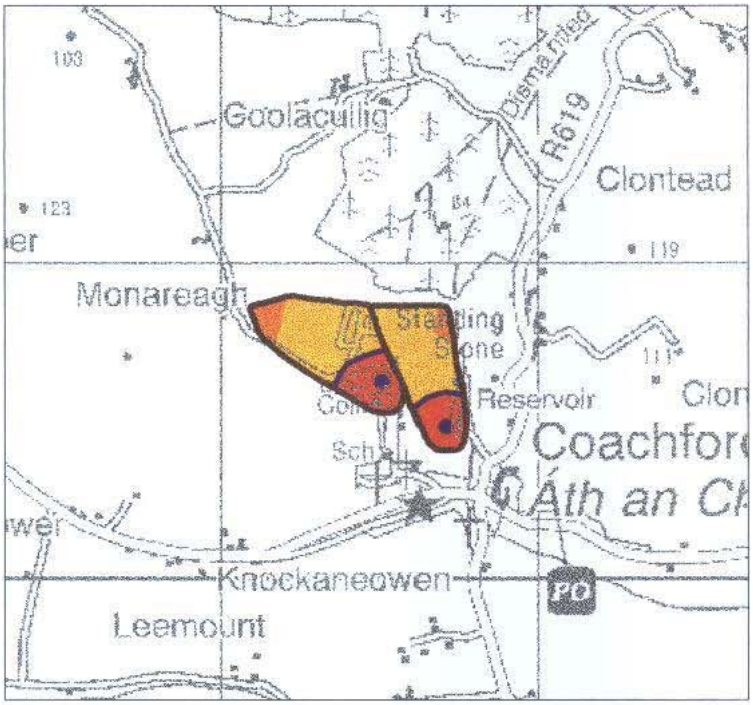
Map 2. Groundwater Vulnerability

- Extreme (E)
- Outcrop/Shallow rock (E)
- High (H)
- Moderate (M)
- Low (L)
- Public Supply Well
- Inner Protection Zone
- Zone of Contribution

Vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities.

The map shows the **vulnerability** of the first groundwater encountered (in either sand/gravel aquifers or in bedrock) to contaminants released at depths of 1-2 m below the ground surface. Where contaminants are released at significantly different depths, there will be a need to determine groundwater vulnerability using site-specific data. The characteristics of individual contaminants have not been taken into account.

This **vulnerability** map is designed for general information and strategic planning usage.The boundaries are based on the available evidence and local details have been generalised to fit the map scale.
Evaluation of specific sites and circumstances will normally require further and more detailed assessements, and will frequently require site investigations to determine the risk to groundwater.



0 500m 1km

Coachford Water Supply Scheme

Map 3. Source Protection Zones

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

Public Supply Well

Inner Protection Zone

Zone of Contribution

This **Source Protection Map** is designed for general information and stragegic planning usage. The boundaries are based on the available evidence and local details have been generalised to fit the map scale.
Evaluation of specific sites and circumstances will normally require further and more detailed assessments, and will frequently require site investigations.
The map is intended for use in conjunction with groundwater protection responses for potentially polluting activities, which lists the degree of acceptability of these activities in each zone and describes the control measures necessary to prevent pollution.