DUNSHAUGHLIN WATER SUPPLY

GROUNDWATER SOURCE PROTECTION ZONES

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DUNSHAUGHLIN WATER SUPPLY

1. WELL LOCATION AND SITE DESCRIPTION

This source is the main public supply well for Dunshaughlin and its surrounds and it is located 300 metres west of the village, off the Trim link road. The Production Well (PW No.1, drilled November 1993) is located within a housing estate, on a small green area and is completed below ground level (June 1996) inside a manhole 1.3 metres deep. The original trial well is located in the same manhole beside the production well. The manhole is well sealed but not fenced off from public access. There is no backup supply for this production well. The Dunshaughlin groundwater is both chlorinated and fluoridated before filtering in the pumphouse, and then pumped to the adjacent storage tower which has a capacity of 20,000 gallons. The pumphouse and the tower are located 600 metres due south of the production well on the southern side of Dunshaughlin. There are very few private wells in the vicinity of this source.

In February 1993 a deep well (300 metres) was drilled for the Council adjacent to the storage tower, and another Council production borehole in College Park (Stoke's Well) in May 1993, approximately 137 m from the supply well.

2. WELL DETAILS

GSI no.:	2925SWW105
Grid ref.:	29660 25224
Owner:	Meath County Council
Well type:	Production Borehole
Elevation (top of casing):	99.26 m OD (Poolbeg). Ground level is 99.00 m OD.
Depth:	122 m
Depth of casing:	12.2 m (300mm), 21.3 m (200mm UPVC)
Depth of grout:	21.3 m (annulus of 200 mm casing)
Diameter:	200 mm (8")
Depth-to-rock:	12.2 m
Static water level:	0.05 m b.g.l. (7-12-95)
Pumping water level:	17.63 m b.g.l. (after 12 hrs continuous pumping)
Drawdown:	17.08 m (after 12 hrs continuous pumping)
Pumping rate:	$810m^3/d$ (7,400 gal/hr)
Normal consumption:	$500m^3/d$ (110,000gal/d on average, over 24 hrs)

Pumping test summary:

(i) abstraction rate:	$810m^3/d$
(ii) specific capacity:	$47m^3/d/m$ (12 hours); $40m^3/d/m$ (extrapolated to 1 week)
(iii) transmissivity:	100 - $300m^2/d$

3. METHODOLOGY

There were three stages involved in assessing the area: (a) detailed desk study, (b) site visits and fieldwork, and (c) analysis of the data. The desk study compiled the geology from all available data sources. Basic public supply well details were obtained from County Council personnel, including precise locations and any relevant borehole, geology logs, chemistry and pumping test data available.

The second stage comprised site visits and fieldwork in the surrounding area. A twelve hour pumping test with a recovery test was carried out to examine the aquifer characteristics. The area within 1km radius was surveyed with regard to geology, hydrogeology, vulnerability to pollution and current pollution loading. Raw water samples were taken in March, June, and September 1995 and January

1996 for full suites of chemical and bacterial analyses. Conductivity measurements were taken at regular intervals from early 1995 to mid-1996.

The assessment stage used analytical equations and hydrogeological mapping to delineate protection zones.

4. TOPOGRAPHY, DRAINAGE AND LAND USE

The ground topography around Dunshaughlin is relatively flat and undulating, ranging from to 98 m OD (320 ft) to 108 m OD (355 ft). The source is located close to the source of a small tributary of the River Boyne, which firstly flows west and then in a northwesterly direction. The stream is piped underground in the vicinity of the well, through the housing estates.

Dunshaughlin is located close to the surface water catchment divide between the River Boyne and the Broadmeadow River. The catchment divide runs approximately in a north-south direction to the east of the village. Drainage is reasonably good with relatively few drainage ditches in the immediate vicinity of the source.

Agriculture is the principal activity outside the village area, with most of the land around the public supply being used primarily for new housing and green belt areas.

5. GEOLOGY

5.1 Bedrock geology

The underlying bedrock in this area is the Calp Limestone (Figure 1) which comprises primarily muddy limestones and calcareous limestones interbedded with calcareous shales. The driller's log (122 metres) for the Dunshaughlin production well (November 1993) indicated 110 m of black limestone with shale bands. The upper 9 metres were reported to be highly broken and were cased for support. The adjacent trial well encountered the same lithologies. The borehole in College Park (Stoke's Well, 33.5 metres deep) approximately 137 m from the supply well, encountered 21.3 metres of dark grey to black limestone and shales and possible interbedded sandstones.

The Council well adjacent to the tower encountered 296 metres of dark grey to black limestones, intermittently shaly. Calcite veining occurred through the sequence and the abundance of shale and veining increased with depth. The rock was competent, indicating no significant fracturing.

5.2 Quaternary (subsoils) geology

Two types of Quaternary deposits are present in the vicinity of the Dunshaughlin source and are shown in Figure 2.

Around Dunshaughlin is an extensive area of limestone dominated till which is very clayey and occasionally stony in texture. Located within the limestone till are small areas of lacustrine deposits which are clayey to marly in texture. These lakes are now dry except for the very marshy area approximately 0.5 km northeast of Dunshaughlin, which is 1200 metres long and 500 metres wide.

The Redbog area (Quaternary lake sediments) which is less than 1 km north of the supply well is approximately one square kilometre in size.

5.3 Soils

The soils information is taken from the published soils map of County Meath (Finch *et al*, 1983).

Soils of the area are primarily derived from a parent material, limestone and shale till. The Great Soil Group for the soils around the source and to the southeast of Dunshaughlin are Gleys (Ashbourne Series). Gleys developed under poor drainage conditions with permanent or intermittent water logging

usually due to a high water table. The soil parent material is very fine grained with an abundance of clay, which gives rise to low permeability and poor drainage even on slopes.

This Ashbourne Series is associated with the Dunboyne Series which is a Grey Brown Podzolic Soil. The Dunboyne Series occur to the northwest of Dunshaughlin on slightly higher ground and are much better drained.

5.4 Depth-to-rock

Depth-to-rock in the public supply borehole and in Stoke's Well indicate 12.2 metres of Limestone till were encountered. Adjacent boreholes indicate variable depths. Rock outcrops occur in small disused quarries throughout the area, although many of these have now been infilled for example at the Dunshaughlin Tower, Sechnallstown House, Cooksland, and in Bonestown.

The subsoils are on average greater than 10 metres thick, especially in the vicinity of the public supply well. The depth-to-rock contours are based on limited data points and may need refining as further depth to bedrock records become available (see Figure 3).

6. HYDROGEOLOGY

6.1 Data availability

Hydrogeological data for the Dunshaughlin area are reasonably good, although lacking in the area of interest around the public supply. A 12 hour pumping test with a recovery test was carried out in December 1995 and a survey of wells and pollution sources was conducted around the source (Figure 4). Water levels in private wells were measured and a water table map constructed to ascertain the groundwater flow direction. Some of these water level readings were used with caution as the well heads were not all accurately levelled in and the survey includes dug wells which may only be tapping a perched water table within the till.

The production well was drilled in November 1993 and tested in December 1993. Stoke's Well was drilled in May 1993, but not tested. The trial well at the Tower was drilled in February 1993 and a short report on the drilling of the well was prepared by ERA-Maptec Ltd. There is no information available for the small supply well located at the Dunshaughlin County Council offices, which is used to supplement the public water for the area. Information from private wells in the area is of varying quality and a well survey was conducted by the GSI in the area during the summer of 1975.

6.2 Groundwater levels

Groundwater is generally close to the surface, generally being less than 2 m below surface. The static water level taken in the production well on 7/12/95, following overnight recovery, was 0.05 m b.g.l. (98.95m OD). The static water level in Stoke's Well was 0.11 m b.g.l. (99.13 m OD).

The pumping water level taken in the public supply well on 7/12/95 was 17.13 m b.g.l. (81.87 m OD) and 0.84 m b.g.l. in Stoke's Well (98.40 m OD) after 12 hours.

6.3 Groundwater flow directions and gradients

The surface water catchment divide between the River Boyne to the west and the Broadmeadow River to the east runs in a north-south direction just to the east of Dunshaughlin village. Groundwater flow, from the regional viewpoint, is towards the east and west from this divide. It is inferred that local groundwater flow is controlled by the pumping of the well.

Groundwater gradients in the general area may range from approximately 0.01 to 0.02.

6.4 Rainfall, Evaporation and Recharge

Rainfall data for the area are taken from the nearest rainfall station in Dunshaughlin, (105 m OD) 300 metres to the southeast. Mean annual rainfall as recorded by Met Eireann for 1951-80 was 871 mm. Potential evapotranspiration (P.E.) is estimated from a Met Eireann contoured map as 550 mm/yr. Actual evapotranspiration (A.E.) is estimated at 522 mm by calculating a percentage (95%) of the P.E., to allow for seasonal soil moisture deficits.

Using the above figures the effective rainfall (E.R.) is taken to be approximately 349 mm/yr. The production well is located within a recently developed residential area and as a result of the high proportion of impermeable surfaces in the immediate area of the supply and the Quaternary deposits are relatively impermeable and generally thick, a low proportion of the effective rainfall will be able to infiltrate to the water table. Estimating run off to be of the order of 50%, the recharge to the aquifer is estimated to be 175 mm/yr.

These calculations are summarised below:

Average annual rainfall	871 mm
Estimated P.E.	550 mm
Estimated A.E. (95% P.E.)	522 mm
Effective rainfall	349 mm
Recharge (50% E.R.)	175 mm

6.5 Hydrochemistry and Water Quality

The hydrochemical analyses of groundwater at the source in Dunshaughlin indicate a very hard water (300-380 mg/l $CaCO_3$), with a high alkalinity (300-330 mg/l $CaCO_3$). Conductivities are also high ranging from 480-670 μS/cm (Table 1). This groundwater can be classed as a calcium bicarbonate water. The groundwater analyses are in the Appendices.

The water quality at Dunshaughlin is good with no bacterial contamination except in one sample, and all the major cations, anions and trace elements are within the Irish Drinking Water Standards, except for iron and manganese which tend to be greater than the MAC. Calcium and sulphate levels are above the guide values. A small number of background coliforms were found in one sample (12-6-95) indicating the potential vulnerability to contamination. Regular sampling of the raw water from Dunshaughlin should be continued to monitor the water quality.

Table 1. Conductivity readings from the Dunshaughlin Source

	Production Well	
Date	**Conductivity**	**Temperature**
*21-2-95	669	13
+20-3-95	488	10.6
16-5-95	505	11.5
+12-6-95	513	11.9
7-7-95	527	13.1
4-8-95	548	14.3
15-9-95	515	12.4
+25-9-95	500	11.6
11-11-95	497	11.1
6-12-95	610-615	10.7-10.9
+8-1-96	620	10.4
1-2-96	618	10.7
20-2-96	628	9.5
20-3-96	624	10.6
26-6-96	634	12.1

* Reading taken using a different conductivity meter + Full Analyses

6.6 Aquifer coefficients

Pumping test analysis provided an apparent transmissivity of around 100-300 m^2/d from the 12 hour pumping test. The higher transmissivity values were obtained from analysis of the observation data collected from Stoke's Well. The pumping test data are in the Appendices.

The specific capacity calculated was 47 $m^3/d/m$ after 12 hours pumping. After an initial drawdown in the well of 9.75 metres during the first minute, drawdown was 7.33 metres over the next 10 hours, with a discharge of 810m^3/d. This suggests that the yield of the well could be increased. However, more comprehensive tests would be needed to confirm the sustainable maximum yield of the well.

The specific yield of 0.0004 was calculated from data from Stoke's well and indicates that the aquifer is confined or is locally confined in the vicinity of the production well.

Analyses of the original 72 hour pumping test (step test), with a final pumping rate of 1300 m^3/d and a drawdown of 54 metres, indicated a transmissivity of around 50-60 m^2/d. The specific capacity calculated was 24 $m^3/d/m$. These figures are much lower than those obtained from the 12 hour test and suggest that the upper 10 metres of the limestone has a much higher permeability and with increasing depth the permeability decreases.

In the 72 hour test, a pumping rate of 900m^3/d for the first hour gave a drawdown of 23.55 m, which compares to the 12 hour test with a pumping rate of 810m^3/d and a one-hour drawdown of 16.22 m.

6.7 Conceptual Model

The aquifer feeding the Dunshaughlin source is the Calp Limestone. This is overlain by over 12 metres of intermediate permeability limestone till, and the aquifer is considered to be confined, at least locally. This well is artesian and thus overflows when not being pumped, indicating an upward groundwater gradient in the vicinity of the production well and also at Stoke's well.

Permeabilities within the bedrock are due to joints and fractures. During the drilling of the production well major inflows of groundwater were recorded in the limestone at 67-73 m and 103-110 m below ground level.

Natural groundwater flow is influenced by topography. The well is located close to a surface water divide, which is assumed also to be a groundwater divide (there is no information to indicate otherwise) running roughly north-south, just east of Dunshaughlin village. Groundwater flow to the well is from all directions and the groundwater catchment is almost entirely created by the pumping.

In the production well, the top 12.2 metres of limestone till overlying a layer of broken limestone to a depth of 21.3 metres was lined with 200 mm steel casing and grouted. The well is open hole at 200mm from 21.3m to a depth of 122 metres (-23m O.D.) The main inflow into the well is probably at the rock head, at the base of the steel casing and at depths between 67 and 110 metres. Direct inflows from the subsoils are prevented by the steel casing.

The pumping test results from 1993 indicated that the optimum yield of the well was around 800m^3/d and an increase in the pumping rate resulted in lowering the water level to the pump intake. The 1995 results indicate that the well may now be capable of a yield higher than 800m^3/d.

6.8 Aquifer category

The aquifer supplying the Dunshaughlin source is the Calp Limestone. In this area this aquifer is classed as a **locally important aquifer which is generally moderately productive (Lm)**

7. GROUNDWATER VULNERABILITY

The vulnerability of the catchment for the Dunshaughlin source is mapped as varying from 'Extreme' to 'Low'. The subsoils are generally intermediate to low permeability.

Under the GSI vulnerability mapping guidelines, areas where rock is less than 3 m below surface are mapped as having a 'probably extreme vulnerability'. Such conditions occur in the quarries, all of which have now been infilled or overgrown. Around these quarries are small zones which are 'highly' to 'moderately' vulnerable. In the remainder of the area around the source, the subsoils are thicker than 10 metres and the area is classified as 'low vulnerability'. The vulnerability zones are shown on Figure 5.

8. DELINEATION OF SOURCE PROTECTION AREAS

Source protection areas are delineated for the present output (810 m^3/d) that is currently abstracted. A buffer zone is included to allow for expansion of the zone of contribution during dry weather.

8.1 Inner Protection Area (SI)

The Inner Protection Area is the area defined by a 100 day time of travel 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 from microbial contamination.

Using the following aquifer coefficients: permeability (k) = 20 m/d, porosity = 0.04, and the hydraulic gradient (i) = 0.01, the 100 day time of travel distance to the well is estimated to be approximately 500 metres (Figure 6).

8.2 Outer Protection Area (SO)

The Outer Protection Area includes the remainder of the catchment area to the source, i.e. the zone of contribution (ZOC), and is defined as the area required to support an abstraction from long-term recharge. The ZOC is shown in Figure 6 and approximates very closely to a circle, because the well is situated close to a groundwater divide and the ZOC is entirely created by the pumping.

The size of the ZOC is based largely on the Recharge Equation. Taking the average annual recharge to be 175 mm, the area required to supply the pumping rate of 810 m^3/d, is calculated to be 1.7 km^2. The final calculated radius (allowing a safety margin) is approximately 800 metres.

9. GROUNDWATER SOURCE PROTECTION ZONES

Combining the Inner and Outer Source Protection Areas, as described above, with the vulnerability ratings produces eight groundwater protection zones for the source at Dunshaughlin. These are listed here in order of decreasing degree of protection required and are shown in Figure 7:

- Inner Protection Area / Extreme (SI/E)
- Inner Protection Area / High (SI/H)
- Inner Protection Area / Moderate (SI/M)
- Inner Protection Area / Low (SI/L)
- Outer Protection Area / Extreme (SO/E)
- Outer Protection Area / High (SO/H)
- Outer Protection Area / Moderate (SO/M)
- Outer Protection Area / Low (SI/L)

10. POTENTIAL POLLUTION SOURCES

The primary threat to the public supply at Dunshaughlin is the village itself, very close to the source, which may be affected in particular, by septic tanks and/or leaky sewers (if present) in the village. At present there is no evidence that the indicator parameters are elevated above the background levels.

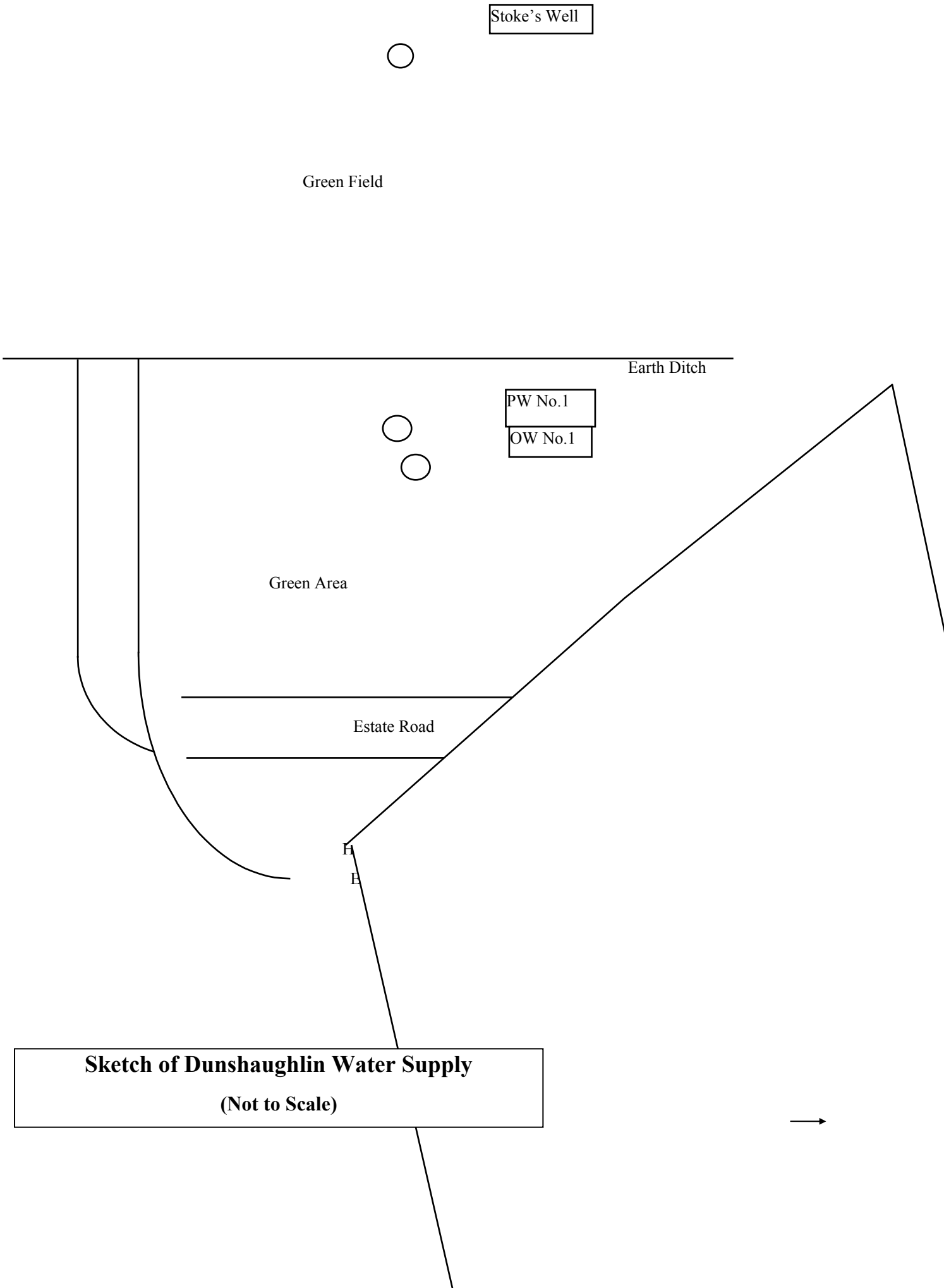
A small number of farmyards are present in the general area of the well. All potentially polluting activities within the zone of contribution should be conducted to very high standards.

11. CONCLUSIONS AND RECOMMENDATIONS

Overall the source at Dunshaughlin is a high yielding well which may be able to support a small increase in yield. The water analyses indicate that there were no water quality problems at this source, except for the naturally high iron and manganese. However the catchment for the supply is mostly moderately vulnerable to pollution due to the thick intermediate permeability subsoils around the source.

It is recommended that the Council continue sampling the raw water from the Dunshaughlin public supply to monitor the effects of the potentially polluting activities. In addition it is recommended that the Council control and monitor potentially polluting activities being carried out on the delineated groundwater source protection zones, particularly in the village.

The production well and the adjacent observation well should be adequately secured from the public. Both wells should be securely fenced off. Stoke's well should also be more adequately secured. The trial well at the Tower should be infilled and plugged with cement. The old quarry at the Tower is presently being infilled, generally with rubble, although some domestic rubbish is present. It should be rehabilitated and all rubbish should be removed and disposed of properly.



Sketch of Dunshaughlin Water Supply

(Not to Scale)

Appendix 1
Pump Test Data

PUMPING TEST DATA SHEET

Location : DUNSHAUGHLIN **Borehole name : PW No.1** **Date : 02-12-93**

Test : Drawdown Data from PW No.1

Duration : 72hrs. Weather :

Distance from Pumping Well : Well depth : 122m

Height of datum point above ground level : ? Datum Point : ?

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	Conductivity uS/cm @20 C
	Step 1						
02-12-93	10:30	0	0.4	0			
		0.5	8.85	8.45			
		1	12.62	12.22			
		1.5	14.65	14.25			
		2	16.1	15.7			
		2.5	17.16	16.76			
		3	17.95	17.55			
		3.5	18.59	18.19	950		
		4	19.3	18.9			
		4.5	19.53	19.13			
		5	19.89	19.49			
		6	20.4	20			
		7	20.85	20.45			
		8	21.13	20.73			
		9	21.35	20.95			
		10	21.55	21.15	935		
		12	21.87	21.47			
		14	22.09	21.69			
		16	22.3	21.9			
		18	22.48	22.08			
		20	22.61	22.21			
		22	22.75	22.35			
		24	22.83	22.43	930		
		26	22.91	22.51			
		28	23	22.6			
		30	23.09	22.69			
		35	23.27	22.87			
		40	23.44	23.04			
		45	23.62	23.22			
		50	23.73	23.33			
		55	23.85	23.45	930		
	Step 2						
	11:30	60 (1hr)	23.95	23.55			
		60.5	26.58	26.18			
		61	28.5	28.1			
		62	30.8	30.4			
		62.5	31.5	31.1			
		63	32.1	31.7			
		63.5	32.42	32.02			
		64	32.76	32.36			
		64.5	33.07	32.67			
		65	33.29	32.89			
		66	33.68	33.28			
		67	33.95	33.55	1145		
		68	34.17	33.77			
		69	34.38	33.98			
		70	34.52	34.12			
		72	34.76	34.36			
		74	34.95	34.55	1177		
		76	35.13	34.73			
		78	35.24	34.84			
		80	35.37	34.97			
		82	35.48	35.08			
		84	35.59	35.19			
		86	35.66	35.26			

PUMPING TEST DATA SHEET

Location : DUNSHAUGHLIN **Borehole name : PW No.1** **Date : 02-12-93**

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	Conductivity uS/cm @20 C
		88	35.74	35.34			
		90	35.82	35.42	1170		
		95	35.99	35.59			
		100	36.15	35.75			
		105	36.28	35.88			
		110	36.38	35.98			
		115	36.47	36.07			
	12:30	120 (2hrs)	36.57	36.17	1145		
		150	36.96	36.56			
	13:30	180 (3hrs)	37.27	36.87			
		210	37.38	36.98			
	14:30	240 (4hrs)	37.53	37.13			
	15:30	300 (5hrs)	38.02	37.62	1145		
	16:30	360 (6hrs)	38.28	37.88			
	17:30	420 (7hrs)	38.44	38.04			
	18:30	480 (8hrs)	38.6	38.2			
	19:30	540 (9hrs)	38.72	38.32			
	20:30	600 (10hrs)	38.83	38.43	1140		
	22:30	720 (12hrs)	39.03	38.63	1145		
03-12-93	00:30	840 (14hrs)	39.2	38.8			
	02:30	960 (16hrs)	39.35	38.95			
	04:30	1080 (18hrs)	39.48	39.08			
	06:30	1200 (20hrs)	39.59	39.19			
	10:30	1440 (24hrs)	39.8	39.4	1130		
	12:30	1560 (26hrs)	39.56	39.16			
	14:30	1680 (28hrs)	39.66	39.26	1130		
	Step 3						
	15:31	1741	40.1	39.7	1340		
		1742	43.7	43			
		1743	46	45.6			
		1744	46.12	45.72			
		1745	46.3	45.9	1340		
		1746	46.3	45.9			
		1747	46.3	45.9			
		1748	46.33	45.93			
		1749	46.87	46.47			
		1752	48.12	47.72			
		1754	48.1	47.7			
		1756	48.06	47.66			
		1758	48.1	47.7			
		1760	48.5	48.1			
		1762	48.6	48.2			
		1764	48.7	48.3			
		1766	48.5	48.1			
		1768	48.36	47.96			
		1770	48.6	48.2			
		1775	48.6	48.2			
		1780	49	48.6			
		1785	49.3	48.9			
		1790	49.48	49.18			
		1795	49.73	49.33			
	16:30	1800 (30hrs)	49.9	49.5			
	18:30	1920 (32hrs)	50.1	49.7			
	20:30	2040 (34hrs)	50.53	50.13			
	22:30	2160 (36hrs)	50.82	50.42			
04/12/93	04:30	2520 (42hrs)	51.46	51.06			
	10:30	2880 (48hrs)	51.9	51.5			
	16:30	3240 (54hrs)	53.2	52.8	1310		
	22:30	3600 (60hrs)	53.52	53.12			
05/12/93	04:30	3960 (66hrs)	54.1	53.7	1310		
	10:30	4320 (72hrs)	54.5	54.1	1310		

PUMPING TEST DATA SHEET

Location : DUNSHAUGHLIN **Borehole name : PW No.1** **Date : 05-12-93**

Test : Recovery Data from PW No.1.

Duration : 2hrs. Weather :

Distance from Pumping Well : Well depth : 122m

Height of datum point above ground level : ? Datum Point : ?

Date	Time	Time since pumping ended (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	Conductivity uS/cm @20 C
05-12-93	10:30	0	54.5	54.1			
		1.5	21	20.6			
		2	14	13.6			
		2.5	12.2	11.8			
		3	10.4	10			
		3.5	9.4	9			
		4	8.5	8.1			
		4.5	7.9	7.5			
		5	7.5	7.1			
		6	6.85	6.45			
		7	6.46	6.06			
		8	6.16	5.76			
		9	5.93	5.53			
		10	5.73	5.33			
		12	5.42	5.02			
		14	5.18	4.78			
		16	4.98	4.58			
		18	4.83	4.43			
		20	4.69	4.29			
		30	4.21	3.81			
	11:30	60 (1hr)	3.5	3.1			
	12:30	120 (2hrs)	3	2.6			

PUMPING TEST DATA SHEET

Location : DUNSHAUGHLIN **Borehole name : PW No.1** **Date : 06-12-1995**

Test : Recovery Data from PW No.1

Duration : 3hrs. Weather : Wintry Showers.

Distance from Pumping Well : Well depth : 122m

Height of datum point above ground level : 0.5m Datum Point : Top of dipping pipe.

Date	Time	Time since pumping ended (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	Conductivity uS/cm @20 C
06-12-95	21:00	0	17.5	16.95			
		0.5	10.2	9.65			
		1	7.35	6.8			
		1.5	5.9	5.35			
		2	5	4.45			
		2.5	4.4	3.85			
		3	4	3.45			
		3.5	3.7	3.15			
		4	3.45	2.9			
		4.5	3.3	2.75			
		5	3.15	2.6			
		6	2.92	2.37			
		7	2.77	2.22			
		8	2.62	2.07			
		9	2.5	1.95			
		10	2.41	1.86			
		12	2.25	1.7			
		14	2.16	1.61			
		16	2.05	1.5			
		18	1.97	1.42			
		20	1.9	1.35			
		22	1.84	1.29			
		24	1.77	1.22			
		26	1.74	1.19			
		28	1.69	1.14			
		30	1.65	1.1			
		35	1.56	1.01			
		40	1.49	0.94			
		45	1.43	0.88			
		50	1.38	0.83			
		55	1.33	0.78			
	22:00	60 (1hr)	1.28	0.73			
		75	1.17	0.62			
		90	1.1	0.55			
		105	1.02	0.47			
	23:00	120 (2hrs)	0.97	0.42			
		135	0.91	0.36			
		150	0.87	0.32			
		165	0.83	0.28			
	24:00	180 (3hrs)	0.8	0.25			

PUMPING TEST DATA SHEET

Location : DUNSHAUGHLIN **Borehole name : PW No.1** **Date : 07-12-95**

Test : Drawdown Data from PW No.1 Weather : Wintry Showers

Duration : 12hrs. Well depth : 122m

Height of datum point above ground level : 0.5m Datum Point : Top of dipping pipe.

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	Conductivity uS/cm @20 C
07-12-95	06:00	0	0.55	0	810		
		0.5	1	0.45			
		1	10.3	9.75			
		1.5	11.6	11.05			
		2	12.6	12.05			
		2.5	13.25	12.7			
		3	13.7	13.15			
		3.5	14.12	13.57			
		4	14.4	13.85			
		4.5	14.2	13.65			
		5	14.8	14.25			
		6	15.1	14.55			
		7	15.33	14.78			
		8	15.48	14.93			
		9	15.6	15.05			
		10	15.7	15.15			
		12	15.85	15.3			
		14	16	15.45			
		16	16.08	15.53			
		18	16.16	15.61			
		20	16.22	15.67			
		22	16.27	15.72			
		24	16.31	15.76			
		26	16.35	15.8			
		28	16.4	15.85			
		30	16.43	15.88			
		35	16.52	15.97			
		40	16.6	16.05			
		45	16.63	16.08			
		50	16.71	16.16			
		55	16.76	16.21			
	07:00	60(1hr)	16.77	16.22			
		75	16.79	16.24			
		90	16.87	16.32		10.8	614
		105	16.95	16.4			
	08:00	120(2hrs)	17.03	16.48			
		135	17.12	16.57			
		150	17.12	16.57		10.7	610
		165	17.12	16.57			
Filter Backwashed at 08:45							
	09:00	180 (3hrs)	15.95	15.4			
		200	16.7	16.15		10.7	612
		220	17.48	16.93			
	10:00	240 (4hrs)	17.53	16.98	810		
		260	17.51	16.96	810		
		280	17.53	16.98			
	11:00	300 (5hrs)	17.55	17			
		330	17.56	17.01		10.8	614
	12:00	360 (6hrs)	17.56	17.01			
		390	17.6	17.05			
	13:00	420 (7hrs)	17.62	17.07			
		450	17.64	17.09		10.8	610
		510	17.64	17.09			
	15:00	540 (9hrs)	17.64	17.09			
		570	17.63	17.08		10.9	610
	16:00	600 (10hrs)	17.63	17.08			
		630	17.55	17			
	17:00	660 (11hrs)	17.53	16.98			
		690	17.41	16.86			
	18:00	720 (12hrs)	17.4	16.85	810		

PUMPING TEST DATA SHEET

Location : DUNSHAUGHLIN **Borehole name : OW No.1** **Date : 06-12-95**

Test : Recovery Data from OW No.1

Duration : 12hrs. Weather : Wintry Showers.

Distance from Pumping Well : 1.2m Well depth :

Height of datum point above ground level : -0.3m Datum Point : Top of casing.

Date	Time	Time since pumping ended (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	Conductivity uS/cm @20 C
06/12/95	21:00	0	11.2	11.2			
		0.5	9.98	9.98			
		1	6.65	6.65			
		1.5	6.15	6.15			
		2	4.95	4.95			
		2.5	4.04	4.04			
		3	3.55	3.55			
		3.5	3.15	3.15			
		4	2.89	2.89			
		4.5	2.71	2.71			
		5	2.52	2.52			
		6	2.29	2.29			
		7	2.12	2.12			
		8	1.95	1.95			
		9	1.83	1.83			
		10	1.79	1.79			
		12	1.61	1.61			
		14	1.43	1.43			
		16	1.34	1.34			
		18	1.24	1.24			
		20	1.2	1.2			
		22	1.14	1.14			
		24	1.07	1.07			
		26	1.04	1.04			
		28	1.04	1.04			
		30	0.96	0.96			
		35	0.85	0.85			
		40	0.79	0.79			
		45	0.76	0.76			
		50	0.68	0.68			
		55	0.64	0.64			
	22:00	60 (1hr)	0.6	0.6			
		75	0.49	0.49			
		90	0.4	0.4			
		105	0.34	0.34			
	23:00	120 (2hrs)	0.28	0.28			
		135	0.23	0.23			
		150	0.19	0.19			
		165	0.15	0.15			

PUMPING TEST DATA SHEET

Location : DUNSHAUGHLIN **Borehole name : OW No.1** **Date : 07-12-95**

Test : Drawdown Data from OW No.1 while PW No.1 is pumping.

Duration : 12hrs. Weather : Wintry Showers.

Distance from Pumping Well : 1.2m. Well depth :

Height of datum point above ground level : -0.3m Datum Point : Top of casing.

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	Conductivity uS/cm @20 C
07/12/95	06:00	0	0	0			
		0.5	1.24	1.24			
		1	2.76	2.76			
		1.5	4.39	4.39			
		2	5.25	5.25			
		2.5	6.21	6.21			
		3	6.59	6.59			
		3.5	7.04	7.04			
		4	7.46	7.46			
		4.5	7.74	7.74			
		5	8.11	8.11			
		6	8.37	8.37			
		7	8.58	8.58			
		8	8.78	8.78			
		9	8.9	8.9			
		10	9.03	9.03			
		12	9.23	9.23			
		14	9.35	9.35			
		16	9.47	9.47			
		18	9.55	9.55			
		20	9.68	9.68			
		22	9.72	9.72			
		24	9.74	9.74			
		26	9.76	9.76			
		28	9.8	9.8			
		30	9.84	9.84			
		35	10.77	10.77			
		40	11.03	11.03			
		45	11.07	11.07			
		50	11.09	11.09			
		55	11.11	11.11			
	07:00	60 (1hr)	11.12	11.12			
		75	11.12	11.12			
		90	11.12	11.12			
		105	10.4	10.4	*Changed dipper for readings*		
	08:00	120 (2hrs)	10.42	10.42			
		135	10.49	10.49			
		150	10.51	10.51			
		165	10.53	10.53			
	09:00	180 (3hrs)	9.93	9.93			
		200	10.32	10.32			
		220	10.76	10.76			
	10:00	240 (4hrs)	10.79	10.79			
		260	10.81	10.81			
		280	10.83	10.83			
	11:00	300 (5hrs)	10.84	10.84			
		330	10.88	10.88			
	12:00	360 (6hrs)	10.89	10.89			
		390	10.92	10.92			
	13:00	420 (7hrs)	10.94	10.94			
		450	10.97	10.97			
		510	10.98	10.98			
	15:00	540 (9hrs)	10.99	10.99			
		570	10.98	10.98			
	16:00	600 (10hrs)	10.99	10.99			
		630	10.97	10.97			
	17:00	660 (11hrs)	10.95	10.95			
		690	10.9	10.9			
	18:00	720 (12hrs)	10.8	10.8			

PUMPING TEST DATA SHEET

Location : DUNSHAUGHLIN **Borehole name : Stoke's Well, OW No.2** **Date: 06-12-95**

Test : Recovery Data from Stoke's Well.

Duration : 3hrs. Weather : Wintry Showers.

Distance from Pumping Well : 137m. Well depth : 33.5m

Height of datum point above ground level : 0.56m Datum Point : Top of casing.

Date	Time	Time since pumping ended (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	Conductivity uS/cm @20 C
06/12/95	21:00	0	1.42	0.75			
		1	1.42	0.75			
		1.5	1.41	0.74			
		2	1.41	0.74			
		2.5	1.41	0.74			
		3	1.41	0.74			
		3.5	1.41	0.74			
		4	1.4	0.73			
		4.5	1.4	0.73			
		5	1.4	0.73			
		6	1.4	0.73			
		7	1.4	0.73			
		8	1.38	0.71			
		9	1.37	0.7			
		10	1.37	0.7			
		12	1.35	0.68			
		14	1.34	0.67			
		16	1.34	0.67			
		18	1.31	0.64			
		20	1.29	0.62			
		22	1.28	0.61			
		24	1.26	0.59			
		26	1.24	0.57			
		28	1.23	0.56			
		30	1.21	0.54			
		35	1.19	0.52			
		40	1.17	0.5			
		45	1.15	0.48			
		50	1.13	0.46			
		55	1.11	0.44			
	22:00	60 (1hr)	1.09	0.42			
		75	1.04	0.37			
		90	1.01	0.34			
	23:00	120 (2hrs)	0.95	0.28			
		150	0.91	0.24			
		165	0.89	0.22			
	00:00	180 (3hrs)	0.88	0.21			

PUMPING TEST DATA SHEET

Location : DUNSHAUGHLIN **Borehole name : Stoke's Well, OW No.2** **Date: 07-12-95**

Test : Drawdown Data from Stoke's Well while PW No.1 is pumping.

Duration : 12hrs. Weather : Wintry Showers.

Distance from Pumping Well : 137m. Well depth : 33.5m

Height of datum point above ground level : 0.56m Datum Point : Top of casing.

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	Conductivity uS/cm @20 C
07-12-95	06:00	0	0.67	0			
		1	0.67	0			
		6	0.68	0.01			
		7	0.69	0.02			
		8	0.69	0.02			
		9	0.7	0.03			
		10	0.7	0.03			
		12	0.72	0.05			
		14	0.73	0.06			
		16	0.75	0.08			
		18	0.76	0.09			
		20	0.77	0.1			
		22	0.79	0.12			
		24	0.8	0.13			
		26	0.81	0.14			
		28	0.82	0.15			
		30	0.83	0.16			
		35	0.86	0.19			
		40	0.88	0.21			
		45	0.91	0.24			
		50	0.93	0.26			
		55	0.94	0.27			
	07:00	60 (1hr)	0.96	0.29			
		75	1	0.33			
		90	1.04	0.37			
		105	1.07	0.4			
	08:00	120 (2hrs)	1.1	0.43			
		135	1.12	0.45			
		150	1.14	0.47			
		165	1.16	0.49			
	09:00	180 (3hrs)	1.17	0.5			
		200	1.18	0.51			
		220	1.19	0.52			
	10:00	240 (4hrs)	1.21	0.54			
		270	1.24	0.57			
	11:00	300 (5hrs)	1.26	0.59			
		330	1.28	0.61			
	12:00	360 (6hrs)	1.3	0.63			
		390	1.31	0.64			
	13:00	420 (7hrs)	1.33	0.66			
		510	1.35	0.68			
	15:00	540 (9hrs)	1.37	0.7			
		570	1.39	0.72			
	16:00	600 (10hrs)	1.4	0.73			
		630	1.41	0.74			
	17:00	660 (11hrs)	1.42	0.75			
		690	1.43	0.76			
	18:00	720 (12hrs)	1.44	0.77			

Groundwater Source :		Dunshaughlin					
Sample Location :		CC Off.	CC Off.	PW No. 1	PW No.1	PW No. 1	PW No.1.
Date :		20/3/95	25/9/95	20/3/95	12/6/95	26/9/95	8/1/96
Parameters	**Units**						
Alkalinity	mg/l	288	272	272	332	182	308
Aluminium	mg/l	<0.02	0.22	<0.02	<0.02	<0.02	<0.02
Ammonium	mg/l						
Ammonium as Nitrogen	mg/l	<0.1	0.025	0.028	0.046	<0.015	<0.015
Arsenic	mg/l	<0.25	<0.05	<0.25		<0.05	<0.05
Barium	mg/l	0.04	0.04	0.1	0.12	0.123	0.128
Bicarbonate	mg/l						
Boron	mg/l	0.035	0.021	0.038	<0.02	0.062	0.03
Cadmium	mg/l	<0.025	<0.005	<0.025	<0.025	<0.005	<0.005
Calcium	mg/l	114	119	108	121	130	135.8
Calcium Hardness	mg/l	285	297	270	302	325	340
Total Hardness	mg/l	302	316	303	338	365	379
Chloride	mg/l	21.7	17.6	16.2	17.2	19.4	20.2
Chromium	mg/l	<0.025	<0.005	<0.025	<0.025	<0.005	<0.005
Copper	mg/l	<0.01	<0.005	<0.01	<0.01	0.006	<0.005
Cyanide	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Electrical Conductivity	mS/cm	0.686	0.641	0.675	0.677	0.454	0.706
Fluoride	mg/l	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Iron (total)	mg/l	0.031	0.139	0.202	0.731	0.127	0.112
Lead	mg/l	<0.25	<0.02	<0.25	<0.25	<0.02	<0.02
Magnesium	mg/l	4.1	4.5	7.9	8.9	9.8	9.6
Magnesium Hardness	mg/l	17	19	33	37	40	40
Manganese	mg/l	0.022	0.034	0.156	0.182	0.085	0.101
Mercury	mg/l					<0.02	<0.02
Nickel	mg/l	<0.05	<0.01	<0.05	<0.05	<0.01	<0.01
Nitrate	mg/l	9.2	5.5	<0.1	<0.1	0.2	<0.1
Nitrite	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
pH		6.9	7	7.4	7.4	7.2	6.9
Phosphate	mg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Phosphorus	mg/l	0.267	<0.25	<0.25	<0.25	<0.25	<0.25
Potassium	mg/l	0.8	0.6	1.5	1.2	1.08	1.1
Selenium	mg/l					<0.05	<0.05
Silver	mg/l	<0.01	<0.005	<0.01	<0.01	<0.005	<0.005
Sodium	mg/l	10	11.2	8	9.2	9.75	9.9
Strontium	mg/l	0.403	0.435	0.729	0.813	<0.862	0.894
Sulphate	mg/l	54.7	45.6	40.4	40.2	37.4	46.1
Temperature	C	10.6	11.5	10.6	11.9	11.8	10.4
Total dissolved solids	mg/l	494	471	511	531	390	531
Zinc	mg/l	0.013	0.165	<0.01	0.035	0.021	0.024
Total Coliforms	/100 ml	0	0	0	2	0	0
E. coli	/100 ml	0	0	0	0	0	0

CC Off. = County Council Offices

Appendix 2
Maps


North
Calp Limestone
Dunshaughlin
PW No.1
Scale: 6 Inches to 1 Mile
DUNSHAUGHLIN GROUNDWATER SOURCE PROTECTION
Public supply well
Geological Boundary
Direction and Dip of Bedding
FIG. 1 GEOLOGY

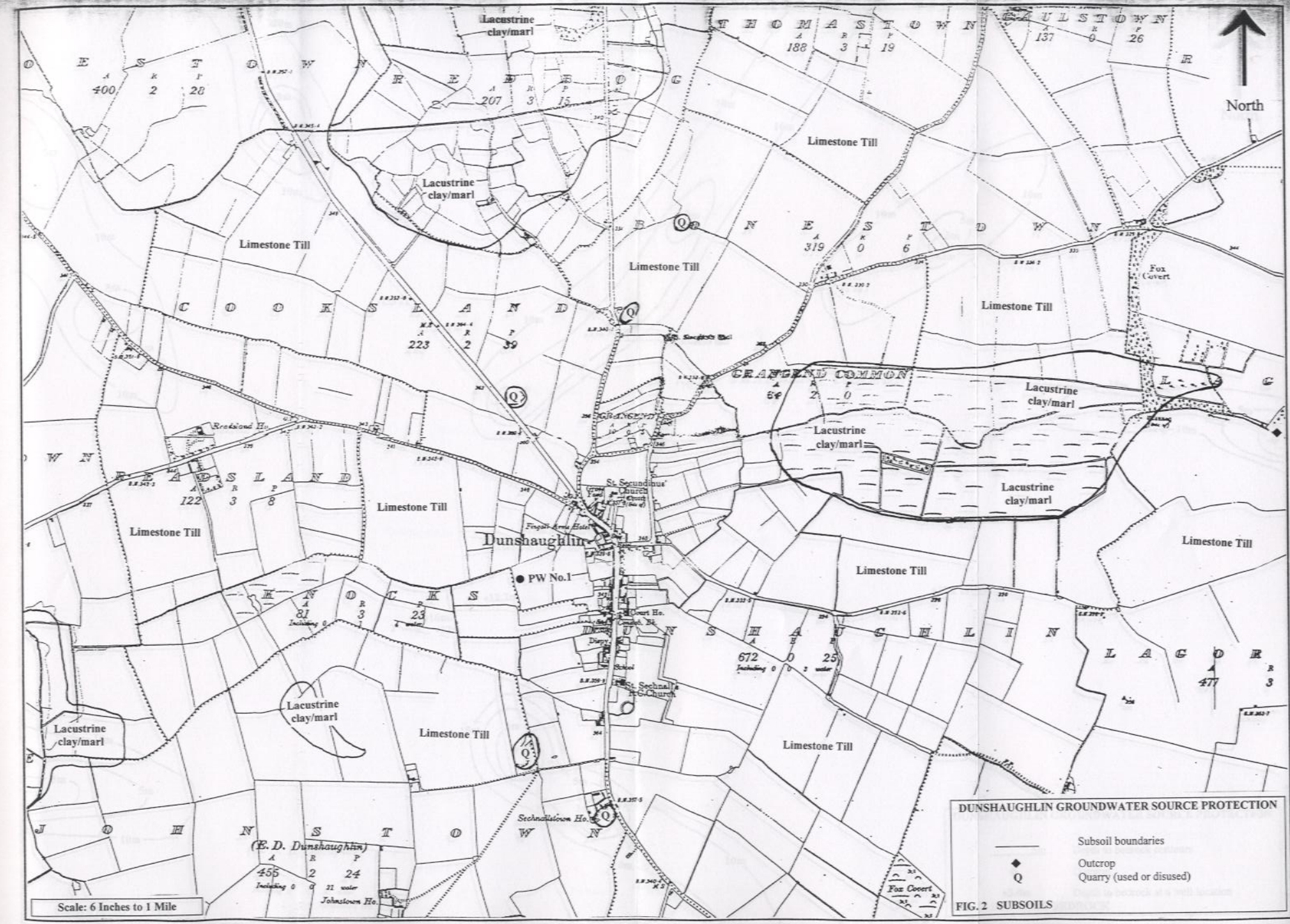


FIG. 2 SUBSOILS

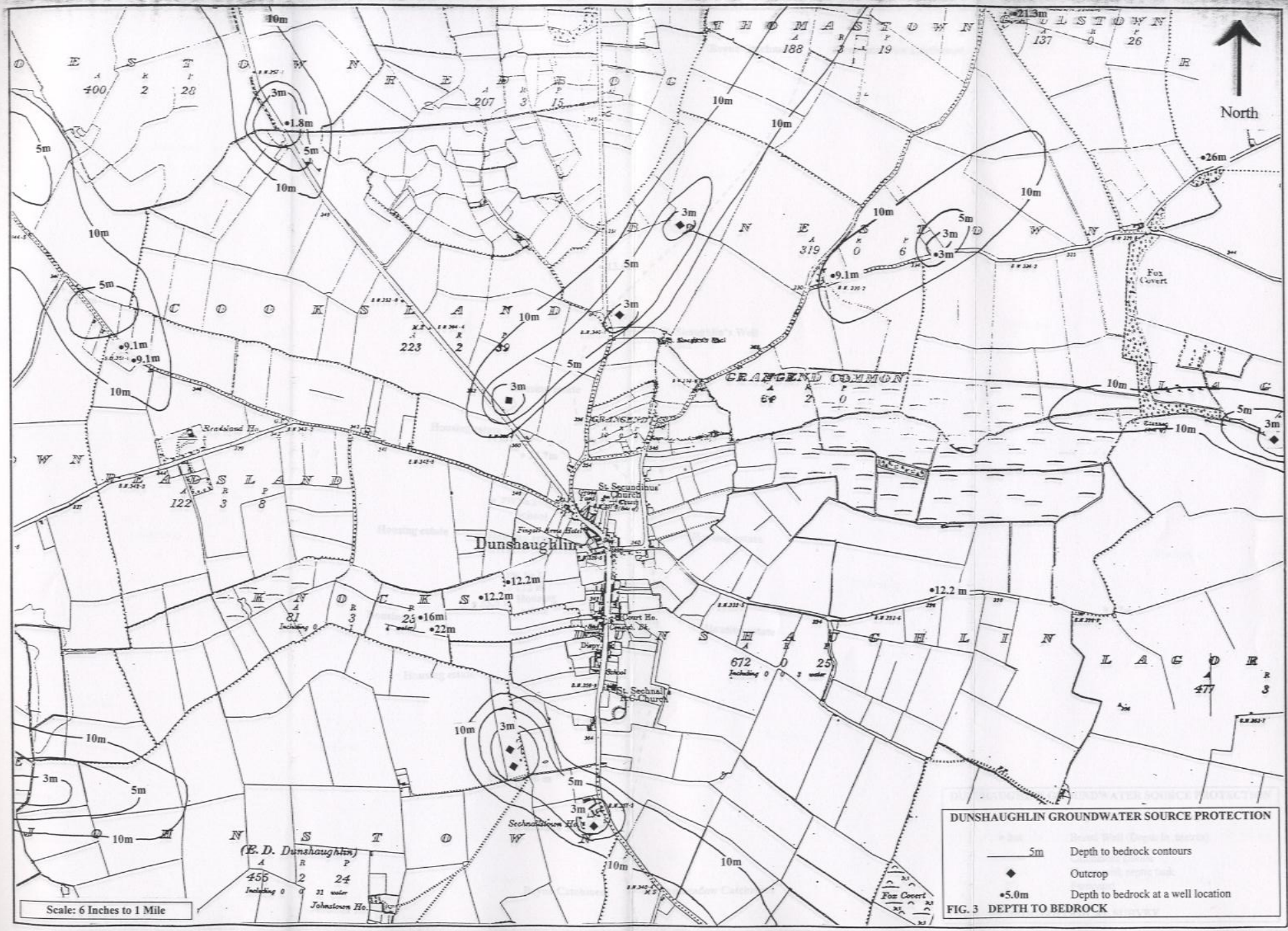
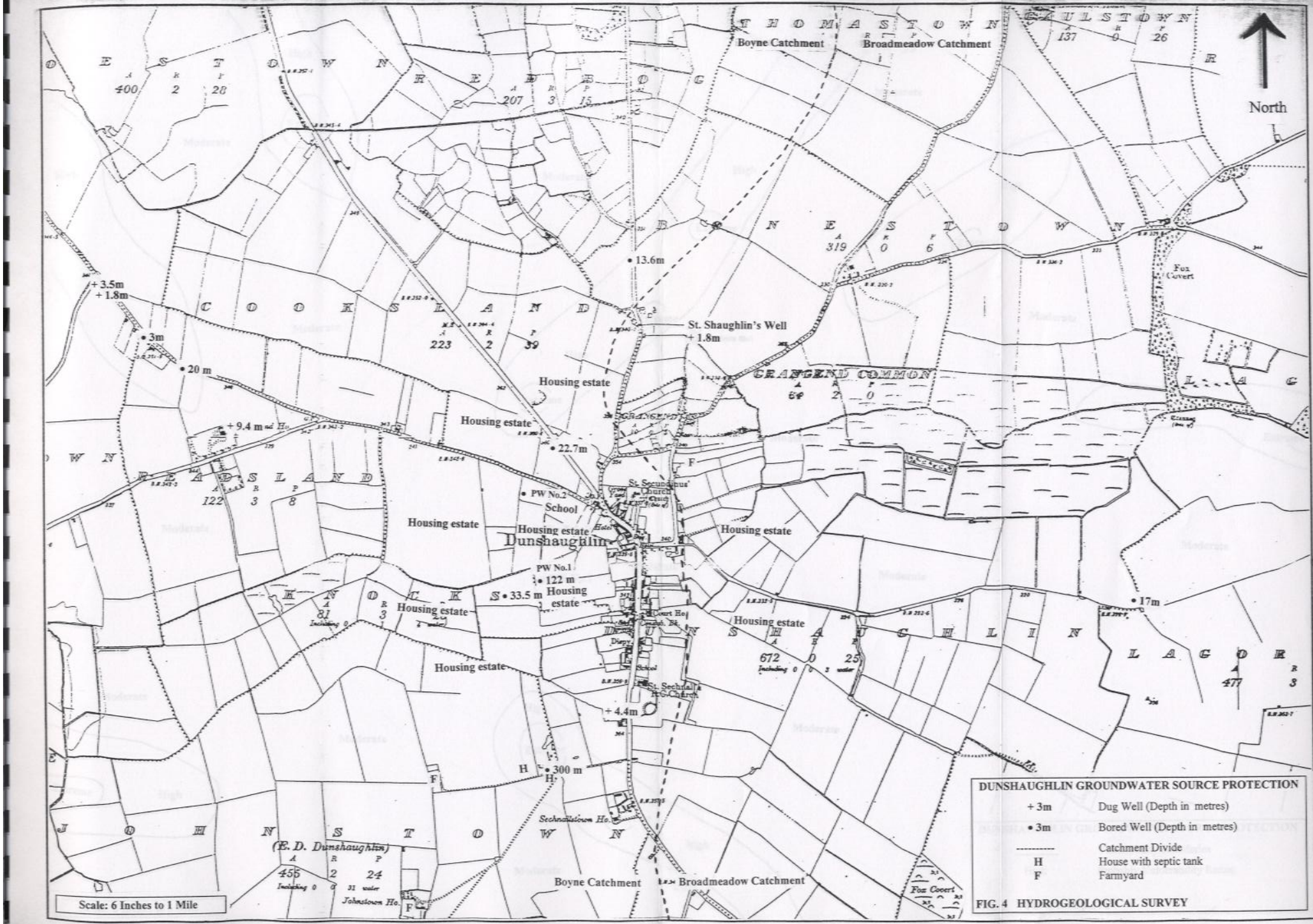


FIG. 3 DEPTH TO BEDROCK


Boyne Catchment
Broadmeadow Catchment
North
+ 3.5m
+ 1.8m
• 3m
• 20 m
+ 9.4 m
• 13.6m
St. Shaughlin's Well
+ 1.8m
• 22.7m
Housing estate
Housing estate
Housing estate
Housing estate
Housing estate
Housing estate
Housing estate
Housing estate
Housing estate
PW No.2
School
PW No.1
• 122 m
S • 33.5 m
Dunshaughlin
+ 4.4m
• 300 m
• 17m
Fox Covert
Fox Covert
Boyne Catchment
Broadmeadow Catchment
Scale: 6 Inches to 1 Mile
DUNSHAUGHLIN GROUNDWATER SOURCE PROTECTION
+ 3m Dug Well (Depth in metres)
• 3m Bored Well (Depth in metres)
---------- Catchment Divide
H House with septic tank
F Farmyard
FIG. 4 HYDROGEOLOGICAL SURVEY

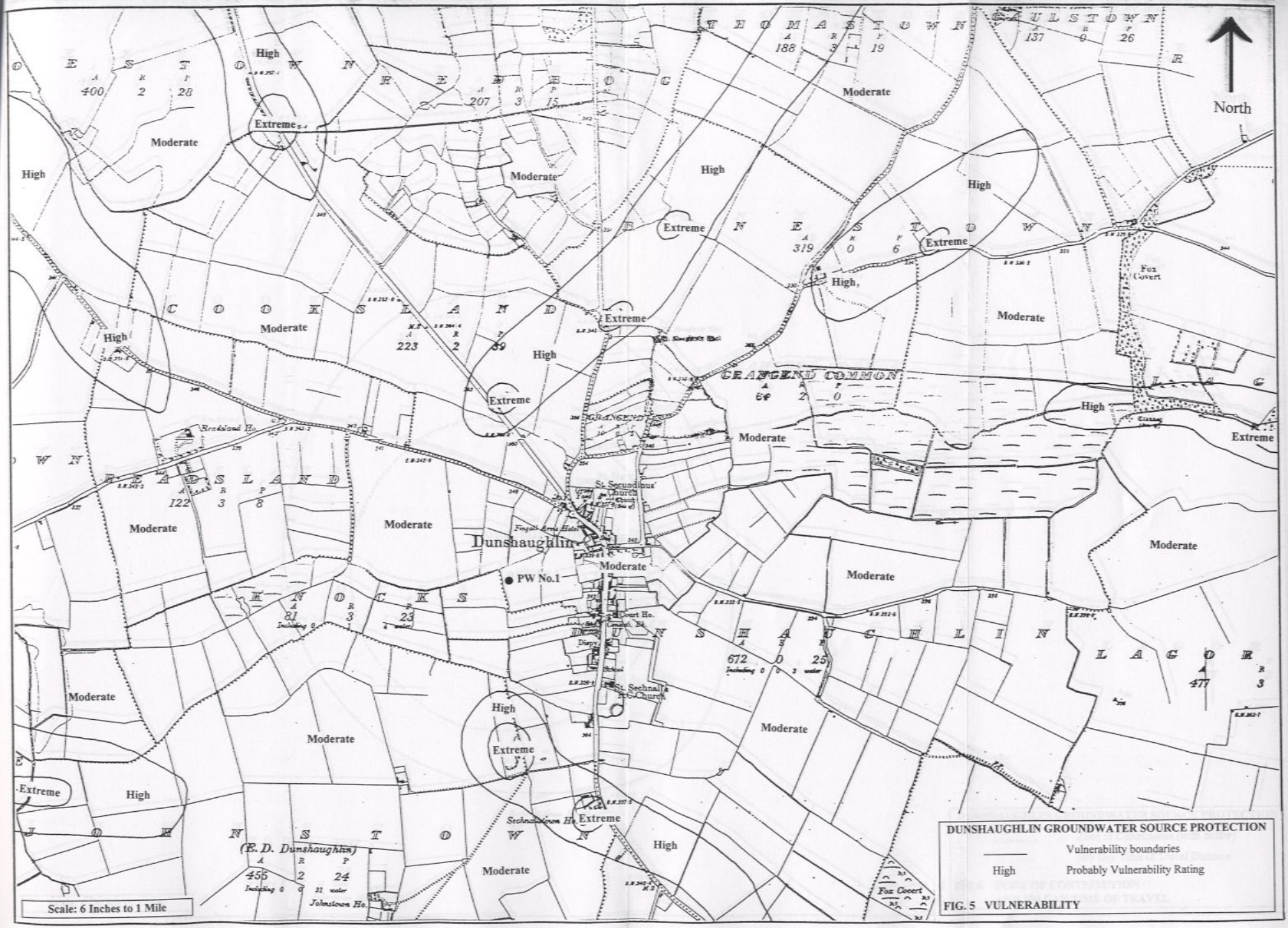


FIG. 5 VULNERABILITY

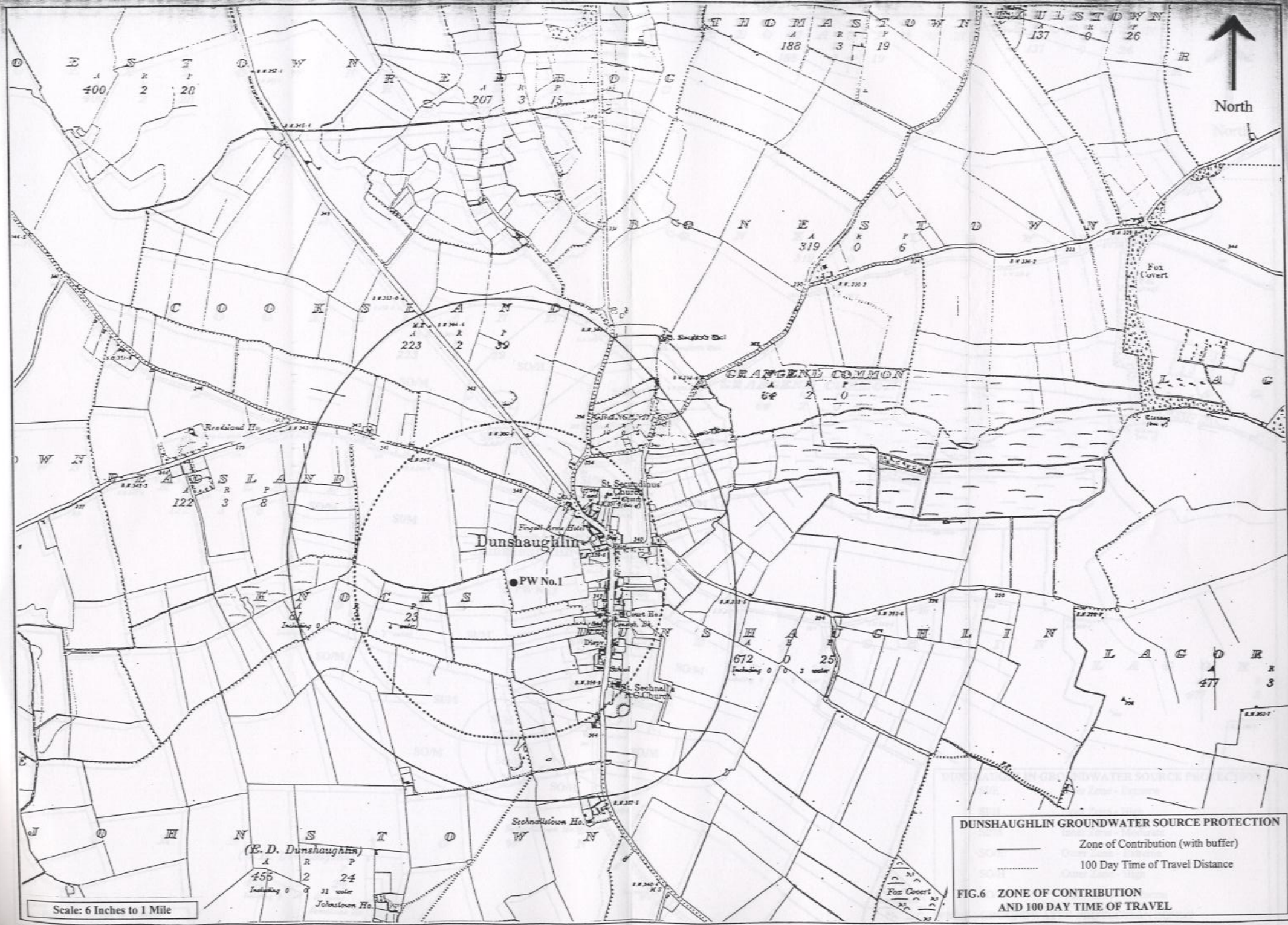


FIG.6 ZONE OF CONTRIBUTION AND 100 DAY TIME OF TRAVEL

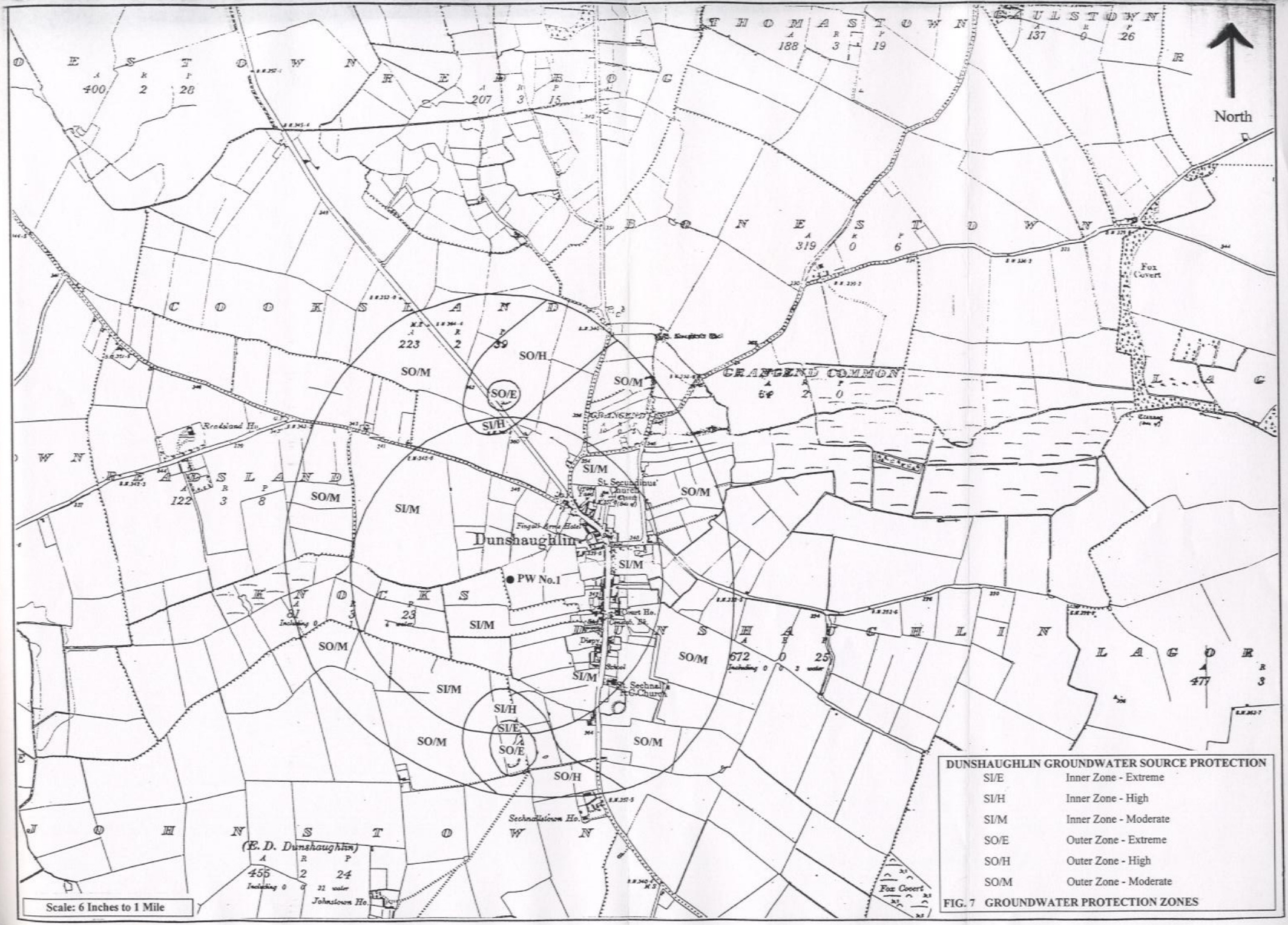
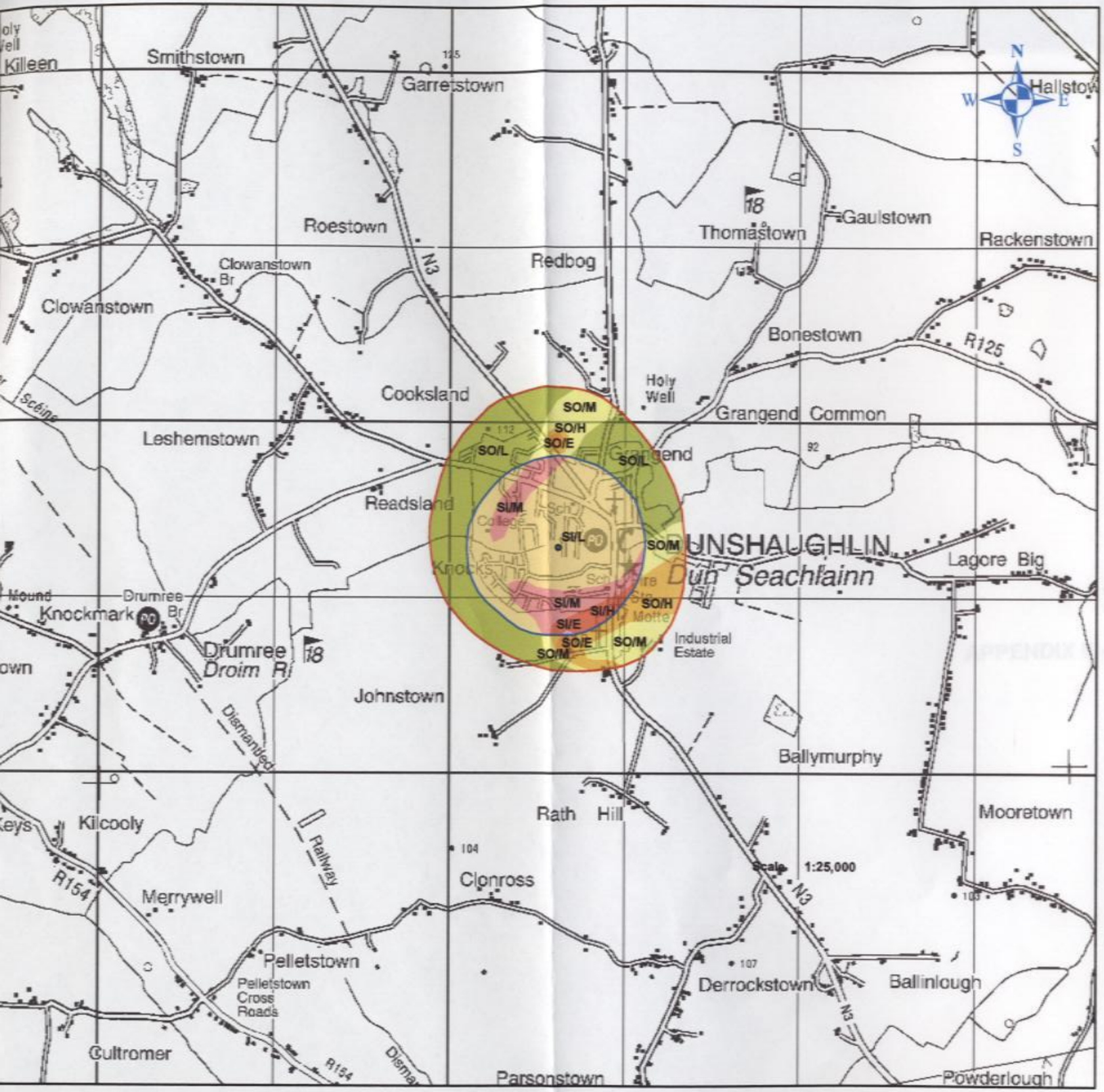


FIG. 7 GROUNDWATER PROTECTION ZONES



COUNTY MEATH
GROUNDWATER PROTECTION SCHEME
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

- Zone of Contribution of Wells (SO)
- Inner protection area (SI)
- County Boundary
- Public Supply Well

Project Hydrogeologist: Ciaran Kelly
Project Manager: Geoff Wright
Digital Map Production: Silvia Caloca

This Source Protection Zone 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 assessments and will frequently require site investigations to determine the risk to groundwater.

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

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GEOLOGICAL SURVEY OF IRELAND
Suirbhéireacht Gheolaíochta Éireann
Beggars Bush, Haddington Rd, Dublin 4

Dunshaughlin

1:25,000

0 0.5 1 2 Kilometers