

BLESSINGTON GRAVEL AQUIFER
GROUNDWATER SOURCE PROTECTION REPORT

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BLESSINGTON GRAVEL AQUIFER

1. Location and Site Description

Blessington is approximately 48 km southwest of Dublin and 10 km southeast of Naas. The Pollaphuca Reservoir was developed at Blessington to provide water for Dublin and is now a popular water recreation centre. In recent years the area has become a popular residential centre. The area depends on both surface water and groundwater for its water supply. It has been known for some years that large gravel deposits exist in the Blessington area which could constitute a significant groundwater resource which is still largely undeveloped. This study was undertaken to assess the groundwater potential and its vulnerability, and was subsequently expanded to outline source protection zones for the Council's wells at its Blessington depot.

These sources provide the main public water supply for Blessington village and area. There are two production wells, one of which is operational at any one time (M.C. O'Sullivan, 2002). Both are located in the Council Depot about 0.5 km west of the village, off the R410 Naas Road (Map 1).

2. Aims and Objectives

The aims of this study were to assess the aquifer potential in the area and vulnerability to groundwater pollution and to delineate source protection zones.

A number of objectives were set:

- To compile all the available geological and hydrogeological information.
- To assess the type of glacial deposits and their thickness.
- To establish the aquifer potential of the gravel deposits.
- To establish the vulnerability of the aquifer.
- To delineate source protection zones for the wells in the Council Depot.

3. Area Description and Topography

The Blessington area is located on the western side of the Wicklow Mountains with elevations between 180 m and 250 m OD (Ordnance Datum).

The topography of the region reflects the glacial overburden rather than any change in bedrock structures. The subsoils are mainly glacial till (Lower Palaeozoic till, i.e. till containing clasts of Lower Palaeozoic rocks) with glaciofluvial sands and gravels especially to the west and northwest of Blessington village.

Surface drainage is southeastwards into the Pollaphuca Reservoir and then northeast and west via the River Liffey.

This study concentrates on the main gravel deposit in the Blessington area, which lies to the north of the village, essentially north of the R410 road and between the Pollaphuca Reservoir and the county boundary with Kildare (Map 1). Other gravel deposits occur a little further from Blessington, but they are much smaller and hence do not have nearly the same groundwater potential.

At present Blessington is served by two separate water schemes: a surface water supply from Woodend Brook stream at Blackrock, and the groundwater sources within the Council Depot.

4. Well Details

PRODUCTION WELL NO.1

GSI no.	:	2921SW W066
Grid ref. (from 1:25,000)	:	29749 21420
Well type	:	Borehole
Elevation (top of casing)	:	c. 200 m OD (Malin Head)
Depth	:	18.6 m
Diameter	:	200 mm (8")
Depth-to-rock	:	> 18.6 m
Static water level	:	2.72 m b.t.c. (20/2/96)
Normal consumption	:	c. 400 m ³ /d (over 24 hrs)
Pumping test summary (20/2/96 – 23/2/96)	:(i) pumping rate	: 455 m ³ /d
	(ii) drawdown	: 5.33 m (after 72 hours)
	(iii) specific capacity	: 85.4 m ³ /d/m (after 72 hours)

PRODUCTION WELL NO.2

GSI no.	:	2921SW W067
Grid ref. (from 1:25,000)	:	29747 21420
Owner	:	Wicklow County Council
Well type	:	Borehole
Elevation (top of casing)	:	c. 200 m OD (Malin Head)
Depth	:	14.6 m
Diameter	:	200 mm (8")
Depth-to-rock	:	>14.6 m
Static water level	:	. 3.4 m b.t.c. (31/10/95); 3.83 m b.t.c. (27/11/95)
Pumping test summary: (27/11/95 – 30/11/95)	(i) pumping rate	: 305 m ³ /d
	(ii) drawdown	: 9.66 m (after 72 hours)
	(iii) specific capacity	: 31.6 m ³ /d/m (after 72 hours)

5. Methodology

Desk Study

The desk study compiled the information from all available data sources.

Site visits and fieldwork

The second stage comprised site visits and fieldwork in the surrounding area by a Quaternary Geologist to determine the nature, thickness and type of glacial deposits. Several depth to bedrock drilling sites were selected to determine the thickness of the underlying subsoils.

No pumping tests were carried out as part of this study to examine the aquifer characteristics nor detailed groundwater analyses to determine the water chemistry and water quality, but pumping test and water quality data were available for the two Council wells and a nearby private well drilled for the Ballymore Homes housing development. This report details the limited information available for the area and highlights the need for more hydrogeological information.

Assessment

Analytical equations and hydrogeological mapping were used to delineate protection zones.

6. Geology

6.1 Bedrock geology

The underlying bedrock geology comprises rocks of the Kilcullen Group which are mainly greywackes and shales deposited as turbidites. The Kilcullen Group rocks are Silurian in age and are divided into five formations, of which only the Pollaphuca, the Slate Quarries, and the Glen Ding formations are present around Blessington. The only rock exposures in the area are on the northwest side of Glen Ding.

The Pollaphuca Formation consists of coarse grey greywacke sandstones and grits and dark grey shales and is classified as a **Poor Aquifer, generally unproductive except in local zones (PI)**. The Slate Quarries Formation consists of dark grey slates with occasional minor interbedded grey greywackes. The Glen Ding Formation has dark green to grey greywacke sandstones and shales. These two formations are classified as a **Poor Aquifer, generally unproductive (Pu)**.

These bedrock aquifers are not considered further in this report. Some further details of their aquifer potential are contained in the Main Report.

6.2 Quaternary (subsoils) geology

The entire area is covered with glacial deposits ranging from tills to glaciofluvial sand and gravel with glaciolacustrine deposits near the reservoir. Information is available from GSI Quaternary mapping in Wicklow and Kildare, and from boreholes and trial pits by K.T. Cullen & Co. (1997a).

The distribution of the subsoils in the area is illustrated in Map 1.

6.2.1 Glaciofluvial sand and gravel

The dominant sediments in the area are the gravels, deposited in a subaqueous environment by glacial meltwaters which drained into a glacial lake which existed between the Wicklow Mountains and the margin of the ice sheet. The meltwater channels cut into the underlying sediments and bedrock indicate flow to the southeast. The gravels occur as delta deposits on the flanks of a ridge. The deposits are characterised by steeply dipping foreset beds and interbedded sands and gravels. Limestone is the dominant clast type. The largest gravel area occupies an area of about 7.5 km², straddling the Wicklow/Kildare county boundary just north and west of Blessington, and is currently being extensively quarried. The gravel deposits occur as hummocks or delta-terraces.

South of Kilbride (at the northern end of Pollaphuca Reservoir) a limestone-dominated gravel occurs and was deposited as a large sheet of about 2 km². These gravels are now being eroded by the meandering River Liffey. Although the exposure is limited and very poor, the flat morphology suggests these gravels were deposited in a pro-glacial outwash plain after the lake had disappeared.

6.2.2 Tills

To the west, south and east of Blessington there are poorly to moderately permeable Lower Palaeozoic tills, matrix supported and characterised by a generally silty to silty sandy texture. Particle size analyses show that 30% of the bulk of the sample are fines (clay and silt) and about 40% sand. Clasts are angular to subangular and consist of mica-schists, shales and granites. Where bedrock is close to the surface, the clast content is higher and the till may be characterised as stony silty.

A small area to the north of Blessington is covered by a chert-rich till which is characterised by a clayey silty or silty matrix and also contains limestone and shale clasts. This till is matrix supported.

The tills are interpreted as lodgement tills deposited by ice from the Wicklow Mountains during the last glacial period.

6.2.3 Glacio-lacustrine deposits

The glaciolacustrine sediments found around the current Pollaphuca Reservoir were deposited in a lake which was maintained between ice masses and between the hills. The deposits are often

laminated, reflecting the annual variations in deposition. The sediments consist of silts, generally deposited in the summer by meltwater discharge, and clays, generally deposited in the winter when the lake was frozen. There is evidence that the lake existed for at least 85 years, in which time the deposits were able to accumulate to a thickness of 1 to 1.5 metres. The fine grained sediments overlie subglacial bedrock or tills. The largest area of lake deposits occurs on the low ground between Blessington and Kilbride.

6.3 Depth-to-bedrock

Rock outcrops occur predominantly in the upland areas along palaeo-meltwater channels, streams and along roads, and in areas with thin till. To the east of Pollaphuca Reservoir the subsoils reach thicknesses of about 2 to 8 m. West and north of the reservoir the Lower Palaeozoic tills seem to be much thicker (up to 14 m) and locally overlie gravelly deposits. The thickest deposits are the glaciofluvial gravels to the west of Blessington, with depths of over 20 m and up to 74 m.

Twenty-four augered holes were drilled by the GSI around this area to investigate the subsoils and determine the depth to bedrock. The locations of these boreholes are shown on Map 1. Depth-to-rock drilling by the GSI revealed depths from approximately 1 m to over 14 m. The exact depths to rock could not be established, as the upper part of the shale bedrock is highly weathered, thus it was often difficult to distinguish between subsoil and rock. The maximum depth of the augering equipment was 14 m.

Six additional boreholes were drilled by Roadstone Ltd. on the Ashton site under supervision by K.T. Cullen & Co. Ltd. (1997c) to depths of 12-14 metres and met no bedrock.

7. Hydrogeology

7.1 Data availability

Hydrogeological data are moderately good for the Blessington area as a whole, although there is little detailed information, in particular pumping test data and water quality data. There are limited records of water level data to construct a water table map to determine the groundwater flow directions. Many wells are dug wells or springs which may only be tapping a perched water table within the till. The groundwater flow direction is generally to the southeast towards the Pollaphuca Reservoir.

Five wells have been drilled within the sand and gravel aquifer at the Council Depot, Naas Road, Blessington. The first two wells were drilled in 1993, for private housing development (Ballymore Homes, 2921SWW030 & 2921SWW064, for their Ashton and Beechdale developments) and there are some pumping test data (see Appendix). Wicklow County Council then drilled a further three wells in 1995, the first of which (2921SWW065) was abandoned as no significant water was encountered. The remaining two wells, WCC No.1 (2921SWW066, 18.6 m) and WCC No.2 (2921SWW067, 14.6 m), were tested. (see data in Appendix).

Site investigations for the Ashton development (K.T. Cullen & Co. Ltd., 1997c) 1 km from the village along the Naas Road, provided details of the subsoils, depths and a pumping test.

In the townlands of Deerpark and Dillonsdown, one mile northwest of Blessington village, extensive drilling to prove the sand and gravel reserves has provided information on the thickness of the gravel deposits and the depth of the water table.

There are also water quality analyses available for this sand and gravel aquifer from 1993 and 1996. No sampling of this source was conducted as part of this project. Analyses are also available from Deerpark and Dillonsdown.

7.2 Groundwater levels, flow directions and gradients

Groundwater is generally close to the surface. The static water levels in the wells range up to 20 metres below ground level.

Regional groundwater flow is generally southeastwards towards the Pollaphuca Reservoir, but locally it is dependent on topography. A report by K.T. Cullen & Co. (1997a) identified a groundwater divide running SW-NE through Deerpark townland, in the northwestern part of the main gravel deposit. This can be taken as the effective boundary of the aquifer.

The Ashton report (K.T. Cullen & Co., 1997c) inferred a flow direction just south of east. This is somewhat at variance with the topographic gradient and is based on just three water levels.

Groundwater gradients in the general area may range from approximately 0.007 to 0.07. Detailed work (K.T. Cullen & Co., 1997a) shows a rather steep gradient in Deerpark, where the saturated aquifer is thin, whereas nearer the Depot a gradient of 0.007 is given (K.T. Cullen & Co., 1997c) By interpolation, an average gradient of about 0.025 is inferred between Deerpark and the Council Depot, and the gradient near the Depot is probably between 0.01 and 0.02.

7.3 Rainfall, Evaporation and Recharge

The nearest rainfall station is at Blessington Garda Station in the village (altitude 206 m). Mean annual rainfall (1951-1980) recorded by Met Eireann was 938 mm. Potential evapotranspiration (PE) is estimated from a Met Eireann contoured map as 500 mm/yr. Actual evapotranspiration (AE) was estimated at 475 mm as a percentage (95%) of the PE, allowing for seasonal soil moisture deficits.

From the above figures the effective rainfall (ER) is taken to be approximately 460 mm/year. As the Quaternary deposits are relatively free-draining, a high proportion of the effective rainfall infiltrates to the water table. Estimating runoff at 20%, the actual annual recharge to the aquifer is estimated to be 370 mm/year. This compares with 375 mm estimated by K.T. Cullen & Co. (1997c).

These calculations are summarised below:

Average annual rainfall	938 mm
Estimated PE	500 mm
Estimated AE (95% PE)	475 mm
Effective rainfall (ER)	460 mm
Recharge (70% ER)	370 mm

7.4 Hydrochemistry and Water Quality

Water quality analyses are available from 1993 (2 no.) and 1996 (4 no.) from wells at the Roadstone site and the County Council Depot (Table 1). These analyses indicate that the water is a calcium bicarbonate type which is hard and typical of a limestone-dominated gravel aquifer. The samples contained abnormally high chloride values (75 to 80 mg/l) and 57 mg/l of sodium. While these values for sodium and chloride pose no threat to health, they may indicate some contamination and further monitoring should be carried out to establish if this aquifer is being contaminated, perhaps by salting of road surfaces. No sampling of this source was conducted as part of this project.

An iron and manganese treatment plant is installed in the pump house at the Council Depot and the water samples were probably taken after treatment as they do not indicate an iron and manganese problem.

Table 1 Water Quality Analyses from boreholes near Blessington

Townland			Deerpark/Dillonstown			Blessington Demesne		
Site			Roadstone Ltd			WCC Depot		
Data source			K.T. Cullen & Co. Ltd.			KTC		WCC
Site id No.			2921SW 022	2921SW 024	2921SW 025	2921SW 030	2921SW 030	2921SW 066
Sample date			21/11/1996	21/11/1996	21/11/1996	07/12/1993	07/12/1993	22/02/1996
Laboratory code								WCC
Sample reference								140
Parameters	Units	MAC						
Colour		20	<5	<5	<5	<5	<5	28
Turbidity		4				<0.05	<0.05	1.3
Temperature								13
Alkalinity	mg/l	-	256	269	218	280	292	205
Aluminium	mg/l	0.2	3.8	2.8	2.4	<0.05	<0.05	
Ammonium as N	mg/l	0.23	<0.05	<0.05	<0.05	<0.05	<0.05	0.02
Arsenic	mg/l	0.05	<0.05	<0.05	<0.05			
Barium	mg/l	0.5	0.22	0.13	0.2			
Boron	mg/l	2	0.01	0.01	0.02			
Cadmium	mg/l	0.005	<0.005	<0.005	<0.005			
Calcium	mg/l	200	100	105	70	113	111	
Chloride	mg/l	250	28	14	12	81	79	76
Chromium	mg/l	0.05	0.01	<0.01	<0.01			
Copper	mg/l	0.5	<0.01	<0.01	<0.01	<0.01	<0.01	
Electrical Conductivity	µS/cm	1,500	530	510	430	735	735	653
Hardness	mg/l	-	303	298	228	309	303	308
Iron (total)	mg/l	0.2	6.6	4.5	4.5	0.01	<0.01	
Lead	mg/l	0.05	<0.05	<0.05	<0.05			
Magnesium	mg/l	50	13	9	13	6.6	6.4	
Manganese	mg/l	0.05	0.4	0.3	0.3	<0.01	<0.01	
Mercury	mg/l	0.001	<0.0005	<0.0005	<0.0005			
Nickel	mg/l	0.05	0.01	0.01	0.01			
Nitrate as N	mg/l	11.3						3.2
Nitrate as NO ₃	mg/l	50	12	8	5	18	18	14
Nitrite as N	mg/l	0.03	0.15	<0.01	0.02	<0.01	<0.01	
pH		6-9	7.5	7.3	7.6	7.4	7.4	7.3
Phosphorus	mg/l	5	0.13	0.05	0.11			0.2
Potassium	mg/l	12	1.7	1.6	2.7	<1	<1	
Sodium	mg/l	150	13	8	10	57	56	
Strontium	mg/l	-	0.25	0.2	0.18			
Sulphate	mg/l	250	20	9	9	14	14	
Zinc	mg/l	1	0.02	0.02	0.03			
Total Coliforms	n/100ml	0				0	0	0
<i>E. coli</i>	n/100ml	0				0	0	0
Greater than Guide levels								
Greater than MAC levels								

The analyses from Deerpark and Dillonstown (Table 1) indicate good water quality and show normal levels of sodium and chloride, although they also showed high iron, manganese and aluminium levels. The water quality as shown is generally good with no bacterial contamination and all the major cations, anions and trace elements are within the Irish Drinking Water Standards and the EU limits except for the iron and manganese levels which are naturally high. Colour and turbidity levels are often high or above the MAC and may be a result of poor well development or precipitation of the iron and manganese upon oxidation at the ground surface.

7.5 Blessington Sand and Gravel Aquifer

The Blessington gravel aquifer covers an area within Co. Wicklow of approximately 5.5 km² and varies in thickness, but is generally 10 to 35 m thick. The area extends from west of Blessington village and continues into Co. Kildare. The extent of the aquifer in Co. Kildare is approximately 2 km². A deep borehole drilled by the GSI in 1980 recorded a depth of 74 m in Newpaddocks, half a mile north of Blessington, with water at 22 m. At Bishopslane, Co. Kildare, two miles south-southwest of Blessington, another deep borehole drilled by the GSI in 1980 encountered gravels to a depth of 104 m and did not hit bedrock.

At the Council Depot on the Naas Road, five wells have been drilled within the sand and gravel aquifer. The first two wells, drilled in 1993 for private housing estates, had yields from 300 to 660 m³/d; a specific capacity was calculated at 2170 m³/d/m and transmissivity estimated at 1500 m²/d.

Wicklow County Council drilled a further three wells in 1995. The first (2921SW065) was abandoned at 33.5 m as no water was encountered. The remaining two wells, WCC No.1 (2921SW066, 18.6 m) and WCC No.2 (2921SW067, 14.6 m) were tested:

- WCC No.1 was tested at 455 m³/d with a drawdown of 5.3 m, giving a specific capacity of 85m³/d/m and an apparent transmissivity of 400 m²/d. The adjacent wells were monitored during the test and none showed drawdowns of more than a few centimetres.
- WCC No.2 was tested at 300 m³/d. The drawdown was 9.66 m, giving a specific capacity of 30 m³/d/m. The adjacent Council well (No.1) showed a drawdown of 0.11 m and the private well 0.12 m from the pumping of Well No.2. No other wells were affected during this pumping test.

The results of the tests (see Appendix) were difficult to analyse as the gravel aquifer responds rapidly to any rainfall events which can mask the effects of the pumping. Analysis was also made difficult by variations in the pumping rate.

Site investigations 1 km from the village along the Naas Road (K.T. Cullen & Co. 1997c) indicated similar geological conditions, with over 14 m of glacial sediments. A pumping test yielded 340 m³/d with a drawdown of 2.4 m, giving a specific capacity of 140 m³/d/m.

In this area of Co. Wicklow, most private groundwater supplies are obtained from the sand and gravel deposits, with many houses being supplied by group scheme wells, sourced in this sand and gravel.

The Blessington sand and gravel aquifer has a high permeability and transmissivity; and if properly developed and managed can provide a significant sustainable groundwater resource. However, Roadstone's drilling in the more elevated part of the deposit indicated very little gravel below the water table. Moreover, the lack of water in the first WCC borehole at the Depot (33.5 m deep), and in two wells at the Ashton site (K.T. Cullen & Co., 1997c) is worrying, suggesting patchy permeability.

7.6 Aquifer category

A sand/gravel deposit is normally classed as an aquifer by GSI if it is greater than one square kilometre in areal extent and is more than 10 m thick (or has a saturated zone more than 5 m thick).

Sand/gravel aquifers are classified as regionally important or locally important, depending on their areal extent and estimated annual throughput.

A regionally important gravel aquifer should have an areal extent greater than 10 km². This is to ensure that, assuming an average annual effective rainfall of 400 mm, there will be enough recharge to provide a supply of one million cubic metres per year from the whole aquifer. A locally important aquifer on the other hand is required to have sufficient yield to supply a small group scheme or village.

Considering the aquifer in terms of its areal extent (7.5 km²), thickness, and well yields the Blessington sand and gravel aquifer is classed as a **Locally important sand and gravel aquifer (Lg)**.

7.7 Aquifer Development Potential

Assuming an aquifer area of 7.5 km² and an annual recharge of 370 mm, a simple calculation reveals that a total of 2.8 x 10⁶ m³/yr would be expected to recharge the aquifer, equivalent to about 7,600 m³ per day. The actual amount which could be exploited would be significantly less than this, but abstraction of over 2,000 m³/day should certainly be possible. The optimum method of abstraction would depend on a number of factors, including the potential borehole vulnerability in relation to likely source of contamination.

As in all gravel aquifers, production wells will require the installation of wellscreens, followed by careful well development. Wells should be appropriately located, designed and constructed in order to work efficiently over a number of years.

Information which has recently come to hand from well drilling near Tulfarris House has revealed a productive gravel aquifer at a depth of over 40 metres, well protected from contamination. The thickness of this aquifer has not been determined. The existence of this aquifer suggests that, where the bedrock is deep (at least 20 metres) careful exploratory drilling may prove very worthwhile.

8. Source Protection Areas

Taking the Council Depot 'wellfield' as the source, provisional source protection areas can be demarcated: Inner (100-day travel time zone) and Outer (remainder of Zone of Contribution, ZOC).

The Inner Protection Area (SI) as defined by an approximate calculation is 120 metres up-gradient and 70 metres down-gradient. To allow a safety margin, an Inner Area of 150 metres radius is recommended, as shown in Map 2.

The Outer Protection Area (SO) or Zone of Contribution extends northwestwards to the groundwater divide, but in County Kildare its extent is difficult to define. Its total area depends on the average abstraction rate: for a hypothetical rate of 1000 m³/d, it amounts to some 1.2 km². This area includes a 'buffer zone' on either side to allow for a possible error in assumed direction of groundwater flow of ±20°.

The down-gradient limit of the ZOC, using the Uniform Flow Equation, is set at 300 m from the wellfield.

The Source Protection Areas, which extend substantially into County Kildare, are shown on Map 2.

9. Groundwater Vulnerability

Sands and gravels have a high permeability. The depth to water table is generally more than three metres. Under the GSI vulnerability mapping criteria (DELG/EPA/GSI 1999) the entire gravel deposit has a 'high' vulnerability rating.

The till deposit in Newtownpark townland, in Co. Kildare, is assumed to be free-draining and therefore of moderate permeability. Its thickness is not known, so is assumed to be not greater than 5 metres (either above rock or above gravel deposits). Hence its vulnerability classification is taken to be 'high'.

There is a small area of exposed rock and very thin subsoils in the northwestern corner of the Zone of Contribution, in Glen Ding and to the west, which is classed as of 'extreme' vulnerability.

10. Groundwater Source Protection Zones

From the above discussion of source protection areas and vulnerability, it follows that there are only three source protection zones to be delineated for the Council Depot Wellfield (Map 2):

SI/H SO/E SO/H

11. Potential Pollution Sources

The primary threat to this gravel aquifer is the major housing development which is occurring in the area. Other obvious potential hazards would be spillages on the R410 road, and possible illegal dumping in gravel workings in the up-gradient area. K.T. Cullen & Co. (1997c) mention three septic tanks on the western boundary of the Ashton site.

In general, the water quality may be affected by landspreading, septic tanks and farm effluent. All potentially polluting activities within the area should be controlled and monitored by the Council. Since some of the aquifer is within County Kildare, this will require co-operation with Kildare County Council.

12. Conclusions and Recommendations

- The Blessington gravel deposits constitute a locally important sand and gravel aquifer which is highly vulnerable to pollution. The aquifer is an important groundwater resource which could be further developed and adequate planning is required to protect this resource.
- The water analyses indicate that there are no major water quality problems, except for the naturally high iron and manganese. While there has been concern regarding possible contamination from illegal landfill sites, groundwater analyses carried out in Spring 2003 have indicated that, so far, this is not the case.
- It is recommended that the Council sample the raw water from the Council Depot to monitor the iron, manganese, nitrate, potassium, chloride and conductivity levels, and to examine the effects of the potentially polluting activities near to the well.
- The Council should control and monitor potentially polluting activities within the aquifer area.
- In order to define source protection areas and the ultimate sustainable yield of the aquifer, it is recommended that a programme of test drilling be carried out, including the area in County Kildare to the west.
- Further controlled pumping tests should be carried out to improve the characterisation of the aquifer and enable numerical modelling to define the source protection areas.

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Appendix

Pumping Test Data

Appendix - Pumping Test Data

**Pumping Test on WCC #1 well, Council Depot, Blessington
(Well No. 2921SWw066)**

Date	Clock Time	elapsed time (min)	water level (m)	drawdown (m)	w/meter litres	pumping rate m ³ /d	Obs. well O'D #2	Obs. well BH #2	Obs. well BH #1
20/2/1996	11:35	0	2.72	0	51050	0	2.99	3.28	3.445
	11:36	1	7.22	4.5	51365	453.60			
	11:37	2	8.2	5.48	51680	453.60			
	11:38	3	8.52	5.80	52000	460.80			
	11:39	4	8.62	5.90	52315	453.60			
	11:40	5	8.65	5.93	52630	453.60			
	11:41	6	8.67	5.95	52950	460.80			
	11:42	7	8.67	5.95	53265	453.60			
	11:43	8	8.68	5.96	53580	453.60			
	11:44	9	8.68	5.96	53895	453.60			
	11:45	10	8.68	5.96	54210	453.60			
	11:47	12	8.69	5.97	54840	453.60			
	11:49	14	8.7	5.98	55470	453.60			
	11:51	16	8.71	5.99	56100	453.60			
	11:53	18	8.71	5.99	56730	453.60			
	11:55	20	8.71	5.99	57360	453.60			
	12:00	25	8.72	6	58945	456.48			
	12:05	30	8.73	6.01	60520	453.60			
	12:10	35	8.73	6.01	62090	452.16			
	12:15	40	8.73	6.01	63670	455.04			
	12:20	45	8.73	6.01	65240	452.16			
	12:25	50	8.73	6.01	66815	453.60			
	12:30	55	8.73	6.01	68390	453.60			
	12:35	60	8.73	6.01	69960	452.16	3.07	3.315	3.34
	12:50	75	8.77	6.05	74695	454.56			
	13:05	90	8.79	6.07	79443	455.81			
	13:20	105	8.79	6.07	84043	441.60			
	13:35	120	8.8	6.08	88920	468.19			
	14:05	150	8.77	6.05	98380	454.08			
	14:35	180	8.8	6.08	107786	451.49			
	15:05	210	8.8	6.08	117254	454.46			
	15:35	240	8.81	6.09	126506	444.10			
	16:35	300	8.81	6.09	145466	455.04			
	17:35	360	8.81	6.09	164446	455.52	3.06	3.3	3.34
	18:35	420	8.56	5.84	182957	444.26			
	19:35	480	8.55	5.83	202138	460.34			
	20:35	540	8.57	5.85	220936	451.15			
	21:35	600	8.58	5.86	240300	464.74		3.3	3.35
	23:35	720	8.601	5.881	278120	453.84	3.06	3.3	3.35
21/2/1996	01:35	840	8.602	5.882	315650	450.36			
	03:35	960	8.602	5.882	354470	465.84			
	05:35	1080	8.603	5.883	392670	458.40			
	08:35	1260	8.62	5.9	448457	446.30			
	11:35	1440	8.61	5.89	505624	457.34	3.06	3.3	3.34
	14:35	1620	8.63	5.91	562765	457.13			
	17:35	1800	8.61	5.89	618594	446.63			
	20:35	1980	8.61	5.89	676816	465.78			
	23:35	2160	8.63	5.91	734524	461.66	3.06	3.3	3.345
22/2/1996	02:35	2340	8.58	5.86	790836	450.50			
	05:35	2520	8.57	5.85	846973	449.10			
	08:35	2700	8.56	5.84	906564	476.73			
	11:35	2880	8.56	5.84	962770	449.65	3.06	3.3	3.345
	14:35	3060	8.555	5.835	1019970	457.60			
	17:35	3240	8.56	5.84	1077020	456.40			
	20:35	3420	8.5	5.78	1134000	455.84			
	23:35	3600	8.56	5.84	1190760	454.08	3.06	3.3	3.34
23/2/1996	02:35	3780	8.62	5.9	1247870	456.88	3.065	3.3	3.335
	05:35	3960	8.5	5.78	1304930	456.48	3.06	3.3	3.345
	08:35	4140	8.05	5.33	1361137	449.66	3.05		
23/2/1996	11:35	4320	8.05	5.33	1419816	469.43	3.05	3.3	3.34

Appendix - Pumping Test Data

WCC #1, Step Tests, 19/2/96

Step 1

Date	Clock Time	elapsed time (min)	water level (m)	drawdown (m)	w/meter litres	pumping rate m ³ /d
19/2/1996	13:21	0	2.72	0	17730	0
	13:22	1	6.89	4.17	18030	432.00
	13:23	2	7.86	5.14	18330	432.00
	13:24	3	8.15	5.43	18620	417.60
	13:25	4	8.26	5.54	18910	417.60
	13:26	5	8.29	5.57	19200	417.60
	13:27	6	8.31	5.59	19490	417.60
	13:28	7	8.32	5.6	19780	417.60
	13:29	8	8.35	5.63	20070	417.60
	13:30	9	8.36	5.64	20360	417.60
	13:31	10	8.36	5.64	20650	417.60
	13:33	12	8.38	5.66	21235	421.20
	13:35	14	8.38	5.66	21815	417.60
	13:37	16	8.38	5.66	22395	417.60
	13:39	18	8.39	5.67	22980	421.20
	13:41	20	8.4	5.68	23565	421.20
	13:46	25	8.4	5.68	25010	416.16
	13:51	30	8.4	5.68	26450	414.72
	13:56	35	8.4	5.68	27900	417.60
	14:01	40	8.4	5.68	29345	416.16
	14:06	45			30790	416.16

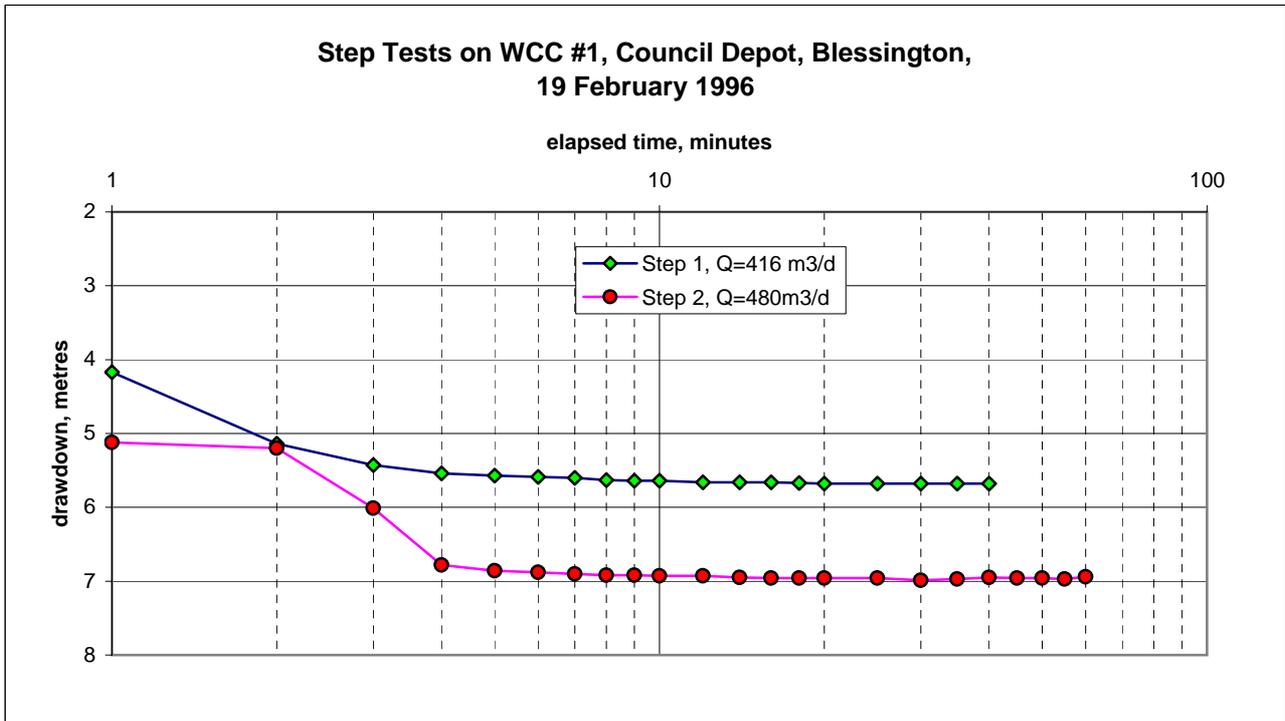
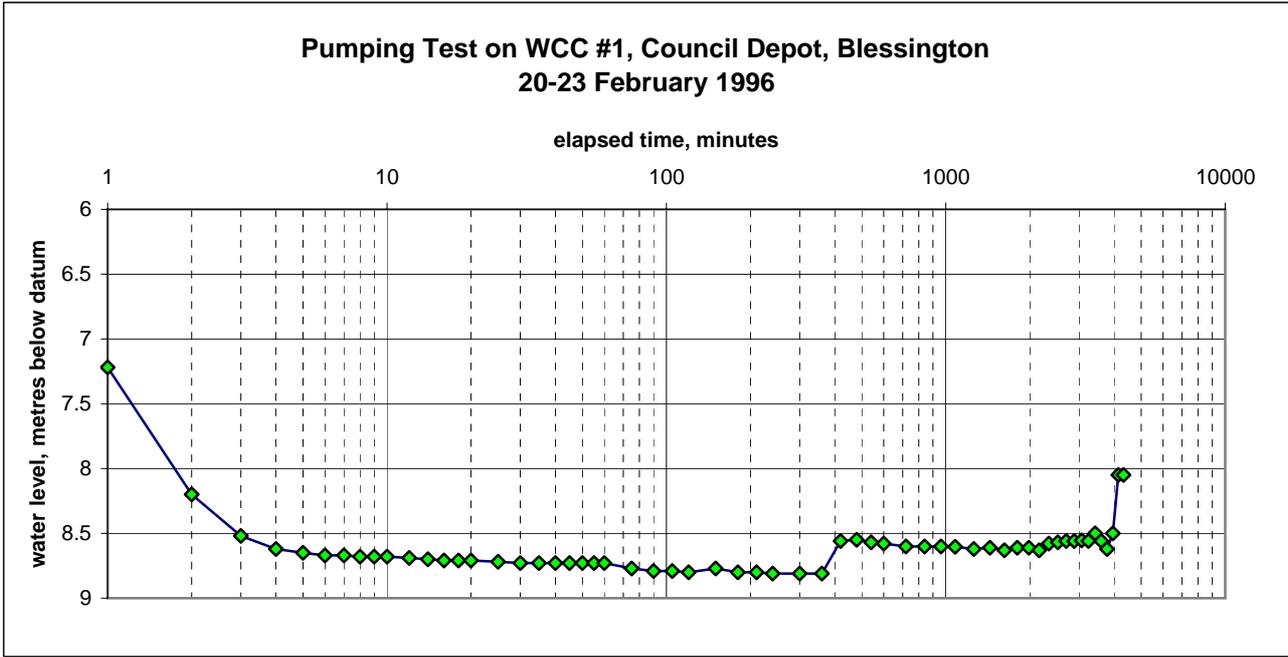
Specific capacity = 416/5.68 = 73.24 m³/d/m

Step 2

Date	Clock Time	elapsed time (min)	water level (m)	drawdown (m)	meter litres	pumping rate m ³ /d
19/2/1996	14:15	0	2.72	0	30780	0
	14:16	1	7.84	5.12	31120	489.60
	14:17	2	7.92	5.20	31455	482.40
	14:18	3	8.73	6.01	31790	482.40
	14:19	4	9.5	6.78	32120	475.20
	14:20	5	9.58	6.86	32460	489.60
	14:21	6	9.6	6.88	32790	475.20
	14:22	7	9.62	6.9	33130	489.60
	14:23	8	9.64	6.92	33460	475.20
	14:24	9	9.64	6.92	33790	475.20
	14:25	10	9.65	6.93	34120	475.20
	14:27	12	9.65	6.93	34790	482.40
	14:29	14	9.67	6.95	35455	478.80
	14:31	16	9.68	6.96	36120	478.80
	14:33	18	9.68	6.96	36790	482.40
	14:35	20	9.68	6.96	37455	478.80
	14:40	25	9.68	6.96	39120	479.52
	14:45	30	9.71	6.99	40785	479.52
	14:50	35	9.69	6.97	42450	479.52
	14:55	40	9.67	6.95	44120	480.96
	15:00	45	9.68	6.96	45790	480.96
	15:05	50	9.68	6.96	47460	480.96
	15:10	55	9.69	6.97	49130	480.96
	15:15	60	9.66	6.94	50795	479.52

Specific capacity = 480/6.94 = 69.16 m³/d/m

Appendix - Pumping Test Data



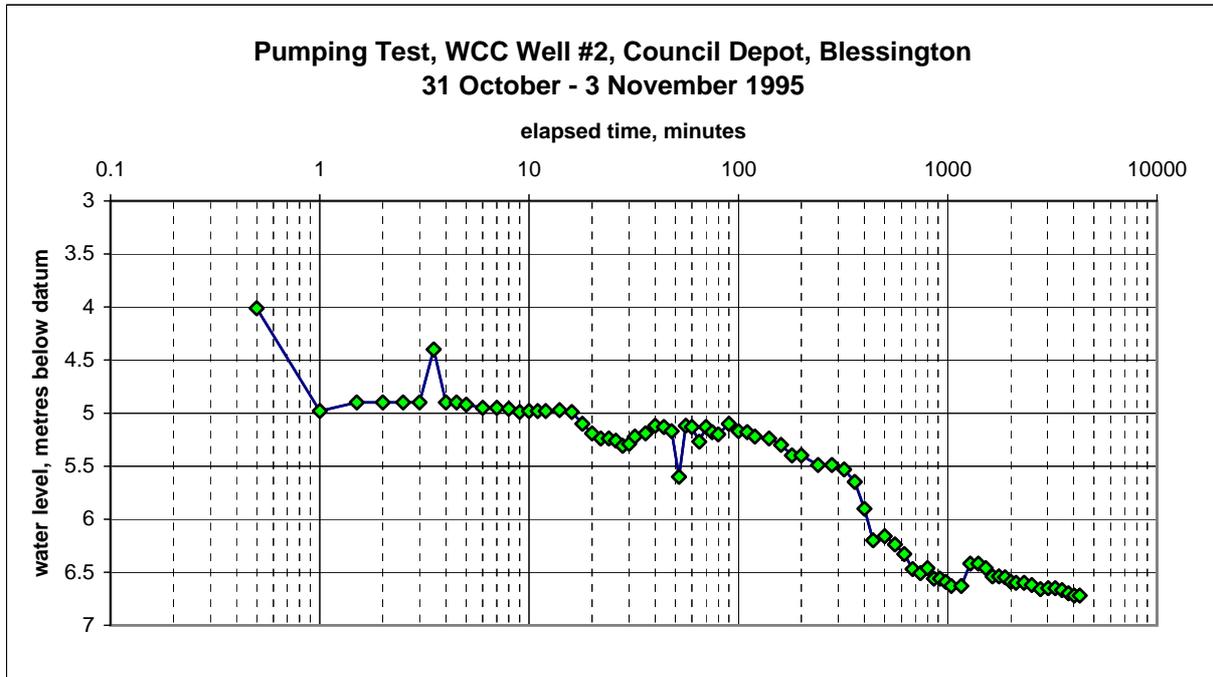
Appendix - Pumping Test Data

**Pumping Test on WCC #2 well, Council Depot, Blessington
(Well No. 2921SWw067)**

Date	Clock Time	elapsed time (min)	water level (m)	drawdown (m)	w/meter gallons	pumping rate m ³ /d
31/10/1995		0	3.4	0	2405600	0
		0.5	4.01	0.61	2405650	655
		1.00	4.98	1.58	2405670	262
		1.50	4.9	1.50	2405700	393
		2.00	4.9	1.50	2405720	262
		2.50	4.9	1.50	2405740	262
		3.00	4.9	1.50	2405765	327
		3.50	4.4	1.00	2405790	327
		4.00	4.9	1.50	2405810	262
		4.50	4.9	1.50	2405830	262
		5	4.92	1.52	2405855	327
		6	4.95	1.55	2405900	295
		7	4.95	1.55	2405943	281
		8	4.96	1.56	2405988	295
		9	4.99	1.59	2406030	275
		10	4.98	1.58	2406077	308
		11	4.98	1.58	2406121	288
		12	4.98	1.58	2406166	295
		14	4.97	1.57	2406256	295
		16	4.99	1.59	2406345	291
		18	5.1	1.7	2406435	295
		20	5.19	1.79	2406525	295
		22	5.24	1.84	2406613	288
		24	5.24	1.84	2406700	285
		26	5.26	1.86	2406793	304
		28	5.31	1.91	2406883	295
		30	5.29	1.89	2406973	295
		32	5.22	1.82	2407064	298
		36	5.19	1.79	2407244	295
		40	5.12	1.72	2407423	293
		44	5.13	1.73	2407603	295
		48	5.17	1.77	2407784	296
		52	5.6	2.2	2407965	296
		56	5.12	1.72	2408146	296
		60	5.13	1.73	2408329	299
		65	5.27	1.87	2408554	295
		70	5.13	1.73	2408780	296
		75	5.18	1.78	2409050	353
		80	5.2	1.8	2409231	237
		90	5.1	1.7	2409684	297
		100	5.17	1.77	2410136	296
		110	5.18	1.78	2410589	297
		120	5.22	1.82	2411043	297
		140	5.24	1.84	2411951	297
		160	5.3	1.9	2412854	296
		180	5.4	2	2413716	282
		200	5.4	2	2414671	313
		240	5.49	2.09	2416595	315
		280	5.49	2.09	2418319	282
		320	5.53	2.13	2420143	298
		360	5.65	2.25	2421972	299
		400	5.9	2.5	2423818	302

Appendix - Pumping Test Data

Date	Clock Time	elapsed time (min)	water level (m)	drawdown (m)	meter gallons	pumping rate m ³ /d
		440	6.2	2.8	2425610	293
		500	6.16	2.76	2428362	300
		560	6.24	2.84	2431015	289
		620	6.33	2.93	2433841	308
		680	6.47	3.07	2436581	299
		740	6.51	3.11	2439318	299
		800	6.46	3.06	2442050	298
		860	6.56	3.16	2444768	297
		920	6.56	3.16	2447474	295
		980	6.59	3.19	2450205	298
		1040	6.63	3.23	2452923	297
		1160	6.63	3.23	2458285	292
		1280	6.42	3.02	2463751	298
		1400	6.42	3.02	2469200	297
		1520	6.46	3.06	2474663	298
		1640	6.54	3.14	2480133	298
		1760	6.54	3.14	2485638	300
		1880	6.55	3.15	2491142	300
		2000	6.59	3.19	2496650	300
		2120	6.6	3.2	2502153	300
		2320	6.6	3.2	2511374	302
		2520	6.62	3.22	2520595	302
		2770	6.66	3.26	2532098	301
		3020	6.65	3.25	2543620	302
		3270	6.65	3.25	2555193	303
		3520	6.67	3.27	2566541	297
		3770	6.7	3.3	2578059	302
		4020	6.72	3.32	2589544	301
3/11/1995		4270	6.72	3.32	2601043	301

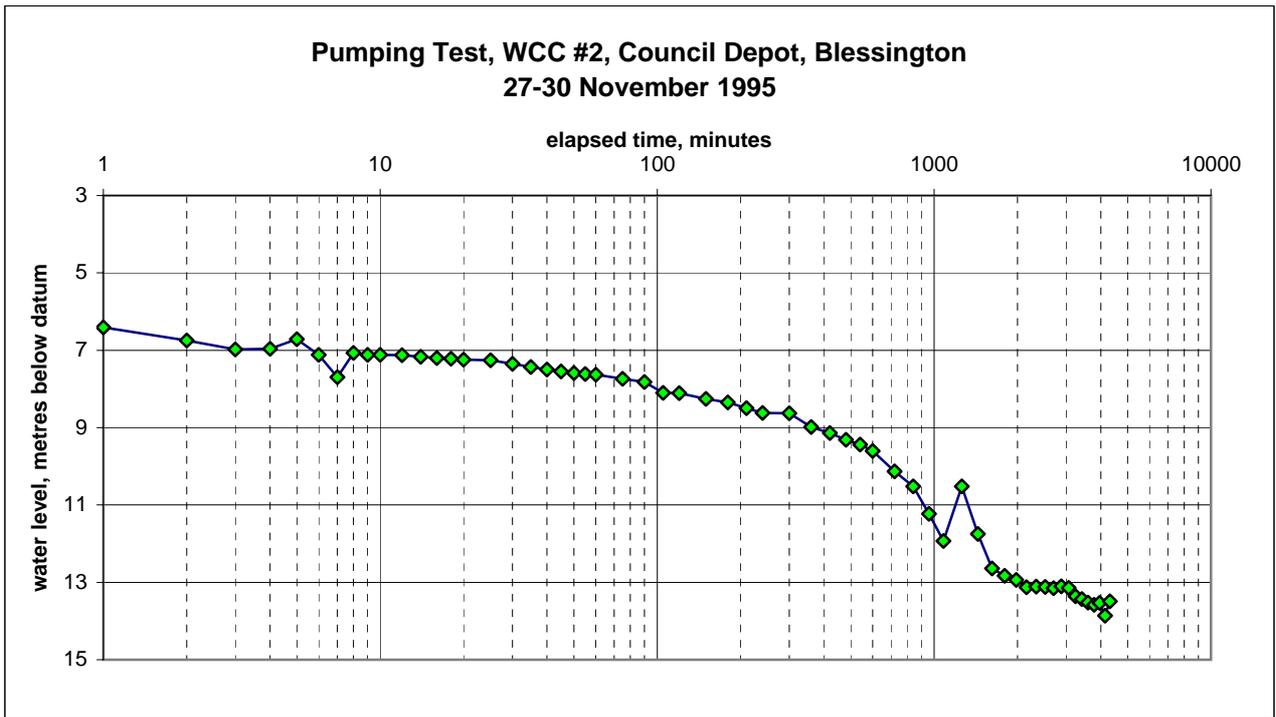


Appendix - Pumping Test Data

**Pumping Test on WCC #2 well, Council Depot, Blessington
(Well No. 2921SWw067)**

Date	Clock Time	elapsed time (min)	water level (m)	drawdown (m)	flow meter litres	pumping rate m ³ /d
27/11/1995	13:01	0	3.83	0	35990	0
	13:02	1	6.41	2.58	36250	374.40
	13:03	2	6.75	2.92	36510	374.40
	13:04	3	6.98	3.15	36770	374.40
	13:05	4	6.96	3.13	37040	388.80
	13:06	5	6.71	2.88	37310	388.80
	13:07	6	7.12	3.29	37570	374.40
	13:08	7	7.7	3.87	37840	388.80
	13:09	8	7.07	3.24	38110	388.80
	13:10	9	7.12	3.29	38380	388.80
	13:11	10	7.12	3.29	38650	388.80
	13:13	12	7.13	3.3	39180	381.60
	13:15	14	7.17	3.34	39710	381.60
	13:17	16	7.2	3.37	40250	388.80
	13:19	18	7.22	3.39	40775	378.00
	13:21	20	7.24	3.41	41310	385.20
	13:26	25	7.26	3.43	42635	381.60
	13:31	30	7.35	3.52	43960	381.60
	13:36	35	7.43	3.6	45285	381.60
	13:41	40	7.5	3.67	46620	384.48
	13:46	45	7.55	3.72	47940	380.16
	13:51	50	7.59	3.76	49270	383.04
	13:56	55	7.61	3.78	50600	383.04
	14:01	60	7.63	3.8	51925	381.60
	14:16	75	7.74	3.91	55920	383.52
	14:31	90	7.82	3.99	59920	384.00
	14:46	105	8.1	4.27	63910	383.04
	15:01	120	8.11	4.28	67640	358.08
	15:31	150	8.26	4.43	75860	394.56
	16:01	180	8.35	4.52	83780	380.16
	16:31	210	8.5	4.67	91360	363.84
	17:01	240	8.62	4.79	99080	370.56
	18:01	300	8.63	4.8	115100	384.48
	19:01	360	8.98	5.15	131090	383.76
	20:01	420	9.14	5.31	146880	378.96
	21:01	480	9.31	5.48	162050	364.08
	22:01	540	9.44	5.61	177690	375.36
	23:01	600	9.6	5.77	193230	372.96
28/11/1995	01:01	720	10.13	6.3	224850	379.44
	03:01	840	10.52	6.69	256000	373.80
	05:01	960	11.23	7.4	286570	366.84
	07:01	1080	11.93	8.1	316950	364.56
	10:01	1260	10.52	6.69	359010	336.48
	13:01	1440	11.75	7.92	398090	312.64
	16:01	1620	12.64	8.81	436640	308.40
	19:01	1800	12.83	9	475180	308.32
	22:01	1980	12.94	9.11	514960	318.24
29/11/1995	01:01	2160	13.13	9.3	552380	299.36
	04:01	2340	13.11	9.28	591450	312.56
	07:01	2520	13.12	9.29	628190	293.92
	10:01	2700	13.15	9.32	667270	312.64
	13:01	2880	13.1	9.27	705040	302.16
	16:01	3060	13.14	9.31	742530	299.92
	19:01	3240	13.36	9.53	781000	307.76
	22:01	3420	13.43	9.6	818720	301.76
30/11/1995	01:01	3600	13.52	9.69	857030	306.48
	04:01	3780	13.58	9.75	894850	302.56
	07:01	3960	13.53	9.7	932980	305.04
	10:01	4140	13.86	10.03	971370	307.12
30/11/1995	13:01	4320	13.49	9.66	1009710	306.72

Appendix - Pumping Test Data



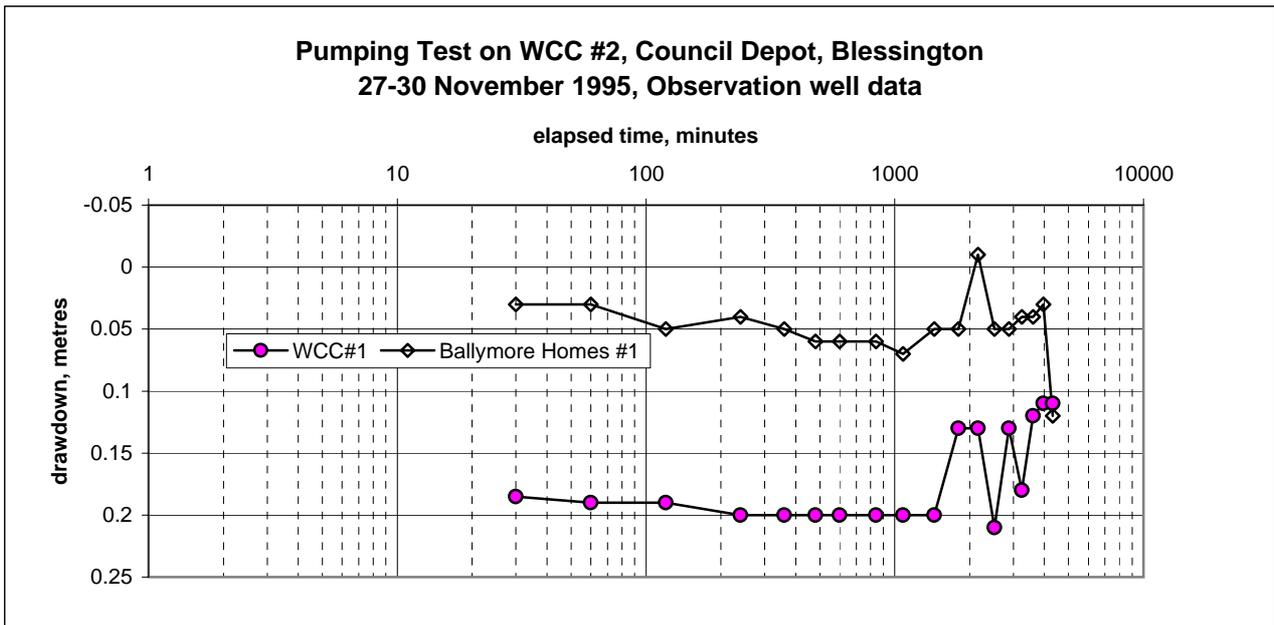
Appendix - Pumping Test Data

Pumping Test on WCC #2 well, Council Depot, Blessington

(Well No. 2921SWw067)

Observation well readings in WCC #1 well (2921SWw066) & Ballymore Homes #2 (2921SWw064)

Date	Clock Time	elapsed time (min)	water level (m)	drawdown (m)	water level (m)	drawdown (m)
27/11/1995	13:01	0	3.57	0	4.13	0
	13:31	30	3.755	0.185	4.16	0.03
	14:01	60	3.76	0.19	4.16	0.03
	15:01	120	3.76	0.19	4.18	0.05
	17:01	240	3.77	0.2	4.17	0.04
	19:01	360	3.77	0.2	4.18	0.05
	21:01	480	3.77	0.2	4.19	0.06
	23:01	600	3.77	0.2	4.19	0.06
28/11/1995	03:01	840	3.77	0.2	4.19	0.06
	07:01	1080	3.77	0.2	4.2	0.07
	13:01	1440	3.77	0.2	4.18	0.05
	19:01	1800	3.7	0.13	4.18	0.05
29/11/1995	01:01	2160	3.7	0.13	4.12	-0.01
	07:01	2520	3.78	0.21	4.18	0.05
	13:01	2880	3.7	0.13	4.18	0.05
	19:01	3240	3.75	0.18	4.17	0.04
30/11/1995	01:01	3600	3.69	0.12	4.17	0.04
	07:01	3960	3.68	0.11	4.16	0.03
30/11/1995	13:01	4320	3.68	0.11	4.25	0.12

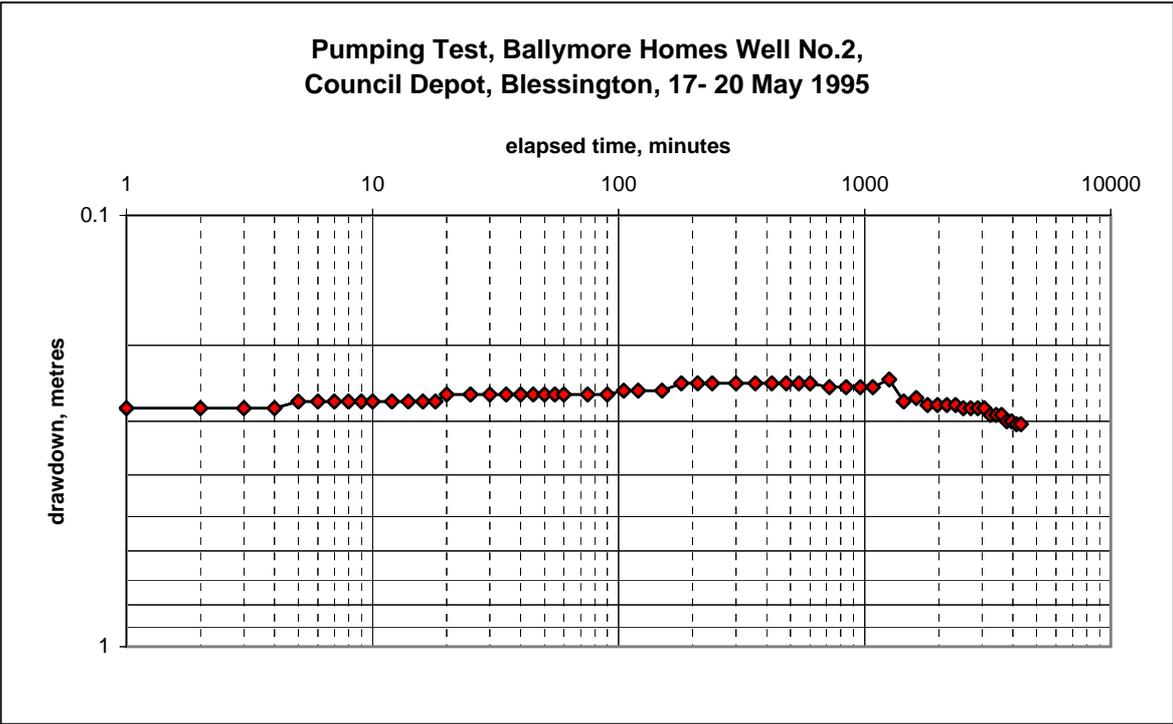


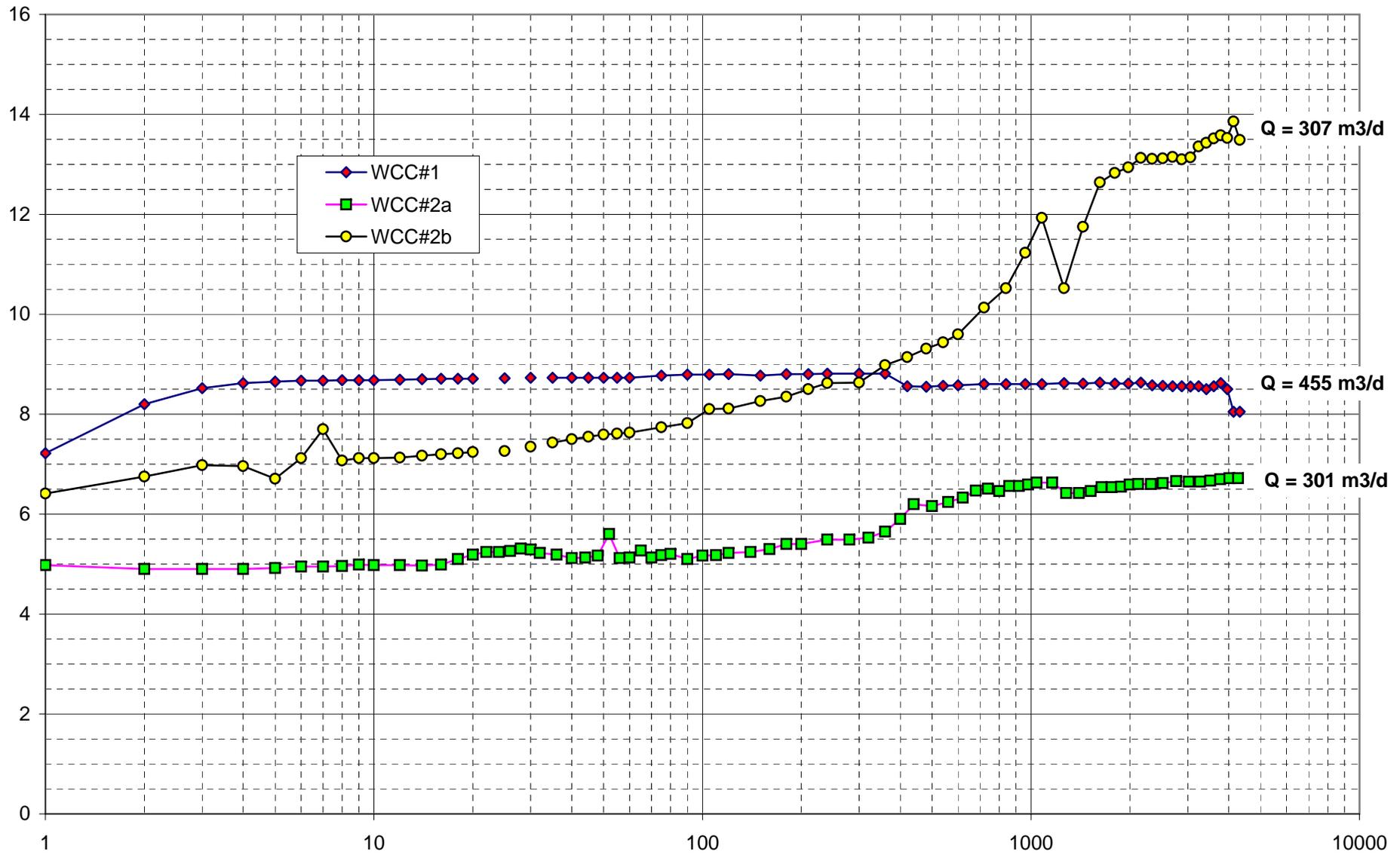
Appendix - Pumping Test Data

Pumping Test on Ballymore Homes Well No.2, Council Depot, Blessington

Date	Clock Time	elapsed time (min)	water level m	drawdown m	pumping rate m ³ /d	temperature	
						well	stream
17/5/1995	13:31	0	3.11	0		10	12.5
	13:32	1	3.39	0.28	662.4		
	13:33	2	3.39	0.28	662.4		
	13:34	3	3.39	0.28	662.4		
	13:35	4	3.39	0.28	676.8		
	13:36	5	3.38	0.27	656.64		
	13:37	6	3.38	0.27	662.4		
	13:38	7	3.38	0.27	676.8		
	13:39	8	3.38	0.27	662.4		
	13:40	9	3.38	0.27	662.4		
	13:41	10	3.38	0.27	662.4		
	13:43	12	3.38	0.27	662.4		
	13:45	14	3.38	0.27	669.6		
	13:47	16	3.38	0.27	662.4		
	13:49	18	3.38	0.27	662.4		
	13:51	20	3.37	0.26	662.4		
	13:56	25	3.37	0.26	665.28	10	12.5
	14:01	30	3.37	0.26	662.4		
	14:06	35	3.37	0.26	662.4		
	14:11	40	3.37	0.26	662.4		
	14:16	45	3.37	0.26	665.28		
	14:21	50	3.37	0.26	665.28		
	14:26	55	3.37	0.26	665.28		
	14:31	60	3.37	0.26	662.4		
	14:46	75	3.37	0.26	662.4	10	13.5
	15:01	90	3.37	0.26	663.84		
	15:16	105	3.365	0.255	663.84		
	15:31	120	3.365	0.255	663.84		
	16:01	150	3.365	0.255	663.84	10	13.5
	16:31	180	3.355	0.245	663.84		
	17:01	210	3.355	0.245	662.4	10	14
	17:31	240	3.355	0.245	663.84		
	18:31	300	3.355	0.245	666.72	10	13
	19:31	360	3.355	0.245	662.4		
	20:31	420	3.355	0.245	663.84	10	12
	21:31	480	3.355	0.245	663.84		
	22:31	540	3.355	0.245	660.96	10	11
	23:31	600	3.355	0.245	662.4		
18/5/1995	01:31	720	3.36	0.25	662.4	10	9
	03:31	840	3.36	0.25	688.32		
	05:31	960	3.36	0.25	637.92	10	8
	07:31	1080	3.36	0.25	662.4		
	10:31	1260	3.35	0.24	662.4	10	10
	13:31	1440	3.38	0.27	665.28	10	10
	16:31	1620	3.375	0.265	669.6		
	19:31	1800	3.385	0.275	653.76		
	22:31	1980	3.385	0.275	665.28		
19/5/1995	01:31	2160	3.385	0.275	655.2		
	04:31	2340	3.385	0.275	666.72		
	07:31	2520	3.39	0.28	663.84	10	9
	10:31	2700	3.39	0.28	658.08	10	12
	13:31	2880	3.39	0.28	662.4	10	15
	16:31	3060	3.39	0.28	665.28	10	14
	19:31	3240	3.4	0.29	659.52	10	13
	22:31	3420	3.4	0.29	636.48		
20/5/1995	01:31	3600	3.4	0.29	709.92		
	04:31	3780	3.41	0.3	640.8	10	11
	07:31	3960	3.41	0.3	662.4	10	10
	10:31	4140	3.415	0.305	665.28	10	10
	13:31	4320	3.415	0.305	662.4	9.9	10.2

Appendix - Pumping Test Data

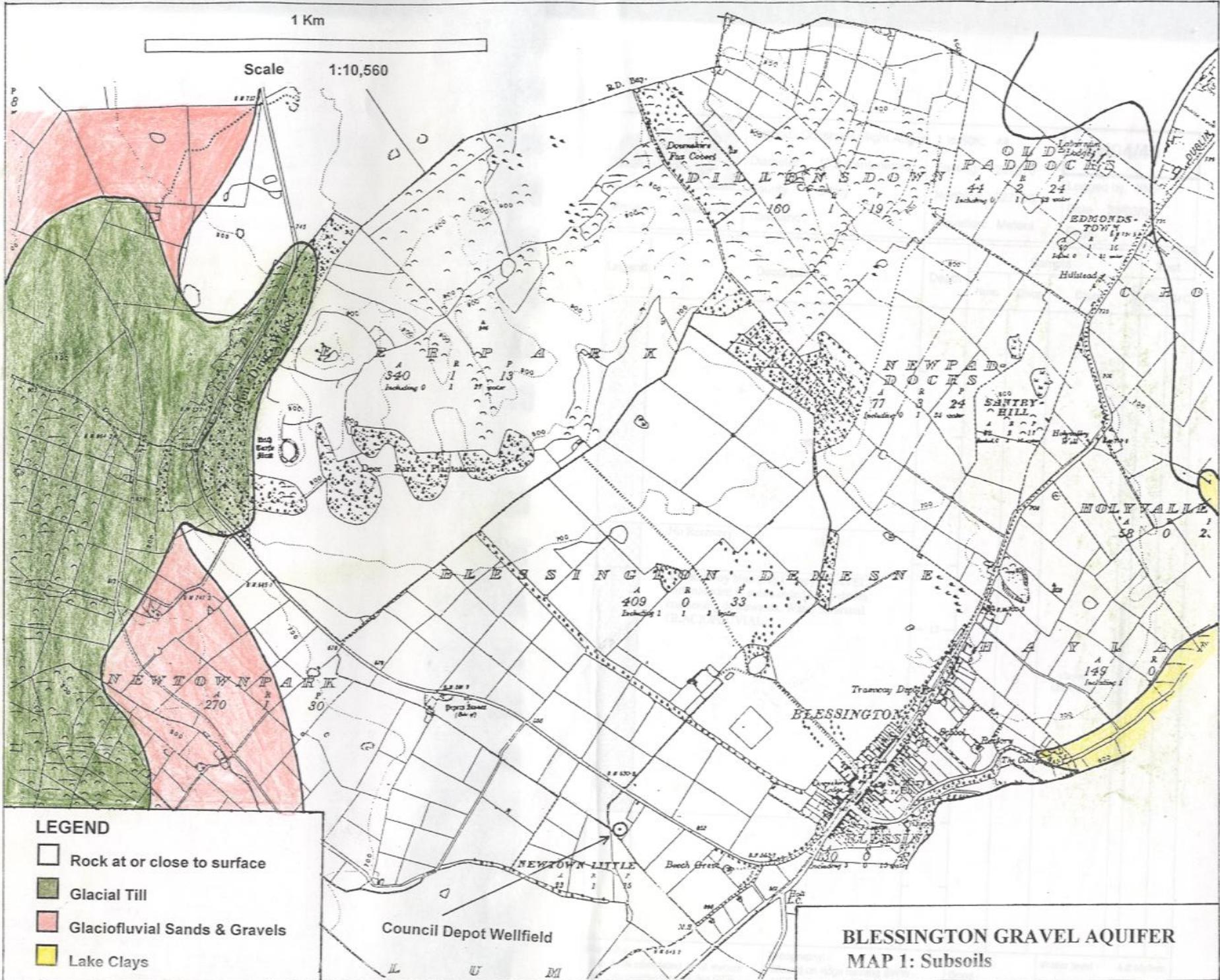




1 Km



Scale 1:10,560



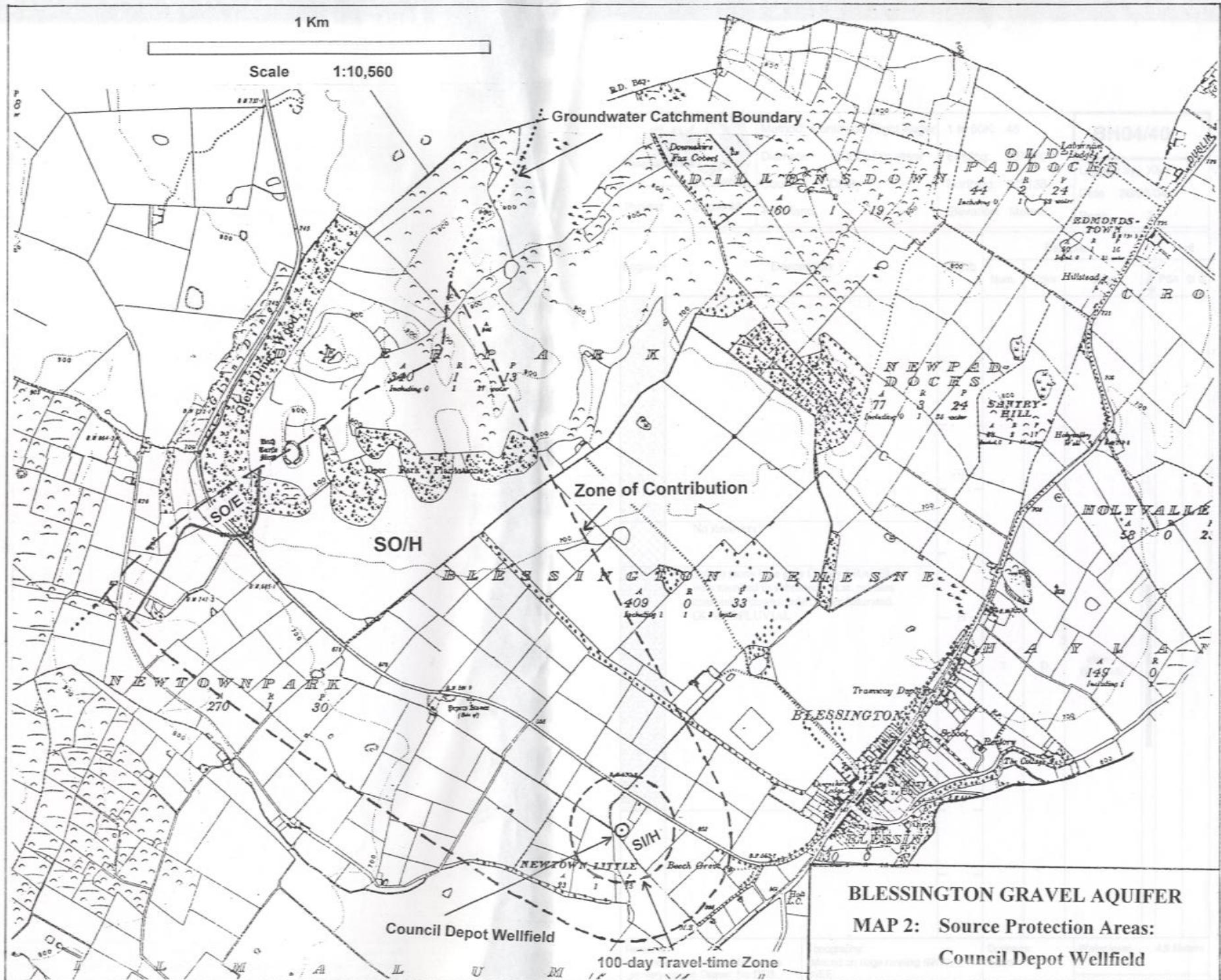
LEGEND

-  Rock at or close to surface
-  Glacial Till
-  Glaciofluvial Sands & Gravels
-  Lake Clays

BLESSINGTON GRAVEL AQUIFER
MAP 1: Subsoils

1 Km

Scale 1:10,560



BLESSINGTON GRAVEL AQUIFER

MAP 2: Source Protection Areas:

Council Depot Wellfield