Technical Report

Investigations and Monitoring Group

Aquifer test at Somerton Station, well L36/1801.

Report No. U07/30

Environment Canterbury

Your regional council

Aquifer test at Somerton Station, well L36/1801.

Report No. U07/30

Mike Thorley

June 2007

ISBN 978-1-86937-654-3

Environment Canterbury
Your regional council

Report U07/30

58 Kilmore Street
PO Box 345
Christchurch
Phone (03) 365 3828
Fax (03) 365 3194

75 Church Street
PO Box 550
Timaru
Phone (03) 688 9069
Fax (03) 688 9067

Website: www.ecan.govt.nz
Customer Services Phone 0800 324 636

Executive Summary

A constant rate discharge test was conducted over 14 days at Somerton Station, using well L36/1801, which is screened from 170.89 m to below ground surface. Observations were made in a nearby well L36/1944 of similar depth, which revealed leaky confined aquifer conditions.

The aquifer parameters inferred to represent aquifer hydraulics in the vicinity of these wells is as follows:

- Transmissivity = 580 m^2/day;
- Storativity = 0.0002;
- Leakage (K'/B') = 0.00015 day^{-1} or Leakage = 1966 m
- Specific yield = 0.1.

The transmissivity and storativity have a high degree of certainty although the leakage term is less certain due to background trends in groundwater levels affecting drawdown throughout the later periods of the testing.

Foreword

This report represents advice to the Canterbury Regional Council and any views, conclusions or recommendations do not represent Council policy.

The information in this report, together with other information may be used by the Council to formulate resource management policies, e.g., in the preparation or review of regional plans.

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Purpose and scope

Recent development of the deep groundwater resource across the upper north-west Ashburton Plains has been substantial and demand for more growth remains. Descriptions of aquifer properties and hydrological behaviour at depths greater than 100 m are currently limited to the ECan monitoring bore at Urrall and constant rate aquifer tests are difficult to find in this area. Strategically located aquifer tests are planned across this area to obtain measurements of aquifer transmissivity, storativity and leakage terms. It is intended that this information will assist existing users, and support resource management decision making.

1.2 Objectives and methods

The main objective of this test was to better define leakage of groundwater into the pumped strata. A longer duration constant rate discharge test was used in order to observe delayed leakage effects. The leakiness of the system becomes critical when assessing drawdown effects, but more importantly, provides an indication of the hydraulic constraint on recharge through overlying layers.

1.3 Location

The location of the aquifer test at Somerton is shown in Figure 1. Somerton is located approximately 6 km northwest of Chertsey and south-west of the Rakaia River. Well L36/1801 was used as the pumping well and is located at Somerton Station at 949 Thompsons Track Road, and the property is owned and farmed by Steven and Freda Bierema.

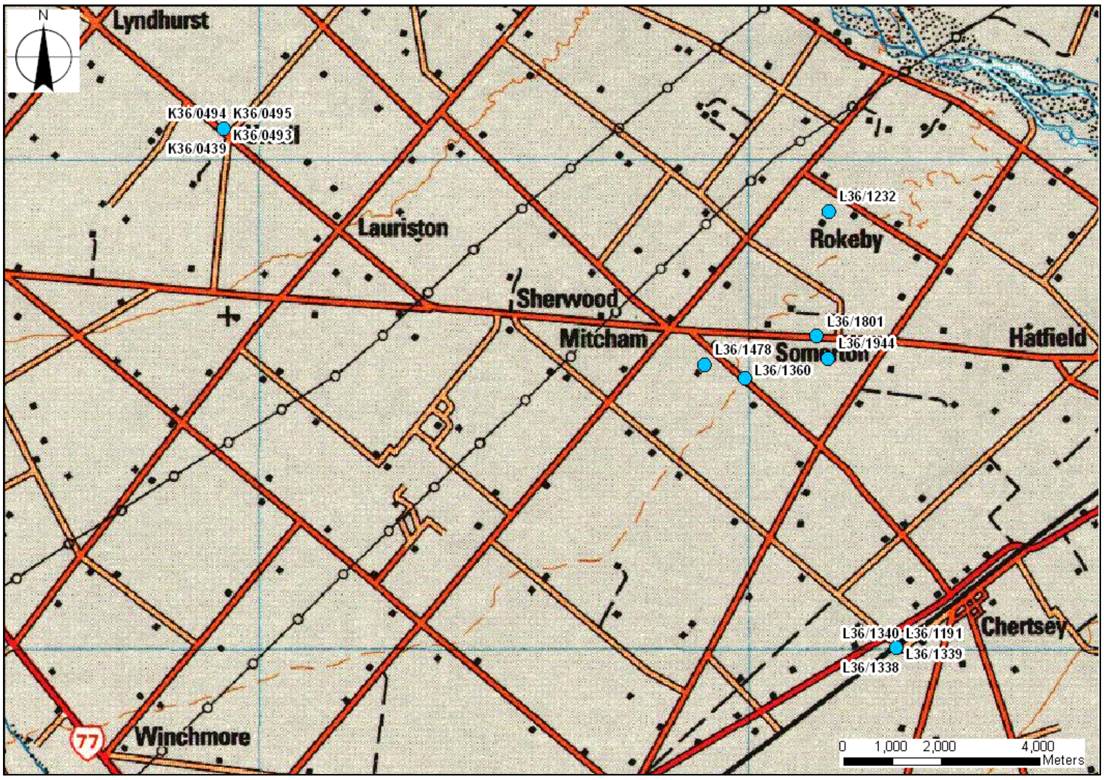

Figure 1: Location map showing general area and those wells used in this study.

2 Well Information

Well screen distributions in the vicinity (5 km) of well L36/1801 show most wells are drilled to depths of about 200 m (Figure 2). Wells in the area are screened between depths ranging from 120 m and 200 m below ground surface. Very few records of pump depths are available: of those refered to in Figure 2 below, 12 wells record pumps having been set between 95 m and 170 m below ground surface. Borelogs from wells used in the aquifer testing are included in Appendix A.

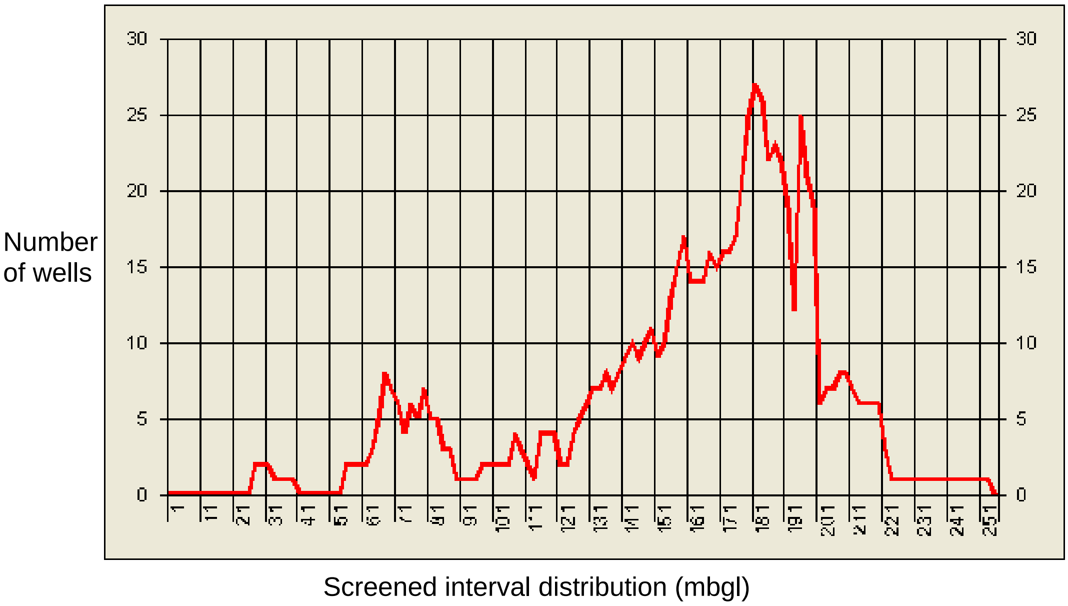

Figure 2: Plot showing well screen distribution within 5 km of well L36/1801, in the Somerton area.

3 Groundwater Hydrology

3.1 Groundwater levels – Regional Trends

Groundwater levels are monitored across Ashburton Plains using a culmination of monthly manual measurements and continuous recorder wells. The monitoring wells are located across the Ashburton Plains area at a range of depths, although deep groundwater monitoring across the upper plains is limited at present to the Urrall monitoring site. As more groundwater consents are exercised across the upper plains area, it is expected more groundwater level data will be collected and made available for analysis.

The seasonal range of groundwater levels in shallow and moderate depth wells during 2006 were close to record highs following above average rainfall and snow events in autumn and early winter. Rapid rises in groundwater levels were noted during April 2006 in shallow and moderate depth wells. However, the winter rise was not noted until May 2006 in wells deeper than ~50 m, and the fluctuation was consistent with previous year i.e. there were no additional effects from the above average recharge event. This time lag of about one month reflects a greater hydraulic resistance in aquifers below ~90 m below ground surface than those found down to approximately 50 m deeper than ground surface.

Deep groundwater abstraction development has predominantly occurred since 2004 across the upper plains area (following the Chertsey zone hearing and appeal). If groundwater level monitoring records collected during the 2004 to 2007 period are compared with antecedent groundwater monitoring records (pre 2004), a persistent response to the abstraction development is observed. The development of the saw-tooth pattern is directly attributable to pumping effects and the overall declining trend can be attributed to pumping and climate. From 2001 to 2007, groundwater levels measured at well K36/0494 (Urrall) have revealed the seasonal maxima to have lowered by 9.2 m and the seasonal minima to have lowered by 10.4 m (Figure 3). It is unclear exactly what the seasonal trends are to the north, south and west of this observation site due to a lack of continuous groundwater level monitoring. However it is likely this monitoring site does represent aquifer conditions at least within, say, 3-5 km of the site. To the east, the Chertsey monitoring site has shown similar patterns to the Urrall site, although the declining inter-seasonal trend has not been as pronounced. At the Chertsey site, groundwater level records from well L36/1191 show the seasonal maxima have lowered by 5.2 m and the seasonal minima have lowered by 10.6 m (Figure 4). The Chertsey site does appear to be affected more by localised interference effects from surrounding pumping than at the Urrall site, and is reflected by the distinctive saw tooth effect, and increasing amplitude in the seasonal variation of the groundwater levels.

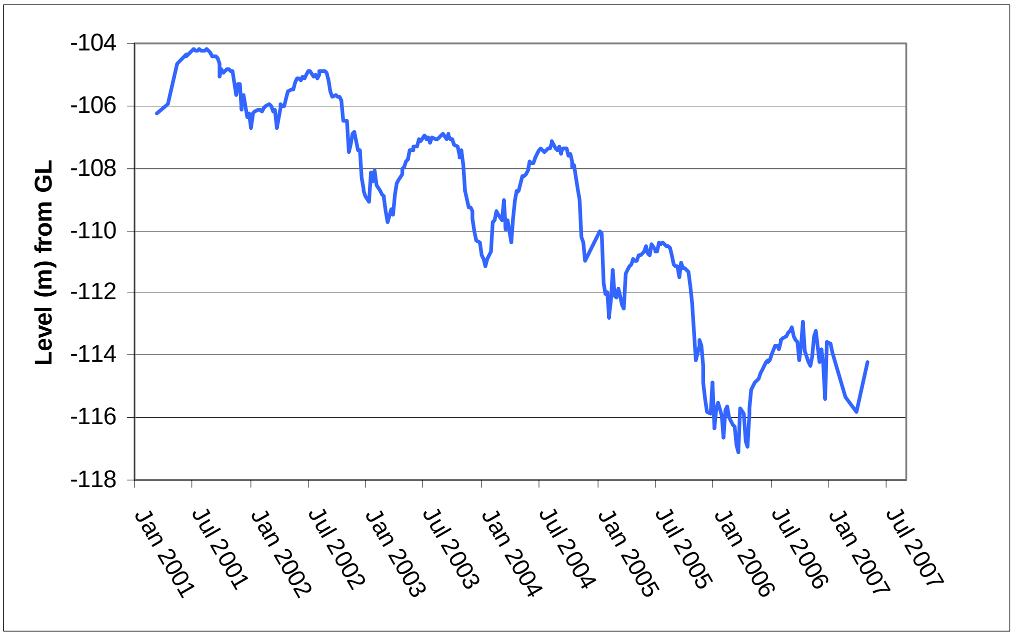

Figure 3: Plot of groundwater levels at the Urrall monitoring site, well K36/0494. The data does include barometric influences.

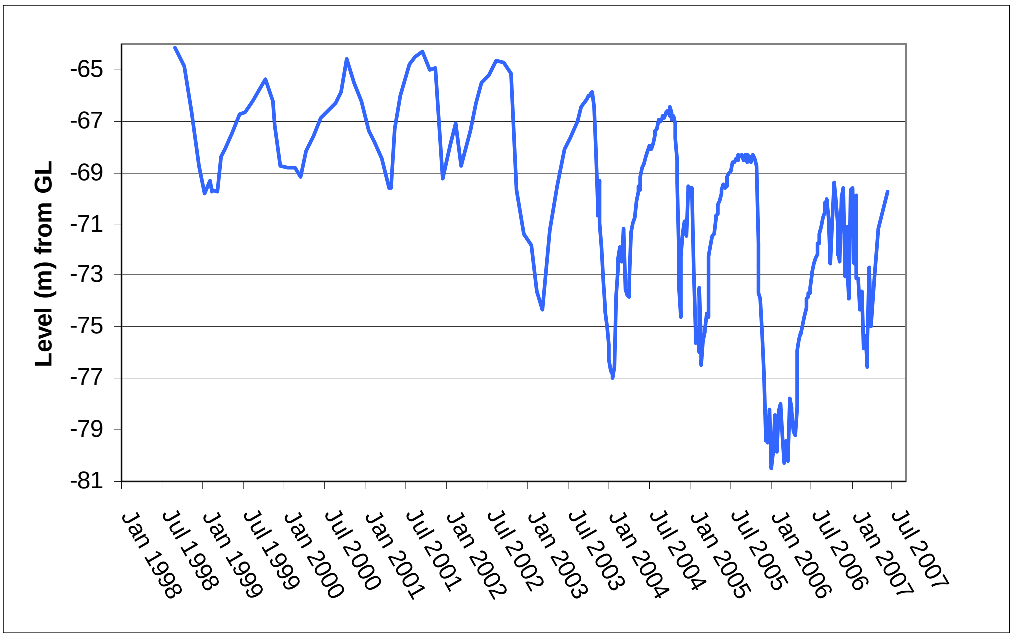

Figure 4: Plot of groundwater levels at the Chertsey monitoring site, well L36/1191. The data does include barometric influences.

Groundwater flow directions in the Somerton area are generally toward the coast with a slight oblique orientation away from the Rakaia River and toward the south-west margin of the Ashburton Plains (Davey, G., 2004) (Figure 5).

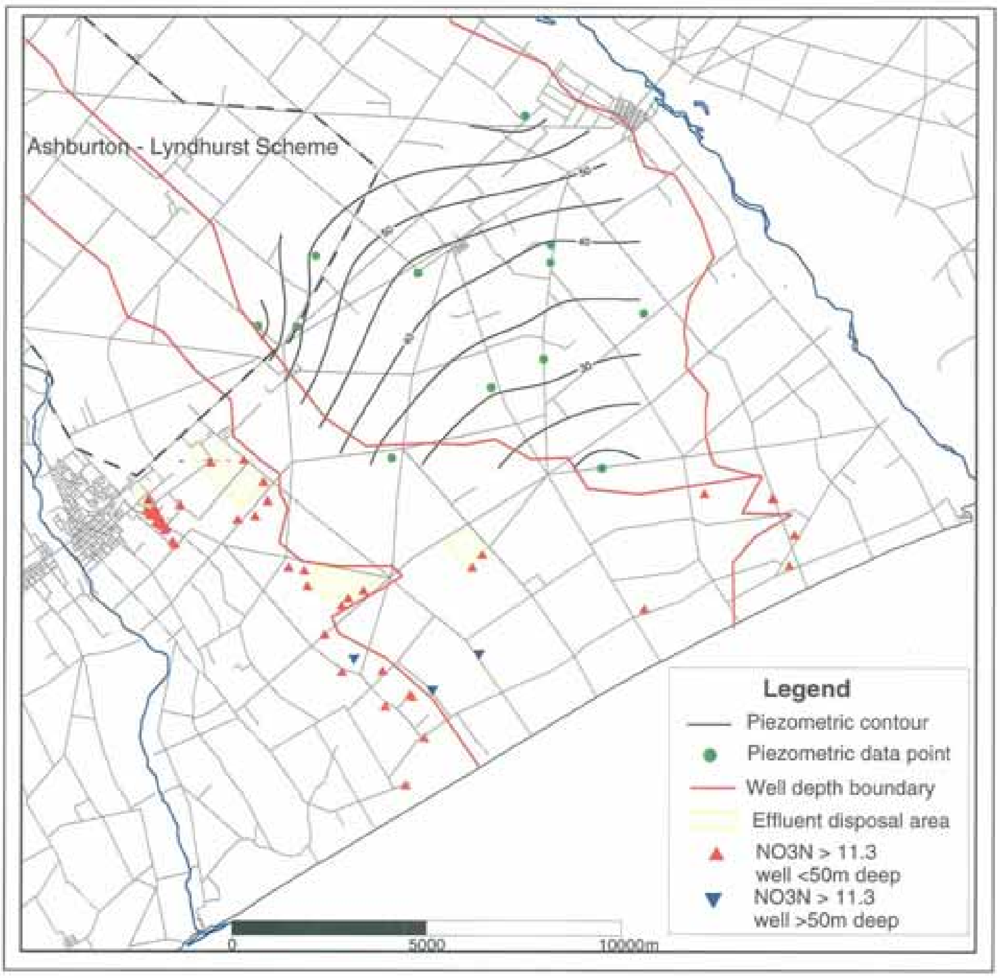

Figure 5: Piezometric contours for deep wells (>90 mbgl) across the lower Ashburton Plains. April 2003 water levels. Taken from Davey (2004), Figure 10.

3.2 Previous aquifer tests

Numerous aquifer tests have been completed across the Rakaia-Ashburton Plains; however, ECan has no records of any other aquifer tests within 5 km of well L36/1801.

4 Constant rate discharge test

4.1 Test configuration

The pumping well was selected as it was the only well in this area with a single length of manufactured stainless steel wire-woven screen, and with a pump not in for servicing during winter 2006. The pumping well, L36/1801, is 191.27 m depth, and screened from 170.89 m to 191.27 m below ground level. Most other wells in the area have multiple screens and/or have slotted casing over extended lengths of the well casing. When pumped, wells with multiple or very long screens spread the stress of pumping over multiple layers of strata, and the measured responses to the pumping will be an effective change over all the strata layers intersected by the screens rather than a specific horizon. A summary of the wells used for the constant rate discharge test is provided in Table 1.

Table 1: Summary of wells used during the constant rate discharge test.

Well	Distance (m)	Direction	Depth	Top Screen	Bottom Screen	Screen Type
L36/1801	-	-	191.27	170.89	191.27	Stainless steel
L36/1944	507	South-east	167.83	157.7	167.8	Stainless steel
L36/1232	2,566	North	197	178	197	Slotted casing & Stainless steel
K36/0494	12,836	North-west	172	170	172	-
L36/1191	6,572	South-east	204.7	197	201	-

Initially, it was hoped that groundwater levels in the pumped aquifer would be measured in conjunction with overlying aquifers (L36/1360). This was constrained by the lack of shallower bores that were accessible to measure groundwater levels. Several deep bores were also investigated as potential observation sites; however, many deep bores in the area do not have sampling tubes to allow the measurement of groundwater levels (L36/1478). After visiting wells in the vicinity of well L36/1801, only two wells were available to use as observations wells during the test (L36/1944 and L36/1232) (shown in Figure 1).

4.2 Test procedure

Natural static groundwater levels were monitored in the pumping well L36/1801 and the observation well L36/1944 over a 3 day period from 3:15 pm on the 24th July 2006 until the start of the constant rate discharge test at 11:00 am on the 27th July 2006. Groundwater levels were monitored using a combination of manual measurements with a water level and automated measurements using pressure transducers.

The pump was started at 11:00 am of the 27th July 2006 at an average daily rate of 41.75 L/s, and ranging from 41.28 L/s to 42.36 L/s using average hourly figures. The pump was switched off 14 days later at 10:15 am on the 10th August 2006. Flow was measured using a magnetic pulse output meter and logged at 5 minute intervals using an electronic logger. The flow rate was set by limiting the power supply to the pump rather than using the gate valve. A plot of the average hourly and daily flow rate is shown in Figure 6. The reason for the step in pumping rate is not clear, although the change is considered minor.

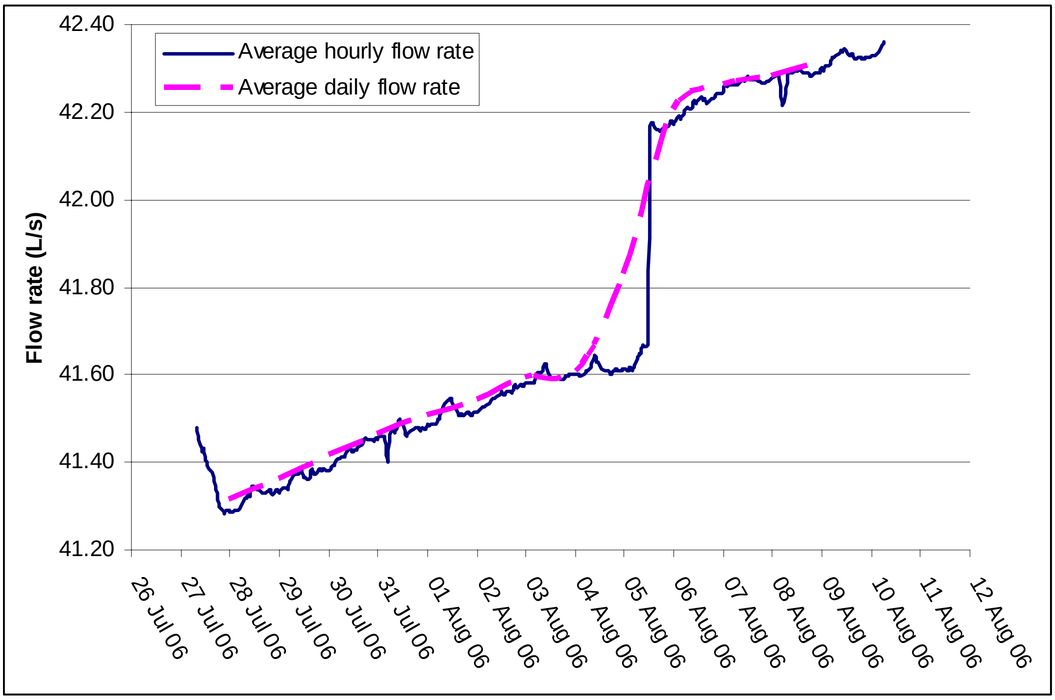

Figure 6: Plot showing average hourly and average daily flow rate from well L36/1801 throughout the constant discharge test.

Groundwater levels in the pumping well (L36/1801) were monitored at -84.98 m below measuring point (MP) prior to the test commencement and drew down to -92.97 m below MP during the test and recovered to -84.2 m below MP (Figure 7). A maximum drawdown of 7.8 m was reached during the test and results in a specific capacity of approximately 5.48 L/s/m.

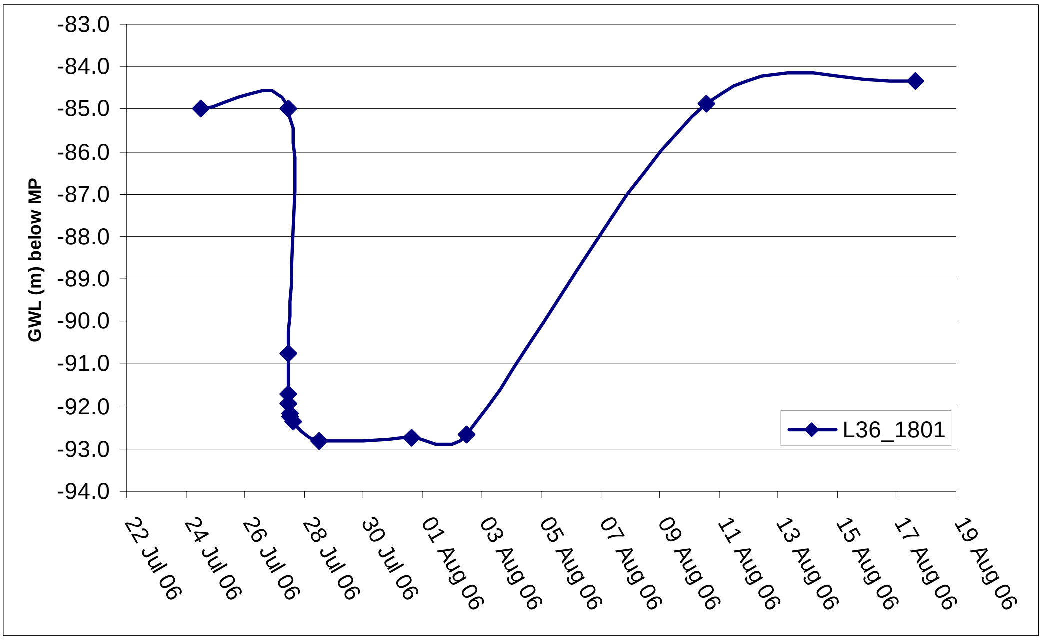

Figure 7: Plot of groundwater levels in the pumping well throughout the test. The data does include barometric influences.

Groundwater levels in the nearest observation well L36/1944 were monitored at -83.34 m below MP and drew down to -84.69 m below MP during the test (uncorrected), although after 8 hours into the test, an upward trend becomes apparent in the data (Figure 8).

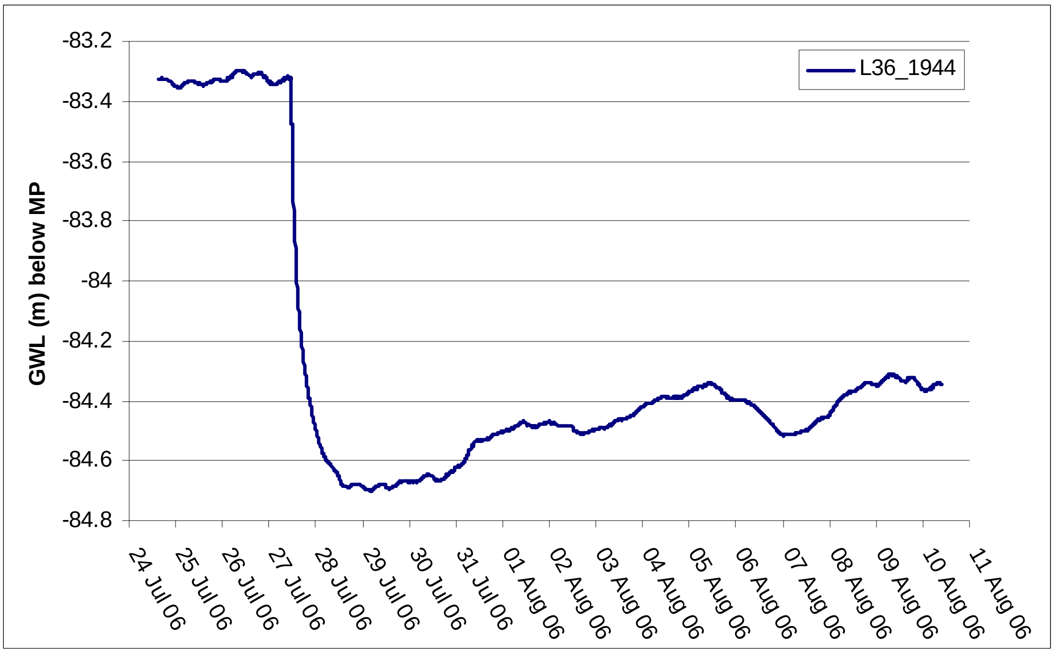

Figure 8: Plot of groundwater level in observation well L36/1944 throughout the constant rate discharge test. The data does not include barometric influences.

Well L36/1232 was located approximately 2.5 km from the pumping bore, and was pumped at regular intervals throughout the test period for domestic and stock water purposes (Figure 9). The degree to which this bore was affected by the pumping bore is unclear, even though some effect was apparent during the testing, many other factors may have affected changes in the groundwater level observed at this well (Figure 9). This well has therefore been omitted from further analysis.

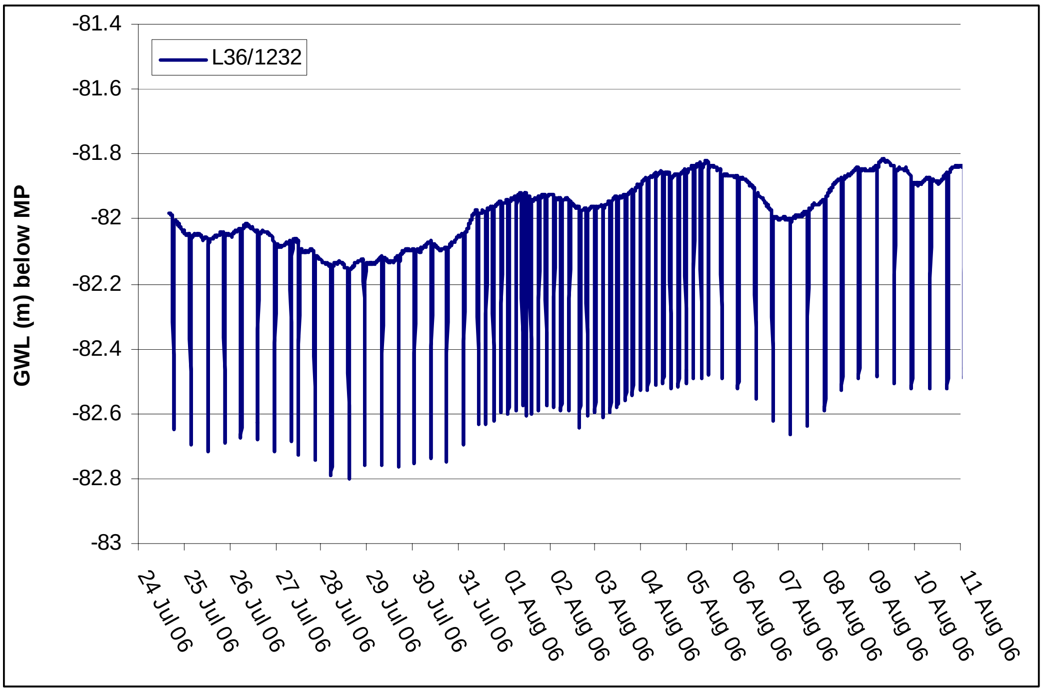

Figure 9: Plot of groundwater levels in furthest observation well L36/1232 throughout the constant rate discharge test. The data does not include barometric influences.

4.3 Data analyses

4.3.1 Barometric corrections

Ambient air pressure was monitored using a pressure transducer located in the pump shed adjacent to the pumping well, L36/1801. Ambient air (barometric) pressure changes throughout the course of the constant discharge test were measured up to 0.5 m, with several cycles of barometric change occurring throughout the testing period. A plot of barometric changes throughout the pumping test is shown in Figure 10. Barometric changes have been taken out of the groundwater monitoring records so that only changes in groundwater pressure are used in the analyses of data for the constant rate discharge test, and can be considered somewhat conservative. An attempt was made to determine the barometric efficiency of the wells or water bearing zones observed throughout the testing, however, the results were inconclusive. Barometric effects have been excluded from the groundwater level data collected using pressure transducers and manual measurements.

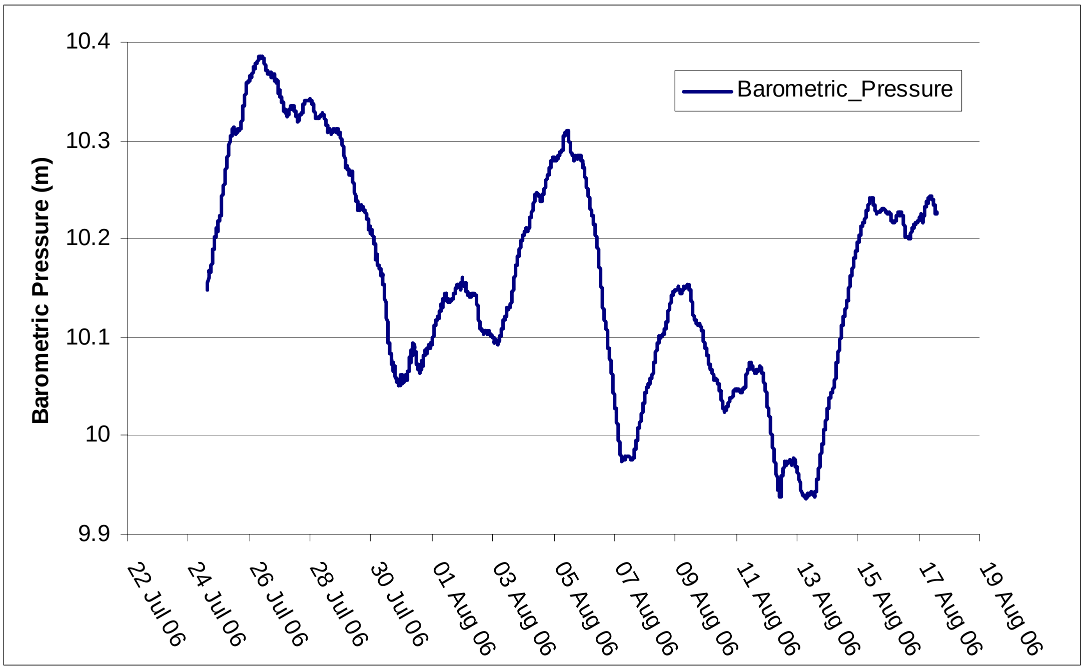

Figure 10: Plot of barometric pressure over throughout the constant rate discharge test.

4.3.2 Background trend in groundwater level

Throughout the duration of the test, upward background trends in groundwater levels were noted at monitoring wells K36/0494 (Figure 11), L36/1191 (Figure 12), and the pumping well L36/1801 Figure 13.

The data collected from the observation well L36/1944 was corrected using data from both of the background monitoring wells. Over the course of the test, water levels in wells K36/0494, L36/1191, and L36/1801 rose in total by approximately 0.32 m, 0.43 m and 0.78 m respectively from the start to finish of the test.

The trend measured at K36/0494 (Urrall) was deducted from the observation data however this was not sufficient to maintain overall drawdown over the longer time periods of the test data. Correction using data from well L36/1191 did correct the data from the latter part of the test so that overall drawdown is achieved. However, significant uncertainty is introduced by applying corrections of this sort, and makes any estimates of overlying leakage unreliable. The results of the correction using background monitoring sites at Urrall and Chertsey are shown in Figure 11 and Figure 12 respectively.

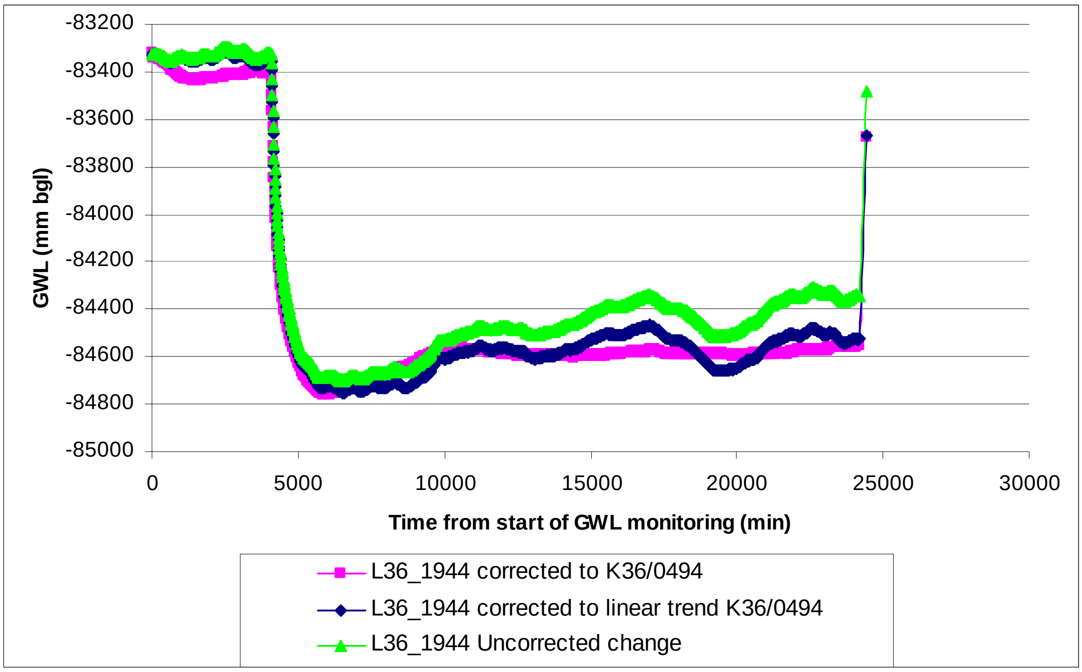

Figure 11: Plot of groundwater levels during the constant rate discharge test in well L36/1944. Corrections for background trends has been applied using concurrent GWL data from well the Urrall monitoring site, well K36/0494, and the linear trend in the GWL from K36/0494. The data does not include barometric influences.

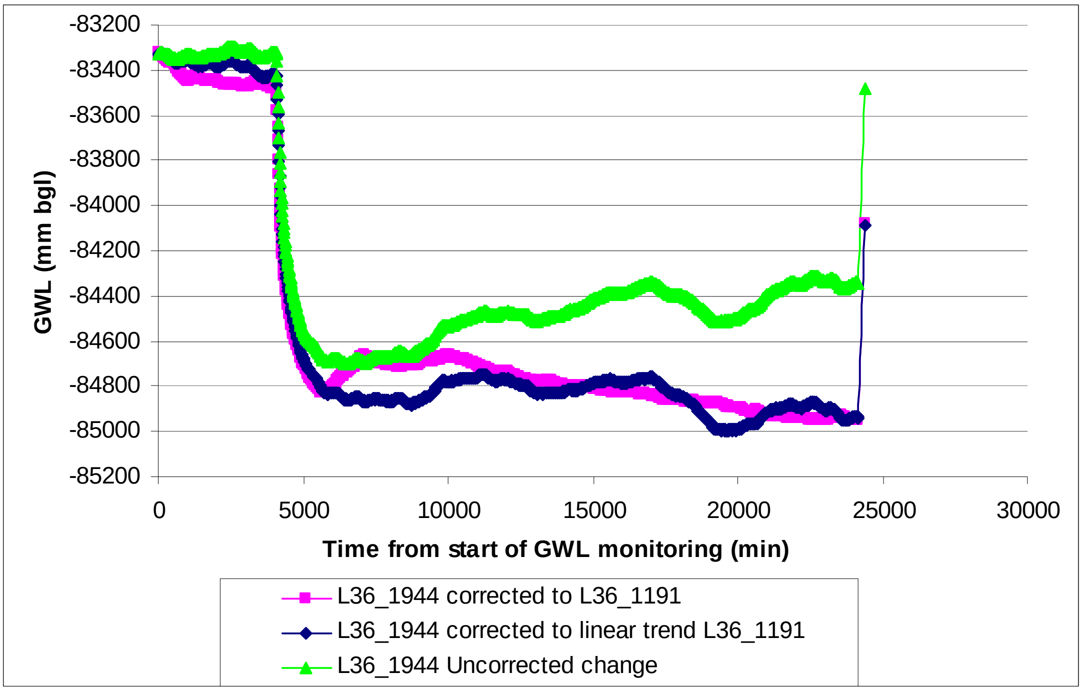

Figure 12: Plot of groundwater levels during the constant rate discharge test in well L36/1944. Corrections for background trends has been applied using concurrent GWL data from well the Urrall monitoring site, well L36/1191, and the linear trend in the GWL from L36/1191. The data does not include barometric influences.

Once the background corrections are applied to the data from L36/1944, the groundwater level record becomes straighter, which reflects the degree that background trends affected groundwater level fluctuations throughout the test period. However, the results of the correction are inconsistent depending on which background groundwater level record is used. Therefore the corrected data is considered very unreliable for use in inferring leakage values from this test.

Several manual measurements of the pumping well were made during the test. A plot of the groundwater levels within the pumping well L36/1801 is shown in Figure 13 below.

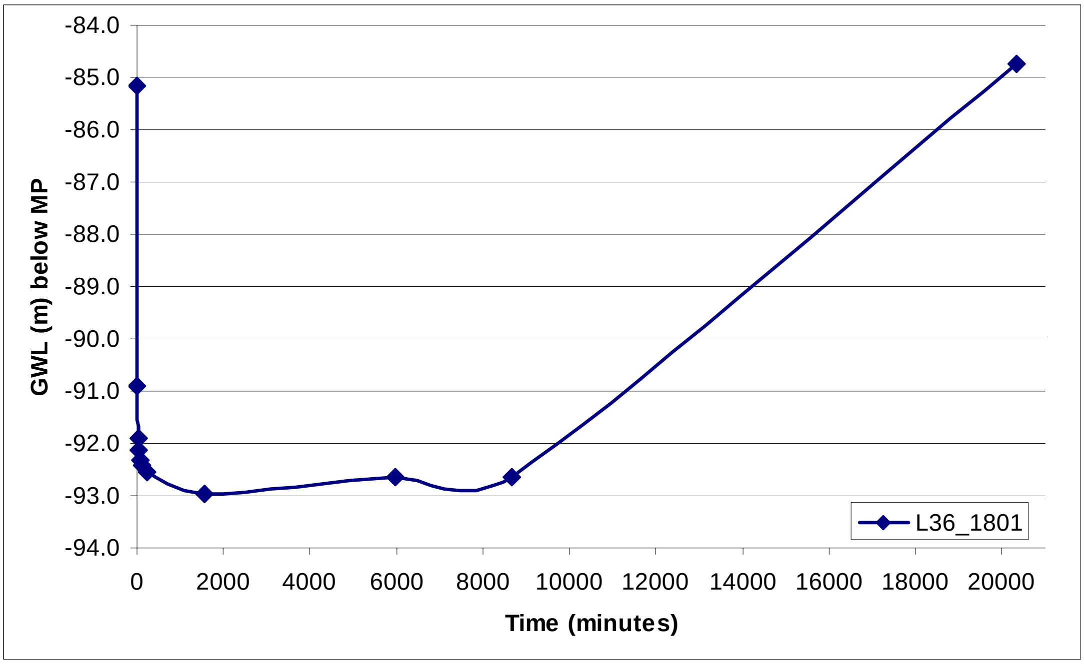

Figure 13: Plot of manual groundwater level measurements made in the pumping well, L36/1801. The data does not include barometric influences.

4.3.3 Analysis

Drawdown analysis
The drawdown data collected from observation well L36/1944 has been analysed using Function.xls (Hunt , 2003). As the geology and groundwater level data indicate leaky-confined conditions, the Theis, Hantush-Jacob and Boulton solutions were used to infer aquifer parameters including Transmissivity, Storativity and aquitard leakage (K'/B').

The uncorrected observation data from well L36/1944 was primarily used to infer Transmissivity and Storativity, and a conservative estimate of the leakage term. The analyses indicated a Transmissivity of 580 m^2/day, a Storativity of 0.0002 and a leakage (K'/B') of 0.00015 day^{-1}. The curve fits are shown in Figure 14 and Figure 15 below.

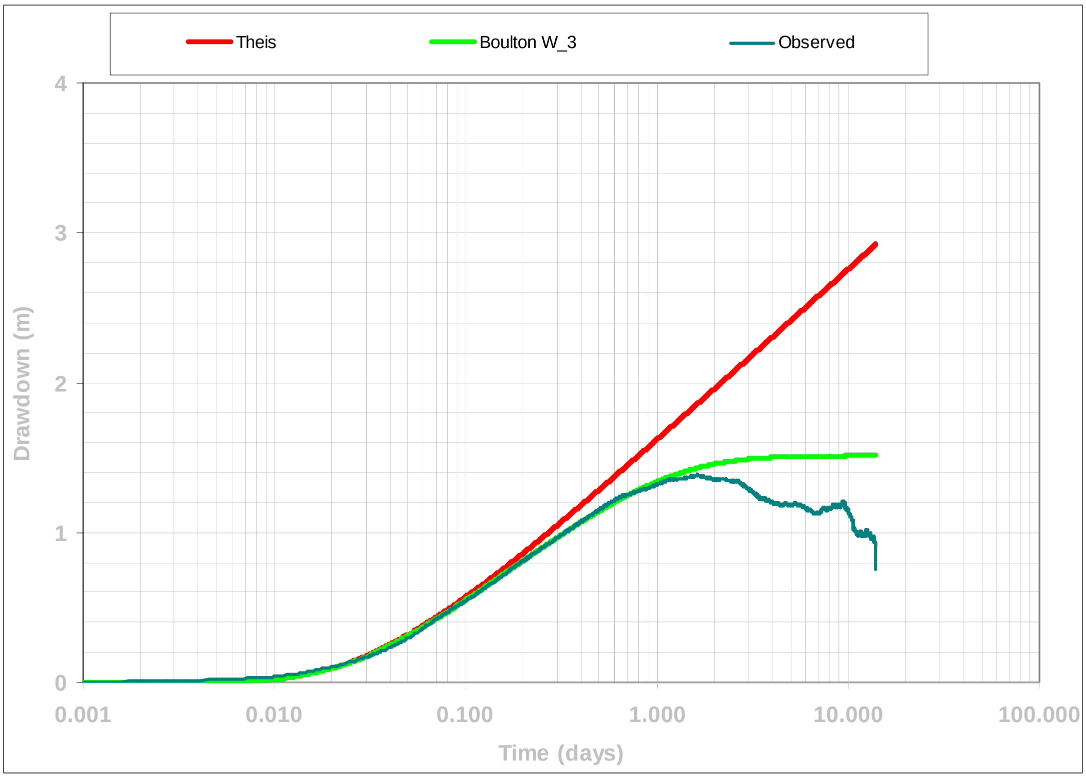

Figure 14: Plot showing observed drawdown and the curve match using the Boulton solution. Theis is shown for comparative purposes. The results show a Transmissivity of 580 m^2/day, Storativity of 0.0002, and leakage of (K/B') 0.00015 day^{-1}.

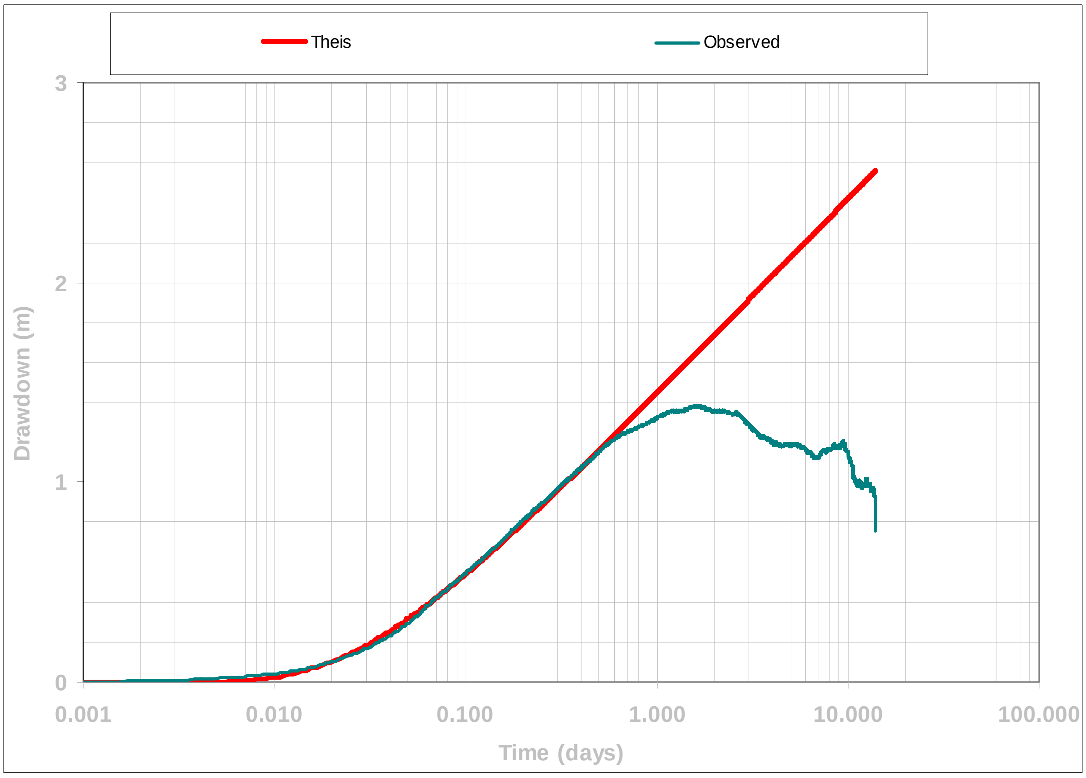

Figure 15: Plot showing observed drawdown and the curve match using the Theis solution only. The results show a Transmissivity of 680 m^2/day, and Storativity of 0.0002.

The data corrected to the Chertsey site (L36/1191) was also used to provide an indication of the possible range in leakage terms that could be derived from the test data. This indicated the leakage term (K'/B') derived by matching uncorrected data after approximately 1 day also fits using the data corrected to the Chertsey monitoring well L36/1191. The curve fit is shown in Figure 16 below.

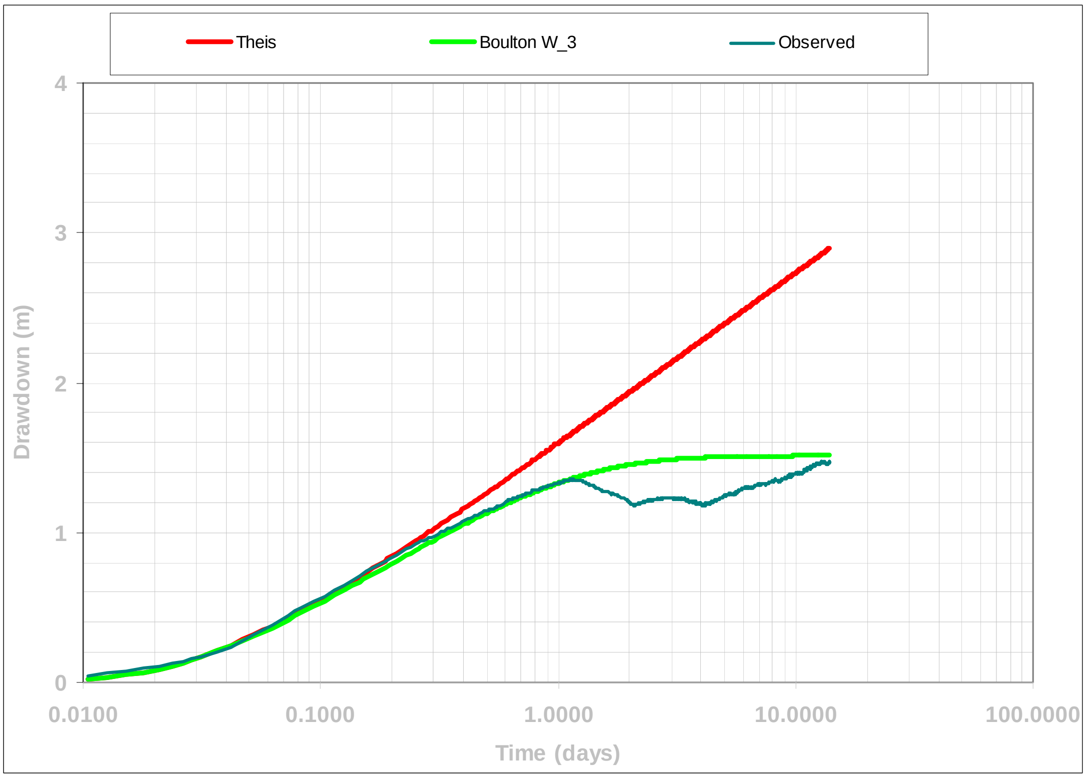

Figure 16: Plot showing observed drawdown (corrected using L36/1191) and the curve match using the Boulton solution. Theis is shown for comparative purposes. The results show a Transmissivity of 580 m^2/day, Storativity of 0.0002, and leakage of (K/B') 0.00015 day^{-1} (same as above).

Recovery analysis

The pressure transducer was removed from well L36/1944 prior to the cessation of pumping. Therefore recovery data was not monitored in this well.

5 Discussion and interpretation

Aquifer test results

The results of the pumping test reflect leaky confined aquifer conditions. The Transmissivity was lower than many other tests in the Ashburton Plains. It is likely that the measure of Transmissivity and Storativity are reasonably reliable given the close proximity of wells L36/1801 and L36/1944. The closeness of the wells means the hydraulic connection should be much better than wells spaced farther apart. The leakage value is not as reliable due to background trends in groundwater levels, however, the curve fits using uncorrected data and corrected data seem to correspond.

The aquifer parameters recommended for use in estimating aquifer responses to pumping in the vicinity of the wells used in this test are as follows:

- Transmissivity = 580 m^2/day;
- Storativity = 0.0002;
- Leakage (K'/B') = 0.00015 day^{-1} or Leakage = 1966 m
- Specific yield = 0.1.

The Transmissivity and Storativity have a high degree of certainty although the leakage term is less certain due to background trends in groundwater levels affecting drawdown throughout the later periods of the testing.

If estimates of aquifer behaviour are required without the leakage term (i.e. Theis) the Transmissivity could be increased to 680 m^2/day.

The influences of background groundwater variability has limited the overall success of this testing. Longer duration tests benefit from stable aquifer conditions, with the experience of this test showing that fluctuations in the aquifer system can be critical in measuring aquifer behaviour by long duration aquifer testing. Other sources of noise should be avoided where possible, including near background observation wells. In this case, localised interference effects with the Chertsey well (L36/1191) possibly limited the usefulness of this data when applying corrections to the drawdown data.

Acknowledgements

Many thanks to Ross Glubb and Bryan Todd for their assistance in setting up the test and liaising with different parties prior to, and during the aquifer testing.

I am very grateful to Steven and Freda Bierema for giving us permission to use the wells and the irrigation system, and assisting with the testing. Without this assistance the aquifer testing could not have proceeded.

6 References

Davey, G., 2004. Ashburton – Rakaia Plains Groundwater Flow Direction. Environment Canterbury Unpublished Technical Report U04/100.

Hunt, 2003. Function.xls. Department of Civil Engineering, University of Canterbury, Christchurch, New Zealand.

Saunders, R., 1996. The Ashburton – Rakaia Groundwater System. Environment Canterbury Unpublished Technical Report U96/20.

Scott, D., 2004. Groundwater Allocation Limit: land-based recharge estimates. Environment Canterbury Unpublished Technical Report U04/97.

7 Appendix A – Borelogs

Borelog for well L36/1801

Gridref: L36:21336-16421 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 148.4 +MSD
Driller : not known
Drill Method : Dual Rotary
Drill Depth : -192m Drill Date : 11/02/2005

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-0.20m	brown topsoil	
-10		- 10.0m	grey claybound gravels	
-20 to -60		- 60.0m	grey sandy gravels	
-70, -80		- 84.0m	grey claybound gravels	
-90 to -150		- 156.0m	brown/grey sandy gravels	
		- 159.0m	brown/grey sandy gravels/cobbles	
-160, -170		- 170.0m	grey sandy gravels/cobbles	
-180, -190		- 192.0m	brown/grey waterbearing gravels	

Borelog for well L36/1944

Gridref: L36:21569-15971 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 143.5 +MSD
Driller : Barber Drilling Pty Ltd
Drill Method : Dual Rotary
Drill Depth : -167m Drill Date : 29/01/2005

Environment Canterbury
Your regional council

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-0.20m	topsoil	
-10		- 26.0m	grey sandy gravels	
-20				
-30		- 48.0m	grey claybound gravels	
-40				
-50		- 92.0m	grey sandy gravels/cobbles	
-60				
-70				
-80				
-90		- 100.0m	brown & grey sandy gravels/cobbles	
-100		- 122.0m	brown & grey sandy gravels/cobbles	
-110				
-120		- 138.0m	brown & grey sandy gravels/cobbles	
-130				
-140		- 148.0m	brown & grey sandy gravels/cobbles	
-150		- 159.0m	brown & grey claybound gravels	
-160		- 167.0m	brown & grey waterbearing gravels	

Borelog for well L36/1232 page 1 of 2

Gridref: L36:21593-18974 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 154 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Rotary/Percussion
Drill Depth : -197.5m Drill Date : 27/03/1998

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-0.20m	Earth	
		-1.20m	Brown sand	
		-4.50m	Grey gravels	
-10		- 15.2m	Clay bound gravels	
-20		- 20.5m	Sandy gravels with clay	
-30, -40, -50, -60, -70, -80, -90		- 93.5m	Clay bound gravels	
		- 103.2m	Sandy gravels	

Borelog for well L36/1232 page 2 of 2

Gridref: L36:21593-18974 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 154 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Rotary/Percussion
Drill Depth : -197.5m Drill Date : 27/03/1998

Environment Canterbury
Your regional council

Scale(m): -100, -110, -120, -130, -140, -150, -160, -170, -180, -190

Depth(m)	Full Drillers Description	Formation Code
- 103.2m	Sandy gravels	
- 112.0m	Sandy gravels with clay	
- 115.0m	Claybound sandy gravels with clay	
- 117.0m	Sandy gravels with clay	
- 118.0m	Free stained sandy gravels	
- 124.0m	Sandy gravels with clay	
- 140.2m	Sandy gravels with clay	
- 153.5m	Small free gravels - some sand	
- 175.5m	Small sandy gravels	
- 179.0m	Small free gravels	
- 185.2m	Small free gravels and sand	
- 189.5m	Free stained gravels - some sand	
- 195.5m	Large free stained gravels	
- 197.0m	Large free stained gravels	
- 197.5m	Clay bound sandy gravels	

Water Level

Borelog for well L36/1191 page 1 of 3

Gridref: L36:22959-10053 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 117.79 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Cable Tool
Drill Depth : -204.7m Drill Date : 1/08/1998

Environment Canterbury
Your regional council

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-0.20m	Earth.	
		-6.50m	Sandy gravels.	
-10				
-20				
-30				
-40				
-50		- 50.0m	Claybound gravel.	
		- 59.4m	Yellow silty claybound Brown and Grey Gravel and sand	
-60		- 62.7m	Light Brown stained soft Yellow claybound sandy gravel	
	-64.15 HWL	- 66.8m	Brown and Grey sandy claybound gravel	
		- 72.4m	Grey sandy Yellow silty claybound gravel	

Borelog for well L36/1191 page 2 of 3

Gridref: L36:22959-10053 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 117.79 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Cable Tool
Drill Depth : -204.7m Drill Date : 1/08/1998

Environment Canterbury
Your regional council

Scale(m): -70, -80, -90, -100, -110, -120, -130

Water Level: -80.47 LWL

Depth(m)	Full Drillers Description	Formation Code
	Grey sandy Yellow silty claybound gravel	
- 72.4m	Light Brown stained soft Yellow claybound gravel	
- 74.0m	Grey and Brown sandy soft Yellow claybound gravel	
- 78.0m	Grey sandy soft Yellow claybound gravel	
- 82.3m	Rusty Brown stained Grey gravel with soft Yellow clay and some sand - Waterbearing lithology	
- 85.2m	White silty claybound Grey gravel sandy gravel	
- 86.4m	Light Brown and Grey sandy claybound gravel	
- 92.8m	Brown sandy Yellow claybound gravel	
- 97.5m	Darkish Brown Yellow claybound sandy gravel	
- 106.3m	Rusty Brown stained Brown soft Yellow claybound sandy gravel	
- 108.7m	Dark Brown stained soft Yellow claybound sandy gravel	
- 117.3m	Brown stained Brown silty Yellow claybound sandy gravel	
- 127.4m	Rusty Brown stained soft Yellow claybound gravel and sand	
- 129.4m	Soft Yellow claybound Grey gravel and sand	
- 131.7m	Rusty Brown stained soft Yellow claybound sandy gravel	
- 132.0m	Brown stained tight Yellow silty claybound sandy gravel	
- 133.6m	Large Brown and Grey gravel with trace of clay and sand - Waterbearing lithology	
- 135.9m		
- 140.8m	Light Brown stained soft Yellow claybound gravel with trace	

>> description did not fit on this page.

Borelog for well L36/1191

Gridref: L36:22959-10053 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 117.79 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Cable Tool
Drill Depth : -204.7m Drill Date : 1/08/1998

Environment Canterbury
Your regional council

Scale(m): -140, -150, -160, -170, -180, -190, -200

Depth(m)	Full Drillers Description	Formation Code
- 140.8m	Light Brown stained soft Yellow claybound gravel with trace of sand	
- 147.0m	Grey sandy gravel with soft Yellow clay	
- 148.2m	Grey sandy gravel with White soft clay	
- 149.5m	Dark Brown stained Grey gravel with silty Brown clay and sand	
- 150.7m	Dark Brown stained very soft White to Yellow claybound gravel with some sand - Waterbearing lithology (conducted a pump test at 150m depth, pumped @ 160gpm for 2 hours for 16.1m of drawdown)	
- 156.2m	Brown stained soft Yellow claybound sandy gravel - Waterbearing lithology	
- 160.8m	Grey sandy Yellow claybound gravel - slight Waterbearing (bailed in this lithology)	
- 161.7m	Light Brown silty Yellow cemented claybound sandy gravel	
- 171.3m	Dark Brown stained Or silty sandy claybound gravel	
- 175.8m	Light Brown and Grey sandy soft Yellow claybound gravel	
- 179.7m	Dark Brown Or silty claybound sandy gravel	
- 181.3m	Rusty Brown stained soft Yellow claybound gravel and sand	
- 183.2m	Dark Brown silty Or claybound sandy gravel	
- 187.5m	Brown hard silty sandy cemented Or claybound gravel and sand	
- 191.4m	Light Brown silty Yellow claybound sandy gravel	
- 194.0m	Dark Brown silty Yellow claybound sandy gravel	
- 194.3m	Tight small dark Brown stained Or claybound gravel	
- 195.8m	Light and dark stained Brown silty soft Yellow Brown claybound gravel	
- 199.7m	Brown sandy soft Yellow claybound gravel	
- 201.0m	Dark Brown Yellow claybound gravel with large amounts of clay - Waterbearing lithology	
- 204.7m	Dark Brown silty Or hard claybound gravel and sand (very hard driving)	

Borelog for well k36/0494 page 1 of 2

Gridref: K36:09221-20662 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 207 +MSD
Driller : Clemence Drilling Contractors
Drill Method : Dual Rotary
Drill Depth : -248m Drill Date : 28/02/2001

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-0.35m	Topsoil	
		-0.70m	Yellow clay	
		-3.00m	Sandy claybound gravel and silt	
-10, -20		- 24.0m	Silty gravel, sandy low clay	
-30		- 34.5m	Larger claybound gravel/boulders and silt	
		- 36.0m	Claybound gravel and yellow clay - soft formation	
-40, -50, -60		- 62.0m	Silty yellow clay, boulders and gravel	
-70, -80, -90, -100		- 101.0m	Medium gravel - loose formation	
	-104.15 HWL	- 108.0m	Silty gravel, orange clay and silt	
-110	-117.10 LWL	- 119.0m	Silty sandy loose medium/large gravel	
-120		- 127.6m	Claywashed gravel, seepage - waterbearing lenses	

Borelog for well k36/0494

Gridref: K36:09221-20662 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 207 +MSD
Driller : Clemence Drilling Contractors
Drill Method : Dual Rotary
Drill Depth : -248m Drill Date : 28/02/2001

Environment Canterbury
Your regional council

Depth(m)	Full Drillers Description	Formation Code
- 127.6m	Claywashed gravel, seepage - waterbearing lenses	
- 132.0m	Waterbearing gravel, medium/large flat gravel and light brown staining and sand. W/L -103.95m	
- 164.0m	Clay washed gravel, medium/large gravel - sandy	
- 168.0m	Larger claybound gravel - yellow clay lenses of waterbearing gravel. W/L -104.2m	
- 172.0m	Waterbearing gravel, sandy. W/L -104.57m	
- 174.0m	Waterbearing gravel, sandy larger gravel	
- 193.0m	Larger gravel, low fines	
- 194.5m	Loose medium/large waterbearing gravel - low clay content. W/L -110.83m. 200-350gpm	
- 206.0m	Larger tight gravel and silty sand	
- 206.8m	Waterbearing gravel loose, clean. W/L -110.83m. 200-300gpm	
- 213.0m	Tight clay washed gravel	
- 220.0m	Clay washed gravel, heavy clay - progressively more claybound	
- 224.0m	Clay washed gravel, silt and fines	
- 228.0m	Waterbearing gravel. W/L -110.83m. 100-200gpm	
- 231.0m	Loose waterbearing gravel, progressively better. 200-350gpm	
- 235.0m	Waterbearing lenses in plastic claybound gravel	
- 240.0m	Gravel with silty clay	
- 248.0m	Progressively tighter - more clay	

Scale(m): -130, -140, -150, -160, -170, -180, -190, -200, -210, -220, -230, -240

Water Level

Christchurch
58 Kilmore Street, PO Box 345, Christchurch

General enquiries: (03) 365-3828
Fax: (03) 365-3194

Customer services: (03) 353-9007
or: 0800 EC INFO (0800 324 636)

Timaru
75 Church Street, PO Box 550, Timaru

General enquiries: (03) 688-9069
Fax: (03) 688-9067

www.ecan.govt.nz