

PATTLE DELAMORE PARTNERS LTD
COASTAL AQUIFER INVESTIGATIONS REPORT:

Coastal Aquifer Investigations Report:

Smith Street Well

September 2006

∴ Prepared for
Waimakariri District Council

∴ October 2006

Executive Summary

The Waimakariri District Council is anticipating a significant increase in the demand for potable water supplies for Rangiora and the surrounding areas over the next 50 years. The peak daily demand is expected to increase from the current peak abstraction of 14,500 m³/day up to a future peak daily abstraction of 30,100 m³/day. The corresponding current average daily abstraction of 5,844 m³/day is expected to increase to 10 050 m³/day. This represents an approximate doubling of the 2003 usage by the year 2053.

Investigations have recently been carried out to assess the potential to use the Coastal Aquifer at Kaiapoi to supply this predicted future demand. These have included a step-drawdown test and a 3-day constant rate test in a new 154 m deep well (M35/11199) that has been installed on the parcel of land bordered by the Kaiapoi River Stop Bank, the Christchurch Northern Motorway and Smith St. This well has been installed as a potential supply well for Rangiora. In addition, water levels in the new Smith Street well and seven other wells have been continuously monitored over a period of 19 days. The purpose of these investigations has been to assess the potential yield of the Smith Street well and to investigate potential interference effects between this well and the existing Kaiapoi supply wells.

This report details the analyses of the test data and the interpretations and predictions made from these analyses. A recommendation on the number of and locations of future Rangiora supply wells is also provided.

In summary, the analysis of the data indicates that well M35/11199 should be able to sustain a long-term pumping rate of 70 L/s. Based on the water level monitoring data, it can be concluded that the pumping from the Smith Street well and any future wells drilled in the same aquifer will not have any direct impact on the operation of the existing Kaiapoi supply wells. A well interference assessment has indicated that four additional wells installed on the parcel of land bordered by the Kaiapoi River Stop Bank, the Christchurch Northern Motorway and Smith St would have the potential to supply Rangiora's predicted 2053 water demand of 30,100 m³/day. In order to minimise drawdown interference between the wells, the maximum separation of around 196 m between the wells that can be achieved within the available land parcel should be utilised.

Table of Contents

SECTION	PAGE
Executive Summary	ii
1.0 Introduction	1
2.0 Background Monitoring	2
2.1 Testing Procedure	2
2.2 Tidal fluctuations	3
2.3 Barometric changes	3
2.4 Interference Effects	4
3.0 Constant Rate Test in New Deep Rangiora Well	5
3.1 Testing Procedure	5
3.2 Well Response	5
3.3 Analysis	6
4.0 Step-Test in New Deep Rangiora Well	8
4.1 Testing Procedure	8
4.2 Well Response	8
4.3 Analysis	8
5.0 Water Quality	12
6.0 Additional Well Requirements	12
6.1 Predicted Rangiora Water Demand	12
6.2 Number and locations of additional wells	12
6.3 Potential Interference Effects	13
7.0 Summary	14
8.0 Recommendations	14
9.0 References	15

Appendices

Appendix A: Figures

Figure 1: Monitoring Wells

Figure 2: Water levels in 8 Kaiapoi Wells during 19 day Monitoring Period

Figure 3: A comparison between the water level records and the barometric data

Figure 4: Artesian pressure in Smith Street well (M35/11199) during constant-rate drawdown test (recorded with a data logger)

Figure 5: Jacob analysis of recorded data on Smith Street well (M35.11199) for constant-rate drawdown test

Figure 6: Jacob analysis of manual data on Smith Street well (M35.11199) for constant-rate drawdown test

Figure 7: Theis recovery analysis on Smith Street well (M35.11199) for constant-rate drawdown test

Figure 8: Artesian pressure in Smith Street well (M35/11199) during step-drawdown test (recorded with a data logger)

Figure 9: Manually Recorded Drawdowns and Drawdowns Predicted with J-step

Figure 10: Predicted Drawdowns for 3 days and 365 days of Pumping

Figure 11: Well and Aquifer Losses after 3 days of Pumping

Figure 12: Wells in theoretical well field

Appendix B: Tables

Table 1: Monitoring Well Details

Table 2: Summary of step-drawdown test data

Table 3: Predicted Interference Effects for Theoretical Well Field at 1 year of Pumping at the Average Pumping Rate

Table 4: Predicted Interference Effects for Theoretical Well Field at 1 day of pumping at Peak Daily Rate

Appendix C: Bore Logs and Well Cards

Appendix D: Test Data

1.0 Introduction

This report has been prepared at the request of the Waimakariri District Council (WDC) and provides advice on the potential to utilise the groundwater resources in the Coastal Aquifer for future water supply to Rangiora Township. The intention of WDC is to find sufficient groundwater resources to supply up to 30,100 m³/day to Rangiora..

To evaluate the potential of the resource, two aquifer pumping tests have been carried out in the coastal confined aquifer at Kaiapoi during August and September 2006 in addition to background water level monitoring of selected wells.

The aquifer tests were carried out following the drilling and installation of a new 300 mm diameter, 154.4 m deep well screened in the coastal aquifer at Smith Street, Kaiapoi. The well is owned by WDC and is intended as a potential supply well for Rangiora. Additional wells will also be required to achieve the desired 30,100 m³/day to supply the township.

This report assesses the potential yield that can be expected from the Smith Street well and also addresses several other related issues including:

- The number of additional wells required to achieve a 30,100 m³/day (348 L/s) supply together with advice on suitable locations for these wells;
- Interference effects on existing Kaiapoi wells created from pumping of the Smith Street well as well as pumping of additional wells;
- Interference effects on the Smith Street well and each of the proposed additional wells created from their collective pumping.

The advice contained in this report is based on the interpretation of background water level monitoring that has been undertaken by WDC and Clemence Drilling contractors in a total of eight wells in the coastal aquifer at Kaiapoi together with the results and subsequent interpretation of a step-drawdown test and a constant-rate drawdown test performed on the newly installed Smith Street well.

2.0 Background Monitoring

2.1 Testing Procedure

Water levels in eight deep wells in the coastal confined aquifer at Kaiapoi were monitored over a 19 day period between the 28th August and 15th September 2006. The eight wells that were monitored included six Kaiapoi supply wells, the Smith Street well (M35/11199) and a well owned by Mr John Shivas (M35/0788). Details of these wells are presented in Table 1 and their locations are plotted in Figure 1. The recorded water levels for each of the wells are presented in metres above sea level (mamsl) in Figure 2.

The main purpose of this monitoring was to investigate whether a hydraulic connection exists between the aquifers that the eight wells draw from, and if so, to identify the magnitude of interference effects between the wells. Three of the wells were pumped over the period - the Smith Street well and the existing Kaiapoi supply wells at Darnley Sq and Sewell St. The Darnley Sq and Sewell St wells were the only wells of the six Kaiapoi supply wells that were pumped over the period for public supply purposes. The Darnley Sq Well was pumped when required for supply purposes for up to several hours at a time at a rate averaging 68 L/s for each pumping cycle. The Sewell St Well was only used three times over the monitoring period on the 2nd, 9th and 10th of September for several hours each time to supply water during peak demand. The Smith Street well was test pumped for 3 days at a constant rate of 70 L/s from the 6th to the 9th of September.

Prior to the interpretation several anomalies were noted in the recorded data which can be observed in Figure 2. The data logger on the Sewell St Well appears to have been misrecording from the 28th of August to the 4th of September and from the 9th of September through to the end of the monitoring period on the 15th September. For this reason this data has been disregarded and only the data recorded between the 4th and the 9th of September has been used for interpretation and analysis. The reason for this anomalous data is not known.

The second anomaly concerns the data recorded by the data logger on the well at Darnley Sq. This data logger indicated that the pressure in the well increased during pumping and subsequently decreased during each recovery period, which is the opposite of what would be expected. Discussions with Gary Boot of WDC revealed that the reason for the reversal in pressure readings at the Darnley Sq well was due to the data logger being positioned on the discharge side of the pump. It was also noted that the piezometric pressure in the Darnley Sq well appears to be several metres higher than the pressure in the other Kaiapoi supply wells which can also be explained as resulting from the data logger being installed downstream of the pump. For this reason, piezometric levels and the recorded drawdown during pumping from the data logger on the Darnley Sq Well have not been used in any interpretation or analysis. However, the record from the data logger did prove to be useful in determining the times during which the well was pumping.

A third anomaly was also noted concerning the data logger on the Porter PI Well which did not record water levels over the entire monitoring period.

Ignoring the anomalous readings from the Sewell St Well, the Darnley Sq Well and the Porter PI Well described above it can be seen in Figure 2 that the piezometric pressure varies between wells. The recorded pressures in the Sewell St Well and the Rugby Park Well are similar and are the lowest of all the wells. By comparing the pressures in the Kaiapoi supply wells and John Shivas' Well with the locations of the wells shown on Figure 1, it is clear that the piezometric pressure decreases in an easterly direction towards the coast, indicating that the groundwater flow direction is eastwards.

2.2 Tidal fluctuations

Confined aquifers located near to the coast often show evidence of tidal loading caused by the weight of seawater placing a load over the top of the low permeability layers that confine the aquifer.

The influence of tidal fluctuations can be seen clearly in the record of water levels shown in Figure 2. A 12 hour cyclic pattern can be observed between peaks and troughs in the water level data for most of the monitored wells; however the pattern is most evident in the data recorded from the Porter PI, Ashley PI and Peraki Street supply wells as well as the John Shivas' Well. The tidal influence can also be seen in the data from the Sewell St and Rugby Park wells, but is less distinguishable as a result of the drawdown effects that appear in this data which are created by pumping of the Darnley Sq Well.

There appears to be some tidal influence on the Smith Street well however most of the data for this well was recorded during the period of the step-drawdown test and the constant-rate drawdown test and therefore any tidal influences are more difficult to see within the data. A cyclic pattern can be seen in the water level record for this well following the step-drawdown test but it is clearly also being affected by other influences such as barometric pressure changes. A search of Environment Canterbury's GIS database indicates that there are no other bores in the Kaiapoi area that are screened within the same aquifer and therefore it seems unlikely that the fluctuations are a result of pumping from other wells screened in the same aquifer.

The tidal effects generally result in water level fluctuations in the order of 0.2-0.4 m in the wells.

2.3 Barometric changes

A comparison between the water level records and the barometric data collected from the 5th of September until the end of the monitoring period indicates that the aquifers are responding to barometric changes as shown on Figure 3, however this correlation is not overly clear due to the more pronounced tidal fluctuations. The range in barometric pressures over the monitoring period was 0.24 m, which is generally less than the magnitude of water level changes due to the tidal effects. This makes it difficult to assess the magnitude of changes in water level that can be attributed to barometric pressure changes. In general, changes in water levels due to barometric pressure changes are 20 to 75% of the change in barometric pressure. The ratio of the change in aquifer pressures to barometric pressure changes is known as the barometric efficiency.

2.4 Interference Effects

The Smith Street well is located at a similar distance from the coast as the wells that supply the Peraki St headworks (the Peraki St Well, the Porter PI Well and the Ashley PI Well). It can be clearly seen in Figure 2 that the piezometric pressure in the Smith Street well is much higher than the Peraki St supply wells (it is approximately 3 m higher than the pressure in Ashley PI). This indicates that the aquifer that Smith Street well is screened in is hydraulically separated from the aquifer utilised for the Kaiapoi supply wells by low permeability confining layers. This conclusion is supported by the bore well log for well which is presented in Appendix B. The deepest of the Kaiapoi supply wells is the well at Porter PI (M35/0834), which is screened from 130 to 136.2 metres below ground level (mbgl). The Smith Street well is screened from 147.7 to 149.7 mbgl. The log for the Smith Street well reveals the presence of a 3.6 m thick layer of hard silty grey pug between 136.4 and 140 mbgl, followed by a hard dry peat layer between 140 and 141 mbgl, which overlies 3.5 m of claybound gravel.

Figure 2 illustrates that there was no observable response in the Kaiapoi supply wells and John Shivas' Well during the 3 day constant-rate pumping test in the Smith Street well. In addition, there was no discernible response to the pumping from the Darnley Sq Well in the data from the Smith Street well. The wells that had the greatest response to the pumping from the Darnley Sq Well were the Sewell St and the Rugby Park wells, which drew down approximately 0.2-0.3 m during most pumping cycles. There was a small response to the pumping from the Darnley Sq Well in the wells at the Peraki St headworks and John Shivas' Well of approximately 0.05 m for each pumping cycle.

Based on several factors it is apparent that the Smith Street well is screened in a different aquifer than the Kaiapoi supply wells. The factors include: the lack of interference effects between the Smith Street well and the other wells, the differences in static water levels between them and the geological evidence for low permeability materials separating the screen zones. It can be concluded that the pumping from the Smith Street well and any future wells in the same aquifer will not have any direct impact on the operation of the existing Kaiapoi supply wells.

3.0 Constant Rate Test in Smith Street Well

3.1 Testing Procedure

A constant-rate pumping test was performed on the Smith Street well to evaluate the hydraulic connection between the Smith Street well and the six Kaiapoi supply wells as well as the John Shivas' Well. The test also enabled a value to be calculated for the transmissivity (T) of the screened aquifer.

The constant-rate test was performed by Clemence Drilling Contractors over a period of 3 days from the 6th to the 9th of September at a constant rate of 70 L/s. The test pumping involved setting the valve size on the pump outlet to a size that would permit a constant artesian flow from the well of 70 L/s. The pumping rate was continuously monitored over the course of the test and the records indicate that it remained at 70 L/s over the entire test.

A pressure transducer had been previously installed on the pumped well and also on seven other deep wells in the area including six Kaiapoi supply wells and the John Shivas' Well as detailed in Section 2.1. These seven wells were intended to be used as observation wells to measure drawdown and subsequent recovery at distance from the pumped well. The artesian pressure was also measured manually in the pumped well at hourly intervals by way of a standpipe connected to the pipework discharging the water from the well.

3.2 Well Response

As outlined in Section 2.4, Figure 2 illustrates that there was no observable response in the Kaiapoi supply wells and John Shivas' Well during the 3 day constant-rate pumping test in the Smith Street well.

The drawdown in the Smith Street well created during the constant rate test can be clearly seen in Figure 2. Both the recorded and manual data show the pressure in the well to have effectively stabilised after a pumping period of approximately 3 hours (Figure 4) however small incremental increases in drawdown can be observed in the manual data up to approximately 28 hours into the test. For unknown reasons the manually measured drawdown varies from the recorded drawdown and at a given time period into the test is larger by up to 0.37 m. The maximum drawdown taken from the recorded data from the Smith Street well over the period of the constant rate test was 6.48 m whereas the maximum drawdown measured manually was 6.67 m. We have discussed these discrepancies in the measurements with Tony Smith of Clemence Drilling Contractors and the following two factors were identified that could have potentially influenced the data. It seems that the reference points in meters above ground level for both the location of the pressure transducer and also the manual measuring datum were determined with a tape measure as opposed to being surveyed locations. In addition Tony Smith mentioned that the water level as measured manually in the standpipe was prone to pulsing and he mentioned that discrepancies of up to 0.1 m were therefore possible in the manual

readings. Both of these factors have the potential to cause differences between the recorded and manual data sets. It should be noted however that the manual and recorded data collected during the step-drawdown test that was undertaken on the Smith Street well were a very good match.

Fluctuations in pressure in the order of 0.2 m can be clearly seen in the recorded data during the constant rate test. The driller's record shows the pumping rate remained constant over the entire period of the test and therefore these fluctuations are attributed to barometric and tidal influences. The barometric pressure varied by up to approximately 0.08 m over the course of the test, however as discussed in Section 2.3 it is difficult to quantify the subsequent influence on water pressure in the aquifer. In addition it is considered that the magnitude of the barometric changes would not significantly affect the analysis of the test data. A closer inspection of the pressure fluctuations reveals a 12 hourly cyclic pattern and therefore most of the variation is considered to be from a tidal influence. For unknown reasons the manual data does not show any evidence of pressure fluctuations.

3.3 Analysis

As there was no observable response in the six Kaiapoi supply wells as well as the John Shivas' Well from pumping of the Smith Street well, only the data from the pumped well could be used to calculate the hydraulic properties of the screened aquifer. Therefore a Jacob straight-line analysis has been used on the data from the pumped well to calculate values for the transmissivity of the aquifer.

The Jacob straight-line method involves plotting the drawdown measured in the well against the corresponding time, where the time interval is plotted on a logarithmic scale. A straight line can then be fitted through the plotted points. The slope of the line gives a value for the term Δs which can then be used in the following equation to calculate the transmissivity (T).

$$T = \frac{2.30Q}{4\pi\Delta s}$$

Where: Δs is the drawdown difference per log cycle of time (in m)

Q is the pumping rate (in m³/day)

Figure 5 and Figure 6 show drawdown plotted against the log of time for the transducer and manual data respectively. In the case of the recorded data a fit through the early time data was used due to the fluctuations of the late time data. The early data also gives a more conservative estimate for the transmissivity which was calculated as 3,526 m²/day. The transmissivity value calculated from the full manual data set was 6100 m²/day.

The recovery water pressure data recorded in the Smith Street well following the completion of the constant rate test allowed an additional transmissivity value to be calculated by using the Theis recovery method. The residual drawdown (s') in the well is plotted against the log of t/t' which is the time since the start of pumping divided by the

time since the cessation of pumping. As for the Jacob straight-line method a straight line is fitted through the plotted points where the slope of the line gives a value for the term $\Delta s'$. The following equation is near identical to that used for the Jacob analysis with the only change being the substitution of Δs with $\Delta s'$.

$$T = \frac{2.30Q}{4\pi\Delta s'}$$

Where: $\Delta s'$ is the residual drawdown difference per log cycle of time (in m)

Figure 7 shows the residual drawdown plotted against t/t' for the recorded data. The recovery of pressure in the Smith Street well was not manually measured. A straight line fitted through the early time data (where higher values of t/t' represent earlier units of time) gave the best transmissivity value which was calculated as 3,916 m²/day.

D
R
A
F
T

4.0 Step-Test in Smith Street Well

4.1 Testing Procedure

A step-drawdown pumping test was conducted on the Smith Street well by Clemence Drilling Contractors to assess the potential yield that can be expected from the well and also to determine the well's efficiency.

The step-drawdown test was performed on the 5th of September over a period of 4 hours. The testing procedure involved allowing the well to free flow at rates of 45 L/s, 60 L/s, 75 L/s and 78 L/s in consecutive 60 minute long steps. It was initially intended that the 4th step would have been discharging at a rate of 90 L/s, however, due to concerns from the drilling contractor on the potential for sand to be drawn into the well, a lower rate was adopted.

As for the constant rate test the desired flow rate was achieved by controlling the natural artesian flow from the pump outlet. Water pressure was measured by both the pressure transducer installed on the well and also by manual standpipe readings of the artesian head.

4.2 Well Response

A summary of the manual test results is presented in Table 2. The manual and recorded data were a good match as can be seen in Figure 8 which shows the recorded and manual water levels measured in the well during the test. The water levels in the well can be clearly seen to rapidly drop at the beginning of a step, approach stable levels and then rapidly drop once more when the pumping rate is increased at the beginning of the following step.

The maximum drawdown calculated from both the manual and recorded data sets is in the order of 7.3 m. At the end of the first step the pressure measured in the well had stabilised and at the end of the subsequent steps the pressure was close to stable levels.

As for the constant rate test there was no detectable pressure response in any of the six Kaiapoi supply wells or the John Shivas' Well during the step-drawdown test and there is not considered to be any direct hydraulic connection between the aquifers.

4.3 Analysis

The J-step computer program was used to analyse the step-test data. The J-step analysis method was used over the manual Biershenk and Wilson method as the Biershenk and Wilson method requires that the water levels have completely stabilised at the end of each step which was not entirely valid for the last three steps of the test.

The J-step program could not be used on the recorded data as the software does not cope with negative changes in drawdown, which occurred due to fluctuations in the water levels. In addition due to the small increase in discharge between the third and fourth

steps, J-step did not recognise the separate steps and instead analysed the data as one longer third step.

The measured and modelled drawdowns for the manual step drawdown test carried out in the Smith Street well are shown in Figure 9. It can be seen that the predicted drawdowns are a good match with the measured drawdowns and therefore the analysis based on a longer third step does not seem to adversely affect the analysis.

The modelled drawdowns were fitted to the measured data using the following equation:

$$s_w = (a + b \log t)Q + CQ^2 + k$$

Where: s_w is the drawdown in the pumped well (in metres)

a is the inertia aquifer loss parameter

b is the time dependent aquifer loss parameter

t is the duration of the pumping period (in minutes)

Q is the pumping rate (in m³/min)

C is the turbulent head loss coefficient

k is a correction factor

From the analysis, the following values for the specific parameters describing the aquifer and well characteristics as described above were determined.

Parameter	Value	Units
a	0.81	min/m²
b	0.076	min/m²
C	0.12	min²/m⁵
K	0.12	m

These parameter values gave the resulting equation:

$$s_w = (0.81 + 0.076 \log(t))Q + 0.12 Q^2 + 0.12$$

This equation was used to create graphs of drawdown as a function of pumping rate for a fixed duration of pumping. The graphs are based on the assumption that the Theis equation is applicable and that the pumped aquifer is laterally extensive. Figure 10 shows the drawdown as a function of the pumping rate with the predicted drawdown shown for pumping periods of 3 days and 365 days.

To calculate the available drawdown in the well, the difference between the lowest expected water level and the depth to the top of the pumping system can be calculated. There has been no long term water level monitoring in deeper aquifers in the area so it is difficult to assess the lowest expected water level. The static water level measured manually prior to the test was 9.12 m above ground level. Based on that measurement, the following comments on available drawdown can be made:

D
R
A
F
T

- Under free-flow conditions of 70 L/s an available drawdown of around 7 m was required;
- A surface pump can lift water from a depth of around 6 m, giving an available drawdown of around 15 m;
- A deep submersible pump could be placed just above the well screen, giving an available drawdown of over 100 m.

It can be seen from Figure 10 that pumping for 365 days at a rate of 90 L/s would produce a drawdown in the well in the order of 10.5 m. It is therefore clear that the available drawdown is not the limiting factor in determining the potential pumping rate for the well. The step drawdown analysis indicates that the well should be capable of supplying a continuous artesian flow of 70 L/s, provided that background water pressures remain at 9 m above ground level at the well. This prediction does not incorporate the potential well interference effects from any future wells drilled at this site to supply the additional water required for the Rangiora water supply which could potentially decrease the available drawdown in the well. This drawdown interference is discussed in section 5.0 of this report.

The total drawdown in the well consists of turbulent head losses within the well casing and linear head losses within the aquifer. Figure 11 is a plot of the well losses and aquifer losses after 3 days of pumping as calculated from the step-drawdown test. The analysis indicates that well losses are less than 50% of the total drawdown, which suggests that the well has been developed to a reasonable standard. It is understood that Clemence Drilling are planning to redevelop the well to prevent sands entering the well, which occurred when the flow from the well was increased to 90 L/s. It is expected that this development process will determine the maximum yield for this well.

An approximate transmissivity of the pumped aquifer was derived from the step-test data using the following equation.

$$T = \frac{2.30}{4\pi b}$$

The calculated value for the transmissivity was 3,455 m²/day. In addition the Jacob straight-line method was used to analyse both the manual and recorded data from the first step of the step-drawdown test. The resulting values for the transmissivity were calculated as 2,740 m²/day and 2,700 m²/day for the manual and recorded data respectively.

As discussed previously the test was undertaken by controlling the rate at which the water flowed freely under artesian pressure from the well. The predictions made from the step-test data are only applicable to the flow from this well if it is operated in this way. If a surface pump or a submersible pump is used to abstract the water, the well losses will be different which may result in different yield-drawdown characteristics. If the well is developed to a standard such that the potential for sand to enter the well is reduced, the large available drawdown in the well indicates that the well could be capable of sustaining

a much larger pumping rate if a surface pump or a submersible pump were used. However, the yield of the well would need to be reconfirmed through a step-drawdown test using these pumps. It is likely that the maximum yield will be determined by the limit at which a flow of sand-free water can be abstracted, rather than a drawdown limitation.

D
R
A
F
T

5.0 Water Quality

The WDC have supplied us with the results of a water quality analysis carried out by the ECan laboratory. The results indicate that the water quality is generally very good and will be suitable to be used for public water supply purposes without treatment. In general, all the determinands were found to be at concentrations well below the Maximum Allowable Values (MAVs) and Guideline Values (GVs) in the Drinking-Water Standards for New Zealand 2005. The iron concentrations were found to be at half the Guideline Value. If the iron concentrations exceeded the guideline value they could cause some discolouration in areas of water use. During the next pumping test that is carried out in the deep aquifer, repeat analyses should be undertaken at the start and end of the pumping period to check for any change in iron concentration. The laboratory report is included in Appendix D.

6.0 Additional Well Requirements

6.1 Predicted Rangiora Water Demand

The WDC anticipates a significant increase in the demand for potable water supplies for Rangiora and the surrounding areas over the next 50 years. The peak daily demand is expected to increase from the current peak abstraction of 14,500 m³/day up to a future peak daily abstraction of 30,100 m³/day (348 L/s). The corresponding current average daily abstraction of 5,844 m³/day is expected to increase to 10,050 m³/day.

The potential to source the entire future required supply from a well field located within the triangular parcel of land bordered by Smith St, the Kaiapoi River Stop Bank and the Christchurch Northern Motorway has been investigated through well interference modelling. This is detailed in this section of the report. Such a source of supply should meet the criteria of a secure drinking water source and minimise water treatment requirements as defined in the Drinking Water Standards for New Zealand (2005).

6.2 Number and locations of additional wells

The modelling was carried out for a theoretical well field consisting of the Smith Street well and four additional wells. A total of four additional wells have been chosen to maximise the potential for the wells to be used as free-flowing artesian wells. Less wells may be required if pumps are installed on all the wells.

The locations of these theoretical wells were chosen to minimise well inference effects by maximising the spacing between the wells. The locations of the Smith Street well and four theoretical wells are illustrated in Figure 12. This achieves a minimum separation distance of 196 metres between each of the wells.

6.3 Potential Interference Effects

The Theis (1935) solution for a confined aquifer was used for the assessment based on an aquifer transmissivity of 2700 m²/day. This transmissivity value was the lowest of the values obtained from the J-Step analysis of the Smith Street well step-drawdown test data, the Jacob analysis of the first step of the step-drawdown test, and the Jacob and Theis Recovery analyses of the constant rate test data. The lowest transmissivity estimate was used as this produced the greatest well interference effects, and hence enabled a conservative assessment to be made. The predicted drawdown at the Smith Street well for a pumping rate of 70 L/s was compared to the drawdown measured during the constant-rate test in this well to assess whether the parameters used for the assessment were reasonable.

The four theoretical wells were assumed to have the same well performance characteristics and screened depths as the Smith Street well (M35/11199). The aquifer storativity was set to a conservatively low value for a confined aquifer (10⁻⁵) and it was assumed that there will be no leakage through the aquifer confining layers.

The interference assessment indicated that for the 50 year predicted average demand for Rangiora of 10,500 m³/day (122 L/s), that the maximum drawdown (including self-induced drawdown) in one of the production wells could reach 5.2 m after 365 days of pumping. This indicates that the wells may be able to be operated using the natural free-flowing artesian pressure in this aquifer (assuming that it remains at or about 9 m above ground level). The predicted drawdown for all wells for the average pumping rate is summarised in Table 3, Appendix B.

For the peak daily demand of 30,100 m³/day (348 L/s), the maximum drawdown (including self-induced drawdown) in one of the production wells was predicted to be 13.4 m after 1 day of pumping at the peak daily rate. This suggests that the wells may need to be pumped as the water levels in the wells are predicted to drop to below ground level. The predicted drawdown for the peak pumping rate is summarised in Table 4, Appendix B.

This assessment has been carried out using an estimated transmissivity and storativity, therefore the flow and drawdown values reported must be viewed as estimates only. If and when additional wells are installed at this site, it will be important to repeat the 3 day constant-rate test in each of the wells and use the surrounding wells as observation wells to enable more accurate values of transmissivity and storativity to be determined.

Based on the assessment, it is feasible for any future Rangiora water supply wells to be located within the Council owned triangle of land at Smith St. As a general rule, it is best for the wells to be located as far apart as possible to minimise well interference effects. However, if deep submersible well pumps are to be used then a closer separation distance can be tolerated.

7.0 Summary

The analysis of the step-drawdown test carried out in well M35/11199 indicates that it should be able to sustain a long-term pumping rate of 70 L/s, provided background aquifer pressures remain at or about 9 m above ground level. If the well is developed to a standard such that the potential for sand to enter the well is reduced, the large available drawdown in the well indicates that the well could be capable of sustaining a larger pumping rate if a surface pump or a submersible pump were used. It is likely that the maximum yield of this well will be determined by the limit at which a flow of sand-free water can be abstracted, rather than a drawdown limitation.

The water level monitoring carried out in eight wells over a 19 day period indicates that the Smith Street well is screened in a different aquifer than the Kaiapoi supply wells. The reasons for this conclusion are the lack of interference effects between the Smith Street well and the other wells, the differences in static water levels between them and the geological evidence for low permeability materials separating the screen zones. Based on this information it can be concluded that the pumping from the Smith Street well and any future wells located in the same aquifer will not have any direct impact on the operation of the existing Kaiapoi supply wells.

A well interference assessment has indicated that four additional wells installed on the parcel of land bordered by the Kaiapoi River Stop Bank, the Christchurch Northern Motorway and Smith St would have the potential to supply Rangiora's predicted water demand on the basis that they perform in a similar manner to the recently drilled bore. The installation of at least four additional wells would maximise the potential for the wells to be used as free-flowing artesian wells. It is recommended that these wells should be located as far apart as practicable.

8.0 Recommendations

Based on the analyses and interpretations of the data that are presented in this report, the following recommendations can be made:

- ✦ Carry out long term water level monitoring in the Smith Street well to determine the range of water level fluctuations in this deep aquifer
- ✦ Perform a step-drawdown using the type of pumping system that will be in place for each of the production wells
- ✦ Perform a constant-rate test on any further wells drilled at the site of the Smith Street well to determine drawdown interference between the wells

D
R
A
F
T

9.0 References

Callander, P.F. Aquifer Test at Kaiapoi. North Canterbury Catchment Board and Regional Water Board Report. September 1986.

Kruseman, G. P., De Ridder, N. A. and Verweij, J. M. (2000). Analysis and Evaluation of Pumping Data, International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands.

Theis, C. V. (1935). "The lowering of the piezometric surface and the rate and discharge of a well using ground-water storage." American Geophysical Union --Transactions, 16, 519-524

D
R
A
F
T