Groundwater Quality State and Trends 2010

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MARLBOROUGH DISTRICT COUNCIL

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Executive Summary

1. Generally speaking the quality of Marlborough's groundwater resources remains high by world and New Zealand standards

2. In part this reflects the natural diluting ability of in particular the transmissive aquifers underlying the northern Wairau Plain

3. Poorer quality water is caused by both man-made and natural processes

4. There are a number of naturally occurring parameters that fall outside the optimum values including:

    (a) Median pH values are below the optimum aesthetic range at 56% of sites monitored

    (b) Median manganese values exceeded the aesthetic threshold at 30% of sites, including 1 site that also exceeded the maximum allowable value for human health

    (c) Median iron concentrations exceeded the aesthetic guideline at 22% of sites monitored

    (d) There are too few arsenic measurements to provide a district wide summary at this stage, however it has been measured at elevated to high concentrations at Rarangi, Wairau Valley and in older groundwaters as part of targeted investigations. This is a naturally occurring constituent of groundwater

    (e) Likewise there is insufficient microbe measurements to provide a representative district wide summary at this stage

    (f) Median ammoniacal-nitrogen levels exceeded the ecological threshold at 13% of sites

5. The only man-made contaminant that is of widespread significance in Marlborough is the nutrient nitrate-nitrogen. The median concentration exceeded the ecological limit at 26% of sites, but was below the drinking water threshold

6. Longer term nitrate-nitrogen records indicate that levels have generally been stable over the past 30 years. Inferring that changing landuse patterns have not had a significant influence, or are yet to become apparent in groundwater

7. There were increasing trends in water quality at 13 sites, of which 7 were meaningful in terms of their respective median values. They involved changes in chloride, pH, nitrate-nitrogen and iron

8. There were also 3 declining trends in water quality involving chloride and nitrate-nitrogen

9. There is unlikely to be a single explanation for these trends with a range of factors including landuse intensification, pumping induced changes in regional flow patterns, geology and climate all contributing. The cause of slight increasing trends in chloride concentrations remains unclear

10. Overall there is no evidence of significant changes in groundwater quality in Marlborough

11. The fragmented nature of Marlborough aquifers and unique chemistry makes it less meaningful to summarise water quality at a district-wide level

Contents

1. Introduction

Marlborough and especially the Wairau Plain is heavily dependant on underground water for its everyday existence and economic prosperity. All of the main settlements rely on groundwater for their public drinking water, and many rural dwellers have water wells.

The Blenheim hinterland relies on groundwater as its prime source of freshwater for irrigating crops and wine processing. It also drives the ecologically important and highly valued freshwater springs such as the Taylor River or Spring Creek.

The quality of groundwater is just as important as having enough of it in the right place at the right time. Groundwater is accorded the highest grading of any natural freshwater body because it is primarily used for human consumption. While potability standards remain the benchmark for freshwater quality, environmental and social criteria are also part of the formula.

1.1. Marlborough Groundwater Quality

Marlborough groundwater quality is generally of a very high standard with some exceptions. This is especially true for the free-flowing aquifers which underlie the northern Wairau Plain. Because of the natural filtering effect of alluvial aquifers, groundwater is also generally of higher quality than river waters, especially in terms of microbiological contamination.

Some local groundwaters are not of optimum quality due to natural processes, and examples of this are low pH waters beneath the northern Wairau Plain, or hard water at Rarangi. Older groundwaters can be degraded through mineralisation which causes elevated levels of natural salts such as boron, chloride, iron, manganese and arsenic. Arsenic is the most harmful substance to human health found in Marlborough groundwaters and is largely naturally occurring.

The focus in terms of man-made groundwater quality issues for Marlborough groundwaters are nutrients from landuses including septic tanks, agricultural fertilisers and urbanisation. The type most commonly found in Marlborough groundwater is nitrate-nitrogen. Moderate levels occur in some areas, and fluctuate seasonally in local unconfined type aquifers.

It is preferable to avoid contamination through sound landuse practices. However there is little that can be done about naturally occurring issues except treat water to reduce concentrations to acceptable levels, but this relies on an awareness that an issue exists.

The purpose of this report is to provide an annual update on the status of Marlborough groundwater quality. It is intended to inform the Marlborough District Council and community of any risks that may affect them, and practices that can influence this natural resource.

1.2. Monitoring Methodology and Network

To identify groundwater pollution issues, potential threats and to improve understanding of aquifer processes, the Marlborough District Council and its predecessors have actively monitored groundwater quality in some shape or form since the 1970s.

The programme has evolved over time to reflect issues of the day and resources. Major reviews occurred in 1998 when it became part of the national groundwater monitoring programme, and again in 2004 when these standards were incorporated across all sites, and the network was enlarged to its current size.

This report represents a significant change in the way groundwater quality information is analysed and applied. It takes into account the state of groundwater quality and any trends over time.

The first part relates groundwater quality to national and local standards. The second part measures whether groundwater quality is changing over time, and if it is improving, deteriorating or staying the same.

While the Marlborough District Council groundwater monitoring network covers a range of locations and threats to groundwater, it is primarily a regional scale tool and may not detect local spills or contamination issues.

Most of the sites are Marlborough District Council monitoring wells with a smaller number of privately owned wells. Dedicated sites are preferred because they provide security of tenure and continuity of information. The aim is to produce long term records of 50 years or more, to identify any trends in groundwater quality in relation to land-uses or environmental changes.

In the past many different sites have been sampled rather than a selected group. This provided a snap-shot of groundwater chemistry, but not the uninterrupted record needed to see what if any trends exist. To ensure continuity of record, the current network will be maintained or added to, but no sites will be removed.

Geographically the focus has always been the Wairau Plain where the main population is located and the highest rates of groundwater use occur to support the most intensive land uses and settlements. The network has evolved over time and includes a reasonably representative series of aquifer types and land-uses, although areas like Rai Valley are not yet included.

1.3. Sampling and Analysis Procedures

Monitoring involves taking samples of groundwater at a network of 34 wells representing the main water supply aquifers, their vulnerability to pollution, proximity to water uses and the type of overlying land-use.

The overall programme is made-up of 4 separate surveys each with specific aims. The details of the 4 surveys are summarised in Table 1. The most frequently conducted survey is for state of the environment monitoring of general chemical parameters, and occurs each season.

It involves sampling 15 wells and analysing for a general range of metals, nutrients and commonly occurring constituents of Marlborough groundwaters. This is referred to as the Marlborough State of the Environment programme (MSOE). The location of the wells sampled is shown in Figure 1.

Table 1: MDC Monitoring Programmes

Survey	Number of wells sampled	Timing	Sampling Frequency
District state of the environment monitoring programme (MSOE)	15	Seasonally	4 times per year
National groundwater monitoring programme (NGMP)	8	Seasonally	4 times per year
Microbiological survey	14	Spring when potential leaching rates are highest and levels are likely to peak	Once each year

Coastal aquifer salinity survey	6	Summer when the potential for seawater intrusion is greatest	Once each year
National pesticide survey (NPS) Marlborough pesticide survey (MPS)	(17 every 4 years) (3 each year)	Spring when potential leaching rates are highest and levels are likely to peak	Once every 4 years Once each year

During the same week a further 8 sites are sampled for a similar group of parameters as part of the National Groundwater Monitoring Programme (NGMP). Coordinated by the Crown Research Institute GNS Science Ltd and involving most regions of New Zealand, the results provide a national perspective of groundwater quality. These sites are also shown in Figure 1.

The information collected by the regions forms the basis for national state of the environment reports, the most recent of which was produced by the Ministry for the Environment in 2007 (Environment New Zealand 2007). The Marlborough District Council first participated in the programme in 1998 and continues to support it. The mutual benefits to Marlborough district and New Zealand are a nationally consistent set of measurement and reporting guidelines.

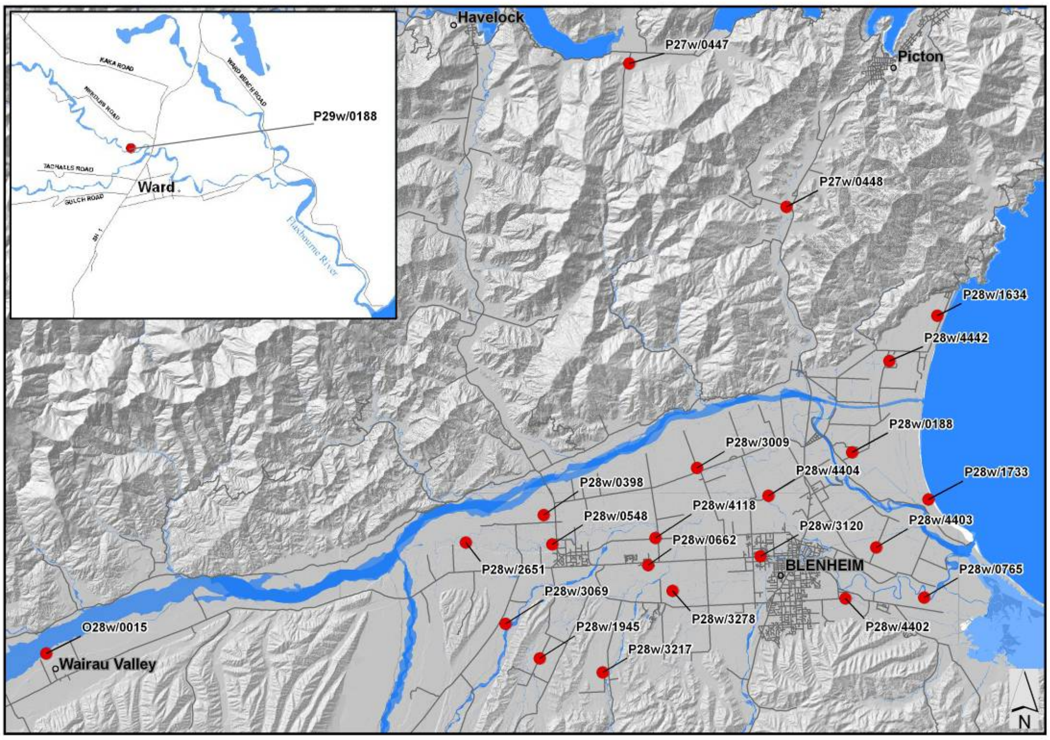


Figure 1 : Seasonal State of the Environment and NGMP Sampling Sites

The remaining 3 surveys are for specific parameters or issues and are carried out at certain times of year when their concentration in groundwater or effect potentially peak. Microbes are surveyed for at the 14 wells shown in Figure 2, in areas downstream of human settlement, or in unconfined aquifers susceptible to landuse contamination.

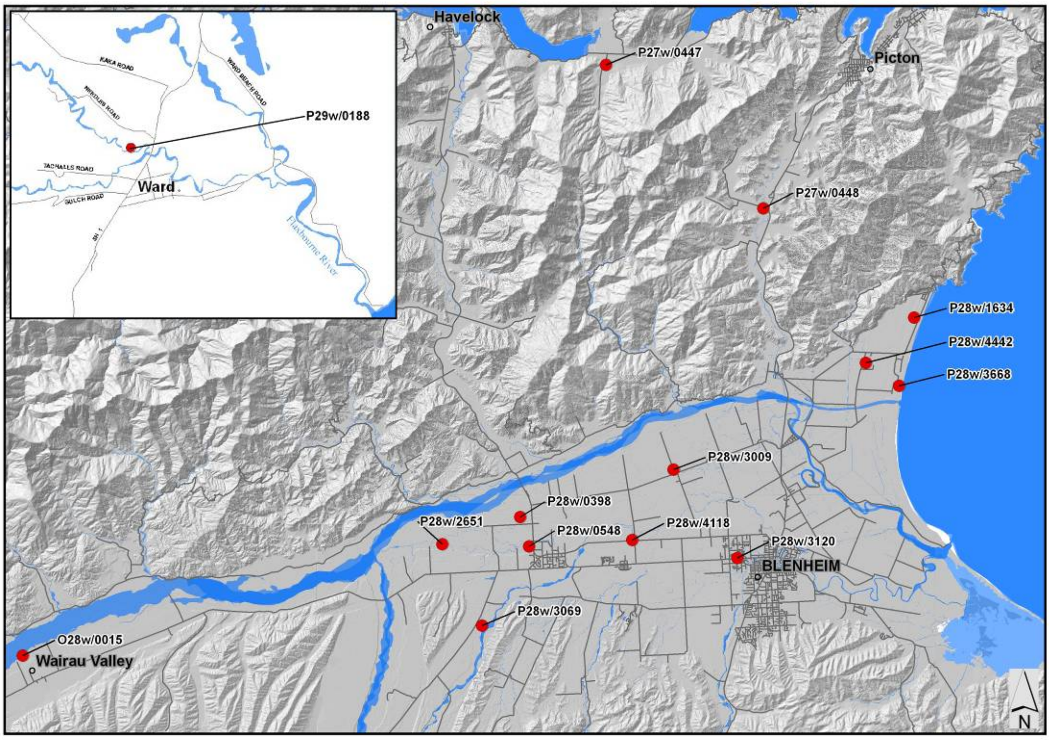


Figure 2 : Microbiological Sampling Sites

Pesticides are another special case of particular interest for the intensively farmed Wairau Plain. Council measures levels of a broad spectrum of pesticides at 3 sites each year, and also participates in the National Pesticide Survey which involves collecting samples in 17 local wells every 4 years. It is coordinated by the crown research institute ESR Ltd and the sample sites are shown in Figure 3.

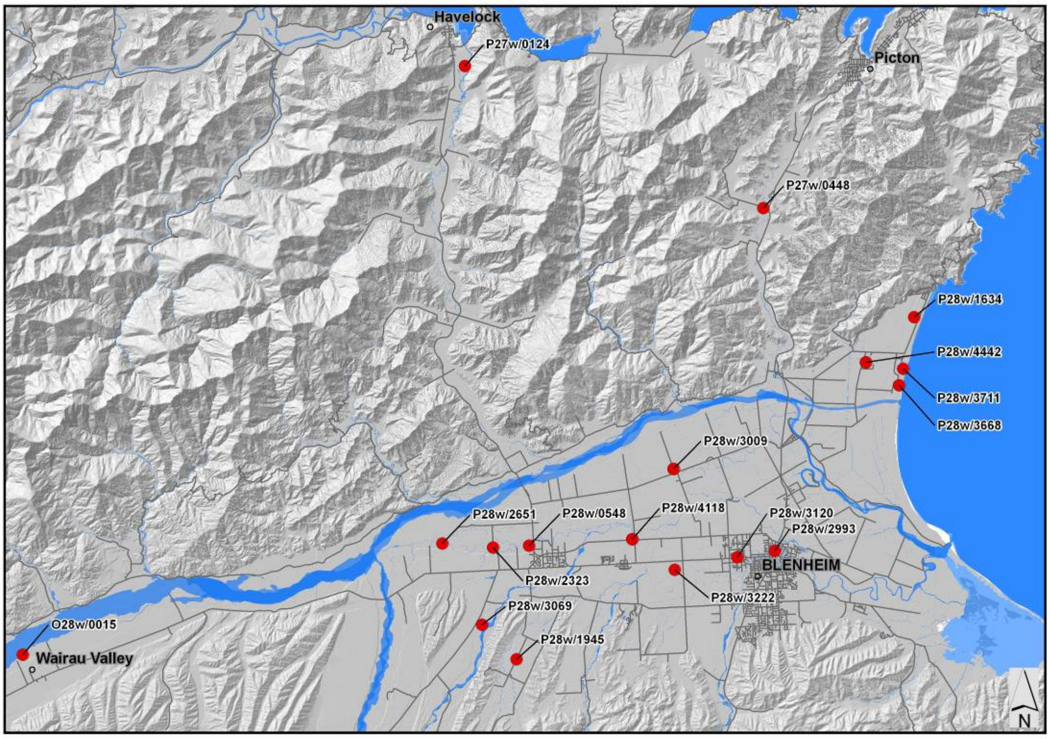


Figure 3 : Pesticide Sampling Sites

The final special interest survey measures indicators of salinity at sentinel wells along the Cloudy Bay coast line in summer each year. Trends in these indicators provides early warning of an inland migration of the seawater interface. The location of these coastal sites are shown in Figure 4.

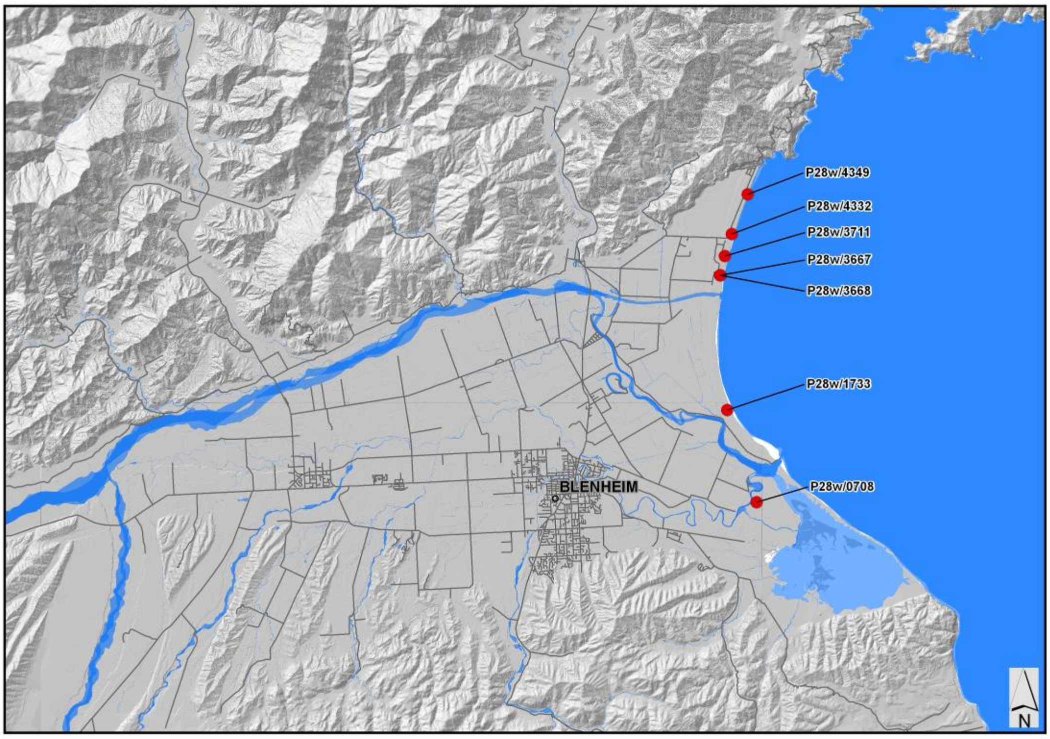


Figure 4 : Coastal Salinity Sampling Sites

1.4. Water Quality Standards and Suitability Thresholds

The primary measure of groundwater quality in New Zealand is its fitness for human consumption or its potability. The Drinking Water Standards for New Zealand 2005 (DWSNZ 2005) were prepared by the Ministry of Health and specify the maximum allowable values of health significance for each of the common parameters in groundwater. This document also contains guidelines to avoid aesthetic issues such as household staining.

Ecological standards also exist to protect wetlands or surface waters that are connected to groundwater. These are specified in the ANZECC 2000 guidelines, or based on local scientific studies.

These are particularly relevant to nutrients such as sulphate and nitrate-nitrogen which are present in groundwater and are transferred to groundwater fed springs such as Spring Creek, where it can could cause weed blooms and affect the health of plants, animals or fish.

1.5. Methodology and Reporting

The methodology adopted by this report and in the future differs from previous MDC groundwater quality reports. The emphasis is now on quantitatively assessing groundwater quality at a fixed number of monitoring sites.

Part 1 of this report assesses the status of aquifer water quality, while part 2 looks for the presence of trends over time. Results will be reported on and formally presented to the Marlborough District Council in June of each year based on the previous years measurements.

Median values are used to assess the suitability or state of groundwater quality to even out seasonal or short-term fluctuations. Actual values are used for reporting on trends over time.

2. Groundwater Quality Status

The following section reviews the median value for each of the 9 parameters where human health or ecological thresholds exist. There is insufficient information yet to report on arsenic or bacteriological levels across the district's groundwater resources, but they are fundamental indicators of water quality and will be reported on in the future.

Because this is the first time this approach has been used, the median values of all historical records have been used. In the future only the median value of the 4 seasonal observations from the previous year will be reported on.

Figure 5 show the water quality results used to compile the district wide summary. The graphs are arranged by parameters and then split according to aquifer structure as this is the dominant influence on groundwater quality, its evolution and susceptibility to landuses.

The left hand plot in each pair of graphs shows the confined aquifer results, while the right hand side shows the unconfined well values. Concentrations or levels of each parameter are scaled on the vertical axis. The MDC well number identifying the site is shown along the bottom of the graph. The middle 50 percentile range is shaded with the median value marked by the horizontal line.

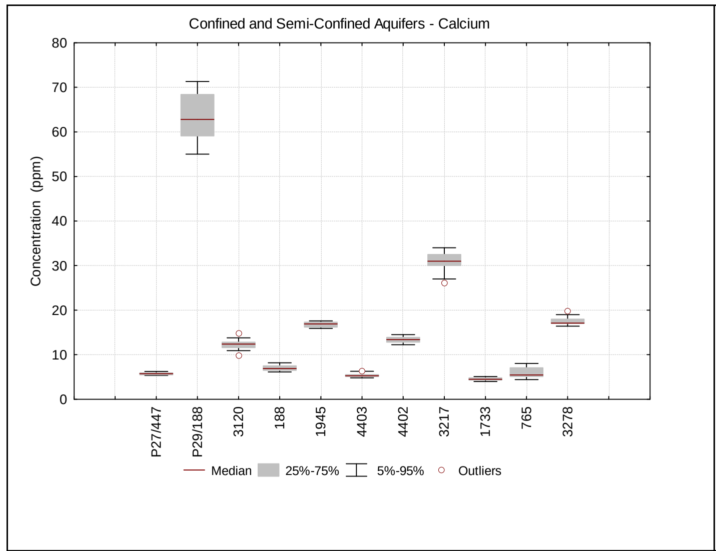
Table 2 : Nitrate-Nitrogen

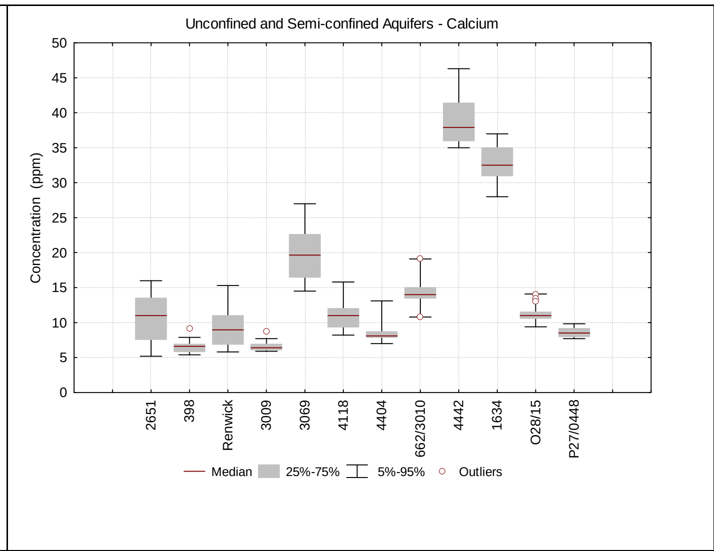
Year	DWSNZ 2005 Maximum allowable value = 11.3 g/m^3	ECAN 2009* Ecological protection guideline value = 1.7 g/m^3
	Number of sites exceeding	Number of sites exceeding
Up to 2009	0	6

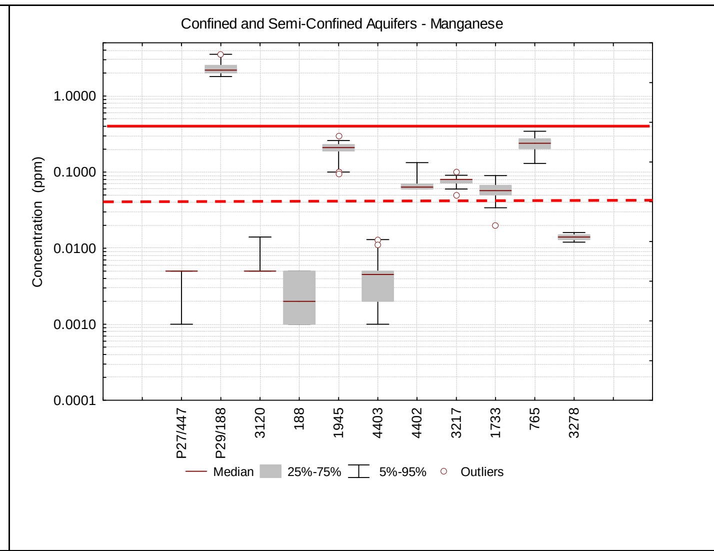
** Guideline value for moderately disturbed systems (95% protection) Environment Canterbury Technical report No. R09/57 2009 : A review of nitrate toxicity to freshwater aquatic species*

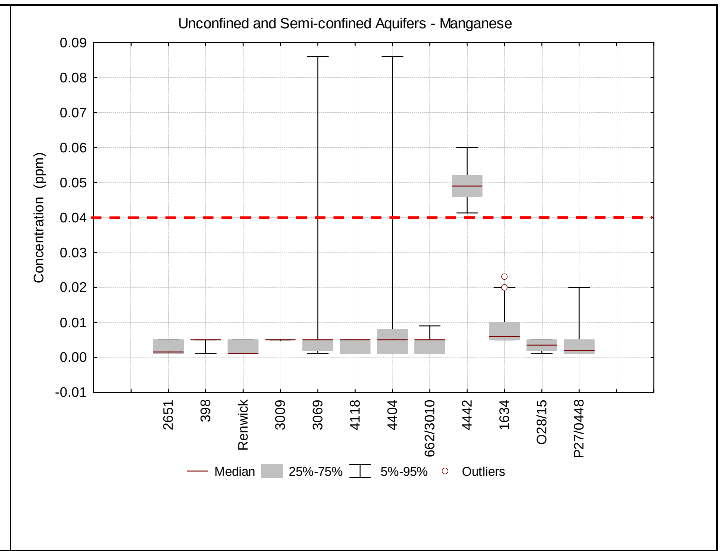
Table 2 and Figure 5 show that the median concentration across all 23 sites was below the maximum allowable value (MAV) of 11.3 g/m^3 in the Drinking Water Standards, and groundwater is safe to drink.

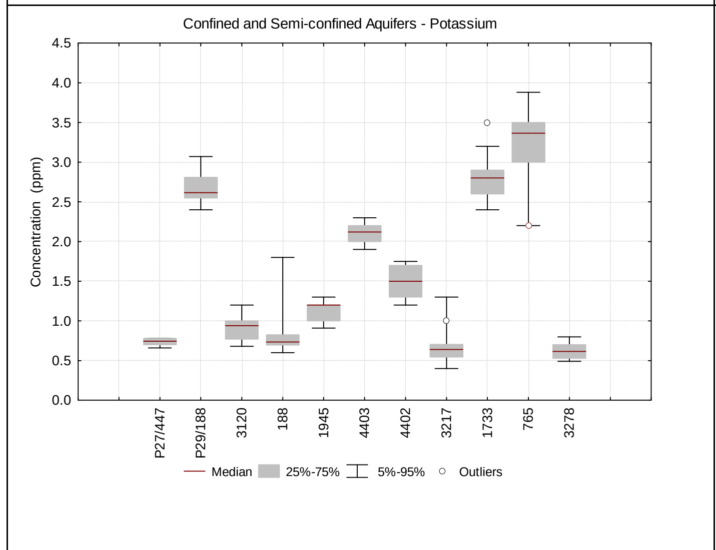
However 6 sites had nitrate concentrations that exceeded the lower ecological concentration of 1.7 g/m^3. This can potentially affect the health of hydraulically connected springs or rivers. The 1.7 g/m^3 threshold was derived by Environment Canterbury for similar types of aquifers and rivers to those which occur in Marlborough.

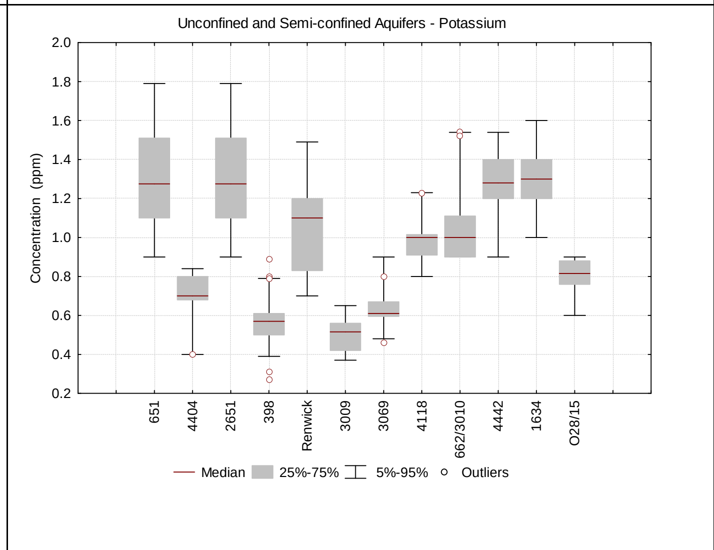

Confined and Semi-Confined Aquifers - Calcium
Concentration (ppm)
P27/447
P29/188
3120
188
1945
4403
4402
3217
1733
765
3278
Median
25%-75%
5%-95%
Outliers

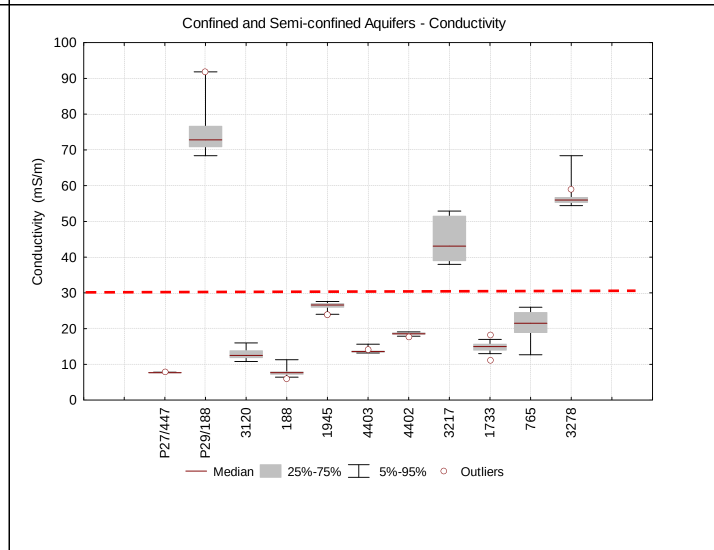

Unconfined and Semi-confined Aquifers - Calcium
Concentration (ppm)
2651
398
Renwick
3009
3069
4118
4404
662/3010
4442
1634
O28/15
P27/0448
Median
25%-75%
5%-95%
Outliers

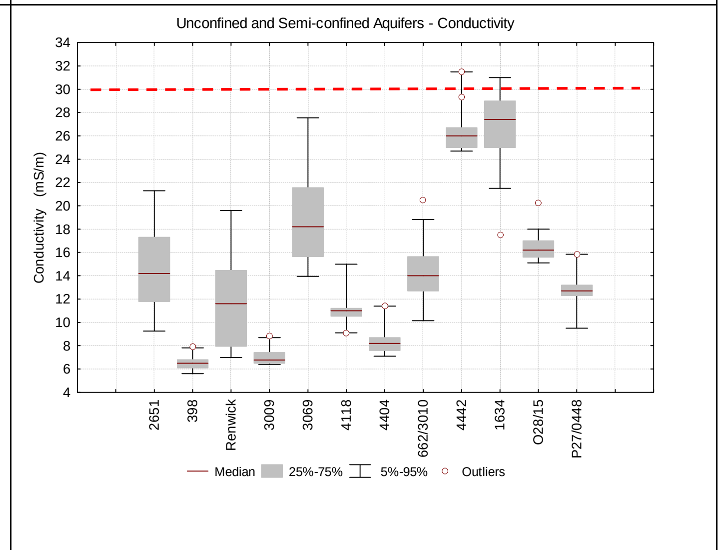

Confined and Semi-Confined Aquifers - Manganese
Concentration (ppm)
P27/447
P29/188
3120
188
1945
4403
4402
3217
1733
765
3278
Median
25%-75%
5%-95%
Outliers

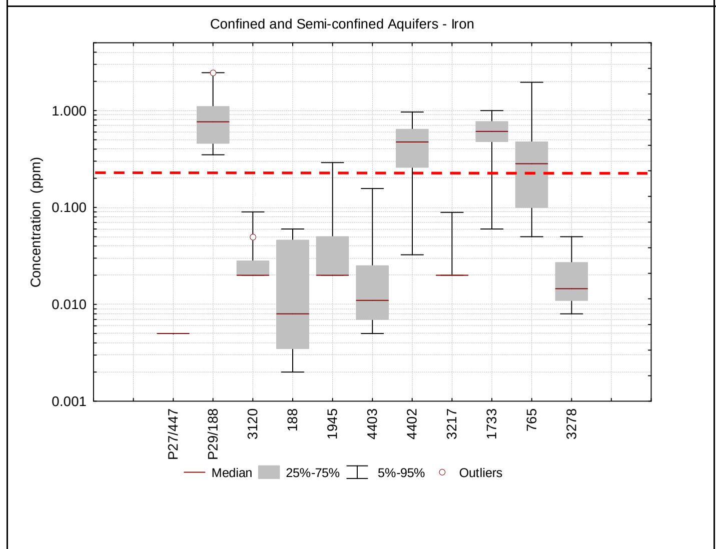

Unconfined and Semi-confined Aquifers - Manganese
Concentration (ppm)
2651
398
Renwick
3009
3069
4118
4404
662/3010
4442
1634
O28/15
P27/0448
Median
25%-75%
5%-95%
Outliers

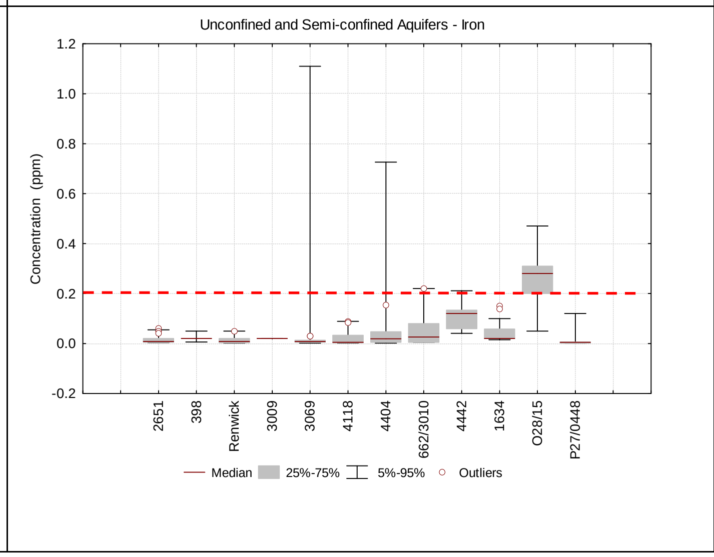

Confined and Semi-confined Aquifers - Potassium
Concentration (ppm)
P27/447
P29/188
3120
188
1945
4403
4402
3217
1733
765
3278
Median
25%-75%
5%-95%
Outliers

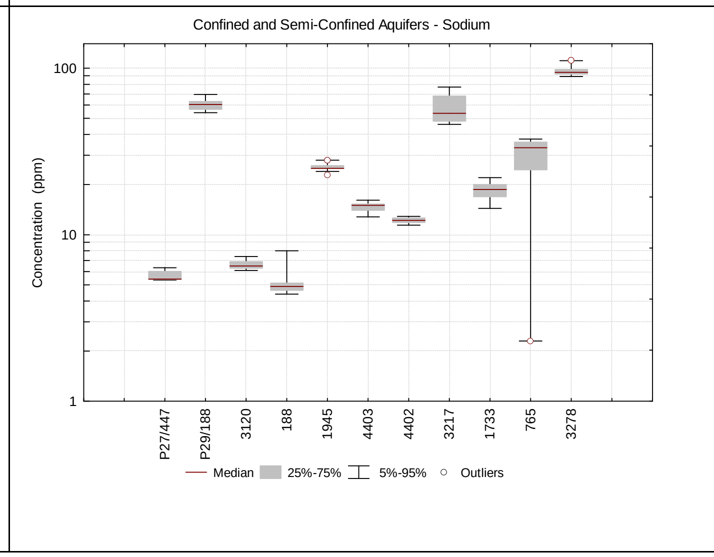

Unconfined and Semi-confined Aquifers - Potassium
Concentration (ppm)
651
4404
2651
398
Renwick
3009
3069
4118
662/3010
4442
1634
O28/15
Median
25%-75%
5%-95%
Outliers

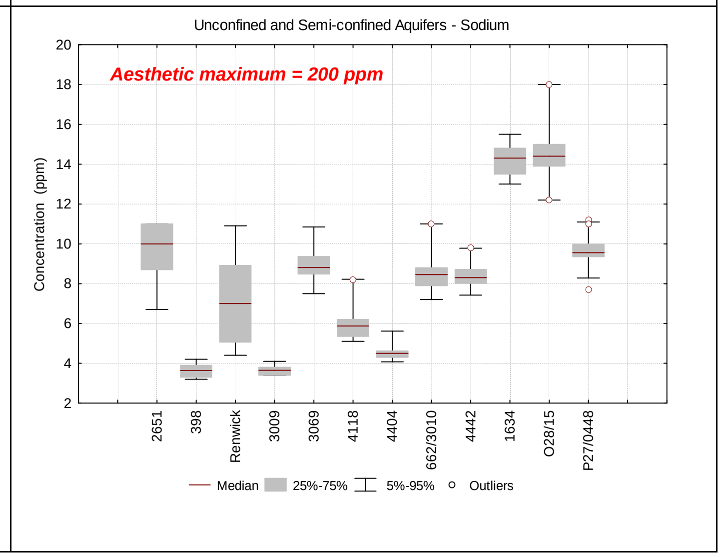

Confined and Semi-confined Aquifers - Conductivity
Conductivity (mS/m)
P27/447
P29/188
3120
188
1945
4403
4402
3217
1733
765
3278
Median
25%-75%
5%-95%
Outliers

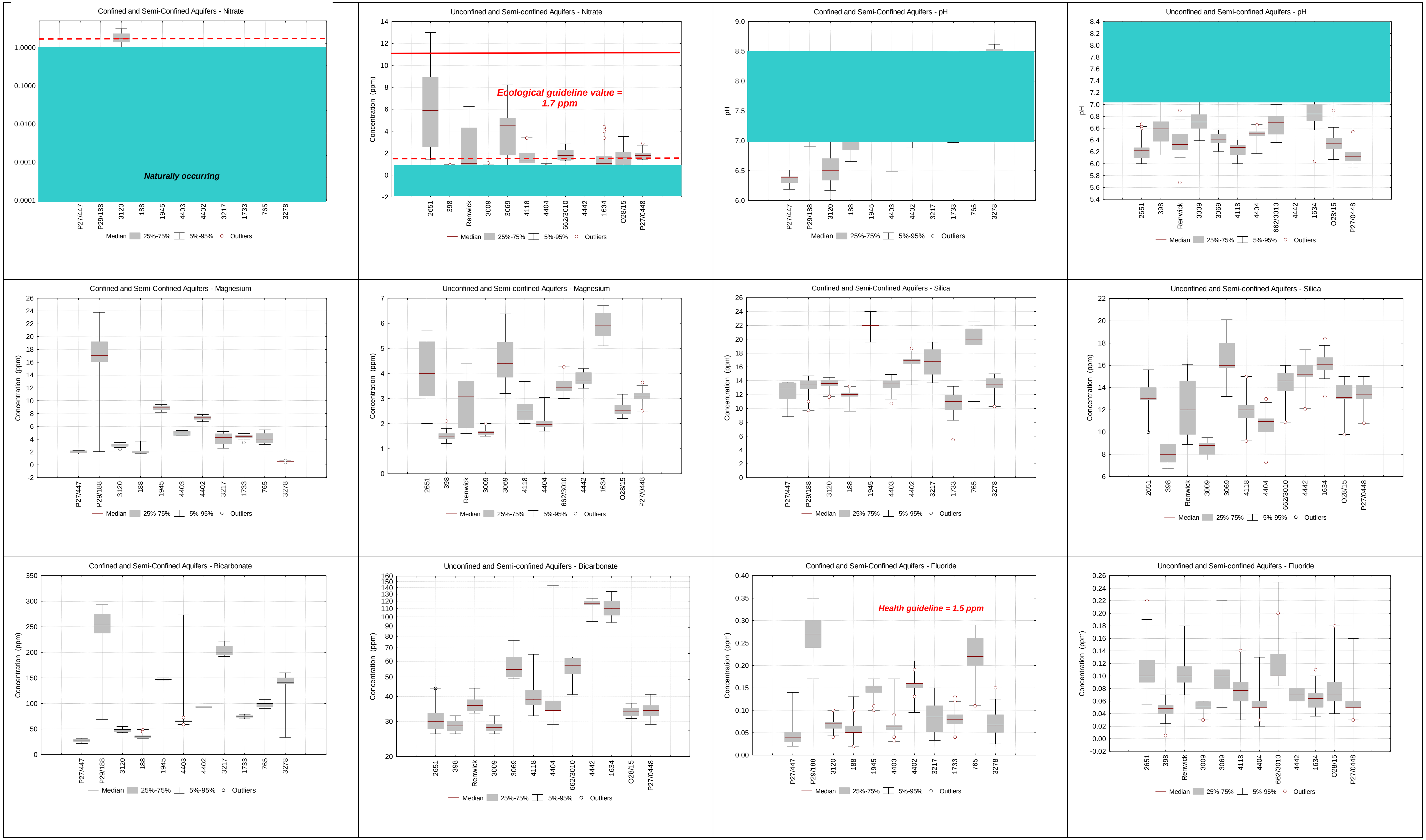

Unconfined and Semi-confined Aquifers - Conductivity
Conductivity (mS/m)
2651
398
Renwick
3009
3069
4118
4404
662/3010
4442
1634
O28/15
P27/0448
Median
25%-75%
5%-95%
Outliers


Confined and Semi-confined Aquifers - Iron
Concentration (ppm)
P27/447
P29/188
3120
188
1945
4403
4402
3217
1733
765
3278
Median
25%-75%
5%-95%
Outliers


Unconfined and Semi-confined Aquifers - Iron
Concentration (ppm)
2651
398
Renwick
3009
3069
4118
4404
662/3010
4442
1634
O28/15
P27/0448
Median
25%-75%
5%-95%
Outliers


Confined and Semi-Confined Aquifers - Sodium
Concentration (ppm)
P27/447
P29/188
3120
188
1945
4403
4402
3217
1733
765
3278
Median
25%-75%
5%-95%
Outliers


Unconfined and Semi-confined Aquifers - Sodium
Aesthetic maximum = 200 ppm
Concentration (ppm)
2651
398
Renwick
3009
3069
4118
4404
662/3010
4442
1634
O28/15
P27/0448
Median
25%-75%
5%-95%
Outliers


Confined and Semi-Confined Aquifers - Nitrate
Naturally occurring
Unconfined and Semi-confined Aquifers - Nitrate
Ecological guideline value = 1.7 ppm
Confined and Semi-Confined Aquifers - pH
Unconfined and Semi-confined Aquifers - pH
Confined and Semi-Confined Aquifers - Magnesium
Unconfined and Semi-confined Aquifers - Magnesium
Confined and Semi-Confined Aquifers - Silica
Unconfined and Semi-confined Aquifers - Silica
Confined and Semi-Confined Aquifers - Bicarbonate
Unconfined and Semi-confined Aquifers - Bicarbonate
Confined and Semi-Confined Aquifers - Fluoride
Health guideline = 1.5 ppm
Unconfined and Semi-confined Aquifers - Fluoride
Concentration (ppm)
pH
Median 25%-75% 5%-95% Outliers

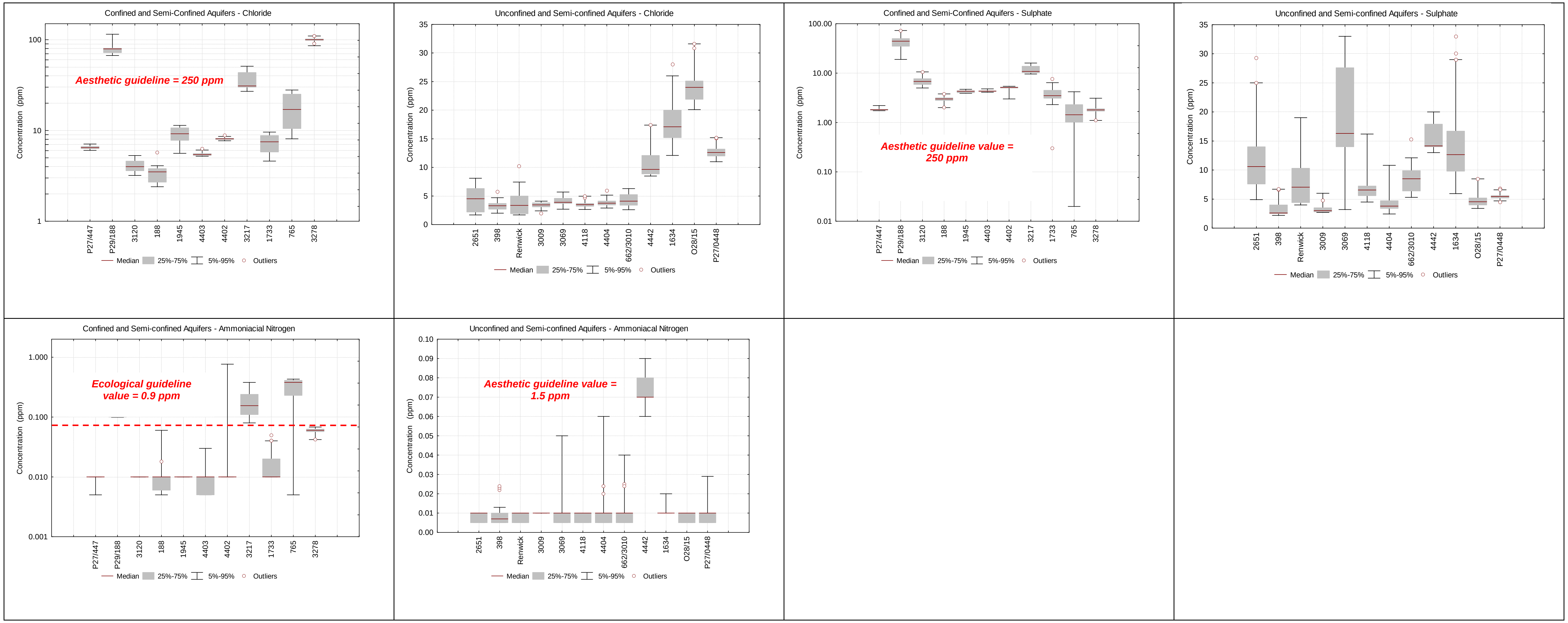


Figure 5 : Median Measured Values Versus Water Quality Standards

Nitrate-Nitrogen values are sensitive to aquifer structure. While nutrient inputs from landuses may originally be the same, levels tend to become lower over time in confined aquifers due to natural denitrification processes and conversely, they persist in unconfined type aquifers.

As Figure 5 shows, the bulk of exceedences occur at sites representing unconfined aquifers reflecting their relative insecurity. The blue shading represents what is considered to be naturally occurring nitrate concentrations of 1 g/m^3 or less. Although in some cases natural processes might cause higher values closer to 3, which exceeds the ecological threshold.

Some sites have large seasonal fluctuations such as well P28w/2651 representing the unconfined Wairau Aquifer west of Renwick, where levels range by more than 10 g/m^3. These high levels are caused by overlying agricultural or human settlement activities.

However it remains uncertain whether it is a legacy of historical or current landuses. It is likely based on longer term records that levels are relatively stable, and there has not been a significant change associated with the widespread practice of vineyard conversion since 1990.

Levels peak in spring or winter when rainfall is highest which leaches fertilisers downwards to the water table. Levels are lower in the free flowing Wairau Aquifer due to dilution. Areas where potential problems may occur in the future are aquifers with lesser natural throughflow and diluting ability, south of Middle Renwick Road.

Table 3 : Chloride

Year	DWSNZ 2005 Guideline = 250 g/m^3
	Number of sites exceeding
Up to 2009	**0**

Table 3 and Figure 5 show that chloride levels are within acceptable limits across all regional monitoring sites based on historical results. The threshold is for aesthetic purposes rather than to protect human health. As Figure 5 shows higher levels were more common in confined aquifers, or those close to the coast where sediments are naturally high in chloride such as at Rarangi. The confining layer which overlies the Wairau Aquifer in the lower Wairau area is naturally high in sodium and chloride as a legacy of its marine origin, and both of these salts are easily dissolved in groundwater

Table 4 : pH

Year	DWSNZ 2005 Optimum range = 7 to 8.5
	Number of sites outside range
Up to 2009	**13**

Table 4 shows that 13 sites were outside the ideal range for water supply mostly due to naturally low pH in local unconfined aquifers. Low pH is a commonly occurring natural problem which is corrected for in the Renwick and Blenheim municipal water supplies by adding lime to reduce the corrosion of water mains and household pipes. Figure 5 shows that unconfined aquifers tend to have low pH whereas confined aquifers naturally have higher values. This is the expected pattern whereby natural chemical degradation processes in oxygen deficient confined aquifers produce bicarbonate which increases pH.

Table 5 : Manganese

Year	DWSNZ 2005 Maximum allowable value = 0.4 g/m^3	DWSNZ 2005 Guideline value = 0.04 g/m^3
	Number of sites exceeding	Number of sites exceeding
Up to 2009	1	6

Table 5 shows that the median value at 1 site exceeded the human health limit of 0.4 g/m^3, and 6 sites were above the aesthetic guideline of 0.04 g/m^3. Higher concentrations were associated with confined aquifers which reflect longer residences times and water-rock interaction. This is a common problem in many parts of Marlborough, especially for older groundwaters, but can be treated.

Table 6 : Iron

Year	DWSNZ 2005 Guideline value = 0.2 g/m^3
	Number of sites exceeding
Up to 2009	5

Table 6 shows that 5 sites exceeded the aesthetic guideline value for iron based on historical information. Because samples have been filtered since 2004 so that only the dissolved fraction is measured, concentrations are lower for more recent surveys. Iron behaves in a similar manner to manganese and commonly occurs in confined aquifers where there is sluggish flow and depleted oxygen levels.

Table 7 : Ammoniacal nitrogen

Year	DWSNZ 2005 Guideline value = 1.5 g/m^3	ANZECC 2000 Trigger value** = 0.9 g/m^3
	Number of sites exceeding	Number of sites exceeding
Up to 2009	0	3

*** Trigger value for ecosystem protection (95% level)specified in ANZECC 2000*

Table 7 shows that no sites exceeded the human health limit but 3 sites representing confined aquifers exceeded the ecological threshold. These elevated levels probably represent natural processes.

Ammoniacal nitrogen is the chemical form this nutrient takes in oxygen depleted confined aquifers such as the Brancott Aquifer, or parts of the coastal Wairau Aquifer.

Table 8 : Fluoride

Year	DWSNZ 2005 Maximum allowable value = 1.5 g/m^3 Number of sites exceeding
Up to 2009	0

Table 8 shows that no median fluoride levels exceeded the human health limit of 1.5 g/m3 at any of the regional groundwater monitoring sites. Higher levels were generally associated with confined aquifers which implies that fluoride levels are unrelated to landuses. It is increasingly being linked to wells influenced by the Wairau Fault such as at Wairau Valley.

Table 9 : Sodium

Year	DWSNZ 2005 Guideline value = 200 g/m^3 Number of sites exceeding
Up to 2009	0

Figure 5 and Table 9 shows that no sites had sodium levels above the aesthetic limit of 200 g/m3. Higher levels more commonly occur in confined aquifers, or where there are marine sediments with residual sodium. These are naturally occurring processes.

Table 10 : Sulphate

Year	DWSNZ 2005 Guideline value = 250 g/m^3 Number of sites exceeding
Up to 2009	0

Figure 5 and Table 10 show that sulphate levels across all aquifers are well below the aesthetic threshold for sulphate. The main source of sulphate in Marlborough groundwaters are agricultural fertilisers and higher values are associated with unconfined aquifers. Levels drop off in confined aquifers as Figure 5 shows through natural degradation processes.

There are no water quality limits for calcium, magnesium, potassium, conductivity, silica or bicarbonate; although the first 2 parameters are responsible for the hardness of groundwater. The remaining parameters have been included in Figure 5 for completeness and to show how their levels differ significantly between aquifers and with the degree of confinement.

Calcium levels are highest in aquifers formed of marine fossils or shells made of calcium carbonate such as at Rarangi or Ward. Levels are significantly lower in all confined aquifers due to natural cation exchange processes.

Higher potassium concentrations are associated with confined aquifers due to a naturally higher level of mineralisation. Higher groundwater conductivity reflects greater concentrations of all dissolved salts and is generally associated with confined aquifers.

Silica is used as an indicator of groundwater age or residence time, although its concentration doesn't vary significantly from young to old groundwaters in Marlborough as Figure 5 shows. This is possibly due to groundwaters becoming naturally saturated in silica although the process is not yet fully understood.

Pesticides are sampled at 3 sites every year, and at 17 sites as part of the National Pesticide Survey which is next scheduled for spring 2010. Apart from isolated incidences, pesticides are not a major issue for Marlborough groundwaters. The results of the upcoming spring survey will be summarised in the 2011 report.

The laboratory analysis of pesticides is very expensive because they occur in such low concentrations in groundwaters. To keep costs at acceptable levels certain active ingredients known to be associated with Marlborough agricultural practices or crops are targeted for analysis.
Bacteria are the only type of microbe measured by the MDC and their presence is surprisingly low at the sites sampled historically. This probably reflects the natural attenuation process, particularly in the finer grained materials such as at Rarangi, which have traditionally been thought to be more vulnerable to land-uses.

2.1. Status Summary

Table 11 summarises the exceedences based on all historic record for the MDC monitoring network sites. Generally speaking naturally occurring poorer water quality is associated with confined aquifers where a lack of oxygen leads to higher levels of mineralisation through a change in chemical equilibria. Conversely man-made influences occur in shallow, unconfined aquifers potentially more vulnerable to overlying landuse activities.

Table 11 : Summary of Exceedences

Origin	Parameter	Historical Exceedences	Cause
Natural	pH	13 (56%)	Naturally low in unconfined aquifers
	Manganese	7 (30%)	Naturally high in reduced conditions in confined aquifers
	iron	5 (22%)	Naturally high in reduced conditions in confined aquifers
	Ammoniacal-nitrogen	3 (13%)	Naturally high in reduced conditions in confined aquifers. There may be some manmade influences
	Arsenic	Summary results unavailable	Naturally high in reduced conditions in confined aquifers
Manmade	Nitrate-nitrogen	6 (26%)	Landuse intensification and urbanisation
	Microbes	Summary results unavailable	Landuse intensification and urbanisation

3. Groundwater Quality Trends

Part 2 of the report focuses on trends in aquifer water quality over time. Long periods of record over several decades in some cases, exist for a small number of well sites monitored by Marlborough District Council. These are very useful for identifying trends and whether the prime driver is climate, natural processes or landuse activities. However many sites only have a moderate length of record so far due to recent reorganisations in the network.

The first step at each site is to graph the results to see if there are any breaks or anomalies which may affect the validity of the trend analysis. The level of constituents in relation to health, aesthetic or ecological thresholds is discussed for each aquifer.

Where there is sufficient record it is analysed using the Time Trends and Equivalence software (NIWA 2009) package to identify if any trends exist. Where the Mann-Kendall test detects a trend at the 95% confidence interval, the magnitude of this trend is quantified using Sen's slope estimator and expressed in terms of the units of the parameter per year.

Trends are reviewed on an aquifer by aquifer basis with a brief introduction of each groundwater resource. In some cases there are multiple monitoring wells for the same aquifer. Where information is available, up to 9 indicators of groundwater quality are plotted for each monitoring site including: ammoniacal-nitrogen, arsenic, boron, chloride, conductivity, iron, manganese, nitrate-nitrogen and pH.

The same thresholds discussed in tables 2 to 10 are marked on the graphs. The lower ecological or aesthetic limits are marked by a dashed line, with human health maximum allowable values denoted by the solid black line. Optimum limits for groundwater pH is between the 2 dashed black lines.

3.1. Wairau Aquifer

The Wairau Aquifer is the predominant groundwater system underlying the Wairau Plain. Due to its size, varying landuses and differing hydraulic properties, it is represented by a number of monitoring sites both for water quality and quantity purposes.

3.1.1. Recharge reach

The Wairau Aquifer is recharged by the Wairau River in the area north-west of Renwick. This area is represented by MDC monitoring well 398 located near the corner of Conders Bend Road and SH6. Due to its unconfined structure this part of the Wairau Aquifer is potentially vulnerable to landuse contamination. On the other hand, its naturally fast flowing groundwater tends to dilute potential surface contaminants.

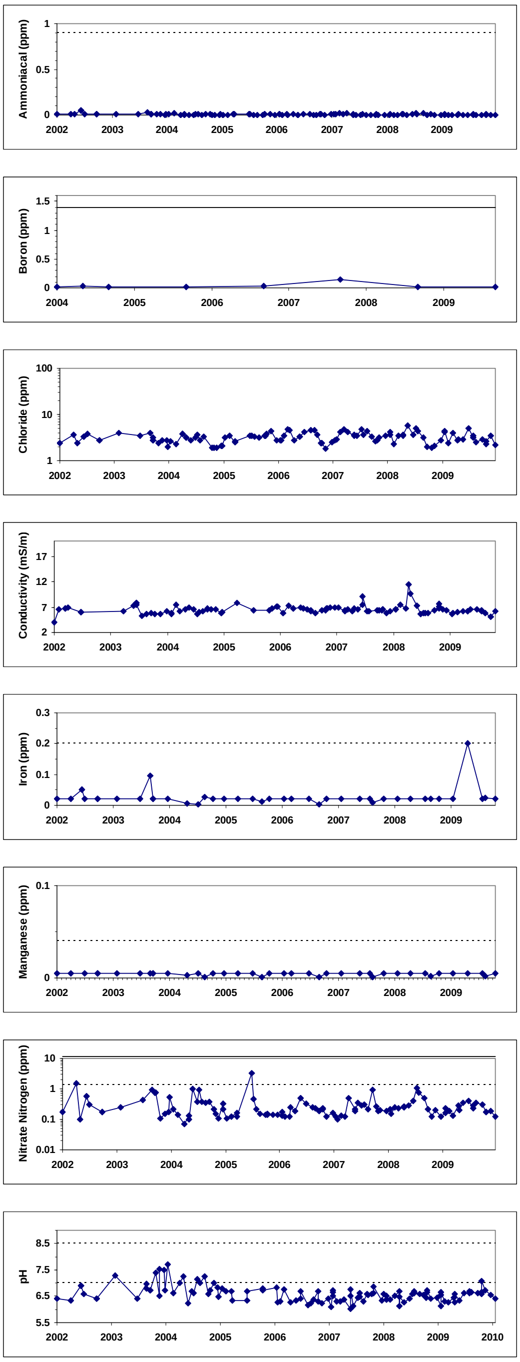


Figure 6 : Well 398 Water Quality Time Series

Groundwater quality is very high with the exception of pH which is naturally low. Nitrate-nitrogen levels are below the lower ecological threshold, and peak in winter or spring when higher rainfall leaches nutrients in the soil downwards to groundwater.

As Figure 6 shows the value of most parameters appears constant over time apart from seasonal cycles in nitrate-nitrogen and chloride. Water quality is similar to that of the Wairau River which is the main source of aquifer recharge, and highlights the need maintain the quality of the Wairau River.

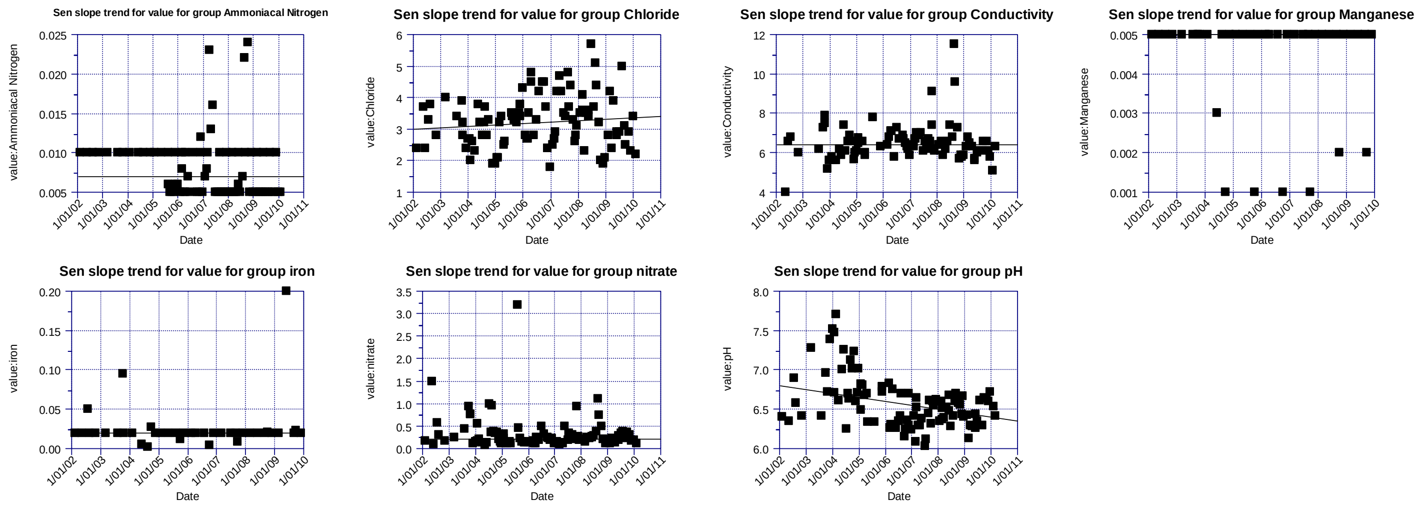


Figure 7 : Well 398 Water Quality Trends

As Figure 7 shows, the only significant trend is a decline in pH, although the rate is minor compared to the median value.

3.1.2. North-West Terrace

Well 2651 represents the southern margin of the Wairau Aquifer near the Renwick Terrace and is also unconfined making it susceptible to landuse contamination. It receives some runoff recharge from the terrace or Delta Hill to the south in addition to the Wairau River channel losses and this water is likely to influence water chemistry as natural rates of groundwater throughflow are less than closer to the Wairau River.

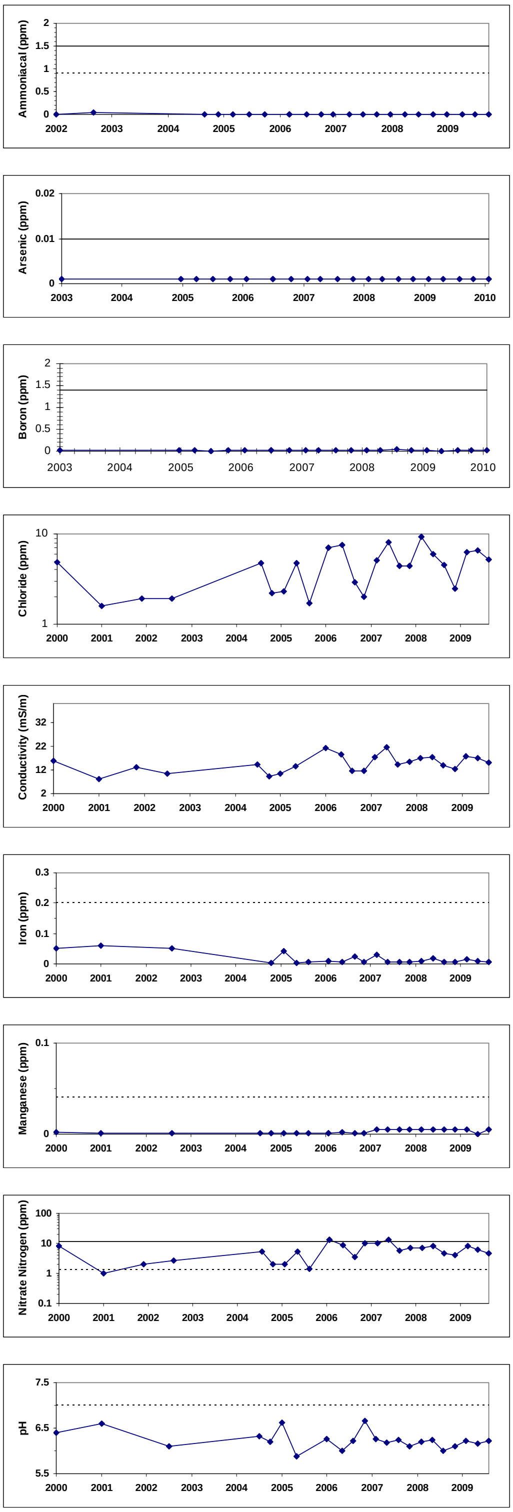


Figure 8 : Well 2651 Water Quality Time Series

As Figure 8 shows there are seasonal variations in nitrate-nitrogen, chloride and conductivity caused by rainfall or irrigation water leaching soil materials to groundwater. A soil source is also consistent with the fall in pH of groundwater over time.

Nitrate levels are above the human health limit during parts of the year, although the median value is around half this number. Investigations indicate some of the nitrate-nitrogen may originate from the top terrace and reflect historic fertiliser use that will take many years to flush through. MDC staff are closely monitoring nitrate-nitrogen levels across this unconfined and intensively farmed area north-west of Renwick.

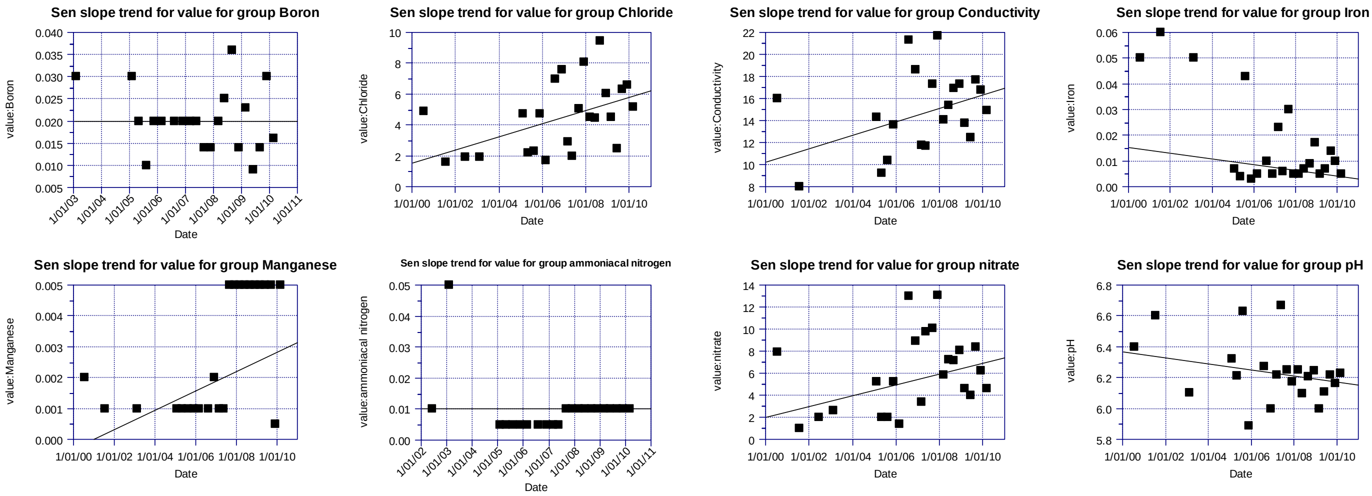


Figure 9 : Well 2651 Water Quality Trends

Figure 9 shows significant increasing trends in chloride and manganese levels, however only the annual change in chloride is meaningful in terms of its median value. The cause of the increasing chloride levels, which is a common trend across the district, is unclear. Conductivity is an indicator of the overall level of dissolved solids in groundwater and rises with the concentration of substances like chloride.

3.1.3. Northern-Central Plain

The northern plains area is represented by the MDC monitoring well 3009 at Wratts Road. This area is near the eastern margin of the unconfined aquifer and has traditionally been used to grow a variety of crops including pipfruit, vegetables and grains. Due to the proximity of the Wairau River, rates of groundwater throughflow are high and tend to dilute any surface contaminants.

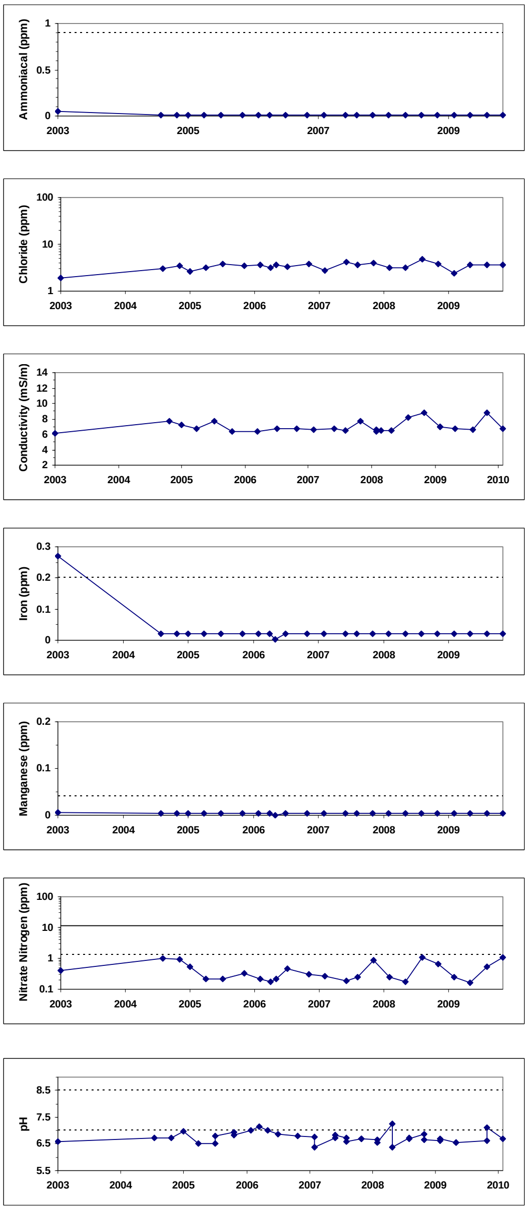


Figure 10 : Well 3009 Water Quality Time Series

As Figure 10 shows nitrate-nitrogen levels are below the ecological threshold and vary seasonally, peaking during high rainfall periods such as in winter 2008. Overall groundwater quality is very high with the exception of low pH which will tend to corrode metal pipes. The high iron value at the start of the record pre-dated filtering of samples and possibly reflects the influence of the steel casing, as it only occurs naturally in low concentrations in groundwater in this area.

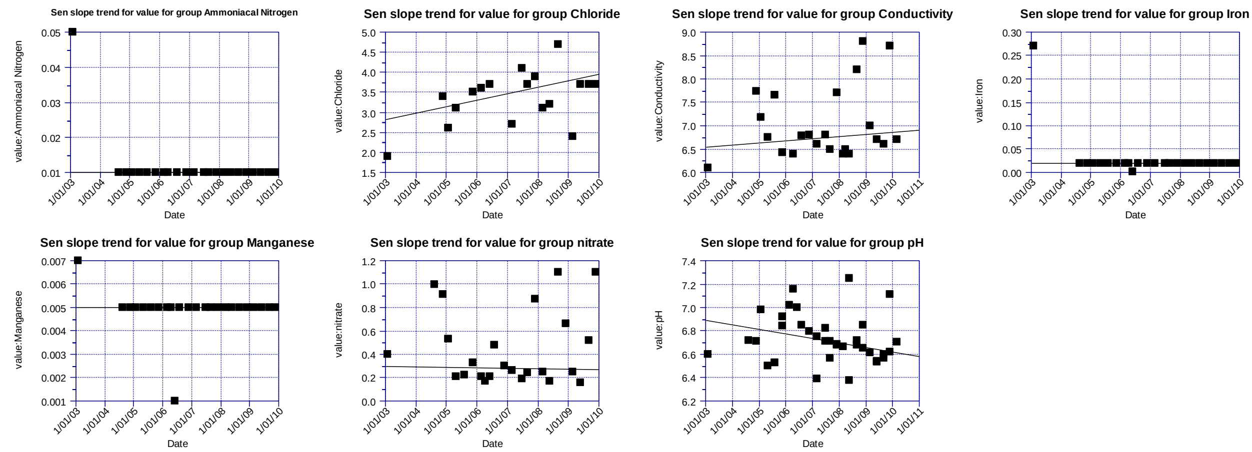


Figure 11 : Well 3009 Trend Analysis

The period of record is relatively short for identifying trends at this stage. Figure 11 shows an upward trend in chloride, but the annual change is minor relative to the median value of 3.6 g/m3, which is well within aesthetic limits.

3.1.4. Mid Plains Spring Belt

Well P28w/4404 is located near the western end of Mills and Ford Road by the Opawa River and represents the semi-confined Wairau Aquifer. This is an area where springs drain large volumes of groundwater from the aquifer, and demonstrates the need to keep aquifer nutrient levels within acceptable levels.

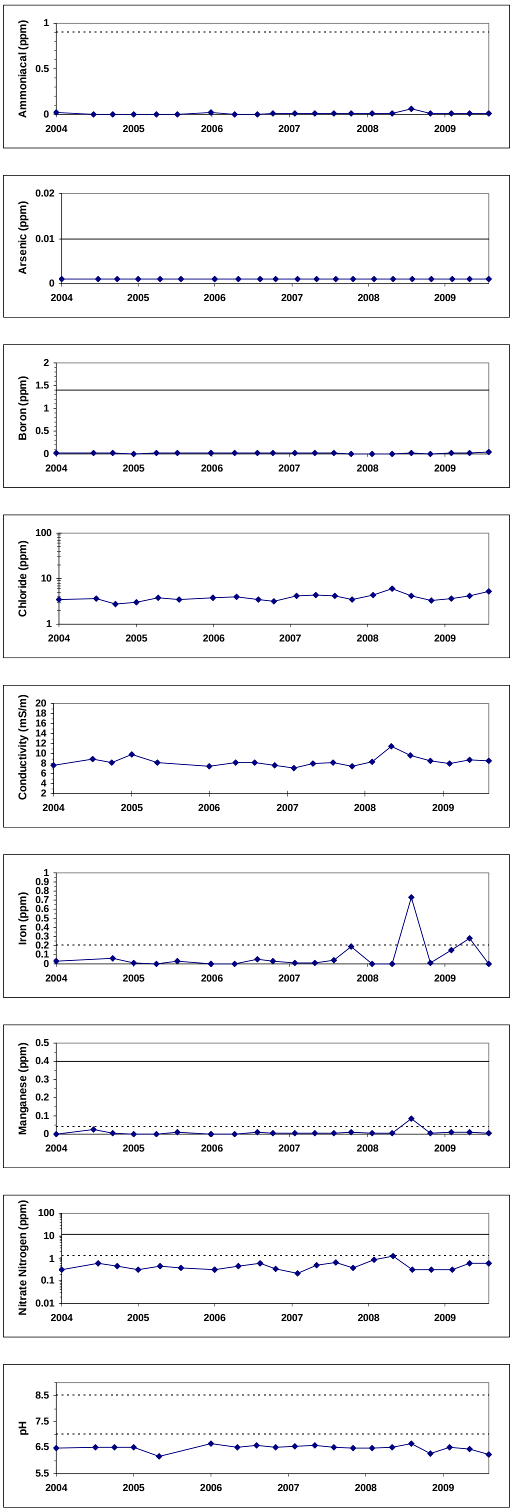


Figure 12 : Well 4404 Water Quality Time Series

Figure 12 shows that concentrations of iron and occasionally manganese exceed the aesthetic limt. Nitrate-nitrogen concentrations vary seasonally but levels are generally below the ecological limit. The causes of the spikes in iron concentrations are unclear but possibly relate to floods in the nearby Opawa River. There is insufficient record for trend analysis at this stage.

3.1.5. Blenheim

The structure of the Wairau Aquifer beneath Blenheim is partly isolated from the surface by a confining layer, although its edge is not far to the west of town. This area is represented by samples from Blenheim municipal water supply well P28w/3120, which is located in the western suburb of Springlands, and only operates during the drier months of the year.

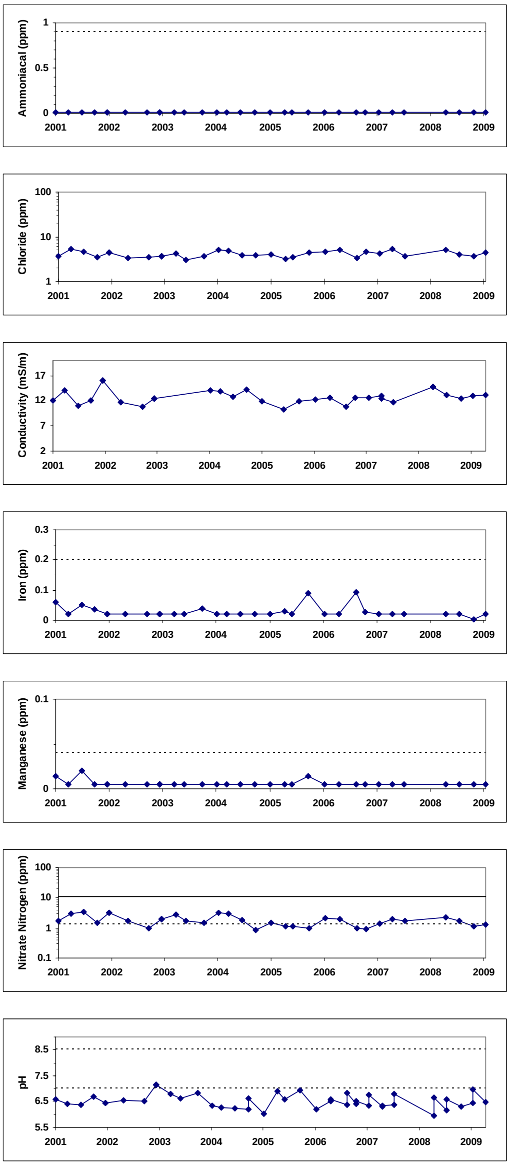


Figure 13 : Well 3120 Water Quality Time Series

Figure 13 shows that nitrate-nitrogen concentrations are generally above the ecological limit, but always less than the health guideline. pH remains low despite the lesser contribution of recharge from the Wairau River. There are distinct seasonal variations in nitrate-nitrogen, pH and conductivity levels driven by differences in rainfall and landuse activities throughout the year. Some of the water pumped from this well originates from Murphys Creek and may influence groundwater microbiology.

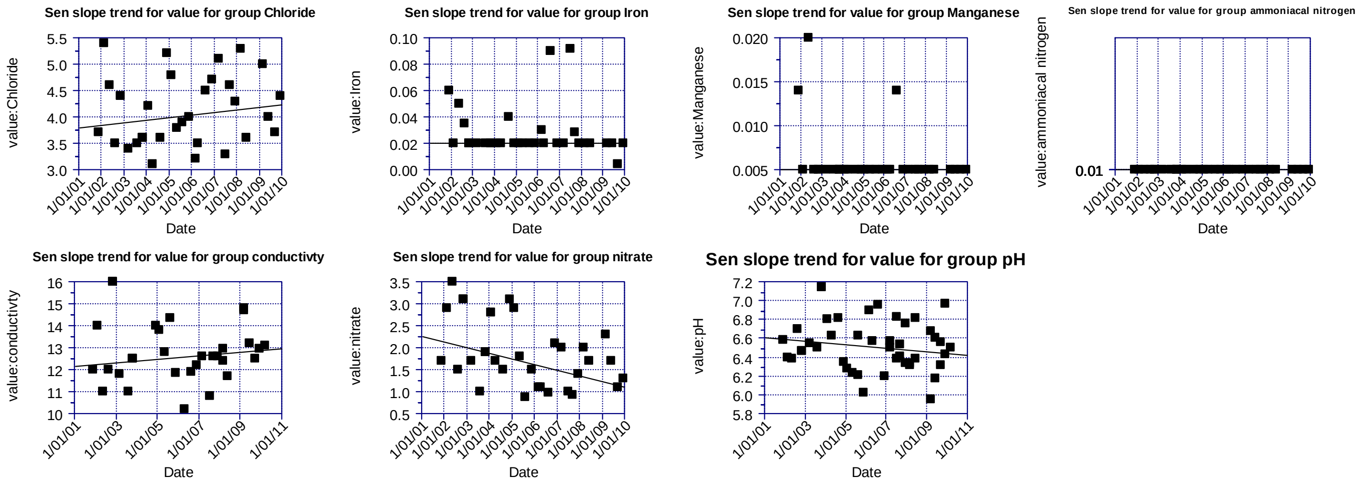


Figure 14 : Well 3120 Water Quality Trends

Figure 14 shows a significant declining trend in nitrate-nitrogen concentrations. There are a number of possible explanations including changes in crop types upstream on the outskirts of Blenheim, urbanisation reducing the number of septic tanks, or less residential runoff draining to groundwater.

3.1.6. Spring Creek

East of SH1 the Wairau Aquifer is confined with slower groundwater flow and longer residence times. Well P28w/0188 represents the area and has been measured sporadically since 1987. Because of the existence of the confining layer and artesian aquifer pressures, landuses near the well have limited influence on groundwater quality because recharge water enters the aquifer further to the west.

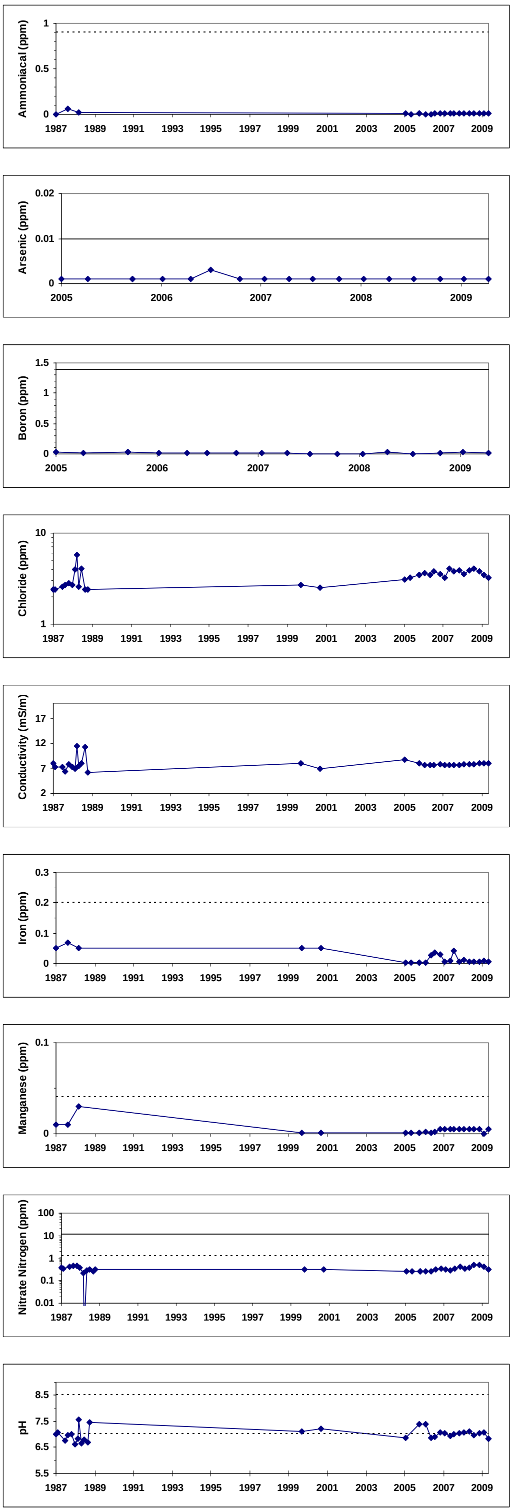


Figure 15 : Well 188 Water Quality Time Series

Figure 15 shows that levels of most parameters do not vary significantly from season to season, which is typical of wells tapping confined type aquifers such as this. Iron and manganese show an apparent fall over time although as with other parameters, this probably reflects differing analytical or sampling methods rather than actual changes in groundwater quality. Changes in pH since 1987 will in part reflect difference in field meters. Nitrate-nitrogen concentrations are low due to natural denitrification and overall groundwater quality is high.

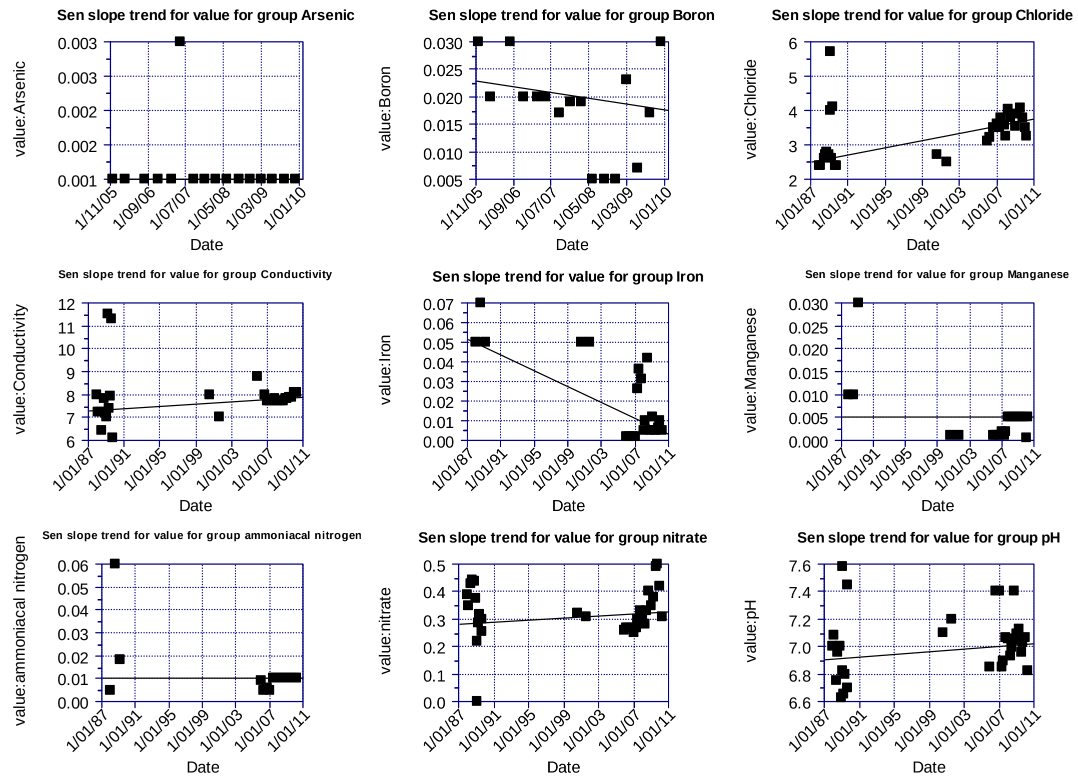


Figure 16 : Well 188 Water Quality Trends

A long record exists for this site although there gaps. Figure 16 shows an increasing trend in chloride although the annual rate of change is small relative to the median. It is likely to be a natural effect related to the geological formations that host the aquifer in this area which are of marine origin and naturally rich in chloride.

3.1.7. Lower Wairau

This aquifer area is highly confined with groundwater being recharged from as far away as Renwick. Well P28w/4403 is located at Morgans Road and represents this part of the Wairau Aquifer. Aquifer flow is slow compared to further west and this results in naturally higher levels of dissolved minerals as groundwater stays in contact with the aquifer forming rocks for longer.

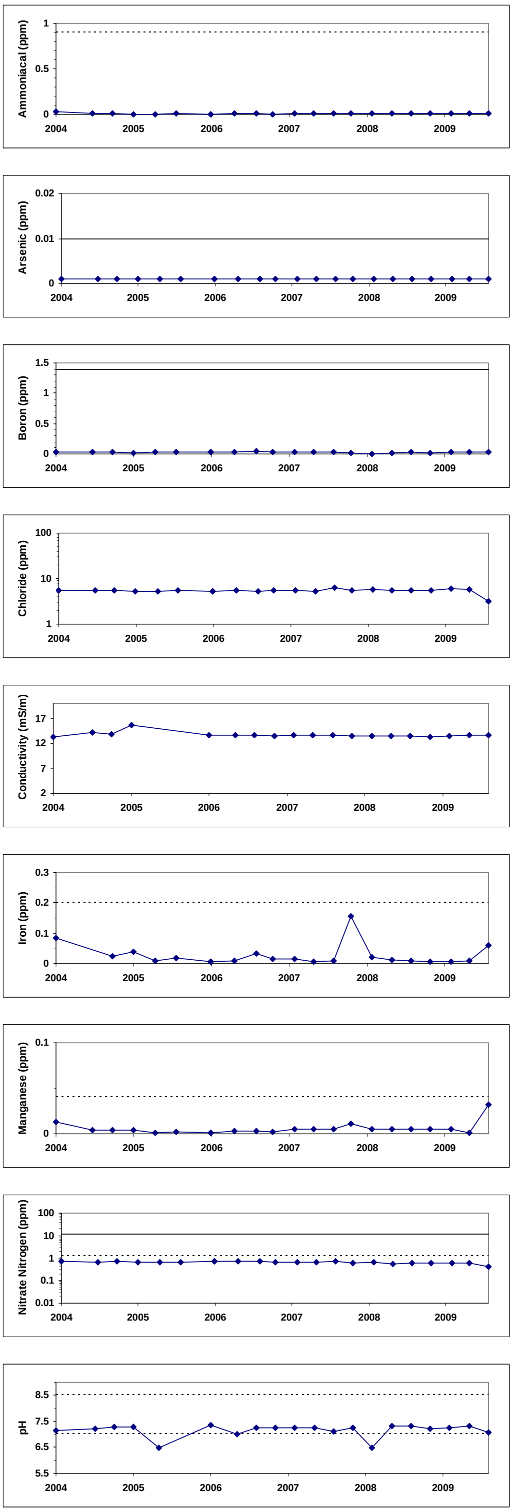


Figure 17 : Well 4403 Water Quality Time Series

The natural confining layer isolates this aquifer from what happens at the immediate surface and for this reason levels of most parameters are stable. For example the level of nitrate-nitrogen is almost unchanging. The cause of the dips or peaks in some parameters is unclear at this stage but it is likely to reflect natural processes, but more record is needed to provide an explanation. There is insufficient length of record for a statistical analysis of trends, but there are no apparent patterns.

3.2. Riverlands Aquifer

The Riverlands Aquifer is also confined and the more southerly areas contain very old water. Recharge comes from a number of sources including the distant Wairau River. Older more mineralised groundwater does cause aesthetic problems for some well owners.

The MDC established well P28w/4402 in 2004 to monitor both the quality and quantity of groundwater in the Riverlands Aquifer. It is located at the Huia vineyard off the eastern end of Alabama Road. In addition the coastal sentinel well P28w/0708 is also located in the Riverlands Aquifer, but measurements are only made of salinity related parameters such as chloride and conductivity. Well 708 is located east of the Opawa River and south of the Wairau Bar estuary.

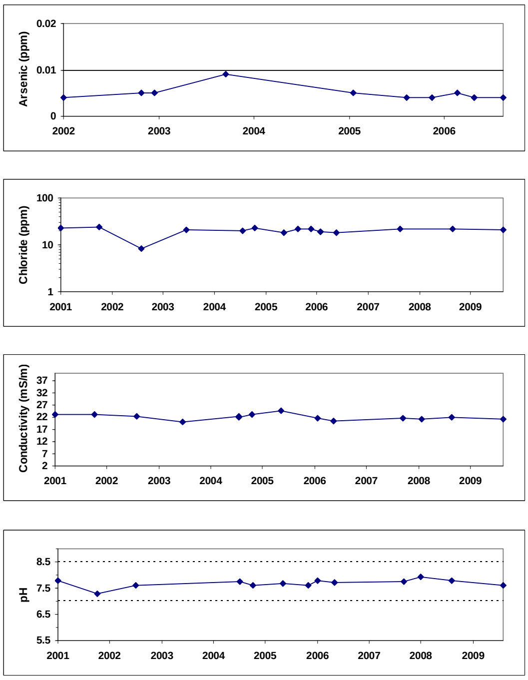


Figure 18 : Well 708 Water Quality Time Series

Figure 18 shows the record of pH, conductivity and chloride for groundwater from well 708 is relatively stable over time which reflects the isolating properties of the confining layer. pH is above the optimum neutral level of 7.

Arsenic is a recently discovered problem in Marlborough groundwaters and appears to be common in confined aquifers. Figure 18 shows that arsenic levels reached 90% of the maximum allowable for human health consumption on one occasion at well 708.

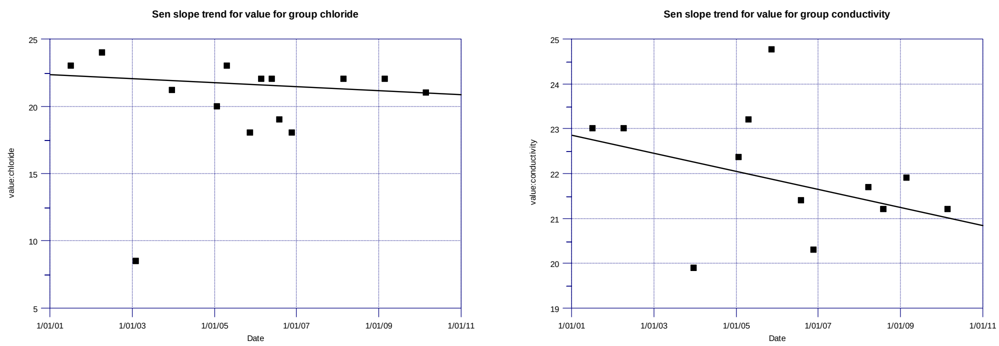


Figure 19 : Well 708 Water Quality Trends

As Figure 19 shows there are no significant trends in chloride or conductivity levels since records began in 2001, with only slight changes over the decade.

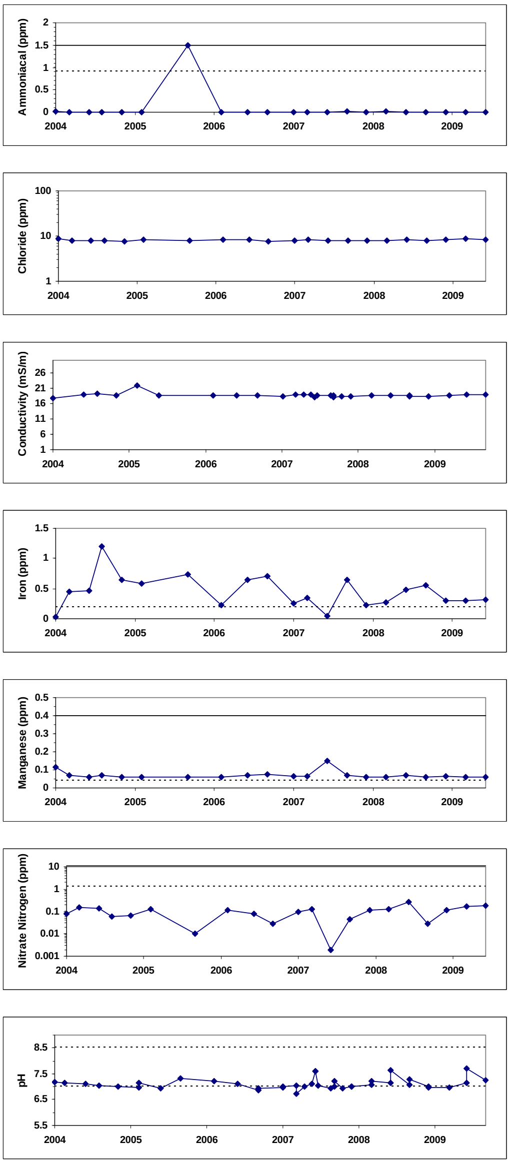


Figure 20 : Well 4402 Water Quality Time Series

Figure 20 shows there is significant variability in the levels of nitrate-nitrogen and iron at well 4402, but more record is needed to understand the causes. Natural denitrification processes common to confined aquifers are responsible for keeping nitrate-nitrogen levels well below below the ecological threshold.

Conversely iron and manganese concentrations exceed the aesthetic thresholds due to the naturally reduced aquifer conditions existing in the Riverlands Aquifer. There is too short a record to analyse for trends at this stage, but there are no apparent patterns with the exception of a decline in iron.

3.3. Woodbourne Sector

There are 2 MDC monitoring wells representing the Woodbourne Sector. Well P28w/0662 was once the main source of water for RNZAF Base Woodbourne and has been sampled by the MDC and its predecessors since the mid 1970s. It is the more southerly of the 2 monitoring sites.

Groundwater levels in wells vary significantly from season to season due to the ephemeral nature of the Southern Valleys sources of recharge.

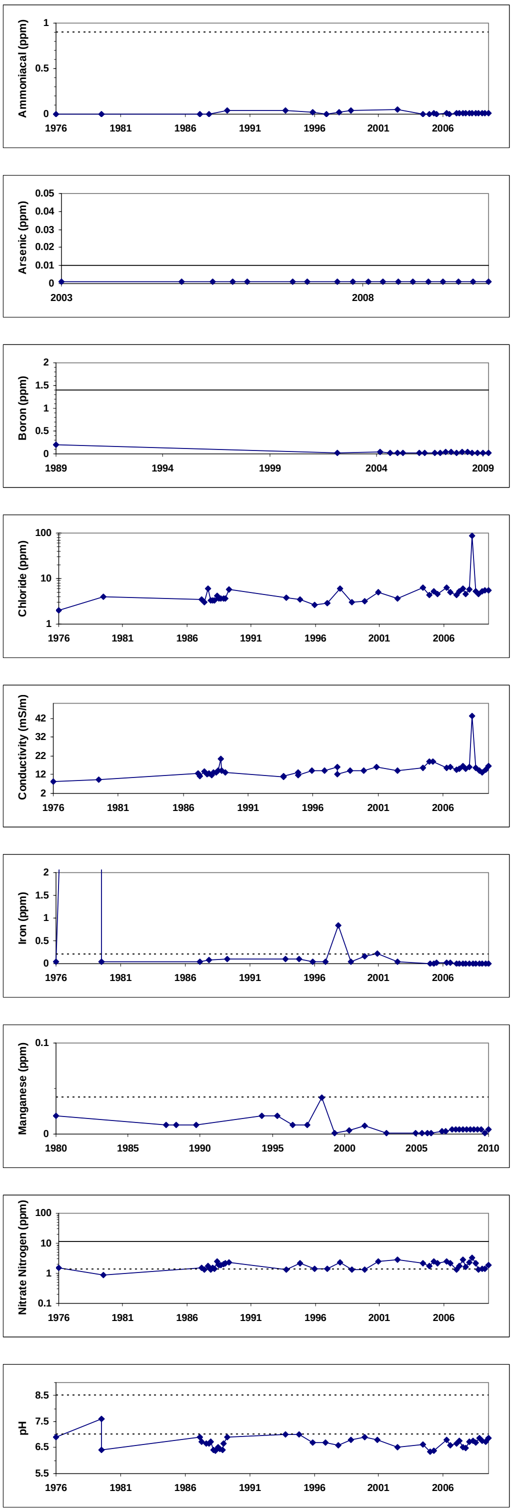


Figure 21 : Well 662 Water Quality Time Series

The series of plots in Figure 21 show that levels of most parameters have been relatively stable over the last 34 years. Chloride appears to be rising as in other unconfined aquifers, but the reason is unclear. pH is naturally low and the RNZAF Base Woodbourne community supply is treated to prevent corrosion of pipes or household metals.

Manganese and iron levels periodically approach the aesthetic guideline. Nitrate-nitrogen levels exceed the ecological threshold, but not the maximum allowable value for human health.

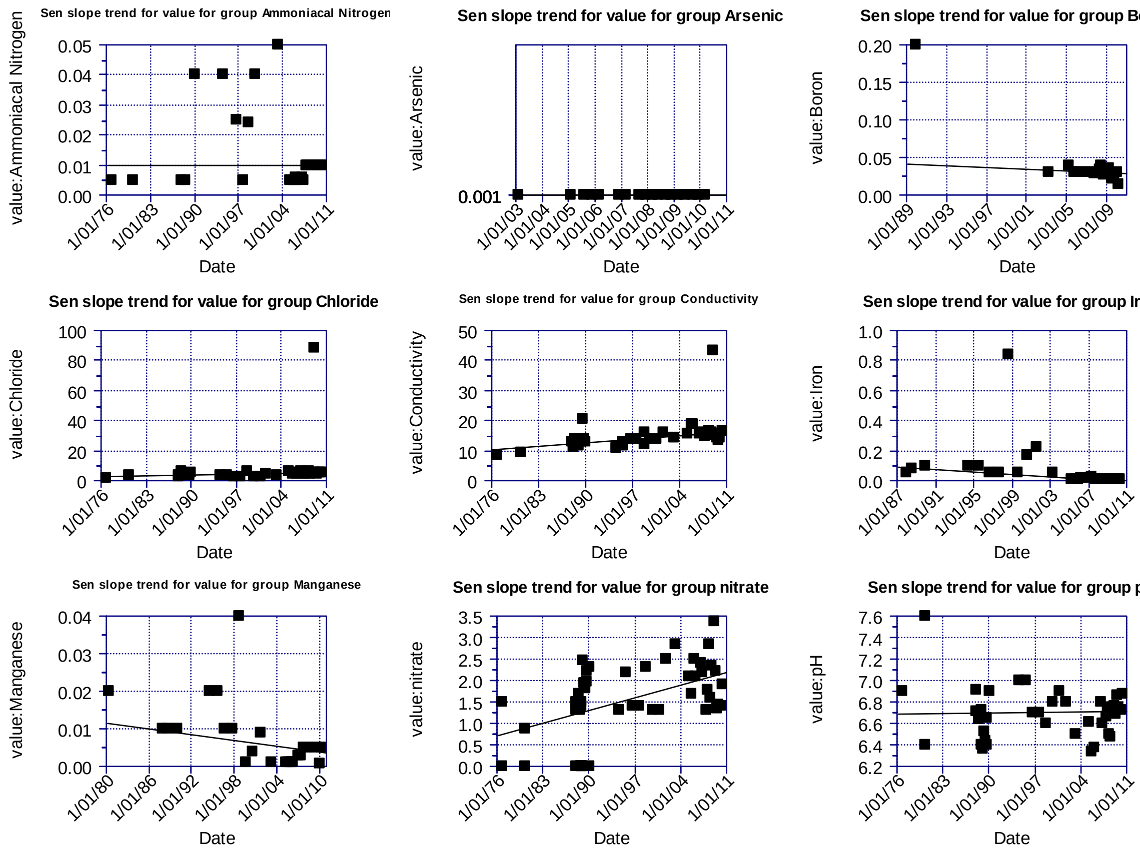


Figure 22 : Well 662 Water Quality Trends

Figures 21 and 22 show there has been a slight increase in nitrate-nitrogen levels since the mid 1970s, although the annual rate of change is small compared to the median concentration. Landuses are impacting on groundwater quality, although they have been moderately high prior to this. Figure 22 indicates an increasing trend in chloride levels due to a single value skewing the record, which in turn is mimicked by conductivity.

The second site representing Woodbourne is well P28w/4118 which is located on the northern side of Old Renwick Road. It represents a mixture of groundwaters originating from both the southern Wairau Aquifer and the Southern Valleys catchments, with the dominant source depending on the prevailing seasonal conditions.

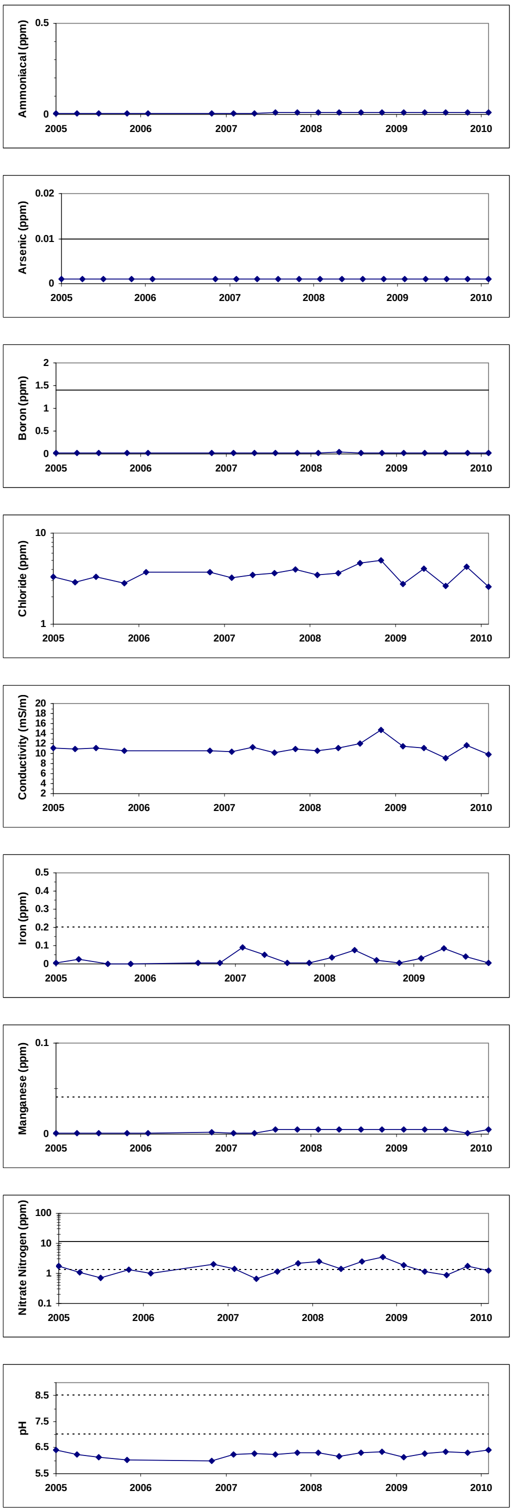


Figure 23 : Well 4118 Water Quality Time Series

Figure 23 shows a distinct seasonal variation in iron and nitrate-nitrogen concentrations. pH is naturally low in common with most young groundwaters across the northern Wairau Plain. There is too short a record to analyse for trends over time at this stage.

However, prior to sampling at well 4118, MDC monitored its predecessor well P28w/1156 nearby starting in 1990. Figure 24 shows nitrate-nitrogen concentrations based on the combined record from both wells.

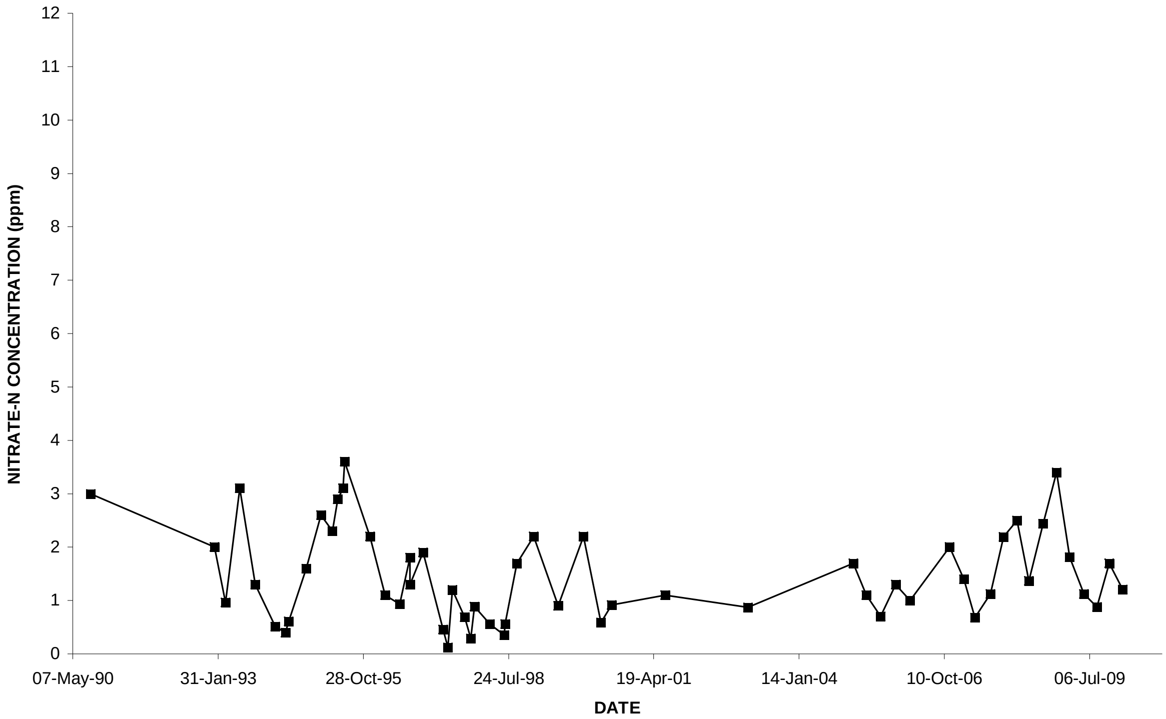


Figure 24 : Combined Record

While nitrate-nitrogen levels have fluctuated over the past 20 years, rising in higher rainfall periods such as the mid 1990s and 2008, overall there has been no significant trend upwards. This long-term record downstream of an area of intensive agriculture suggests that levels of nutrients in groundwater haven't changed significantly since the widespread conversion of land to vineyard. Instead the largest changes probably correspond with natural processes such as rainfall and natural leaching of soil products.

3.4. Deep Wairau Aquifer

The Deep Wairau Aquifer (DWA) was discovered as recently as 1998, but has been closely studied since then to determine its reservoir size. Geochemical tools have played an important part in improving our understanding and as a consequence the MDC has a moderately long record of changes in groundwater chemistry since the aquifer was first exploited.

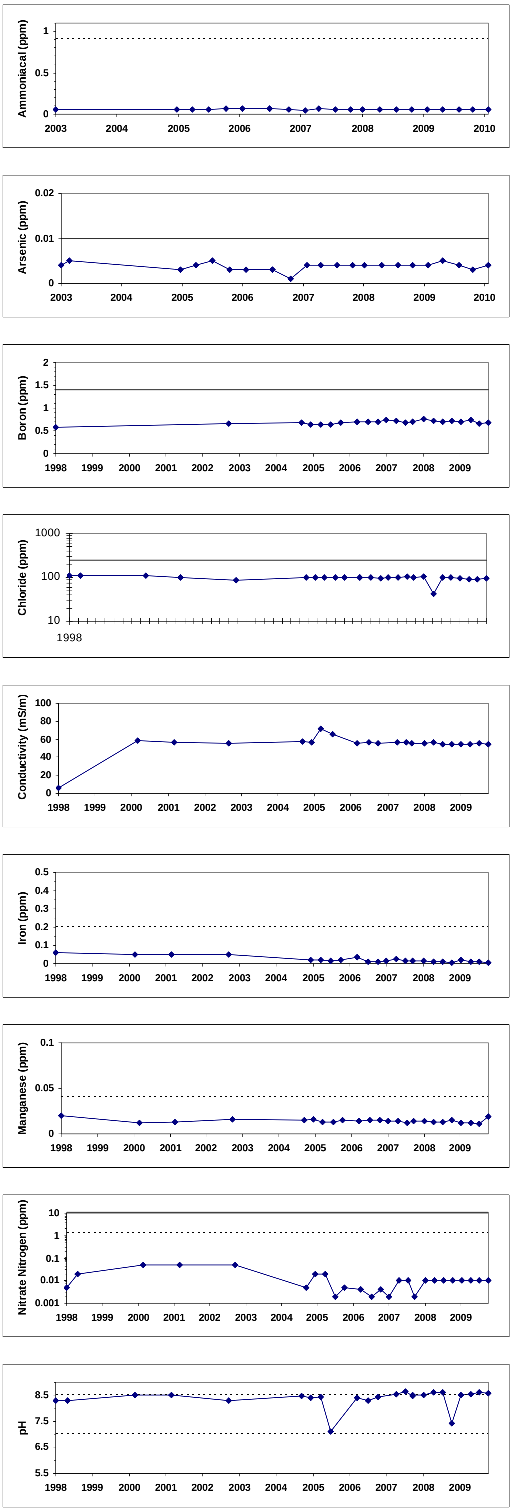


Figure 25 : Well 3278 Water Quality Time Series

Groundwater in this aquifer is very old and highly mineralised as a result. Due to this relative isolation from surface activities the levels of the 9 indicator parameters shown in Figure 25 are relatively stable. For example nitrate-nitrogen concentrations are 100 times less than the drinking water guideline.

The aquifer is anaerobic meaning there is no oxygen in the groundwater and as a consequence ammoniacal nitrogen is the dominant form of that nutrient. Chloride levels are high probably due to residual salts in the marine deposits forming the aquifer. pH is amongst the highest of any groundwater in the district.

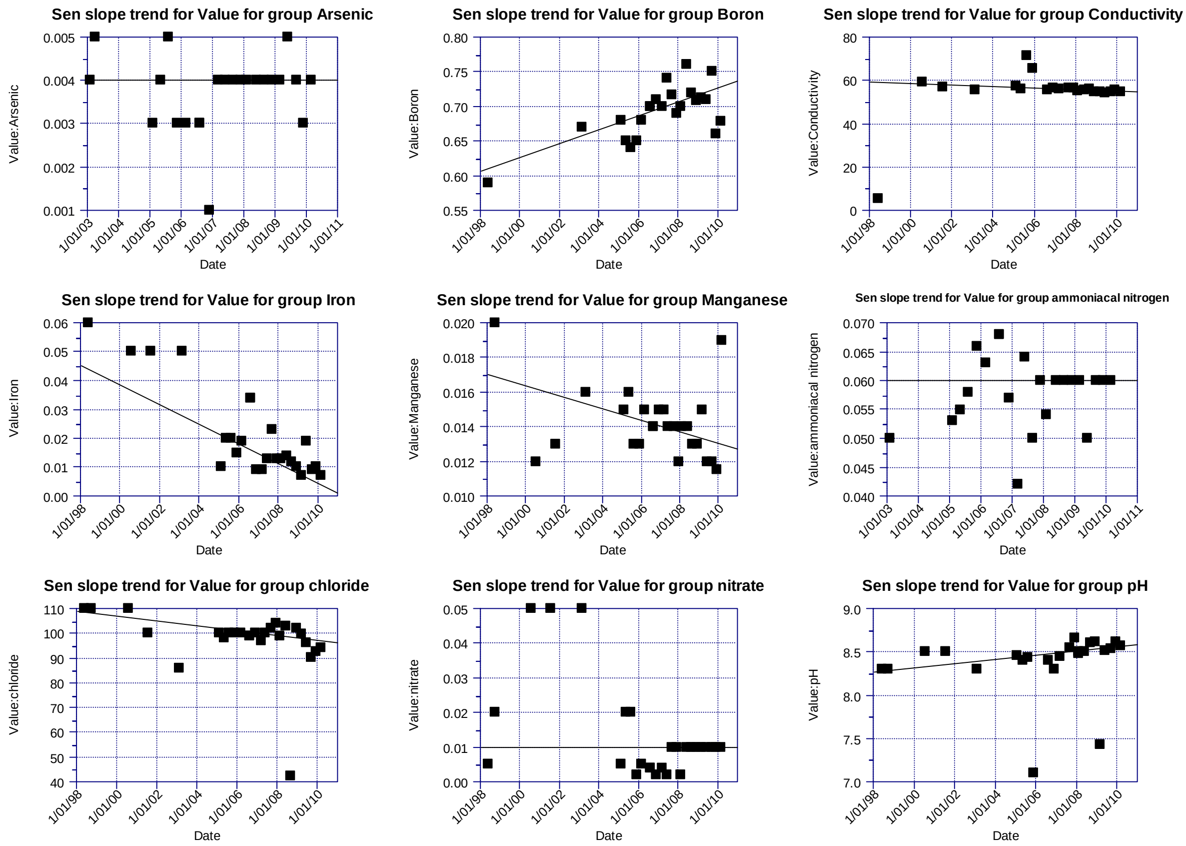


Figure 26 : Well 3278 Water Quality Trends

There is a significant increasing trend in boron and pH, and falling trends in conductivity and chloride. However they are not considered meaningful in terms of the rate of annual change compared to the median value of each parameter. This is an important finding as it shows that current abstraction is not inducing younger water into the DWA.

3.5. Omaka River Aquifer Shallow Layer

This aquifer forms part of the Southern Valleys Catchments and is recharged by the Omaka River. It comprises of a shallow layer and a deep layer. Well P28w/3069 is located in the middle reaches of the catchment and represents the shallow unconfined layer of the Omaka River Aquifer.

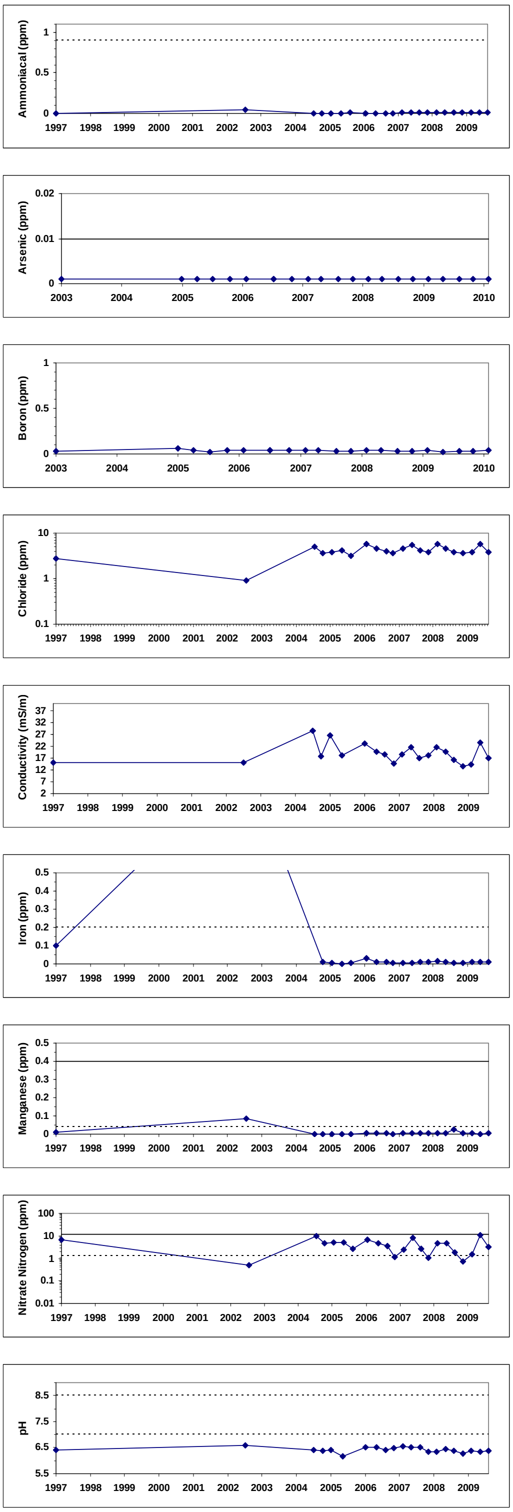


Figure 27 : Well 3069 Water Quality Time Series

Figure 27 shows values of nitrate-nitrogen, conductivity and chloride vary throughout the year and mostly peak in spring due to rainfall leaching. This variability is common in shallow, unconfined type aquifers that respond quickly to rainfall and in this case Omaka River recharge.

pH is characteristically low due to the leaching of organic rich biochemicals. Nitrate-nitrogen levels are relatively high, alternating between the ecological threshold and the human health maximum allowable value, although the median value is only 4.5 g/m3. MDC staff are investigating the causes of the elevated nitrate-nitrogen levels in groundwater.

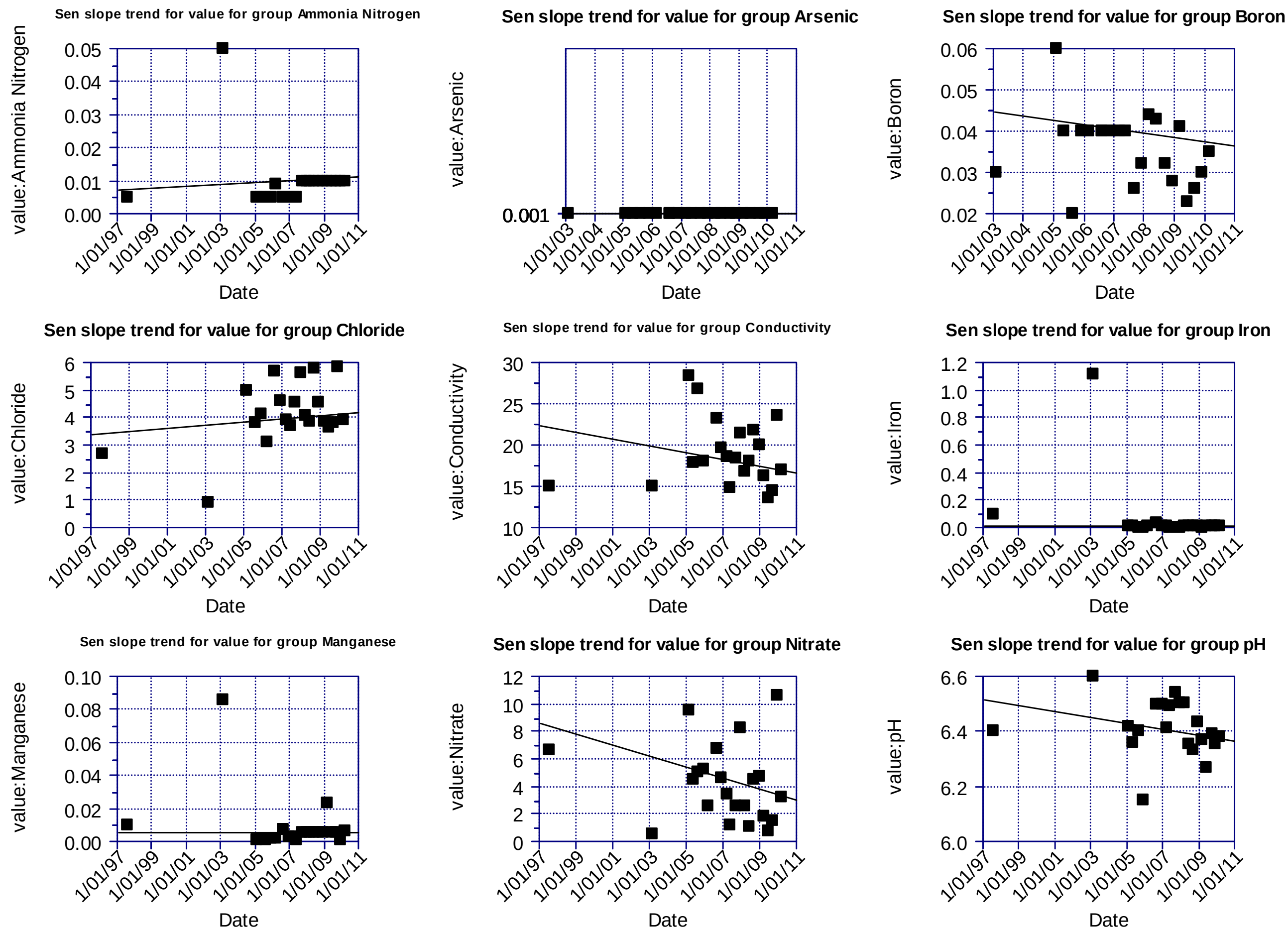


Figure 28 : Well 3069 Water Quality Trends

As Figure 28 shows there are no significant trends in any of the parameters measured at well P28w/3069 since 1997.

3.6. Brancott Aquifer

The Brancott Aquifer forms part of the Southern Valleys Aquifers suite of low yielding groundwater systems. Well P28w/3217 is used to monitor groundwater quality in the Brancott Aquifer. Figure 29 shows the variation over time of the indicator parameters since sampling began in 2001.

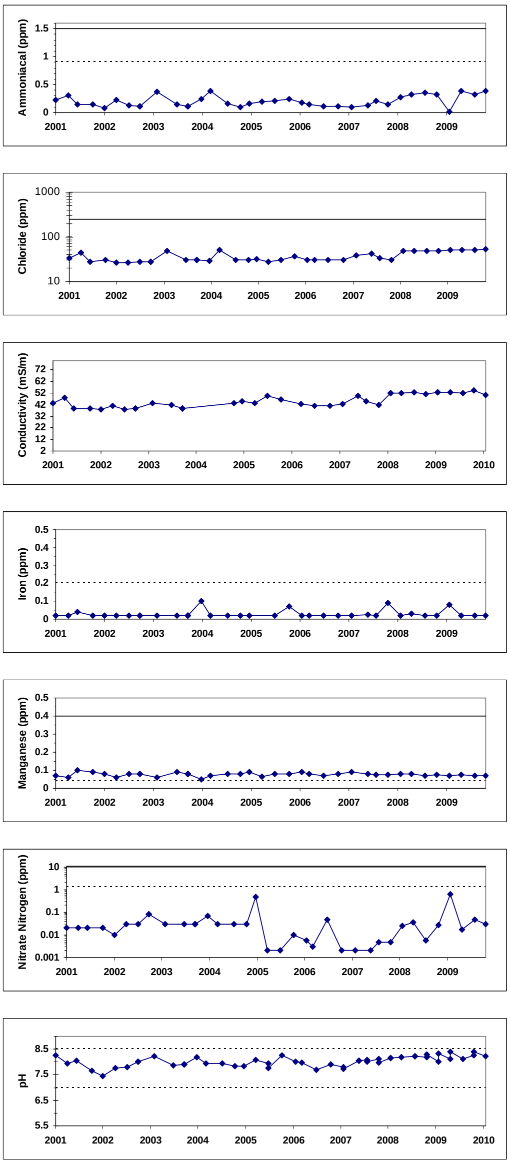


Figure 29 : Well 3217 Water Quality Time Series

Because of its highly confined structure and depth below the surface, seasonal variations in most parameters are small. Nitrate-nitrogen levels are naturally low, but conversely the groundwater has moderately high levels of dissolved minerals such as manganese which exceeds the aesthetic threshold.

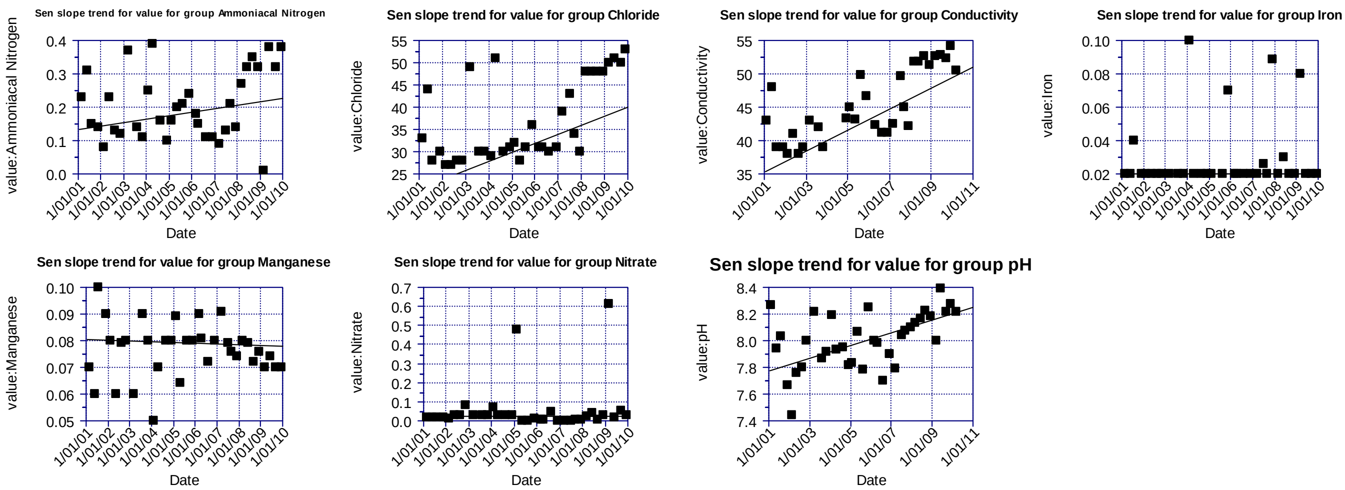


Figure 30 : Well 3217 Water Quality Trends

As Figure 30 shows levels of chloride, conductivity and pH exhibit significant increasing trends over time. However only annual changes in chloride at 2 g/m3/year and conductivity at 1.6 mS/m/year, were meaningful in relation to their median values. This is consistent with increasing pH and decreasing nitrate-nitrogen levels, representing more evolved groundwater.

This suggests that over time the groundwater is becoming older which is the opposite to what is expected to happen in these heavily committed aquifers. Pumping is known to cause large drawdowns and induce a turn-over of water. One possibility is that older water is being drawn upwards from depth or there is mixing of groundwaters of different ages from separate water bearing layers.

3.7. Omaka Aquifer

The Omaka Aquifer forms part of the low yielding Southern Valleys suite of aquifer systems. It is recharged by a combination of rainfall and losses from local streams such as Wards/Mill Stream. In common with the other Southern Valleys Aquifers, groundwater travel times are slower due to the lower permeabilities of the aquifer geology. Well P28w/1945 located in Hawkesbury Road represents the medium depth layers of the Omaka Aquifer.

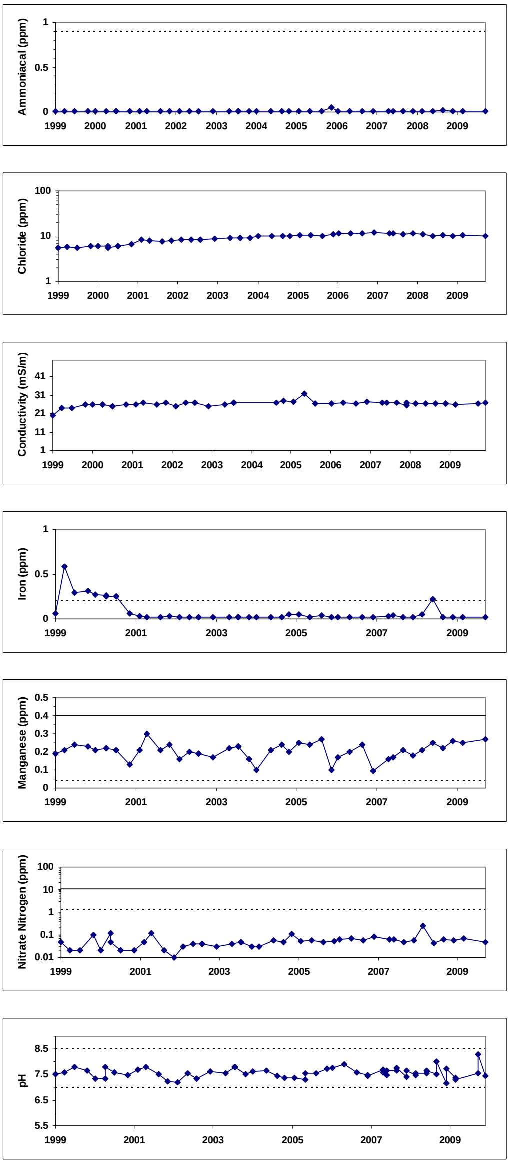


Figure 31 : Well 1945 Water Quality Time Series

The fall in iron concentrations is more likely to reflect changes in sampling procedures and detection limits over time than actual changes in groundwater concentrations. Figure 31 shows that manganese and occasionally iron cause issues for well owners due the moderate reducing conditions, and also explains why nitrate-nitrogen levels are naturally low. As water gets older it becomes more mineralised through natural processes.

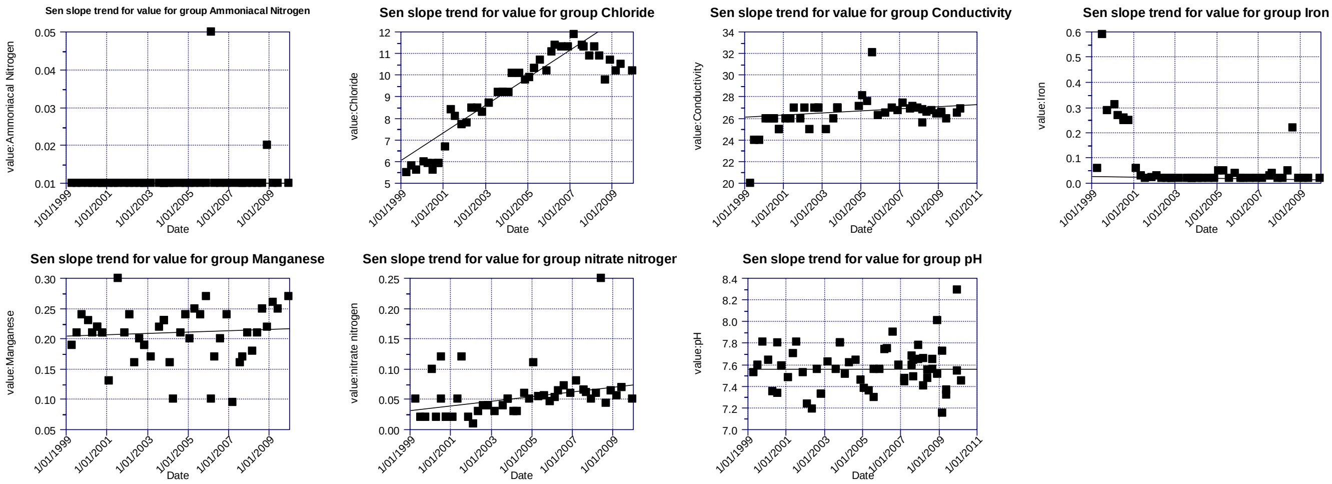


Figure 32 : Well 1945 Water Quality Trends

Figure 32 shows a significant increasing trend in chloride concentrations since sampling began in 1999 with an annual change of 6.5% of the median value although levels remain well below the aesthetic value of 250 g/m3. The reason could be pumping inducing older groundwater into the well, or leaching of soil materials.

3.8. Coastal Wairau Aquifer

The potential exists for seawater intrusion to occur along the Cloudy Bay coast as water demand increases for crop irrigation and settlement. The MDC established a sentinel well network to provide early warning of an inland shift in the natural interface between freshwater and saltwater.

3.8.1. Northern Coastal Wairau Aquifer

Well P28w/3667 located near Hinepango Drive was established in 2000 to provide early warning of seawater intrusion of the deeper aquifer in the coastal area north of the Wairau Diversion channel. Because it is only sampled once each year, it doesn't provide the seasonal detail of the regular state of the environment sites. However continuous measurements of conductivity, which is an indicator of seawater are made.

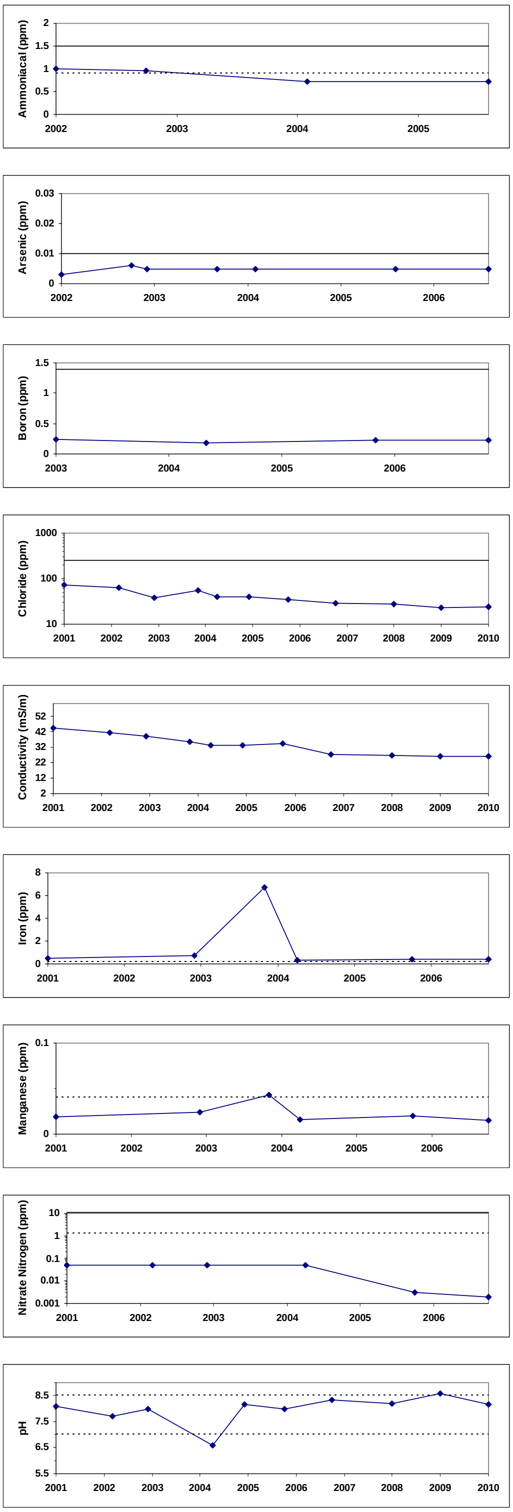
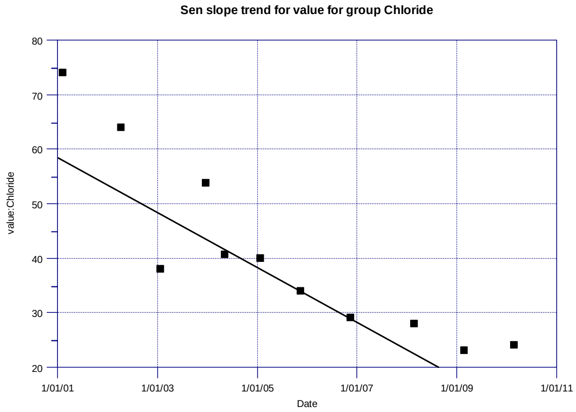


Figure 33 : Well 3667 Water Quality Time Series

There are a number of interesting features about its groundwater chemistry, mostly caused by natural processes. Figure 33 shows elevated but stable arsenic levels, iron and ammoniacal-nitrogen levels which exceed their aesthetic limits, manganese levels that approach the aesthetic threshold and high pH.



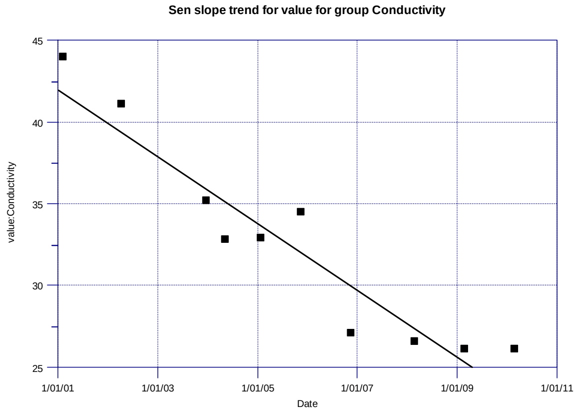


Figure 34 : Well 3667 Water Quality Trends

In terms of trends Figure 34 shows an obvious downward trend in chloride concentrations of 5 $g/m^3/year$ which in turn is mimicked by conductivity levels. This represents a significant rate of change of 13% of the median chloride concentration.

This is likely to reflect younger groundwater being induced into this backwater area of the main aquifer following increases in consented levels of pumping since 2000. Younger groundwater originating from further south has lower levels of chloride than the more evolved groundwater it replaces.

3.8.2. Central Coastal Wairau Aquifer

Higher rates of groundwater flow occur beneath the central Cloudy Bay coastline compared to Rarangi or Riverlands due to the existence of more permeable gravels. The MDC permanent monitoring well for the area is well P28w/1733 located north of the Wairau River mouth. It is a longstanding site having been established in 1987 and taps a highly confined aquifer which receives recharge from Wairau River losses at Renwick.

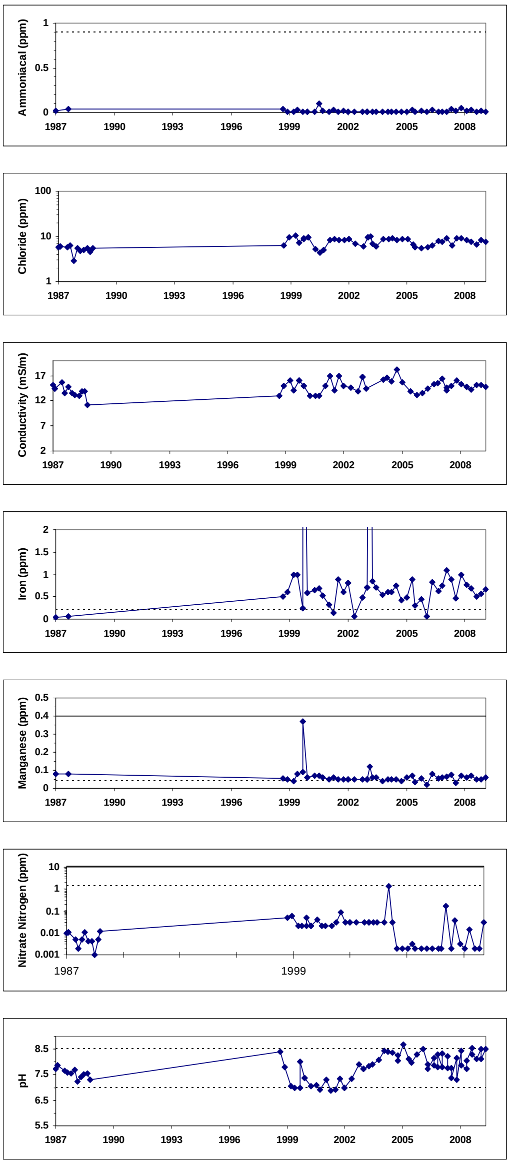


Figure 35 : Well 1733 Water Quality Time Series

As Figure 35 shows concentrations of iron and manganese are naturally elevated above their aesthetic thresholds due to the reducing chemical conditions associated with confined type aquifers. This also accounts for the low nitrate-nitrogen and high pH of groundwater from well 1733. The variation in pH and iron levels will partly reflect the filtering of samples since 2004 and changes in the sensitivity of field meters.

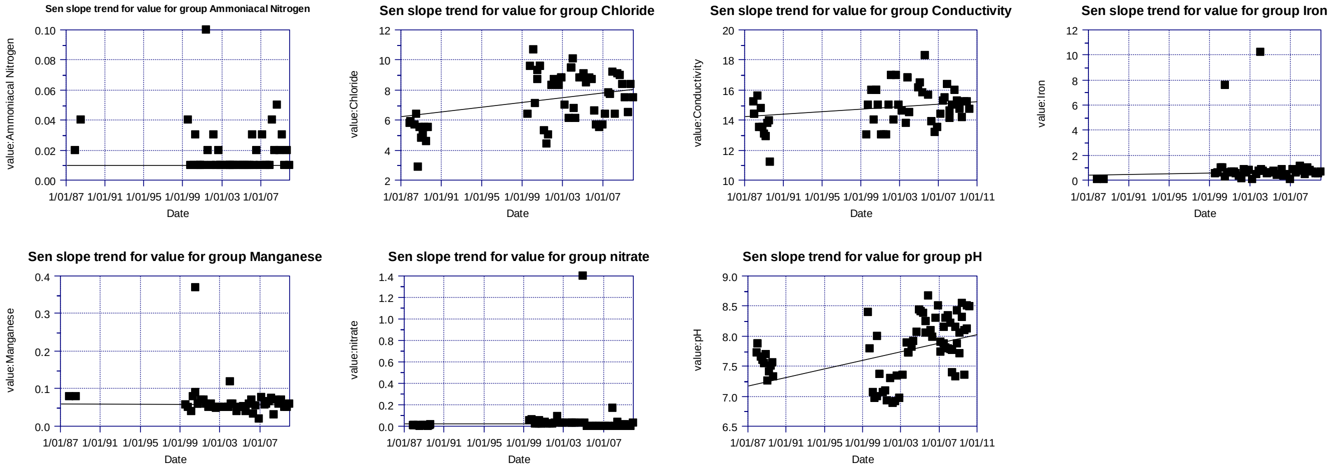


Figure 36 : Well 1733 Water Quality Trends

As Figure 36 shows values of most parameters are stable which reflects the confined aquifer structure. This tends to isolate landuse contaminants from entering groundwater directly although pumping can induce groundwater of a different quality to migrate from further afield within the aquifer. There were significant increasing trends in chloride and pH, although the annual rate of change was not meaningful in terms of the median value.

3.9. Rarangi Shallow Aquifer

The Rarangi Shallow Aquifer is a small coastal groundwater system formed of fine gravels and coarse sands that bounds the coast. Its groundwater chemistry varies naturally from being oxygen rich beneath the sand dunes, to oxygen poor near wetlands due to biochemical demand. The availability of oxygen determines the solubility of iron, manganese and arsenic in groundwater.

3.9.1. Inland Unconfined RSA

Several wells are needed to represent the differing natural chemical and physical conditions of RSA groundwater. The MDC monitoring network includes 2 inland wells tapping the Rarangi Shallow Aquifer in addition to the series of saltwater intrusion sentinel wells along the coast.

Well P28w/4442 is used to monitor the seasonal and long-term variation in shallow groundwater associated with wetlands, which are naturally oxygen deficient and as a consequence have poorer water quality. The site was also chosen to observe the effects of residential settlement on RSA water quality.

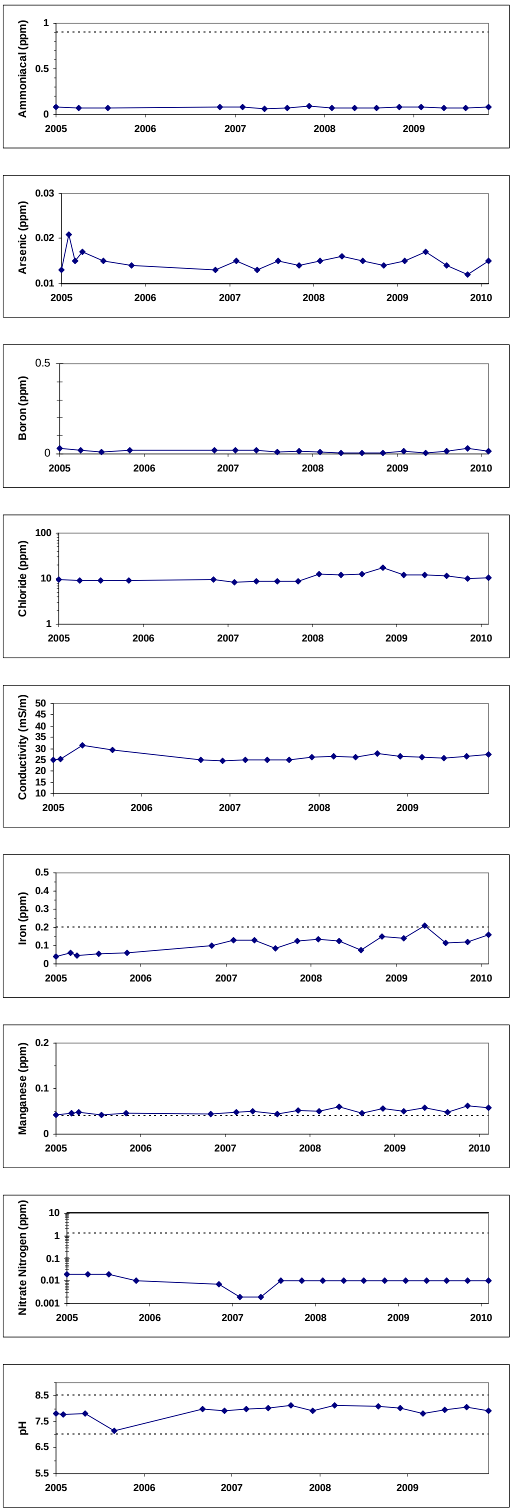


Figure 37 : Well 4442 Water Quality Time Series

Figure 37 shows that manganese and occasionally iron concentrations exceed the aesthetic guideline. The concentration of arsenic is consistently above the maximum acceptable value in the Drinking Water Standards (NZMH – 2005) but is naturally occurring. There are apparent upwards trends in iron and manganese, but the period of record is too short to test if these are statistically significant yet.

Well P28w/1634 is the second inland well and it is more representative of the oxygen abundant dune areas. It belongs to the Rarangi Golf Club and is used to supply domestic quantities of groundwater to their clubrooms. It is located 400 metres inland and has been sampled by the Marlborough District Council over a long period of time from 1989 onwards.

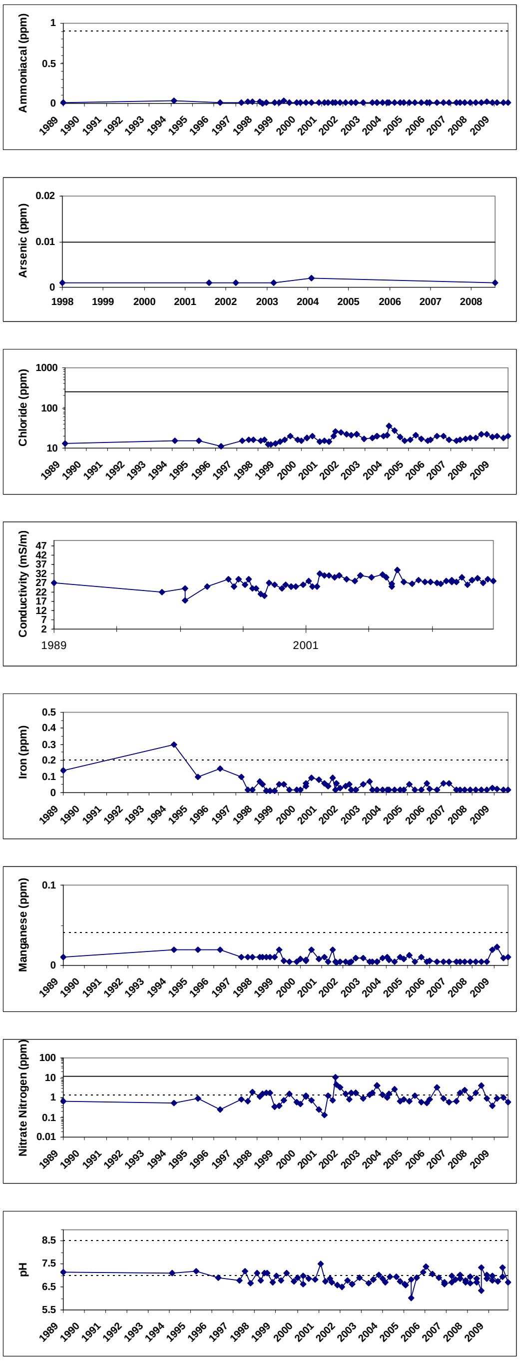


Figure 38 : Well 1634 Water Quality Time Series

The 2 items of note in Figure 38 are elevated iron levels during the mid 1990s, and short term fluctuations in nitrate levels which can exceed the drinking water guideline. The seasonal variability in nitrate concentration is typical of shallow unconfined type aquifers like the Rarangi Shallow Aquifer which are sensitive to leaching of overlying landuses contaminants such as nitrate-nitrogen fertilisers which spike following rain or golf course irrigation.

The reason for the decline in iron levels is uncertain but could reflect a number of factors such as the pumping system which includes a pressure tank, field filtering of samples since 1998, or differing laboratory detection limits.

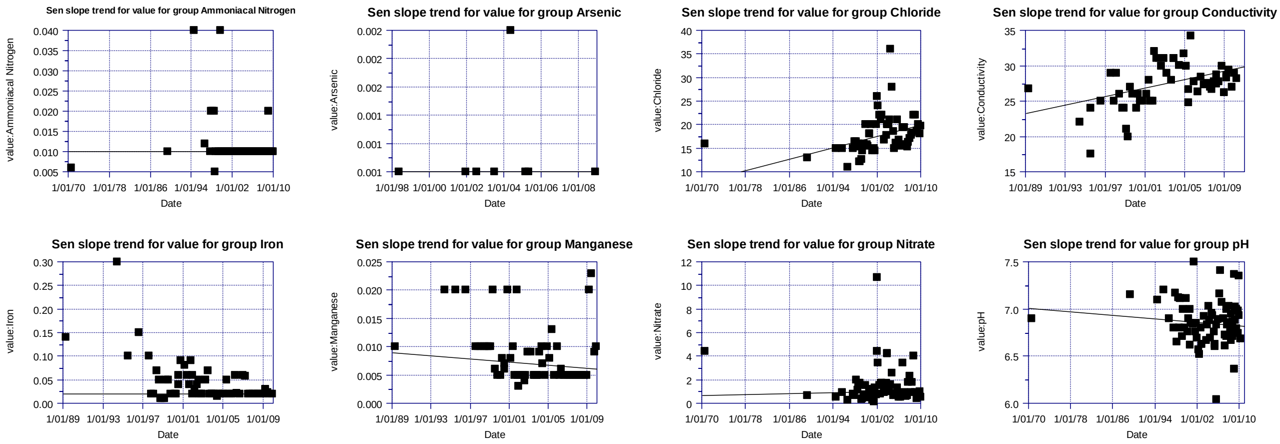


Figure 39 : Well 1634 Water Quality Trends

There is an increasing trend over time in chloride although the annual rate of change is small at only 2% of the median concentration. While nitrate-nitrogen concentrations fluctuate over short time periods following rainfall or irrigation, they appear to return to background values with no apparent long-term trends at this stage.

3.9.2. Coastal Unconfined RSA

The MDC operate a series of permanent sentinel wells to provide early warning of seawater intrusion of shallow domestic wells along the beach front. Seawater intrusion has not occurred to date in either of the coastal aquifers, but the shallow unconfined Rarangi Shallow Aquifer is most at risk because it does not have the confining layer that naturally isolates the underlying Wairau Aquifer from the sea.

There are 4 dedicated MDC wells north of the Diversion monitoring RSA groundwater elevation and conductivity, an indicator of salinity. Only information from wells P28w/3668 and P28w/3711 has sufficient length of record for analysis purposes at this stage and is included in this report.

Recorders installed at the base of these sentinel wells automatically measure the conductivity of RSA groundwater on a continuous basis. Calibration readings of conductivity and chloride are made in a laboratory each year based on samples taken in summer to verify these downhole instruments are operating correctly.

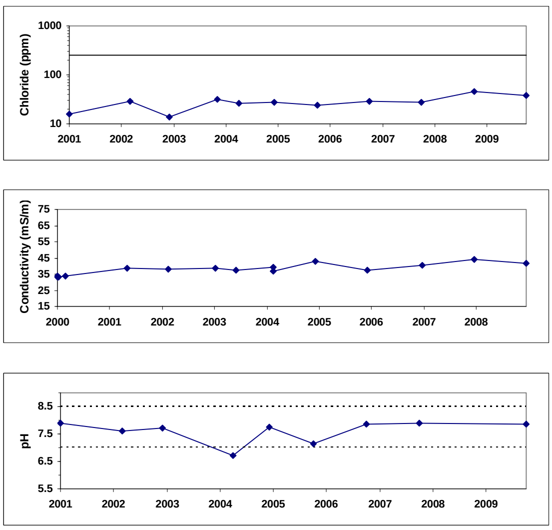


Figure 40 : Well 3668 Water Quality Time Series

Figure 40 shows that ambient concentrations of chloride and conductivity are currently within acceptable limits.

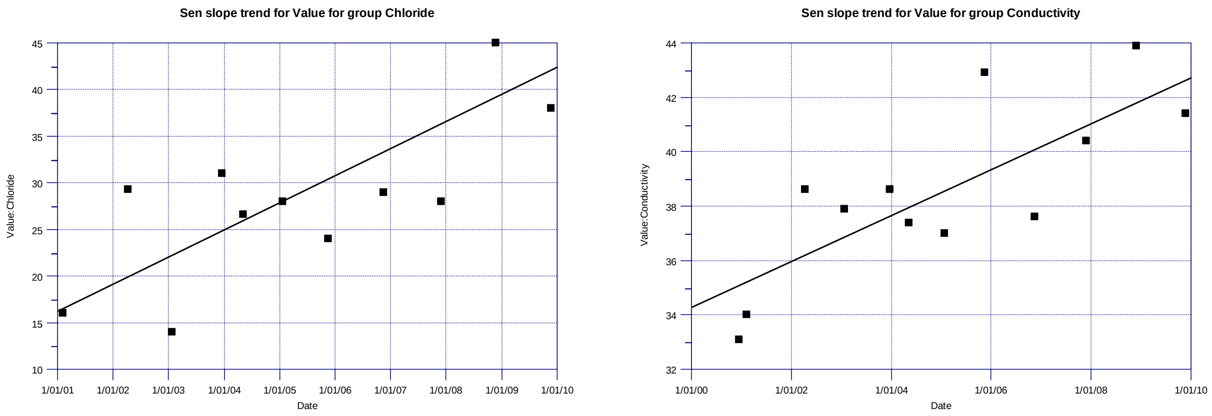


Figure 41 : Well 3668 Water Quality Trends

In this case the Mann-kendall test showed no significant trends existed at the 95% confidence limit for chloride, but a trend did exist for conductivity which closely mimics chloride. It is apparent from Figure 40 that both chloride concentrations and conductivity levels are climbing over time. There may be too few observations for the statistical method.

Nothwithstanding this, because levels of conductivity and presumably chloride peak in spring rather than summer, the trend is likely to reflect leaching of wind blown salts accumulating in the soil rather than a shift of the seawater interface caused by well pumping, which is the primary issue. MDC staff are monitoring patterns closely to confirm this mechanism over a range of seasonal conditions.

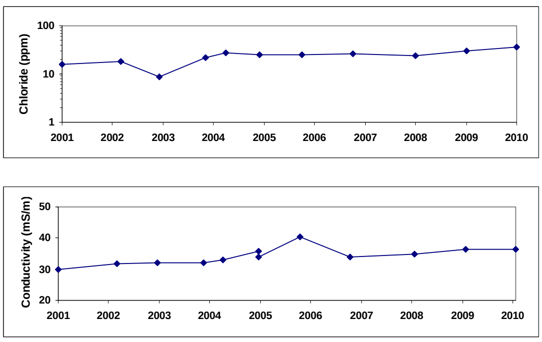
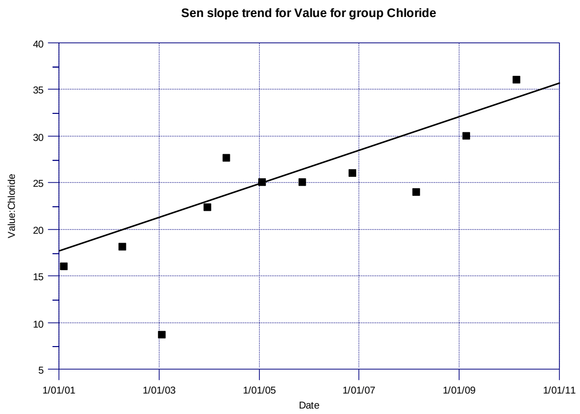


Figure 42 : Well 3711 Water Quality Time Series

The second sentinel site being reported on is well P28w/3711 which is located further north of well P28w/3668 and is referred to as the Bluegums site. Figure 42 shows that chloride concentrations are currently within acceptable limits, but in common with its sister site 3668, there is a slight upwards trend.



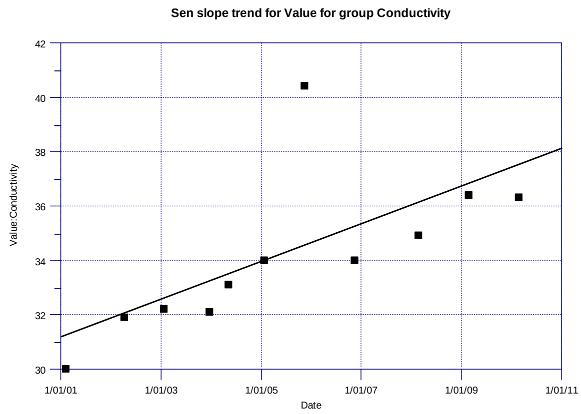


Figure 43 : Well 3711 Water Quality Trends

As Figure 43 shows a significant increasing trend in chloride concentration exists of 7% of the median value. As with well 3668, chloride values peak in spring and do not appear to be associated with summer pumping.

3.10. Needles Creek Gravels Aquifer

The Needles Creek Gravels is a riparian type aquifer associated with Needles Creek near Ward township. It supplies water for both domestic, community and crop irrigation. Well P28w/0188 located just upstream of the SH1 bridge is used by the MDC for monitoring water quality.

Its water quality is used to represent the unique geology of the Flaxbourne River Catchment which influences groundwater quality. It is also used to monitor any changes which may accompany increased consented water demand.

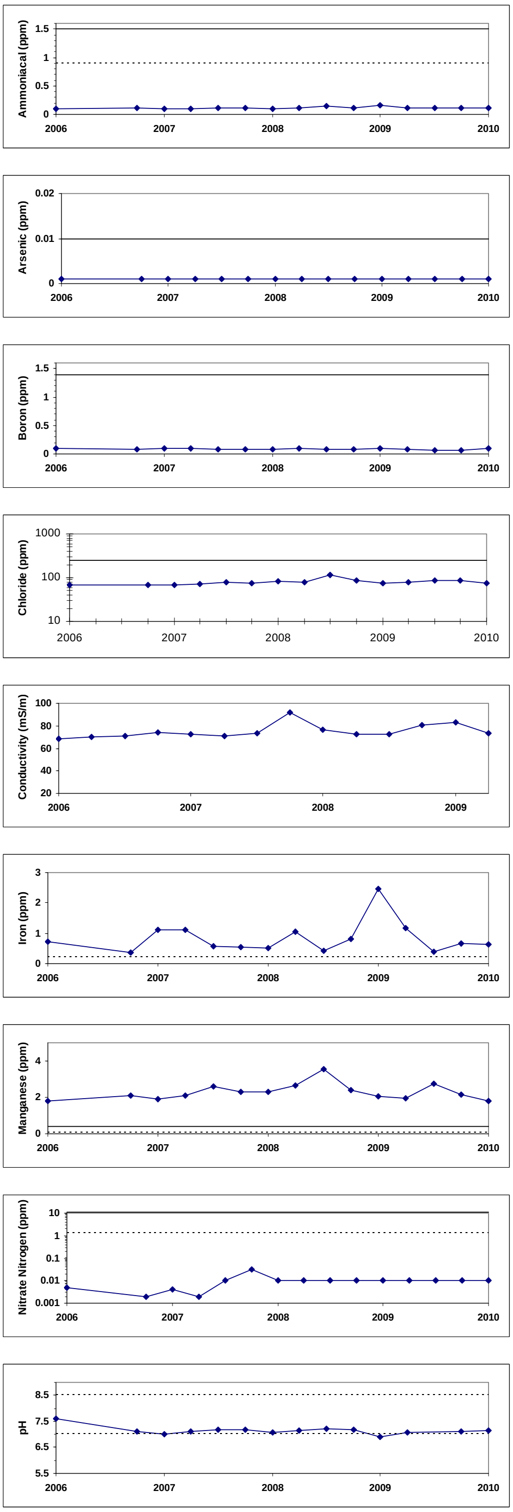


Figure 44 : Well P29w/0188 Water Quality Time Series

As Figure 44 shows chloride concentrations are elevated due probably to the influence of residual salt in the Papa mudstone that underlies the area. Iron concentrations are consistently above the aesthetic threshold. Manganese levels exceed the human health maximum allowable value and this water is not suitable for human consumption.

These deficiencies are the results of natural processes rather than landuses. There is too short a period of record to analyse for long-term trends at this stage although the levels of all 9 groundwater quality indicators appear relatively stable over time.

3.11. Wairau Valley Aquifer

Groundwater resources at Wairau Valley have become of increasing importance from a water supply perspective and also to understand the potential risk of contamination from naturally saline water now thought to underlie much of the area.

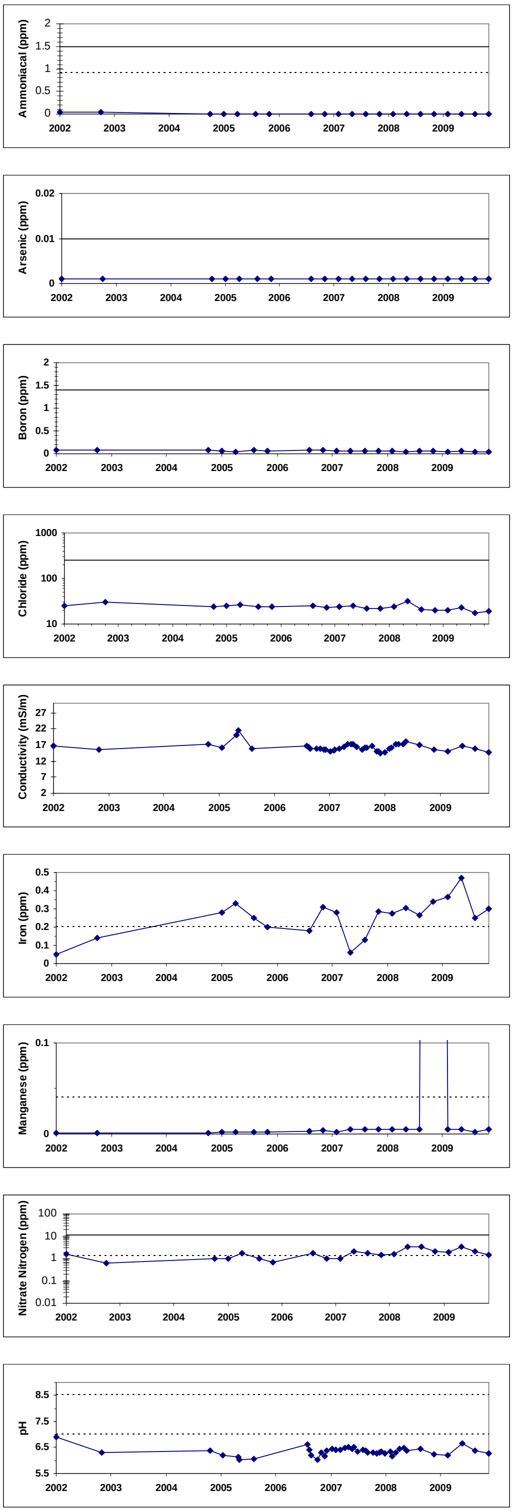


Figure 45 : Well O28w/0015 Water Quality Time Series

Figure 45 shows that iron and nitrate-nitrogen concentrations are elevated above their aesthetic ecological thresholds respectively. The reason for such high values of dissolved iron in such low pH groundwater is uncertain, particularly as manganese concentrations are low. Both iron and manganese become soluble at a similar redox potential and pH.

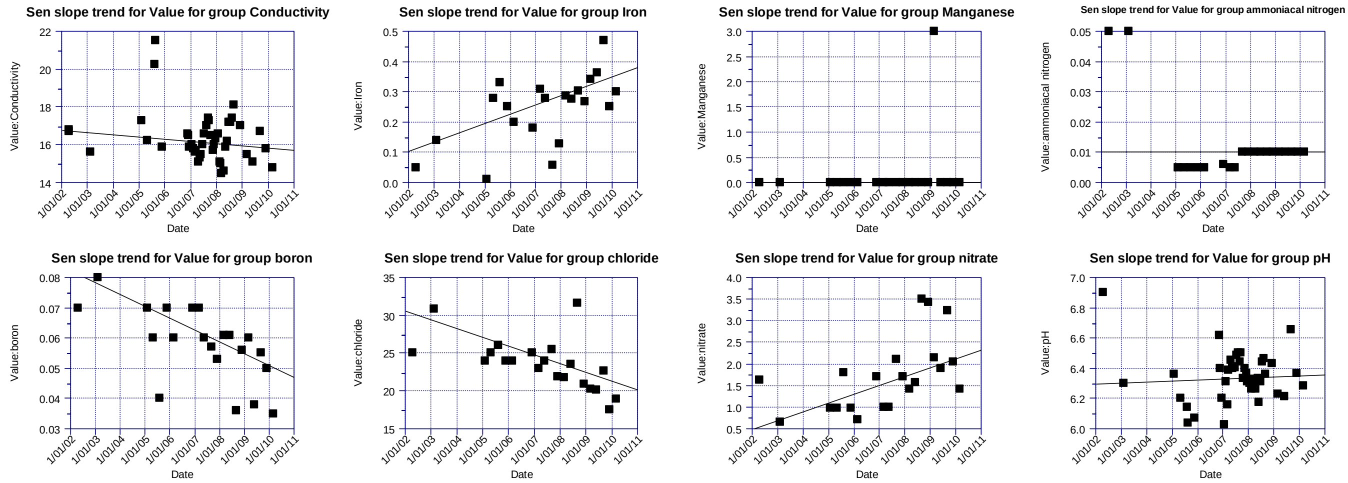


Figure 46 : Well O28w/0015 Water Quality Trends

There are statistically significant increasing trends in iron and nitrate concentrations, and a decreasing trend in chloride. The cause of the changes probably reflects general intensification but care is needed not to generalise as the results from a single well may not be representative.

The period of record is too short to come to any firm conclusions at this stage but MDC staff will closely monitor nitrate-nitrogen trends in particular, given the significant rate of change and its potential relevance to landuse.

3.12. Tuamarina River Aquifer

The Tuamarina River Aquifer is an important source of water for domestic or stock supply, irrigating dairy pasture, washdown and for Picton public water supply in late summer. This is a a relatively shallow groundwater system which as the name implies is linked to Tuamarina River flow. The MDC monitoring site for the area is the Speeds Road wellfield which is made-up of 3 production wells.

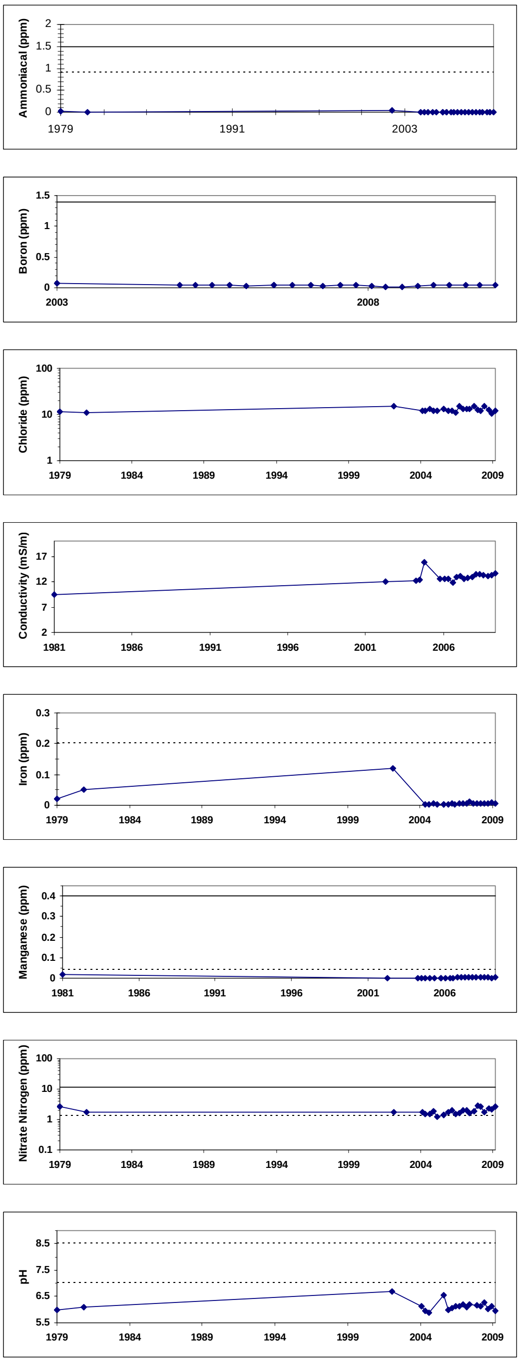


Figure 47 : Well P27w/0448 Water Quality Time Series

Figure 47 shows a long record exists dating from 1979, but there are gaps which is not ideal for identifying trends. Nitrate-nitrate concentrations exceed the aesthetic threshold but are surprisingly low for an intensively farmed dairying area. The large fluctuations in iron concentrations will partly reflect differences in sampling procedures since the 1970s.

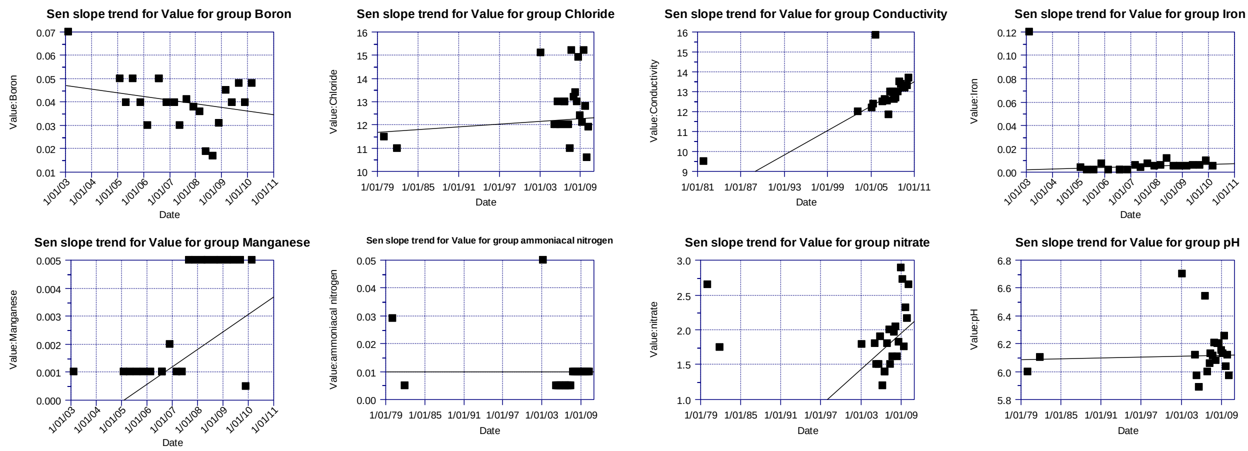


Figure 48 : Well P27w/0448 Water Quality Trends

The only statistically significant and meaningful trend were increasing concentrations of nitrate-nitrogen, but as Figures 47 and 48 show, the overall change since 1979 is minor. Nothwithstanding this MDC staff will continue to monitor levels closely.

3.13. Linkwater Aquifer

Linkwater is underlain by alluvial gravels which form a series of groundwater bearing layers which are generally unconfined and susceptible to landuse contamination. The aquifer is recharged by a combination of rainfall and seepage losses from Cullens Creek. Groundwater is used for a variety of purposes including domestic or stock supply, crop irrigation and washdown.

Monitoring of the Linkwater Aquifer was started in 2006 in response to the potential for increased demand on groundwater resources, and to fulfil the aim of having a regionally representative groundwater quality monitoring network across the district.

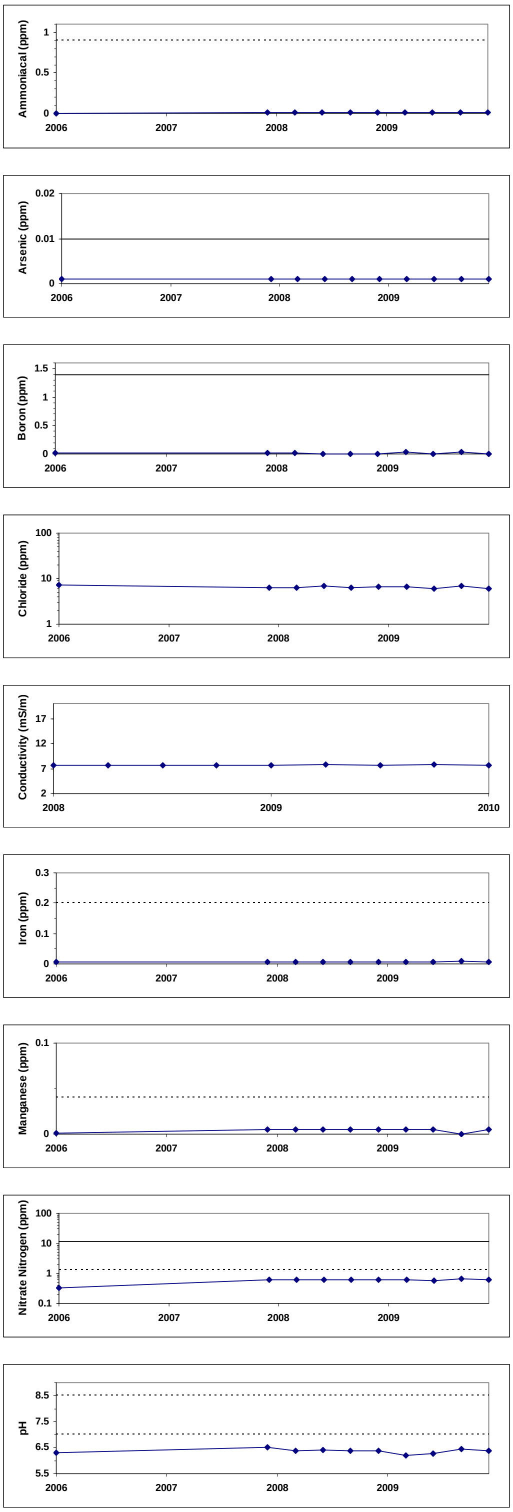


Figure 49 : Well P27w/0447 Water Quality Time Series

Figure 49 shows that water quality is of a high standard with the level of all indicator species within the various health or ecological thresholds, with the exception of pH which does not fall within the optimum range. There is insufficient length of record to analyse for trends at this stage.

3.14. Trend Summary

There were 13 significant increasing trends in water quality of which 7 were meaningful in terms of the respective median value. They involved changes in chloride, pH, nitrate-nitrogen and iron. There were also 3 meaningful decreasing trends in water quality involving chloride and nitrate-nitrogen, and 1 minor change over time in pH.

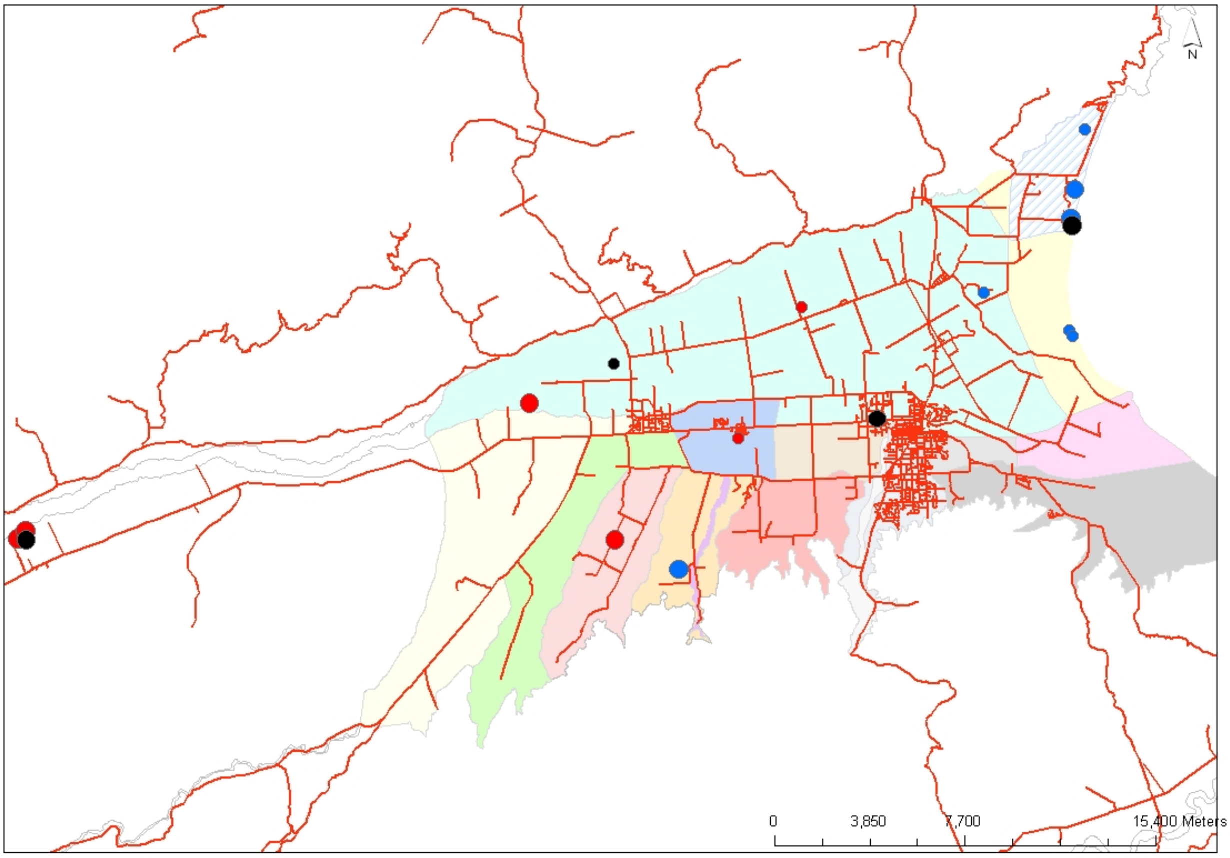


Figure 50 : Location of Trend Sites

Figure 50 shows the location of MDC monitoring sites where changes in groundwater quality are occurring over time. The underlying colour shading marks the boundaries of defined aquifers underlying the Wairau Plain.

A large circle represents a meaningful rate of change relative to the median and the smaller circle a minor change. The blue colour infers a geological influence such as a greater influence from older more mineralised groundwater or connate water. A red circle almost certainly means a man-made effect, especially inland and beneath the northern Wairau Plain where wells are shallow.

Some trends could be influenced by well pumping changing natural flow patterns and resulting in either a dilution or concentration of a particular parameter such as chloride. Black means the level or concentration of a parameter is falling over time.

There does not appear to be a single explanation for the changes and for this reason it is not easy to conclude whether groundwater quality at a district level is improving or declining. Nitrate-nitrogen is the key indicator of human influence on groundwater and the focus of MDC monitoring. However there were only increasing trends at 2 sites and a fall in concentrations at another site. The most common trend involved chloride but the causes are uncertain.

There are a number of possible reasons such as an increased input from fertiliser, human or animal effluent. Secondly, there is more evaporation relative to rainfall or a greater proportion of aquifer recharge is originating from rainfall compared to rivers. This could come about through changing rainfall patterns and less floods. It is more likely that given the level of consented water demand, pumping inducing changes in groundwater quality is a contributing factor.

It is fair to say that the explanation is likely to involve a number of influences and there is no cause for concern at this stage given the absolute value of the water quality parameters involved.

4. References

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