MARLBOROUGH
DISTRICT COUNCIL

Groundwater Quality State and Trends 2012

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Executive Summary

1. The quality of Marlborough groundwaters remains high and there have been no major changes from the initial findings of the state and trends report presented to Marlborough District Council in 2010.

2. There are minor trends in some parameters that Marlborough District Council is investigating in relation to landuse and climate factors.

3. Peak concentrations of nutrients and chloride in shallow groundwaters commonly occur in winter or spring showing they are related to the leaching of soil materials.

4. With the introduction of the Rai Valley site in 2012, Marlborough District Council has a stable network of wells representing the full spectrum of groundwater chemistry types and land use impacts in Marlborough.

5. As part of this systematic approach a formal process exists for identifying and reporting changes in groundwater quality and providing feedback to influence policy or land use practices.

6. Water quality information from key indicator wells will be added to the Marlborough District Council website by the end of 2012 to provide the community with access to the raw data used for reporting.

7. Ongoing monitoring of groundwater quality is essential because of the value of the resource to residents for drinking, the economy and ecologically. The potential exists for groundwater quality to be quickly degraded because of the insecure type aquifers in many parts of the district.

8. Longer records of the time scale of decades will isolate the influence of climate variability and the residual effects of past versus current land uses on groundwater quality.

9. Information collected today will answer the management questions of tomorrow.

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 baseflow of 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.

There is growing awareness of the need to manage freshwater quality at a catchment scale given the connectivity of rivers with lowland springs and groundwater. With the exception of very old groundwater that is relatively isolated from other parts of the hydrological cycle, water quality should be preserved for the next stage in the continuum.

Generally speaking naturally occurring poorer groundwater quality in Marlborough is associated with confined aquifers where a lack of oxygen leads to higher levels of mineralisation through change in chemical equilibria. Conversely man-made influences occur in shallow, unconfined aquifers that are potentially more vulnerable to overlying landuse activities.

1.1. Marlborough Groundwater Quality

Marlborough groundwater quality is generally of a very high standard with some exceptions. This is especially true of the free-flowing aquifers which underlie the northern Wairau Plain and tend to dilute the concentration of any contaminants that are present. Because of the natural filtering effect of alluvial aquifers, groundwater is generally of higher quality than river waters, especially in terms of microbe levels.

Some local groundwaters are not of optimum quality due to natural processes and examples of this are the typically 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 mostly naturally occurring.

Table 1: Causes Of Groundwater Quality Problems

Common Origin	Parameter
Predominantly the result of natural processes	pH
	manganese
	iron
	ammoniacal-nitrogen
	sodium
	chloride
	fluoride
	arsenic
	boron
Predominantly the result of human activities	nitrate-nitrogen
	sulphate
	microbes

The focus in terms of poor groundwater quality caused by human activities is nutrients. They can come from septic tanks, agricultural fertilisers and the general effects of urbanisation or landuse intensification. These issues are normally linked to water that has drained downwards from the surface. The most common problem is elevated levels of nitrate-nitrogen linked to wells tapping unconfined aquifers.

The split between those contaminants that are commonly the result of naturally occurring processes versus those that are the result of human activities is summarised in Table 1.

Avoiding contamination through sound landuse practices is always preferable to fixing things later. 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 that will track changes over time. It is intended to inform the Marlborough District Council and community of regional scale risks that may affect them, and practices that can influence this valuable 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 the issues of the day and monitoring resources or staff levels. 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.

The core component of the programme which is reported on each year compares groundwater quality to national and local standards. This ranks its suitability for various uses and tracks changes from year to year. Every 5 years a more detailed assessment is made of whether groundwater quality is improving, deteriorating or staying the same, along with the possible causes.

While the Marlborough District Council groundwater monitoring network covers a representative range of locations and threats to groundwater, it is primarily a regional scale tool and may not detect local spills or contamination issues. Marlborough District Council still relies on reports from well owners to identify these smaller scale problems.

Most of the sites used for sampling groundwater 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 fixed 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 based and the highest rates of groundwater use occur to support the most intensive land uses and largest settlements. The network has evolved over time and includes a reasonably representative series of aquifer types and land-uses. A site representing the upper Rai-Pelorus catchment was added in 2012 to complete the district-wide coverage.

1.3. Methodology and Reporting

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

Results will be reported on and formally presented to the Marlborough District Council in June of each year based on all records at a particular site updated with measurements from the last 12 months. Median values are used to assess the suitability or state of groundwater quality to even out seasonal or short-term fluctuations. Every 5 years there will be a more detailed analysis of trends in water quality over time.

Because pesticides and microbes are often either present or absent in groundwater their levels relative to safe thresholds is not as adequately defined by median values. Levels of microbes are not reported on yet because the precision of the sample results are still being standardised. Notwithstanding this there are currently no widespread issues with microbe contamination of Marlborough groundwaters.

Pesticides are of high public interest but are not surveyed as often as other chemicals in groundwater because they can potentially be toxic in very small concentrations and laboratory analyses at these low levels are very expensive. To narrow down the search, certain active ingredients known to be associated with Marlborough agricultural practices or crops are targeted for analysis. Apart from isolated incidences, pesticides are not a major issue in Marlborough groundwaters.

1.4. Sampling and Analysis Procedures

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

The overall monitoring programme is made-up of 5 separate surveys each with specific aims. The details of the 5 surveys are summarised in Table 2. The most frequently conducted survey is for state of the environment monitoring of general chemical parameters and is conducted 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.

A further 8 well sites are sampled each season 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. 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.

Table 2: MDC Monitoring Programme Details

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 a year
Coastal aquifer salinity survey	6	Summer when the potential for seawater intrusion is greatest	Once a 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 a year

As well as collecting information on the general constituents of groundwater, Marlborough District Council staff also measure levels of pesticides, microbes; and the salinity of groundwater near the coast. These surveys are carried out at specific times of year when their concentration in groundwater is likely to peak. Microbes are surveyed for at 14 wells located in areas downstream of human settlement or in unconfined aquifers susceptible to landuse contamination (Figure 2).

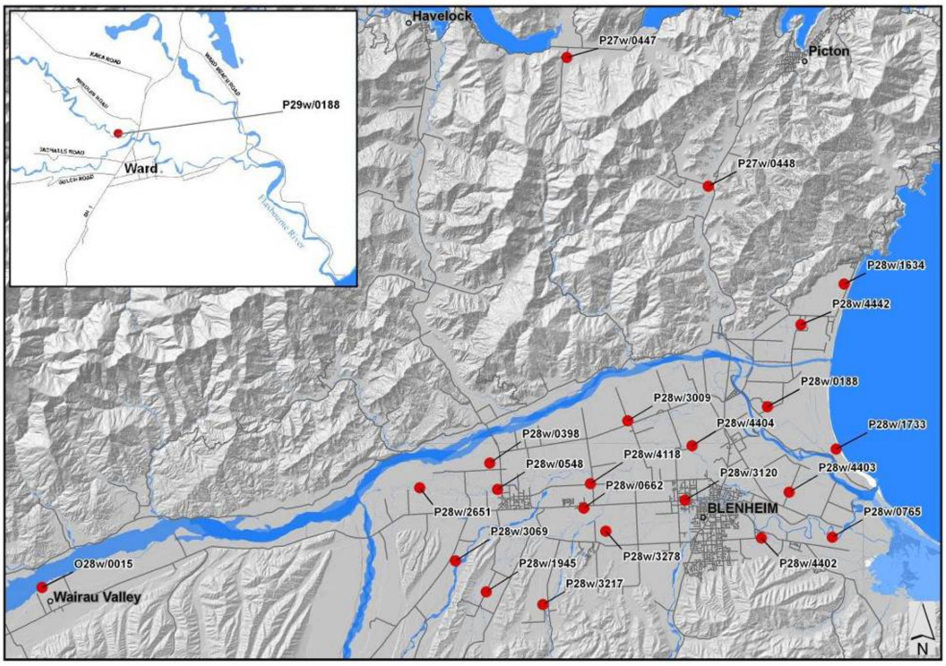

Figure 1: Seasonal State of the Environment and NGMP Sampling Sites

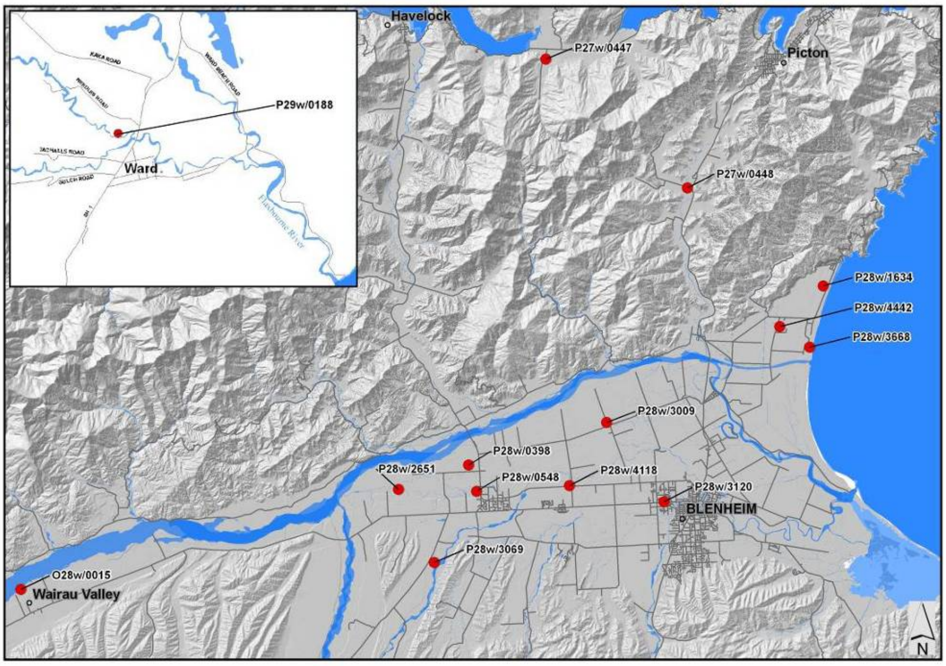

Figure 2: Microbiological Sampling Sites

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 at 17 local wells every 4 years. It is coordinated by the crown research institute ESR Ltd. Sampling is focused on aquifers that are most vulnerable to landuse contamination and have high current or historic pesticide use (Figure 3).

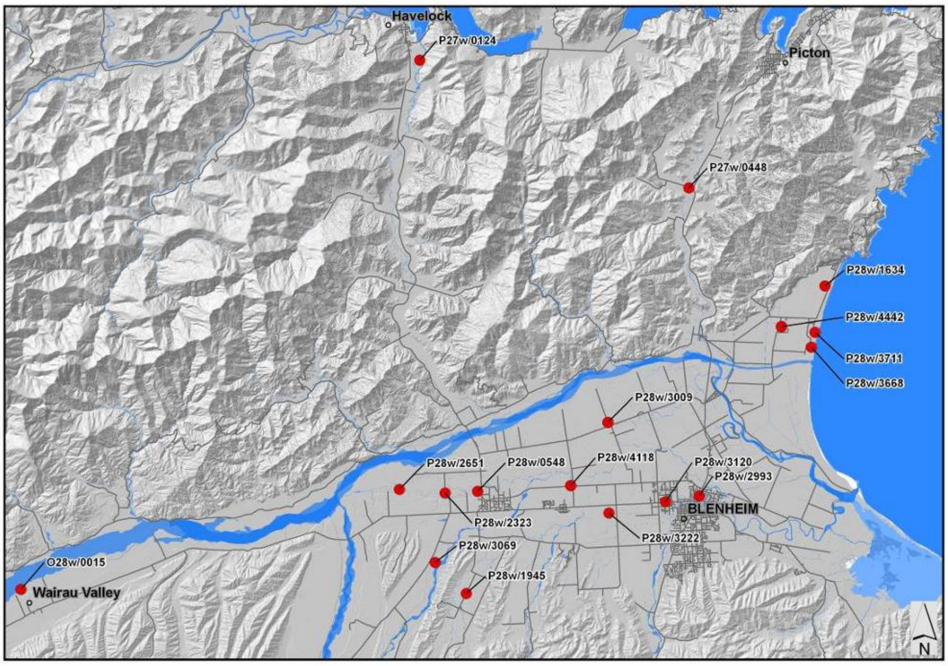

Figure 3: Pesticide Sampling Sites

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 provide early warning of an inland migration of the seawater interface. The locations of these coastal sites where laboratory calibration samples are taken are shown in Figure 4.

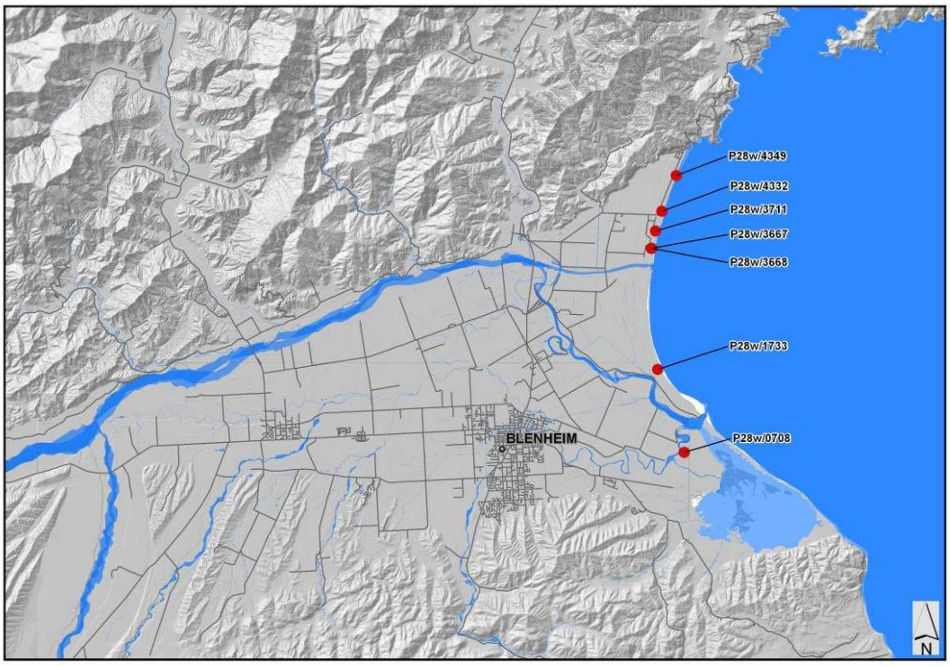

Figure 4: Coastal Salinity Sampling Sites

1.5. Water Quality Standards and Suitability Threshold

Measuring the chemical or microbial makeup of groundwater is of little practical use unless it is compared to thresholds that indicate its fitness for a certain purpose. 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. These are not life threatening but cause nuisance problems depending on their concentrations such as staining, odours, smells or residues.

Ecological standards also exist to gauge the threat to the normal biological functioning of wetlands or surface waters connected to groundwater. These are specified in the ANZECC 2000 guidelines, or based on local scientific studies. These are used as a performance measure but are not formalised as rules in the district plan.

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 could cause weed blooms and affect the health of plants, animals or fish.

The graphs in the appendix colour code the 3 types of thresholds with those of health significance (MAV) shown as a solid red line, aesthetic guidelines are marked as a dashed red line (GV) and ecological protection guideline values (EPGV) in green.

2. Groundwater Quality Status

The following section reviews the median values for each of the 12 parameters where human health, aesthetic or ecological thresholds exist for all monitoring sites and updated for the latest records since the initial SER report was produced in 2010.

The approach used to identify changes over time in groundwater quality involves comparing the median value for each parameter based on the entire length of record including the most recent measurements. So that the median value is sensitive to environmental changes, the same start date is fixed for each parameter at each well site and these are listed in the appendix at the back of the report.

The series of box whisker plots in the appendix show the water quality results used to compile the district wide summary. The graphs are arranged by parameter and split according to aquifer structure as this is the dominant influence on groundwater quality, its evolution and susceptibility to landuses. Each parameter has a pair of graphs representing the unconfined and confined well sites.

The left hand plot in each pair of graphs shows the unconfined aquifer results and the right hand graph is the equivalent for confined aquifer monitoring sites. Concentrations or levels of each parameter are shown on the vertical axis in units of parts per million (g/m^3) or pH.

In some cases where there are large ranges in value a logarithmic scale is used instead of a linear scale to see the detailed variation from well to well. The Marlborough District Council well number identifying the site is shown along the bottom of the graph. The middle 50 percentile range is shaded grey with the median value marked by the horizontal red line. The black whiskers indicate the range of values measured at each site from the maximum to the minimum.

2.1. Nitrate-Nitrogen

Naturally occurring nitrate concentrations are generally considered to be 1 g/m^3 or less although in some cases the value may be closer to 3 g/m^3 which in turn exceeds the ecological threshold.

Nitrate-Nitrogen values are sensitive to aquifer structure and this explains the large range in values between unconfined and confined aquifers. The bulk of exceedences occur at sites representing unconfined aquifers reflecting their relative insecurity to surface activities.

Sites close to the Wairau River have lower values and a smaller range due to the moderating influence of Wairau River recharge water. Conversely, areas where potential problems may occur in the future are aquifers with lower natural throughflow and diluting ability such as the Southern Valleys which are also affected by landuse activities.

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. Conversely nitrates persist for longer in unconfined type aquifers.

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

Table 3: 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
2010	**0**	**6**
2011	**0**	**5**
2012	**0**	**5**

** 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*

Notwithstanding this 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. The number of exceedences has remained the same as the last survey.

Some sites representing unconfined aquifers have large seasonal fluctuations of around 10 g/m^3 including wells 2651, 3069 and 1634 (Appendix). These variations reflect differing landuse practices and the location of these wells on aquifer boundaries where there is less throughflow to dilute landuse contaminants.

The elevated concentration at well 3120 located in the western suburbs of Blenheim, is explained by the partial confinement of the aquifer meaning it is not subject to denitrification processes but is still influenced by surface activities.

The era of some nitrate in groundwater remains uncertain, but it is more likely that elevated levels are related to recent rather than historic agricultural practices based on recent knowledge. Longer term records indicate nitrate levels are relatively stable and there has been no significant change associated with vineyard conversion since about 1990.

Nitrate levels tend to peak in spring or winter when rainfall is highest and leaches fertilisers to groundwater. Rainfall is the driver but relies on a build-up in the soil of nutrients from human activities.

Trends were not reported on in detail as part of this annual report, but there has been a slight fall in levels since 2010 which corresponds with the rainfall pattern over that time.

2.2. Ammoniacal Nitrogen

Ammoniacal nitrogen is the form of nitrogen present in oxygen depleted confined aquifers. The median value at no site exceeded either the human health limit or the ecological threshold (Table 4).

Table 4: 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
2010	0	0
2011	0	0
2012	0	0

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

Three groundwaters at Ward, Brancott and the Lower Wairau had median concentrations above 0.1 g/m^3 indicating the presence of chemical reduced aquifer conditions. This threshold is not related to human health issues, but shows the aquifer is closed without access to the atmosphere and that influences the type of chemical reactions that take place and the presence or absence of some problem species. Levels were much lower across all monitoring sites in unconfined aquifers.

2.3. Chloride

Chloride is largely a naturally occurring component of Marlborough groundwaters. Levels are within acceptable limits across all sites and median values have not changed significantly between 2010 and 2012 (Table 5). The threshold is for aesthetic purposes in this case.

Table 5: Chloride

Year	DWSNZ 2005 Guideline = 250 g/m^3
	Number of sites exceeding
2010	0
2011	0
2012	0

Higher levels are more common in older groundwaters or those close to the coast where marine sediments are naturally high in chloride such as at Rarangi or Wairau Valley. The highest median concentrations are found in groundwater from the Deep Wairau Aquifer and near Ward.

At depth below the Wairau Plain the confining layer capping the Wairau Aquifer and similar material at Ward is naturally high in sodium and chloride as a legacy of its marine origin. Both of these salts are easily dissolved in groundwater. The high value measured at the Woodbourne wells 662/3010 is an outlier and not representative of local groundwater quality.

Slight upwards trends were observed at several sites and the reasons for this increase are still being analysed.

2.4. pH

The pH of local groundwater is largely driven by natural processes with unconfined aquifers tending to have lower values and confined aquifers higher values. This is the expected pattern whereby natural chemical degradation processes in oxygen deficient confined aquifers produce bicarbonate which increases pH. Conversely rainfall enriched in CO_2 has the opposite effect and pH falls as this water leaches or reacts with soil material as it travels down to the groundwater table.

Table 6: pH

Year	DWSNZ 2005 Optimum range = 7 to 8.5 Number of sites outside range
2010	13
2011	13
2012	13

Thirteen sites were outside the ideal range for water supply mostly due to naturally low pH in local unconfined aquifers (Table 6). This is the same number as for the 2010 and 2011 reports. Low pH is a common naturally occurring 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 or appliances.

2.5. Manganese

Along with iron, manganese is a naturally occurring constituent of groundwater. Elevated or high concentrations of manganese are mostly associated with confined aquifers which reflects longer residence times and as a consequence more water-rock interaction. Excessive levels of manganese are a common problem in many parts of Marlborough, but groundwater can be treated to make it safe to drink or prevent staining.

Table 7: Manganese

Year	DWSNZ 2005 Maximum allowable value = 0.4 g/m^3 Number of sites exceeding	DWSNZ 2005 Guideline value = 0.04 g/m^3 Number of sites exceeding
2010	1	6
2011	1	6
2012	1	6

The updated median values for 2012 exceeded the human health limit of 0.4 g/m^3 at 1 site and the aesthetic guideline of 0.04 g/m^3 at 6 sites (Table 7). This high level occurred in groundwater at Ward and is caused by naturally occurring processes. Elevated levels of manganese were not only restricted to confined type aquifers but also the Rarangi Shallow Aquifer well 4442 which is thought to be linked to fossil wetlands.

2.6. Iron

Iron is mostly a natural component of Marlborough groundwaters which generally only occurs in higher enough concentrations to cause aesthetic problems in confined aquifers where there is sluggish flow and depleted oxygen levels. Chemically, iron behaves in a similar manner to manganese and high levels of one are likely to indicate the presence of the other. Iron issues can also be caused by corrosion in some cases in pipes or tanks.

Table 8: Iron

Year	DWSNZ 2005 Guideline value = 0.2 g/m^3
	Number of sites exceeding
2010	5
2011	5
2012	5

Five sites exceeded the aesthetic guideline value for iron in 2010, 2011 and 2011 (Table 8). All were associated with confined type aquifers except the Marlborough District Council Wairau Valley public water supply well O28w/0015. While there are 5 sites with concentrations above the threshold, the consequences of drinking the groundwater are not life threatening and can be treated by residents to avoid staining problems.

Groundwater samples have been filtered as standard practice since 2004 so that only the dissolved fraction is measured. This is in line with the national practice recommended by GNS Science and is intended to exclude rust or other corrosion from the sample analysis. As a consequence concentrations are generally lower for more recent surveys than historical records.

2.7. Fluoride

Fluoride is a naturally occurring component of groundwater that is increasingly being linked to aquifers influenced by leakage from geological faults such as at Wairau Valley.

Table 9: Fluoride

Year	DWSNZ 2005 Maximum allowable value = 1.5 g/m^3
	Number of sites exceeding
2010	0
2011	0
2012	0

Concentrations are slightly higher in confined versus unconfined aquifers. There were no exceedences of the human health limit of 1.5 g/m^3 at any of the regional groundwater monitoring sites (Table 9).

2.8. Sodium

Sodium is largely a naturally occurring component of groundwater. This is demonstrated by the fact that levels are much higher from wells penetrating confined aquifers. Sodium is usually associated with chloride in groundwater.

Table 10: Sodium

Year	DWSNZ 2005 Guideline value = 200 g/m^3 Number of sites exceeding
2010	0
2011	0
2012	0

No sites in either 2010, 2011 or 2012 had groundwater sodium levels above the aesthetic limit of 200 g/m^3 (Table 10). The highest concentrations were observed in groundwaters at Ward, the Deep Wairau Aquifer and the Brancott Aquifer. Relative concentrations broadly shadow groundwater age.

2.9. Sulphate

Sulphate occurs in groundwater naturally through mineralisation processes. It can also originate from fungicide chemicals, fertilisers or waste products as a result of human activities. Long-term time trends in sulphate levels are being tracked in relation to soil levels and for different agricultural practices.

Table 11: Sulphate

Year	DWSNZ 2005 Guideline value = 250 g/m^3 Number of sites exceeding
2010	0
2011	0
2012	0

Overall, sulphate concentrations are highest in unconfined aquifers which points to an influence from overlying landuses. One exception was the elevated level at Ward which may be due to natural reaction processes associated with sulphides. Sulphate levels across all sites are well below the aesthetic threshold for sulphate (Table 11).

2.10. Arsenic

Concentrations of arsenic were above the human health value of 0.01 g/ m^3 at 2 sites in 2012 and both cases were caused by natural processes. These were the same 2 sites that transgressed in 2011.

Assuming the Marlborough District Council monitoring network is representative of groundwater quality across the district, it is likely that other wells will potentially have similar concentrations (Table 12).

Because Marlborough District Council does not have a complete picture of the distribution of naturally occurring arsenic yet, well owners should have their water tested if their well is in a high risk area.

The risk factors for naturally high levels of arsenic are old or chemically reduced groundwaters which tend to mobilise it. Higher levels are most commonly linked with confined aquifers such as well 3278 tapping the Deep Wairau Aquifer or well 3217 penetrating the Brancott Aquifer. The exception is well 4442 tapping the Rarangi Shallow Aquifer.

Table 12: Arsenic

Year	DWSNZ 2005 Maximum allowable value = 0.01 g/m^3
	Number of sites exceeding
2011	2
2012	2

2.11. Boron

Boron in groundwater originates from natural interaction with minerals in local rocks such as the greywacke sandstone that predominates south of the Wairau River.

Table 13: Boron

Year	DWSNZ 2005 Maximum allowable value = 1.4 g/m^3
	Number of sites exceeding
2011	0
2012	0

Concentrations were well below the human health value of 1.4 g/m^3 at all sites except for the deep well 3278 which penetrates the Deep Wairau Aquifer at Fairhall and taps ancient groundwater. A correlation commonly exists between high levels of boron and arsenic in Marlborough groundwaters.

2.12. Microbes

Because of recent changes in field practices and the laboratory standards that Marlborough District Council have used for the analysis of samples, levels of microbes will not be reported on until we are confident that the results are representative.

3. Conclusions

The quality of Marlborough groundwater remains high and there have been no detectable regional scale changes since the last report was prepared in mid 2011.

Trends in some parameters have changed since the baseline analysis in 2010 and are probably a reflection of less rainfall in more recent times. This finding emphasises the important of the time scale to give context to any pattern.

The regional monitoring network is now complete and representative of the full spectrum of ambient groundwater conditions, landuses and potential issues.

4. References

Australia and New Zealand Conservation Council, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000, (ANZECC 2000)

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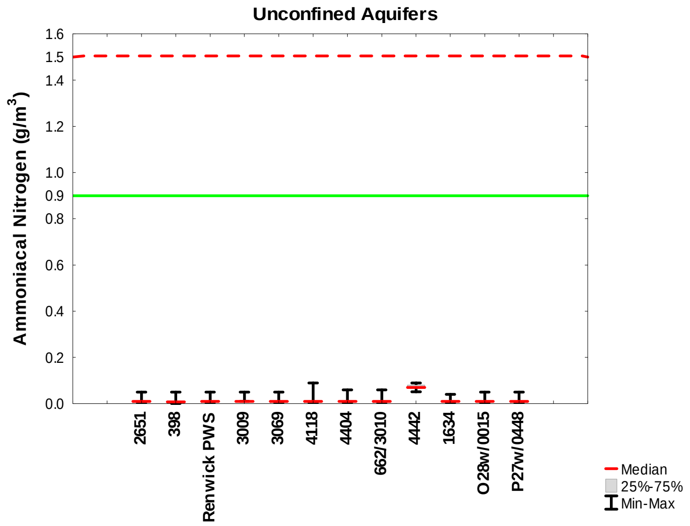
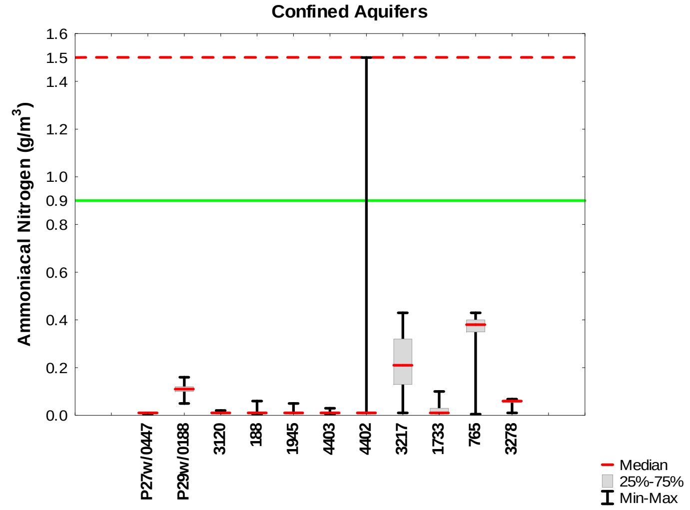
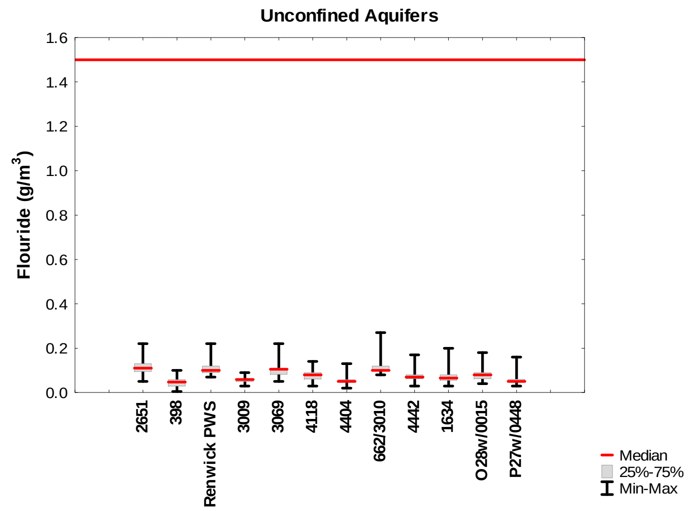
NZ Ministry of Health, 2005. Drinking Water Standards for New Zealand

5. Appendices


Unconfined Aquifers
Ammoniacal Nitrogen (g/m³)
2651
398
Renwick PWS
3009
3069
4118
4404
662/3010
4442
1634
O28w/0015
P27w/0448
Median
25%-75%
Min-Max


Confined Aquifers
Ammoniacal Nitrogen (g/m³)
P27w/0447
P29w/0188
3120
188
1945
4403
4402
3217
1733
765
3278
Median
25%-75%
Min-Max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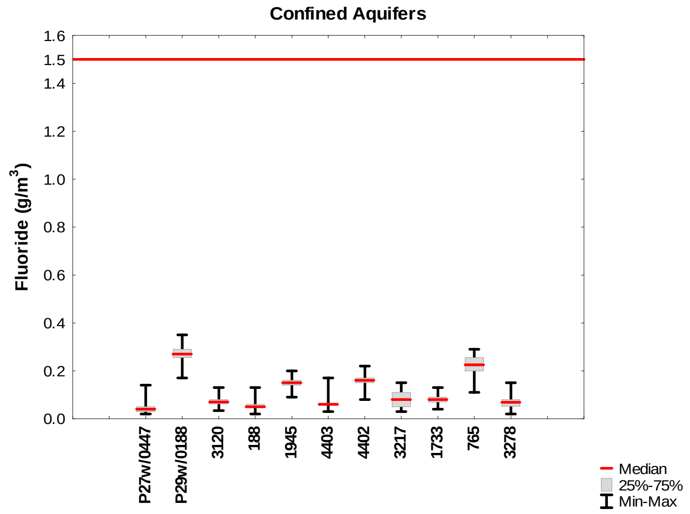
Confined Aquifers
Fluoride (g/m³)
P27w/0447
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4402
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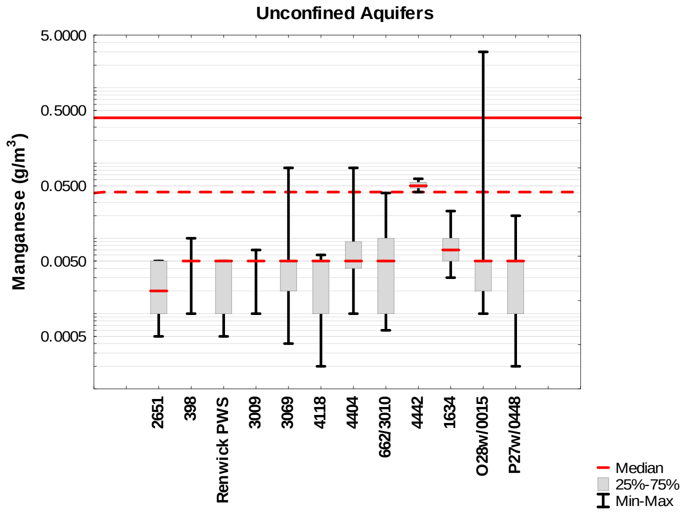
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Manganese (g/m³)
2651
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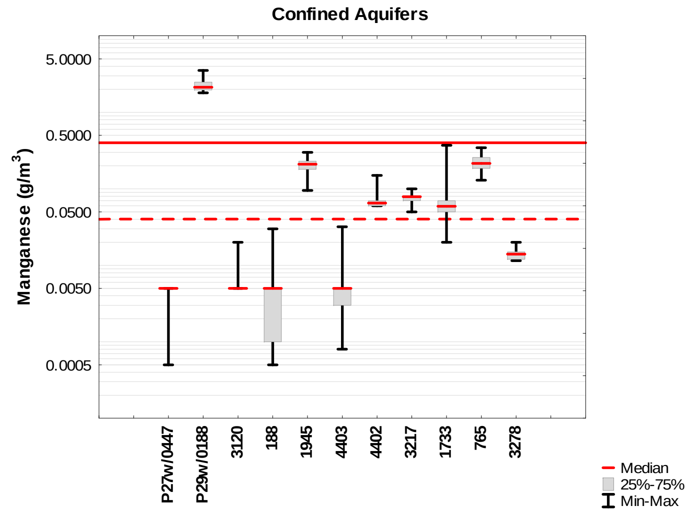
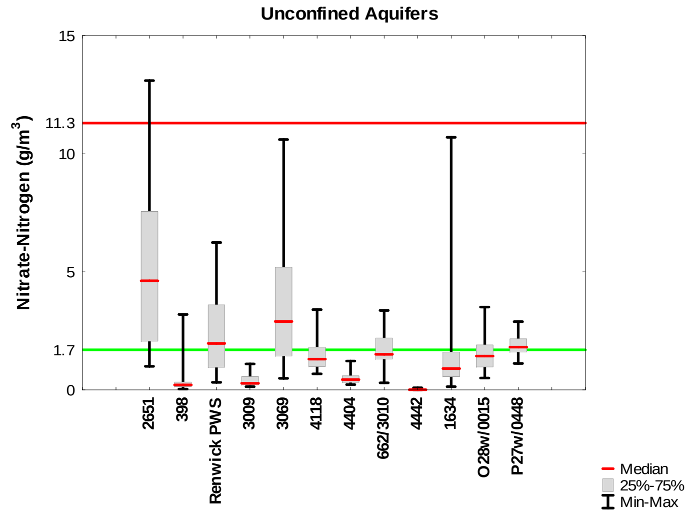
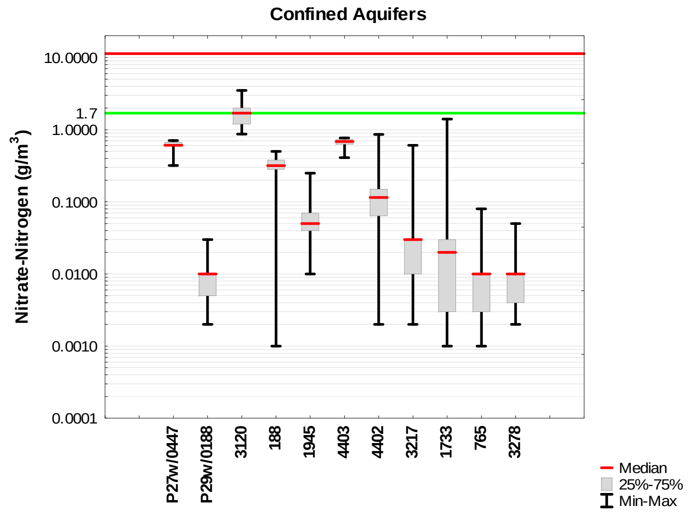
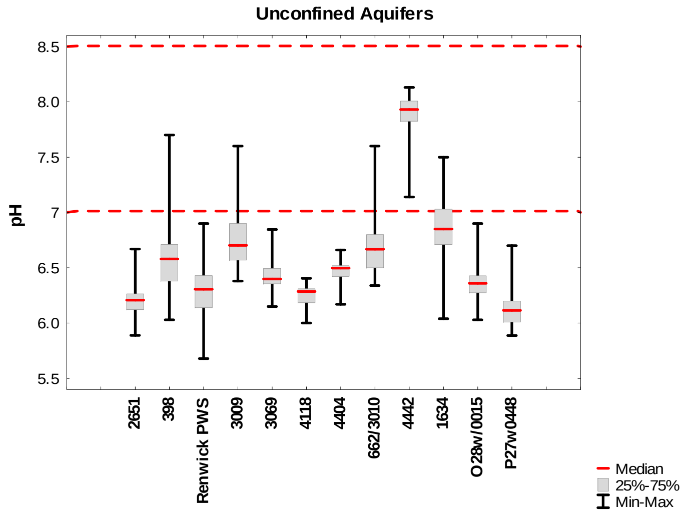
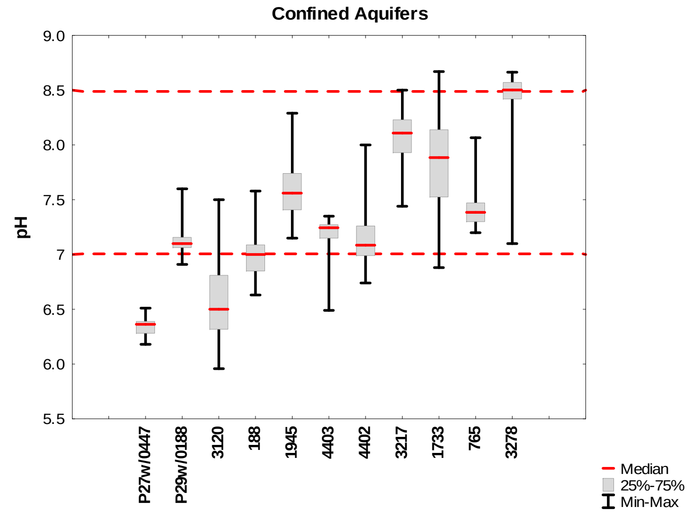
4442
1634
O28w/0015
P27w/0448
Median
25%-75%
Min-Max

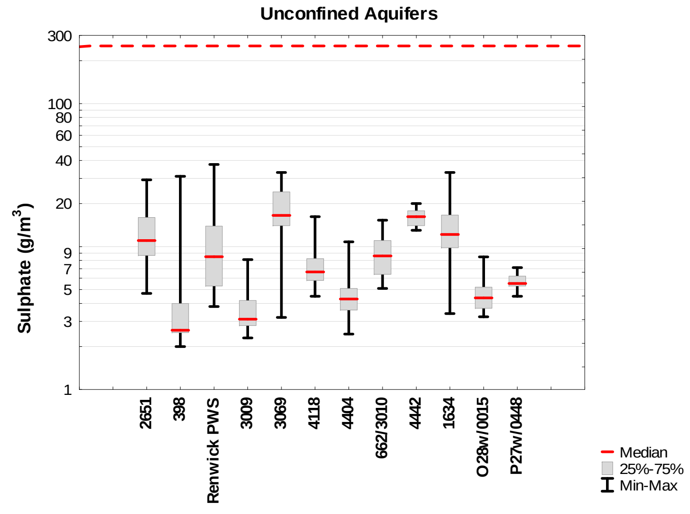

Confined Aquifers
Manganese (g/m³)
P27w/0447
P29w/0188
3120
188
1945
4403
4402
3217
1733
765
3278
Median
25%-75%
Min-Max

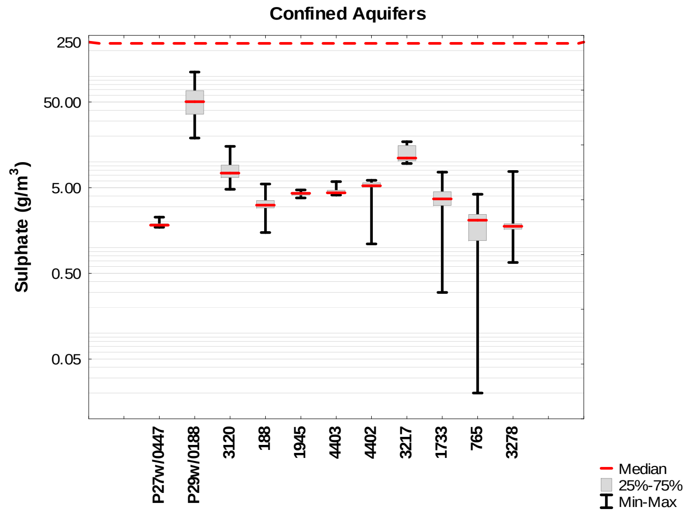

Unconfined Aquifers
Nitrate-Nitrogen (g/m³)
2651
398
Renwick PWS
3009
3069
4118
4404
662/3010
4442
1634
O28w/0015
P27w/0448
Median
25%-75%
Min-Max

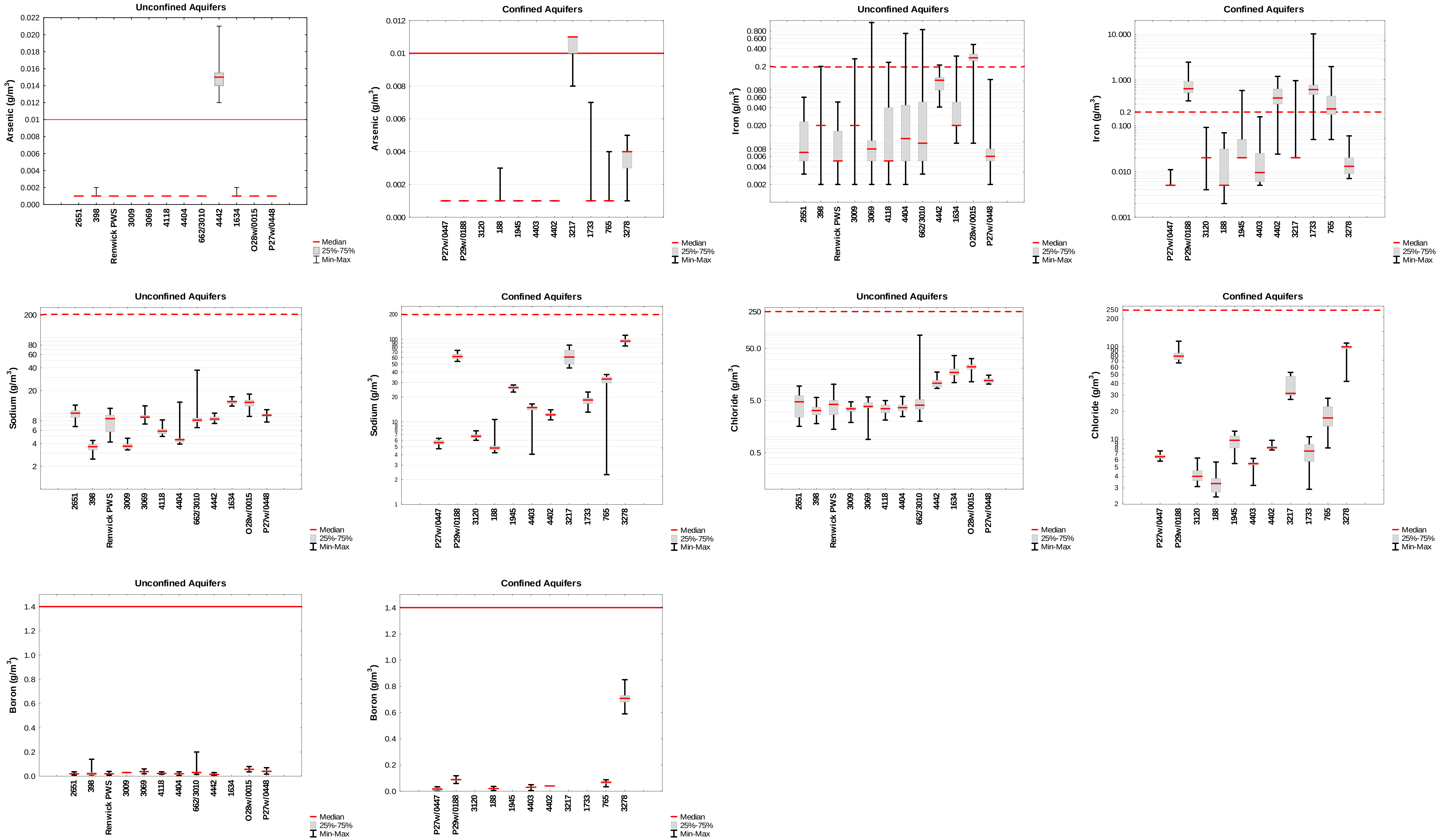

Confined Aquifers
Nitrate-Nitrogen (g/m³)
P27w/0447
P29w/0188
3120
188
1945
4403
4402
3217
1733
765
3278
Median
25%-75%
Min-Max


Unconfined Aquifers
pH
2651
398
Renwick PWS
3009
3069
4118
4404
662/3010
4442
1634
O28w/0015
P27w/0448
Median
25%-75%
Min-Max


Confined Aquifers
pH
P27w/0447
P29w/0188
3120
188
1945
4403
4402
3217
1733
765
3278
Median
25%-75%
Min-Max


Unconfined Aquifers
Sulphate (g/m³)
2651
398
Renwick PWS
3009
3069
4118
4404
662/3010
4442
1634
O28w/0015
P27w/0448
Median
25%-75%
Min-Max


Confined Aquifers
Sulphate (g/m³)
P27w/0447
P29w/0188
3120
188
1945
4403
4402
3217
1733
765
3278
Median
25%-75%
Min-Max



Median Measured Values Versus Water Quality Standards

Dataset Start Dates

Nitrate nitrogen	Chloride	pH	Manganese	Iron	Ammoniacal nitrogen	Fluoride	Sodium	Sulphate	Arsenic	Boron	Well
21/1/2003	21/1/2003	21/1/2003	21/1/2003	21/1/2003	21/1/2003	21/1/2003	21/1/2003	21/1/2003	21/1/2003	21/1/2003	**P28w/3009**
11/1/2005	11/1/2005	**20/3/2005**	11/1/2005	11/1/2005	**20/4/2005**	**27/7/2005**	11/1/2005	11/1/2005	11/1/2005	11/1/2005	**P28w/4442**
8/7/1997	8/7/1997	8/7/1997	8/7/1997	8/7/1997	8/7/1997	8/7/1997	8/7/1997	8/7/1997	21/1/2003	21/1/2003	**P28w/3069**
4/4/2002	4/4/2002	4/4/2002	4/4/2002	4/4/2002	4/4/2002	4/4/2002	4/4/2002	4/4/2002	4/4/2002	4/4/2002	**O28w/0015**
21/3/1989	21/3/1989	21/3/1989	21/3/1989	21/3/1989	21/3/1989	11/5/1994	21/3/1989	21/3/1989	28/4/1998	-	**P28w/1634**
27/7/2004	27/7/2004	27/7/2004	27/7/2004	27/7/2004	27/7/2004	27/7/2004	27/7/2004	27/7/2004	27/7/2004	27/7/2004	**P28w/4404**
4/7/2000	4/7/2000	4/7/2000	4/7/2000	4/7/2000	**28/5/2002**	4/7/2000	4/7/2000	4/7/2000	**28/1/2003**	**28/1/2003**	**P28w/2651**
13/10/1981	13/10/1981	13/10/1981	13/10/1981	29/1/2003	13/10/1981	13/10/1981	13/10/1981	13/10/1981	29/1/2003	29/1/2003	**P27w/0448**
7/5/1981	7/5/1981	7/5/1981	7/5/1981	7/5/1981	7/5/1981	30/1/2002	7/5/1981	7/5/1981	**Exclude 1981 & 16/9/2004**	15/1/2004	**P28w/0398**
19/1/2005	19/1/2005	19/1/2005	19/1/2005	19/1/2005	19/1/2005	27/7/2005	19/1/2005	19/1/2005	19/1/2005	19/1/2005	**P28w/4118**
20/4/2005	20/4/2005	20/4/2005	20/4/2005	20/4/2005	20/4/2005	25/7/2006	20/4/2005	20/4/2005	20/4/2005	20/4/2005	**3010**
11/8/1976	11/8/1976	11/8/1976	**20/2/1980**	**16/10/1987**	11/8/1976	11/8/1976	11/8/1976	11/8/1976	**28/1/2003**	**8/11/1989**	**662 (just update this site & not 3010)**
4/7/2000	4/7/2000	4/7/2000	4/7/2000	4/7/2000	20/4/2005	4/7/2000	4/7/2000	4/7/2000	20/4/2005	20/4/2005	**1652**
14/5/2008	14/5/2008	14/5/2008	14/5/2008	14/5/2008	14/5/2008	14/5/2008	14/5/2008	14/5/2008	14/5/2008	14/5/2008	**548 (just update this site for Renwick PWS)**
29/1/2003	29/1/2003	29/1/2003	29/1/2003	29/1/2003	29/1/2003	29/1/2003	29/1/2003	29/1/2003	29/1/2003	29/1/2003	**2333**
7/3/2006	7/3/2006	7/3/2006	7/3/2006	7/3/2006	7/3/2006	7/3/2006	7/3/2006	7/3/2006	7/3/2006	7/3/2006	**P27w/0447**
21/2/2006	21/2/2006	21/2/2006	21/2/2006	21/2/2006	21/2/2006	21/2/2006	21/2/2006	21/2/2006	21/2/2006	21/2/2006	**P29w/0188**
6/11/2001	6/11/2001	6/11/2001	6/11/2001	6/11/2001	6/11/2001	6/11/2001	6/11/2001	6/11/2001	**18/5/2010**	-	**3120**
28/10/1987	28/10/1987	28/10/1987	28/10/1987	28/10/1987	28/10/1987	**4/7/2000**	28/10/1987	28/10/1987	**9/11/2005**	9/11/2005	**188**
29/3/1999	29/3/1999	29/3/1999	29/3/1999	29/3/1999	29/3/1999	**22/6/1999**	29/3/1999	29/3/1999	18/11/2008	-	**1945**
29/7/2004	29/7/2004	29/7/2004	29/7/2004	29/7/2004	29/7/2004	29/7/2004	29/7/2004	29/7/2004	29/7/2004	29/7/2004	**4403**
17/6/2004	17/6/2004	17/6/2004	17/6/2004	17/6/2004	17/6/2004	17/6/2004	17/6/2004	17/6/2004	17/6/2004	17/6/2004	**4402**
30/1/2001	30/1/2001	30/1/2001	30/1/2001	30/1/2001	30/1/2001	30/1/2001	30/1/2001	30/1/2001	18/11/2008	-	**3217**
27/10/1987	27/10/1987	27/10/1987	27/10/1987	27/10/1987	27/10/1987	23/6/1999	27/10/1987	27/10/1987	**16/12/2003**	-	**1733**
29/10/1987	29/10/1987	29/10/1987	29/10/1987	29/10/1987	29/10/1987	1/7/1997	29/10/1987	29/10/1987	**8/3/2006**	**8/3/2006**	**765**
13/5/1998	13/5/1998	13/5/1998	13/5/1998	13/5/1998	**28/1/2003**	**5/7/2000**	13/5/1998	13/5/1998	**28/1/2003**	13/5/1998	**3278**