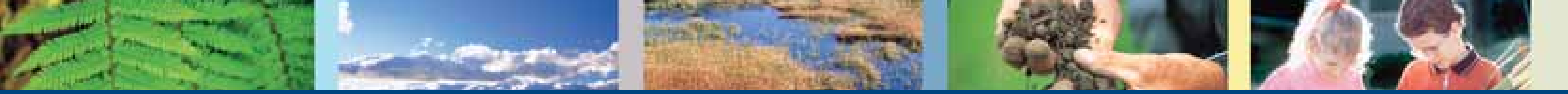

Annual groundwater monitoring report for the Wellington region, 2009/10

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Annual groundwater monitoring report for the Wellington region, 2009/10

Sheree Tidswell
Lindsay Annear
Edward Lee

Environmental Monitoring and Investigation Department

For more information, contact Greater Wellington:

Wellington
PO Box 11646

T 04 384 5708
F 04 385 6960
www.gw.govt.nz

Masterton
PO Box 41

T 06 378 2484
F 06 378 2146
www.gw.govt.nz

GW/EMI-G-10/162

November 2010

www.gw.govt.nz
info@gw.govt.nz

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1. Introduction

Groundwater in the Wellington region is highly valued for a variety of uses. Groundwater under the Lower Hutt Valley alone supplies about a third of Wellington's[1] water supply. Otaki, Waikanae[2], Martinborough, Carterton[3] and Greytown[4] also rely on groundwater for public supply. In rural areas of the Kapiti Coast and the Wairarapa, groundwater is an important water source for domestic supply, stock water and irrigation. Groundwater is also an important water source for many springs and wetlands, and the successful protection of these groundwater dependant ecosystems requires careful management of groundwater use.

To assist with the sustainable management of groundwater resources in the Wellington region, Greater Wellington Regional Council (Greater Wellington) conducts regular monitoring of groundwater levels and quality. This report summarises the results of groundwater monitoring undertaken over the period 1 July 2009 to 30 June 2010 inclusive, as well as investigations carried out during the year relating to wetland hydrology, groundwater-surface water interaction, and water quality in groundwater-dependent ecosystems. A report containing a detailed analysis of long-term trends is produced every six years (e.g., see Jones & Baker 2005).

As groundwater recharge in the region is strongly influenced by rainfall and river flows, it is recommended that this report is read in conjunction with the 2009/10 annual hydrology monitoring report (Thompson & Gordon 2010).

[1] Groundwater is usually used to supply Lower Hutt and supplements supplies to Wellington City's Central Business District, and southern and eastern suburbs. It may also be used to supplement supplies to Upper Hutt and Porirua.

[2] In Waikanae, the Kapiti Coast District Council uses groundwater as a backup water supply to its surface water take from the Waikanae River.

[3] Primary supply to Carterton is from surface water.

[4] Primary supply to Greytown is from surface water.

2. Overview of the groundwater monitoring programme

There are three principal groundwater areas in the Wellington region: the Lower Hutt Valley, the Kapiti Coast and the Wairarapa Valley. Secondary groundwater areas include Upper Hutt, Mangaroa valley, Wainuiomata valley and sections of the eastern Wairarapa coastline. Aquifers in all of these areas are found in unconsolidated alluvial, aeolian (wind-blown) and beach sediments of varying grain size. Minor aquifers are also found in limestone and fractured greywacke in some areas of the region.

Groundwater management zones have been defined in all principal and some secondary groundwater areas in Greater Wellington's Regional Freshwater Plan (WRC 1999, Figure 2.1). These zones have been used as a framework for describing groundwater areas in this report. However, it should be noted that investigations into the groundwater resources in the Wairarapa valley being carried out to inform the current review of the Regional Freshwater Plan are expected to propose a reduction in the number of groundwater management zones in this part of the region (Hughes & Gyopari in prep).

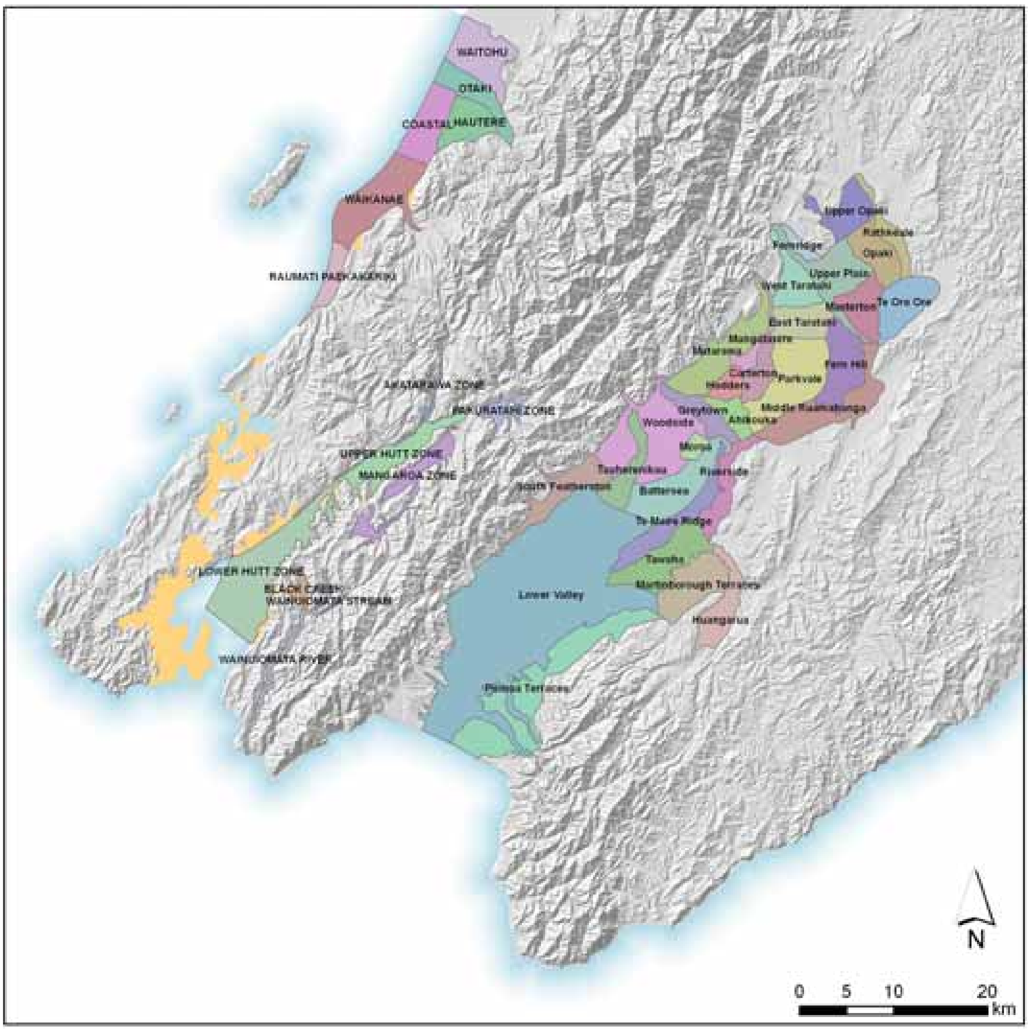

Figure 2.1: Groundwater management zones in the Wellington region as defined in the Regional Freshwater Plan (WRC 1999)

2.1 Objectives

The aims of Greater Wellington's groundwater monitoring programme are to:

- Provide information on the baseline quantity and quality of groundwater;
- Describe the current state of Greater Wellington's groundwater resource at a regional scale;
- Assist in the detection of spatial and temporal changes in groundwater quantity and quality;
- Recommend the suitability of groundwater for designated uses; and
- Provide a mechanism to determine the effectiveness of regional policies and plans.

2.2 Monitoring network

Greater Wellington monitors a network of bores for groundwater level and quality. This network utilises dedicated monitoring bores as well as used[5] and un-used[6] privately owned bores. The groundwater level network currently consists of 76 automatic and 76 manually dipped[7] bores (Figure 2.2 and Appendix 1).

The core groundwater quality monitoring network, referred to as the Groundwater State of the Environment (GWSoE) network, comprises 71 bores (Figure 2.3, Appendix 1), sampled quarterly for a wide range of physico-chemical and microbiological variables. A full list of groundwater quality variables monitored, together with details of field and analytical methods, is provided in Appendix 2.

Other selected groundwater level and quality monitoring is carried out on a project-specific basis. Some of this project-related monitoring is outlined in Section 5 (Groundwater investigations).

---

[5] Bores that are currently pumped for water supply (this pumping may have short term effects on water level readings).

[6] Bores previously pumped for supply but no longer utilised for this purpose.

[7] Bores are manually dipped to test depth to groundwater, generally on a four or six week rotation.

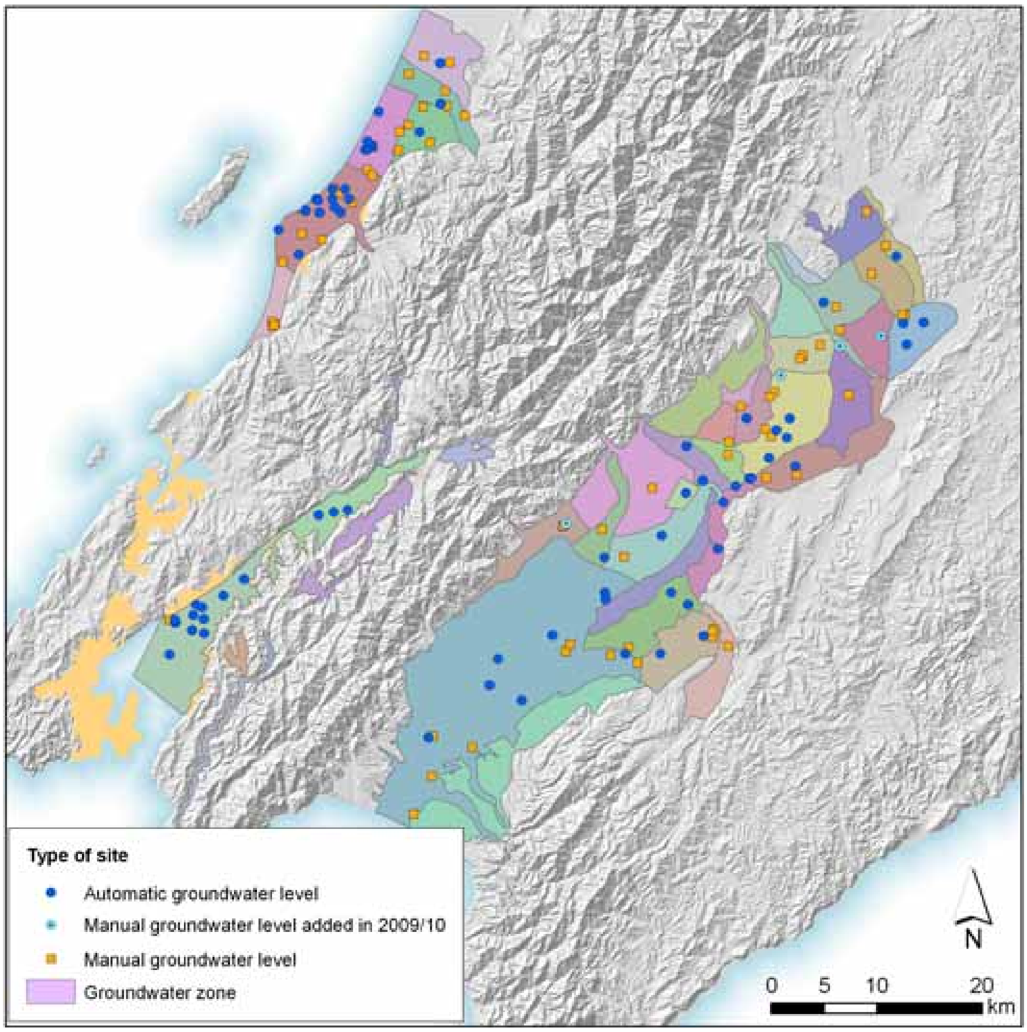

Figure 2.2: Location of groundwater level sites in the Wellington region monitored over 1 July 2009 to 30 June 2010, including four manual groundwater level monitoring sites added to the monitoring network in the Wairarapa Valley

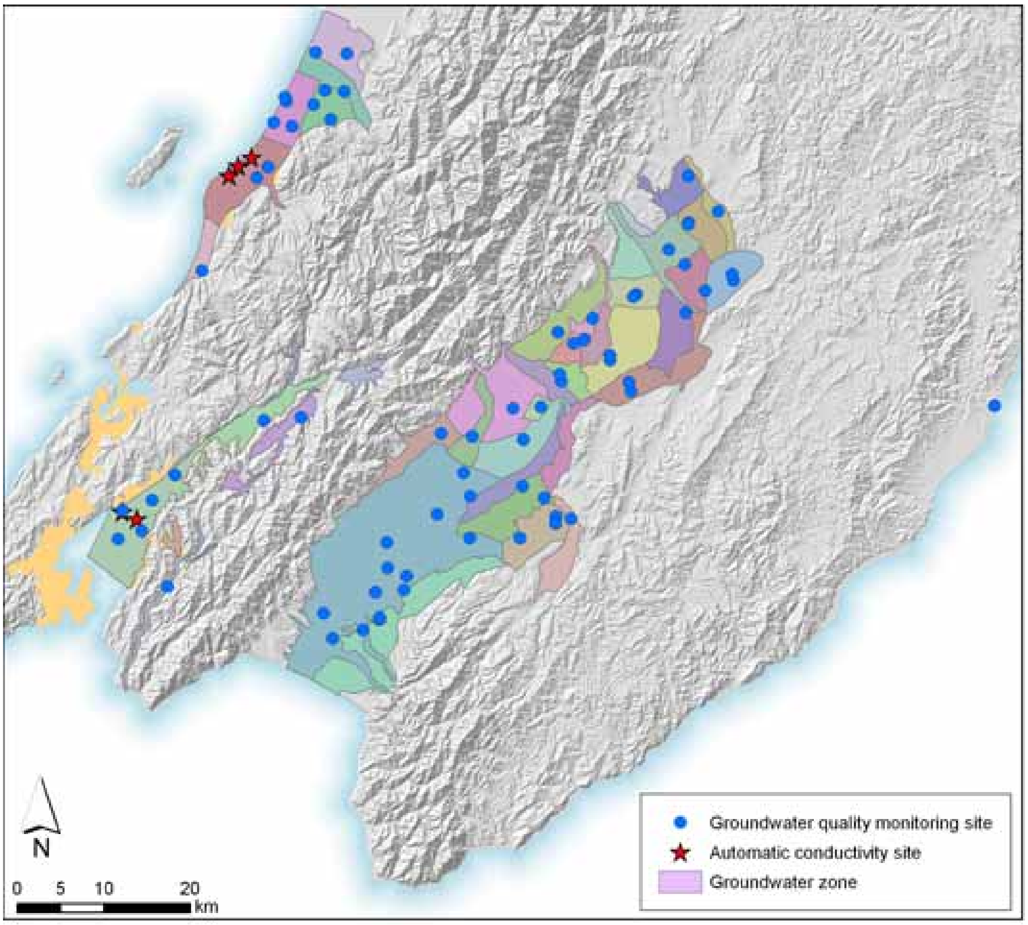

Figure 2.3: Location of existing routine groundwater quality monitoring sites in the Wellington region. Automated saline intrusion (conductivity) groundwater monitoring sites are also shown.

2.3 Changes to the monitoring network in 2009/10

Four manually dipped bores located in the Masterton, Parkvale, South Featherston and Upper Plain aquifers were added to the groundwater level monitoring network this year. Groundwater levels in these bores were monitored previously for groundwater level investigations in specific areas but are now monitored regularly.

3. Groundwater quantity

3.1 Groundwater level monitoring

Aquifers are recharged by either rainfall infiltration or leakage of water from rivers and throughflow from other aquifers. In some cases aquifers may receive recharge from multiple sources in different proportions. Therefore, trends in rainfall and river flows are often reflected in trends in groundwater levels. The response in groundwater levels to recharge events may be pronounced in shallow (unconfined) aquifers, but may be more subdued in deeper (confined) aquifers[8].

The short-term trends and patterns in rainfall and river flows of the Wellington region during 2009/10 are described by Thompson and Gordon (2010). In order to interpret regional groundwater level patterns during 2009/10, some of the information presented in that report is given in Table 3.1 and Figure 3.2.

Table 3.1 indicates that rainfall was below average during winter 2009 and average to above average during spring. The Hutt Valley received average to less than average rainfall during the summer months of 2009/10 and Wellington City received about average rainfall. However, for the rest of the region, summer was unusually wet. Rainfall was generally below average during autumn 2010, particularly in the eastern Wairarapa with a medium-level drought declared in late May.

Table 3.1: Percentage of mean rainfall over 2009/10 at selected rainfall monitoring sites in the Wellington region, based on information derived from Thompson and Gordon (2010). Shading indicates where rainfall departed by more than 10% from the long term average (blue=higher and orange=lower). No colour indicates rainfall was about average.

Lowland rainfall sites	Percentage of mean rainfall (%)				
	Winter 2009 (Jun-Aug)	Spring 2009 (Sept-Nov)	Summer 2009/10 (Dec-Feb)	Autumn 2010 (Mar-May)	Overall 2009/10
Hutt Valley					
Lower Hutt	63	101	69	96	82
Kaitoke	75	86	100	75	84
Wellington City					
Central city	64	114	91	103	93
Kapiti Coast					
Waikanae	70	134	107	76	97
Otaki	71	138	114	90	103
Wairarapa Plains					
Featherston	76	101	113	89	95
Masterton	75	115	204	96	123
Eastern Wairarapa					
Tanawa Hut (near Tinui)	80	123	182	69	113
Longbush[4]	73	108	164	95	110

[8] Deeper aquifers are recharged through the downward percolation of water from shallow aquifers.

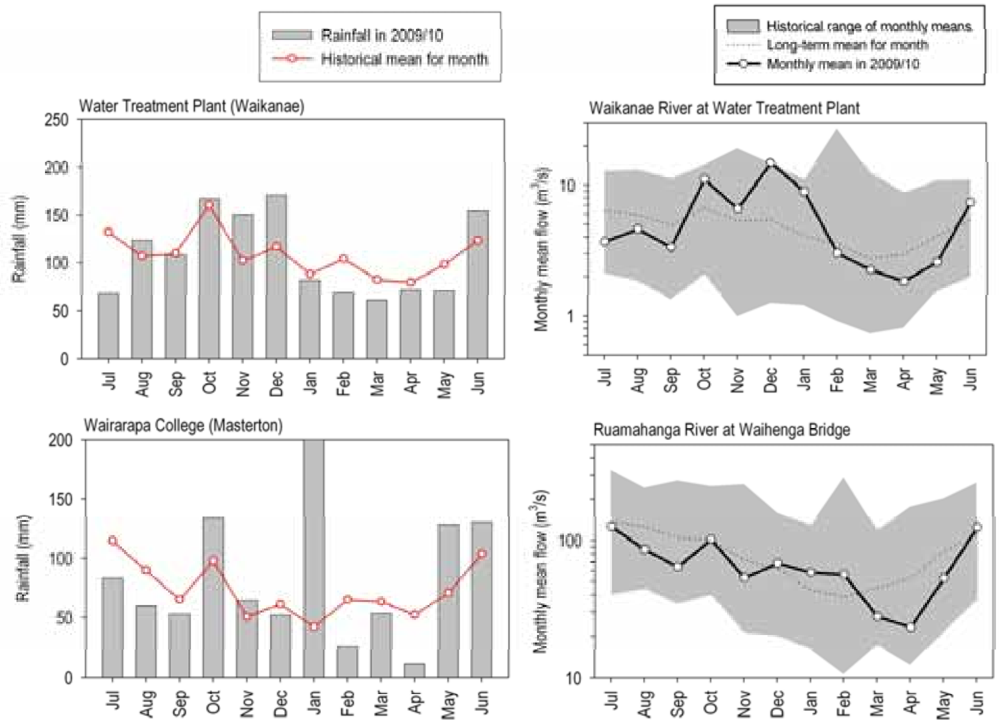

Figure 3.1: Left – monthly rainfall totals for 2009/10 (grey bars) compared to historical mean monthly rainfall (red line) at rainfall monitoring locations in Waikanae and Masterton. Right – monthly mean river flows for 2009/10 (black line) compared to historical mean monthly river flows (dotted line) for the Waikanae and Ruamahanga rivers (grey area represents the range of historical monthly mean river flows).
(Source: Thompson and Gordon (2010)).

Groundwater levels during 2009/10 tended to follow historic trends and were generally higher during the months of June to late December, and lower from February (Figures 3.3-3.4) onwards. This reflects the rainfall patterns shown above in Table 3.1 and Figure 3.1. Groundwater levels for the three main sub-areas of the Wellington region (Wairarapa, Hutt Valley and Kapiti Coast) are described separately below.

3.2 Wairarapa Valley

Groundwater levels in the Wairarapa Valley remained below average at many of Greater Wellington's monitoring sites during 2009/10 (Figure 3.2). However, compared to 2008/09, groundwater levels were closer to average. Groundwater levels at many sites showed an increase in February 2010 following very high rainfall in January, but this was followed by a decline in autumn; and an increase at the start of winter.

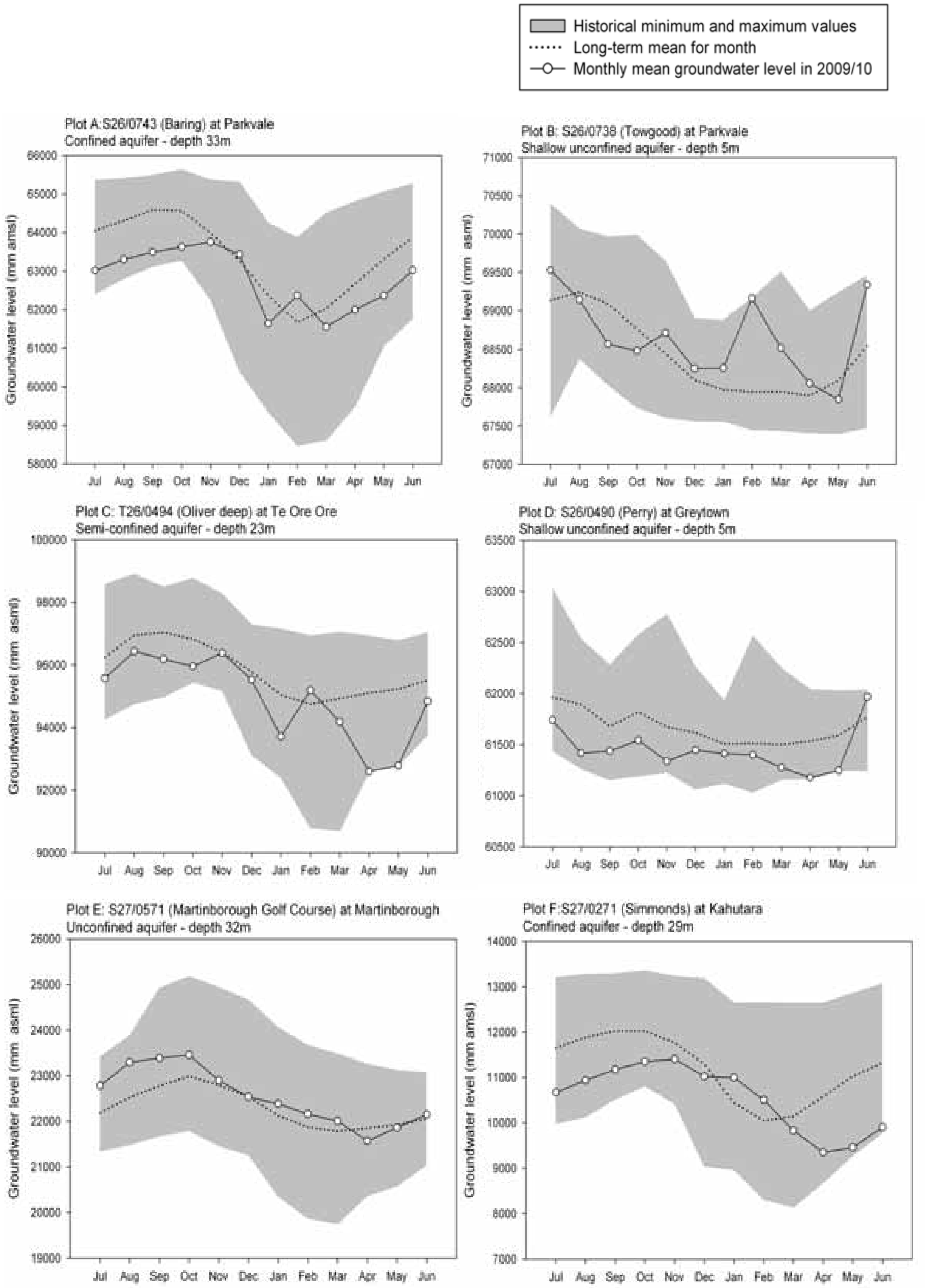

Figure 3.2: Monthly mean groundwater levels for 2009/10 (black line) compared to historical mean monthly groundwater levels (dotted line) at selected sites in the Wairarapa. The grey shaded areas represent the range of historical minimum and maximum monthly mean groundwater levels.

Groundwater levels in confined aquifers and deeper bores were generally just below average due to the drier than average winter in 2009. Some recovery towards average levels was made during spring 2009 and in January/February 2010, when high rainfall delayed the onset of the irrigation season until autumn. Groundwater levels decreased during autumn due to abstraction for irrigation and extended periods of drier weather (Figure 3.2, Plots A, C and F). Record-low, or near record-low, monthly average water levels were recorded in some monitoring locations (e.g., Te Ore Ore and Kahutara in Plots C and F, Figure 3.2) during autumn 2010.

Groundwater levels in unconfined aquifers, shallow bores and bores recharged by river flow, were generally average to just below average in winter 2009. However, groundwater levels responded more rapidly than those in the confined aquifers to rainfall events and rose well above average levels following during the unusually wet period in January 2010. Again, there was a steady decline in groundwater levels during autumn 2010 due to abstraction for irrigation and lower rainfall (Figure 3.2, Plots B and D). However, groundwater levels in the unconfined Martinborough Terraces aquifer (Figure 3.2, Plot E), remained above average throughout the entire year (except in April and May). This suggests that the settled weather during the winter months did not cause any significant reduction in aquifer levels and lower abstraction rates during the irrigation season did not cause any further decline in groundwater levels.

3.3 Hutt Valley

Groundwater levels were generally above average for the entire year in the Hutt Valley aquifer, except at four sites located in the southern-most part of the Lower Hutt aquifer management zone. Groundwater levels at these sites were above average but dropped slightly below average during February 2010. Groundwater levels remained above warning levels for saline intrusion (Figure 3.3, Plot F).

3.4 Kapiti Coast

Overall, groundwater levels in Kapiti Coast aquifers during 2009/10 were around average or slightly above the historic average, although water levels at some monitoring sites dropped below average during late January/early February and didn’t recover until May or June (Figure 3.3). The shallow semi-confined aquifer at Waikanae (Figure 3.3, Plot A) showed a strong response to recharge (from river and rainfall) with groundwater levels at historic minimum values during July and August 2009, and April and May 2010, reflecting periods of low rainfall during previous months (June to July 2009 and February to April 2010). A noticeable decrease in river flows and rainfall was also seen during February to April, as noted by Thompson and Gordon (2010).

Groundwater levels in the Waikanae potable borefield were generally above average and there were no significant groundwater level drops in the deep Waikanae aquifer (Figure 3.3, Plot B).

Groundwater levels in the 160-m deep Centrepoint bore in the Te Horo area were generally around average for the entire year (Figure 3.3, Plot D). This suggests further groundwater level recovery, after declining water levels were seen in this bore in previous years.

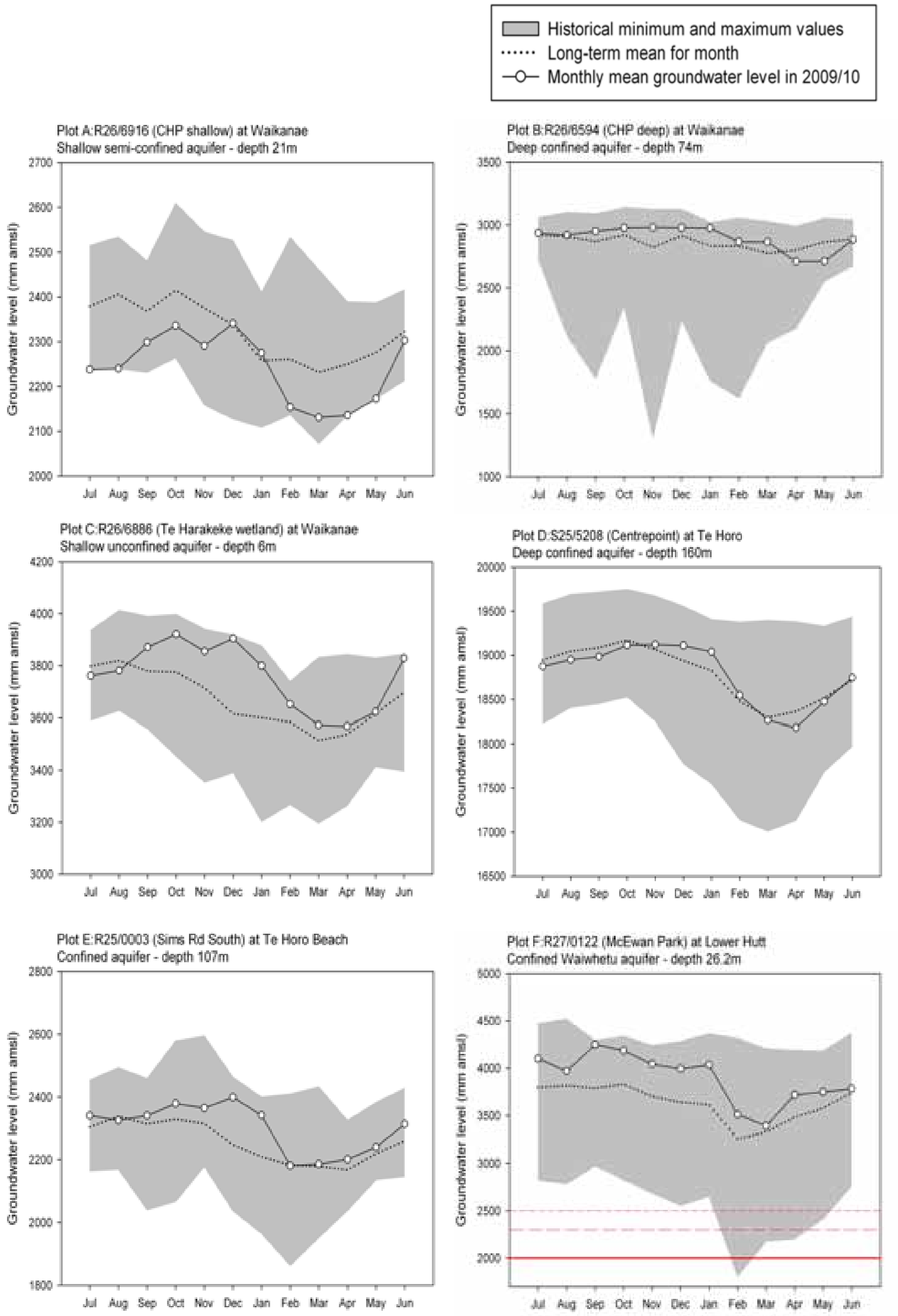

Figure 3.3: Monthly mean groundwater levels for 2009/10 (black line) compared to historical mean monthly groundwater levels (dotted line) at selected sites in Kapiti and Hutt Valley. The grey shaded areas represent the range of historical minimum and maximum monthly mean groundwater levels.

4. Groundwater quality

This section provides a brief overview of the results of routine groundwater state of the environment (GWSoE) groundwater quality monitoring conducted in the Wellington region over 2009/10.

Water 'quality' is a difficult concept to define, even though it is a commonly used term. The quality of groundwater can be described through the analysis of physical, chemical and microbiological variables. The GWSoE programme analyses groundwater samples from 71 bores across the region for a range of these variables, including dissolved oxygen, conductivity, pH, faecal bacteria[9], major ions, nutrients, and trace metals.

There are a number of human factors that influence groundwater quality, notably land use (e.g., additional inputs of nutrients for agriculture, horticulture and effluent disposal) and in some cases water abstraction. However, natural variables such as the source of the water (rainfall or river), aquifer geology and residence time of water in the aquifer also influence groundwater quality.

4.1 GWSoE monitoring – key findings

As outlined in subsection 2.2, Greater Wellington's routine groundwater quality monitoring involves quarterly sampling of 71 bores across the region (Figure 2.3). With only four sets of sampling results per year, a comprehensive evaluation of all of the data is not undertaken on an annual basis. The analysis in this report has therefore been restricted to two key indicators of groundwater contamination arising from landuse intensification and/or on-site wastewater disposal: nitrate-nitrogen (nitrate) and *Escherichia coli (E. coli)* bacteria.

Figure 4.1: Purging a bore during routine groundwater monitoring

9 Faecal bacteria are only tested in groundwater samples from 44 of the 71 GWSoE bores.

4.1.1 Nitrate nitrogen (nitrate)

Based on median values recorded over 2009/10, eight of 71 (11.3%) GWSoE bores had elevated (3–7 mg/L)[10] concentrations of nitrate (Figure 4.2). A further six bores in Kapiti and the upper Wairarapa Valley had median nitrate concentrations in the relatively high range (7–11.3 mg/L). No median nitrate concentrations were above the Ministry of Health Drinking Water Standards (DWSNZ 2005) maximum acceptable value (MAV) of 11.3 mg/L. However, the highest nitrate concentration recorded on one sampling occasion was 12 mg/L in bore T26/0489, which is above the DWSNZ (2005) MAV. This bore is located in the upper Wairarapa Valley and is 54 metres deep.

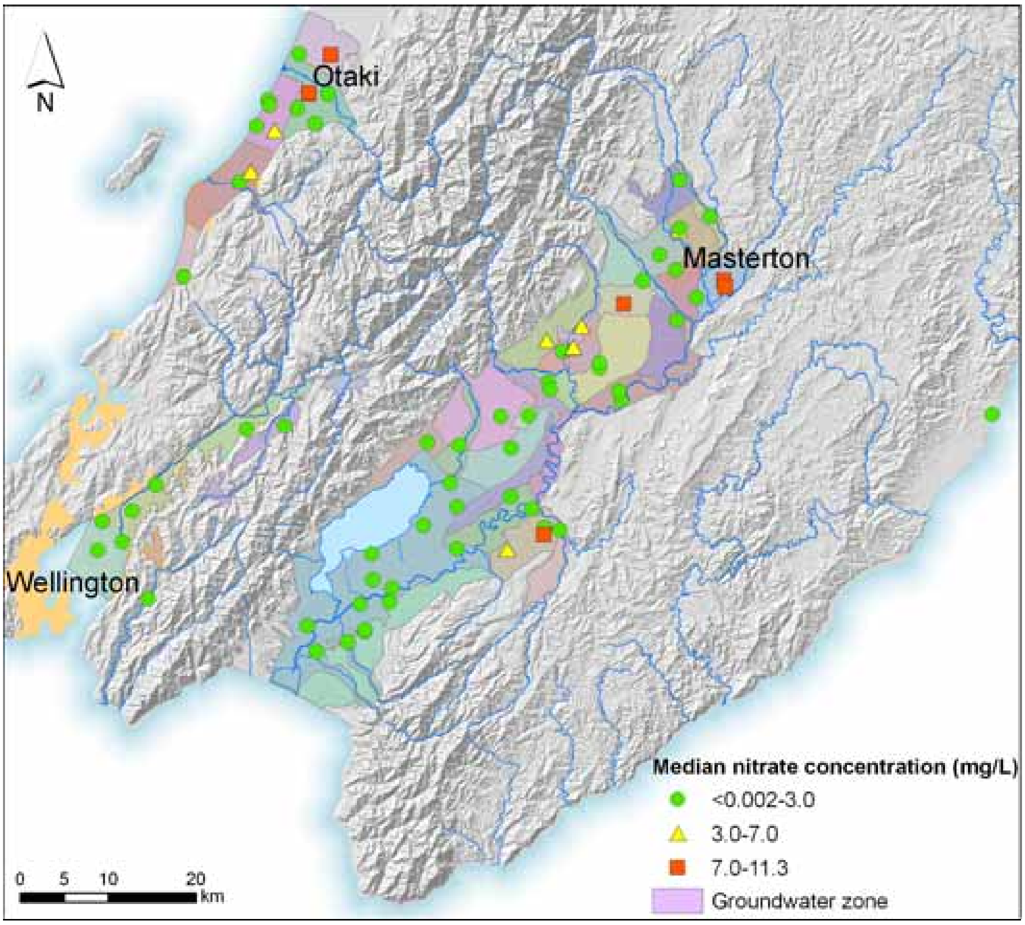

Figure 4.2: Median nitrate nitrogen concentrations recorded in GWSoE monitoring bores sampled over 2009/10

Overall, nitrate contamination was found in bores where previous sampling has detected elevated nitrate concentrations, in areas of intensive agriculture (Wairarapa) and horticulture (Kapiti Coast). The wide ranging depth of the bores with elevated nitrate concentrations (<5 m to 54 m) suggests that nitrate contamination is not limited to shallow unconfined aquifers but is able to migrate into deeper aquifer systems[11].

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[10] While most groundwater in New Zealand rarely has background nitrate-nitrogen concentrations exceeding 1 mg/L (Close et al. 2001), in this report 3 mg/L NO_3-N is used as an indicator of anthropogenic influence in order to increase certainty caused by variability. A threshold concentration of 3 mg/L was also used by Madison & Brunett (1985) and Close et al. (2001).

[11] This is particularly evident in recharge areas, with elevated nitrate concentrations not commonly found in deeper confined aquifers.

Groundwater discharges to a number of surface water bodies throughout the region and there is the potential that groundwater discharge high in nitrogen could contribute to the decline of surface water quality. The Australian and New Zealand guidelines (ANZECC) 2000 are commonly used to assess physico-chemical and microbiological aspects of surface water quality in New Zealand streams and rivers. The 2009/10 results show that the median nitrate concentrations in 35 of the 71 GWSoE bores were above the ANZECC (2000) trigger value for lowland ecosystems (0.444 mg/L).

4.1.2 *E. coli*

The DWSNZ (2005) use *E. coli* as an indicator of contamination of drinking water by faecal material[12]. For drinking water supplies, *E. coli* counts should be <1 cfu/100 mL.

E. coli was detected in 15 bores on one or more occasions during the four rounds of GWSoE sampling over 2009/10 (Figure 4.3). The highest *E. coli* count was 800 cfu/100mL in a bore (R25/5164) at Te Horo Beach. Te Horo Beach is a small settlement reliant on onsite wastewater treatment systems for effluent disposal. Previous studies involving dye tracer tests have confirmed that groundwater at Te Horo Beach is able to move from wastewater treatment systems to nearby bores relatively quickly (Hughes 1998). It is possible that the microbial contamination in bore R25/5164 is due to the bore's proximity to a nearby wastewater treatment system. This bore is not used as a potable drinking water supply.

[12] It is impracticable to monitor water supplies for all potential human pathogens, so surrogates are used to indicate possible contamination from such things as human and animal excrement, these being the most frequent causes of health-significant microbial contamination in drinking water supplies.

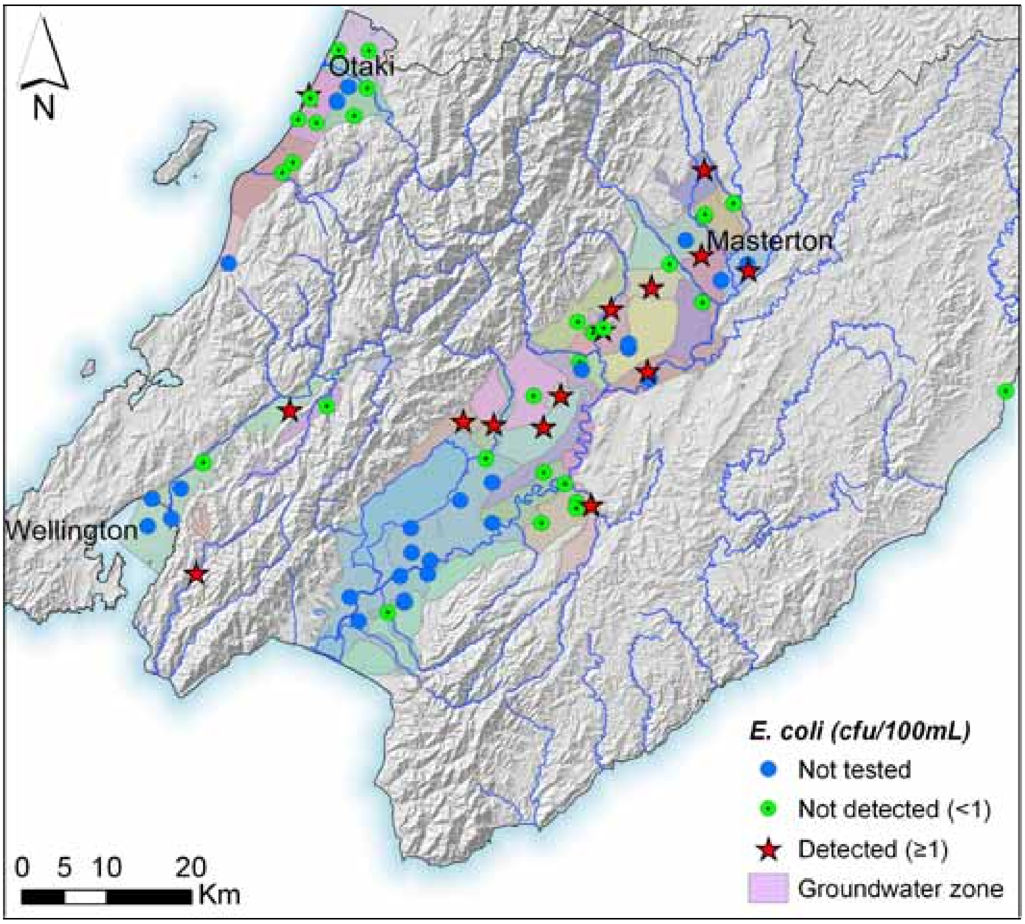

Figure 4.3: Detection (on one or more sampling occasions) of *E. coli* bacteria in GWSoE bores sampled quarterly over 2009/10

5. Groundwater investigations

In addition to routine SoE monitoring of groundwater levels and quantity, some specific groundwater-related investigations were undertaken over 2009/10. These included completion of numerical groundwater flow models for the Wairarapa Valley, an assessment of groundwater/surface water interaction in the Wairarapa Valley, a combined surface water and groundwater investigation of water quality in the Mangatarere catchment near Carterton, a survey of selected wetlands in the Wellington region (incorporating hydrology) and one-off sampling of shallow groundwater bores and surface water sites around Lake Wairarapa.

5.1 Wairarapa Valley groundwater modelling investigation

Phase 2 of the Wairarapa Valley groundwater investigation drew to a close in 2009/10, following the completion of transient numerical groundwater flow models (using FEFLOW) and low flow surface models (Mike11) for the three modelling areas (upper, middle and lower Wairarapa Valley). As noted in previous annual reports (e.g., McAlister & Tidswell 2008), the Wairarapa Valley groundwater investigation was initiated in response to increasing demand for groundwater for irrigation in the Wairarapa.

The Phase 2 modelling process has been documented in the form of three technical reports (Gyopari & McAlister 2010a, 2010b and 2010c) and Phase 3 of the groundwater investigation has commenced. This phase, due for completion in 2010/11, involves modelling different water abstraction and climatic scenarios. Information from these scenarios will be used to help review Regional Freshwater Plan groundwater allocation policies for the Wairarapa Valley. Concurrent with Phase 3 of the modelling investigation, an assessment is being undertaken to measure the uncertainty associated with the predictive simulations.

5.2 Groundwater/surface water interaction project

Current policies in the Regional Freshwater Plan (WRC 1999) provide limited guidance for the management of the potential effects of groundwater abstraction on river and stream flows. In addition, current policies make limited provision for the management of the cumulative effects of groundwater and surface water abstraction at a catchment scale to enable integrated water resource management. To address these matters in the review of the Regional Freshwater Plan, Greater Wellington commenced a technical project to define groundwater/surface water “interaction zones” for the Wellington region. The initial work in 2009/10 focussed on the Wairarapa Valley, and has been run in conjunction with Phase 3 of the Wairarapa groundwater modelling project.

The project involves developing a sustainable groundwater allocation methodology approached from a conjunctive water management perspective. This proposes that groundwater takes that have a direct or immediate “depletion” effect on water levels in surface water bodies are managed by making these takes subject to the environmental flow policies (e.g., minimum flows and core allocation) for the relevant river, stream, lake or wetland. In other situations where groundwater takes do not have an immediate depletion effect on rivers or streams, but may contribute to a cumulative reduction in stream baseflow, such takes may be managed by establishing fixed groundwater allocation volumes that recognise the linkages between groundwater and surface water bodies.

The findings of the work to date will be published in Phase 3 of the Wairarapa Valley groundwater resource investigation later in 2010/11.

5.3 Wetland hydrology and monitoring

Little is known about the hydrology of wetlands in the Wellington region and the effect of nearby groundwater abstraction on these wetlands. This information is important to ensure that suitable water allocation regimes are set up and effects of consented water takes on wetlands can be better identified and managed. A wetland investigation was carried out in early 2010, with the aim of obtaining hydrological (and other) information on a number of significant wetlands in the Wellington region considered to be vulnerable to stress from groundwater abstraction.

Ten 'vulnerable' wetlands were identified and visited in late March or early April (Figure 5.1). These wetlands were assessed for:

- Wetland extent (coverage) and wetland type;
- Hydrological drivers – groundwater and surface water inputs and outputs;
- Water quality indicators – water chemistry analysis (for selected variables such as nutrients, pH, dissolved oxygen, conductivity, and temperature), and visual inspection for macrophytes, algae and clarity etc;
- Wildlife – native fauna and flora; and
- Current stressors such as water level modification, water abstraction, undesirable and invasive species, and animal access.

The findings of the wetland hydrology and monitoring investigation are currently being compiled. Recommendations will also be provided for potential permanent hydrological monitoring, and potential hydrological thresholds as per the proposed National Environmental Standard on Ecological Flows and Water Levels (Ministry for the Environment 2008). The investigation findings will also assist Greater Wellington in developing policies, rules, and abstraction thresholds for the surveyed areas and for other wetlands with similar characteristics.

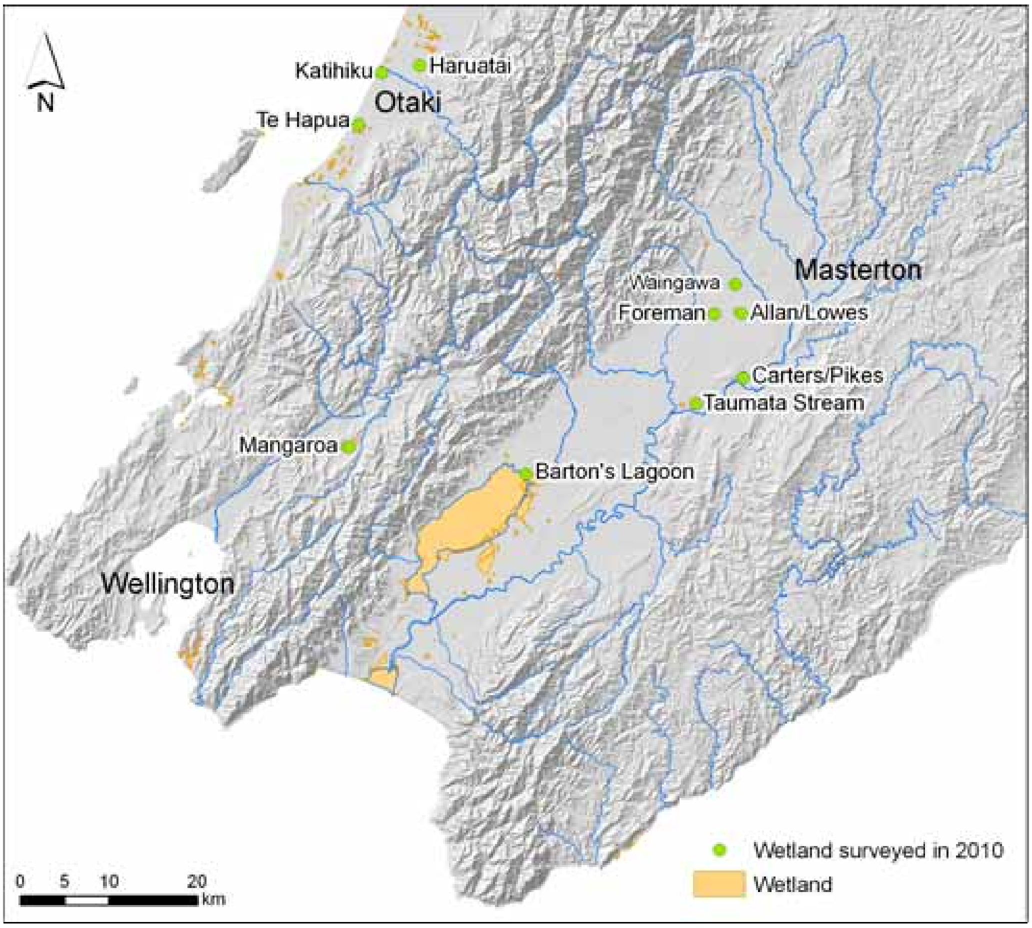

Figure 5.1: The 10 wetlands assessed as part of an investigation into wetland hydrology in March-April 2010

5.4 Mangatarere catchment investigation

As previously reported by Tidswell and McAlister (2009), in September 2008 Greater Wellington commenced a year-long integrated study of the Mangatarere catchment in Carterton. Water quality in the lower reaches of the Mangatarere Stream is amongst the poorest in rivers and streams in the Wellington region, particularly in terms of dissolved nutrient concentrations. Therefore there was a need for more information to better understand water quality within the catchment, and to determine the primary nutrient sources and the potential migration of nutrients from the soil zone to groundwater aquifers to surface water.

The findings of the investigation are documented in a detailed report by Milne et al. (2010) and so only a brief summary of the groundwater component of the investigation is made here. This component involved two-monthly testing of water quality in 13 bores (Figure 5.2).

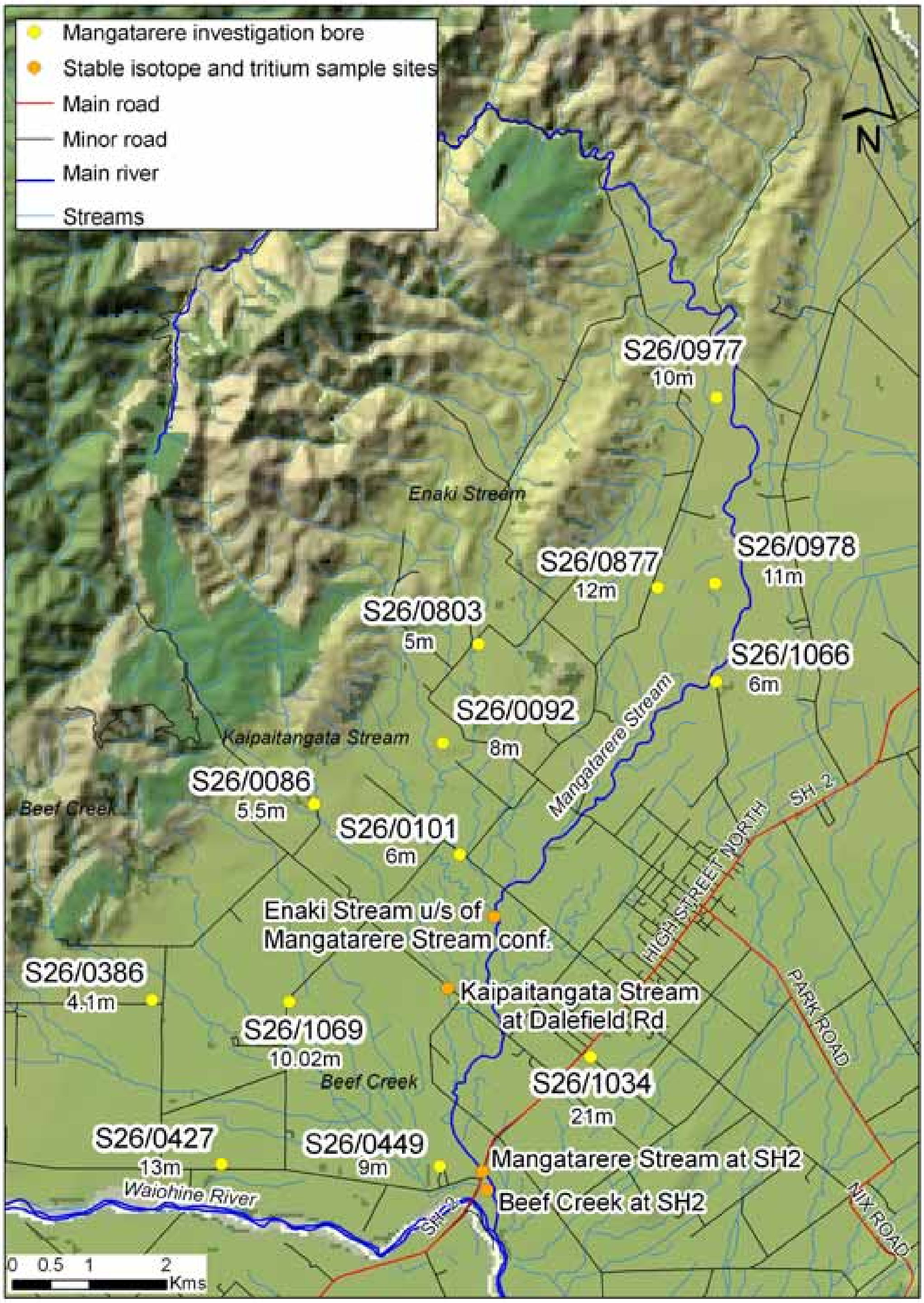

Figure 5.2: Location and depth of the 13 groundwater bores sampled on seven occasions from October 2008 to October 2009 in the Mangatarere area. One-off stream sites sampled for stable isotopes and tritium are also shown.

Monitoring results indicate that groundwater quality in the Mangatarere catchment is impacted by intensive land use. Of the 13 bores sampled bi-monthly between October 2008 and October 2009, the groundwater in those bores located in areas of agriculture and near consented dairyshed and piggery discharges to land tended to have the highest nutrient (Figure 5.3), metal and major ion concentrations.

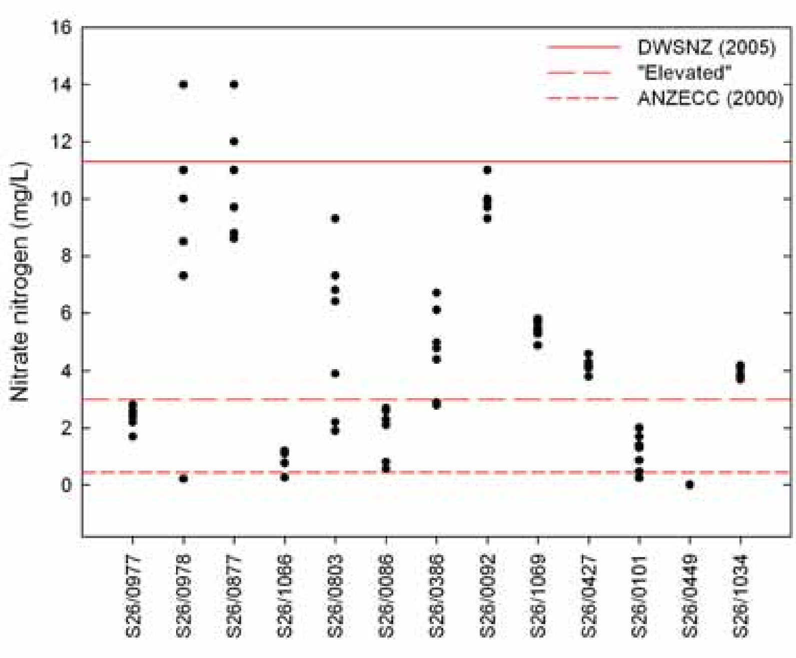

Figure 5.3: Dot plot of nitrate nitrogen concentrations in groundwater samples collected from 13 bores in the Mangatarere catchment at two-monthly intervals over October 2008 to October 2009. The three lines indicate the DWSNZ (2005) MAV, the "elevated" nitrate nitrogen threshold and the ANZECC (2000) trigger value for nitrite-nitrate nitrogen in lowland streams.

Higher nitrate concentrations were generally seen in the shallow unconfined aquifers and in winter when rainfall was greater, soils more saturated and groundwater levels higher (Figure 5.4). This is thought to be due to groundwater incepting saturated soils and leachate from intensive land use.

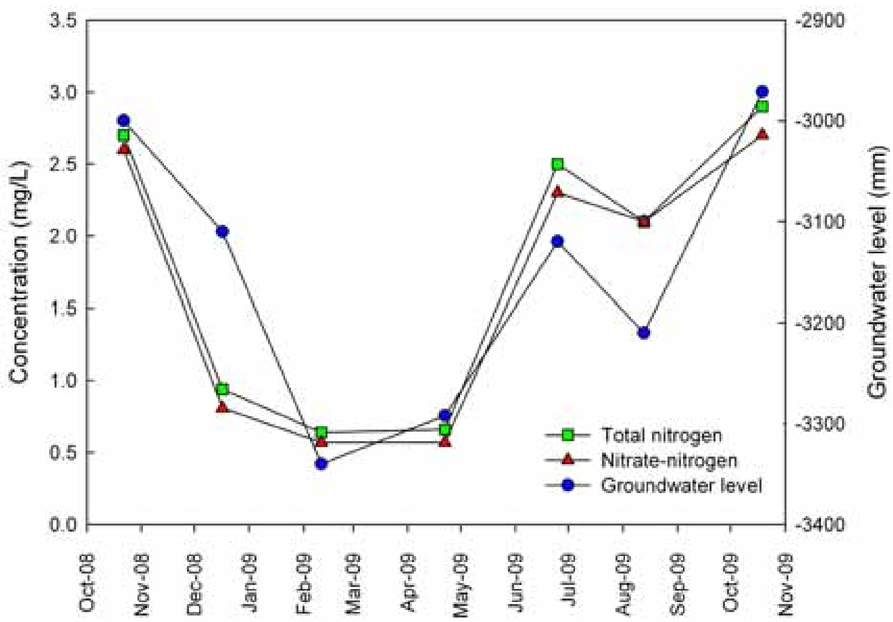

Figure 5.4: Nitrate nitrogen and total nitrogen concentrations (left axis) and groundwater level (right axis) in bore S26/0086 in the Mangatarere catchment, based on seven sampling occasion over October 2008 to October 2009

In addition to the targeted investigation into water quality of the Mangatarere Stream catchment, water samples from the lower reaches of the main tributaries (Enaki Stream, Kaipaitangata Stream and Beef Creek) and the Mangatarere Stream (refer Figure 5.2) were collected on 19 March 2010 and tested for stable isotopes and tritium. The aim of this exercise was to identify the age and source of water entering the stream as an indication of the relationship between nutrient contamination and land use.

The stable isotope and tritium results indicate that at the time of sampling, water flowing in the Mangatarere Stream was approximately two years old and was sourced from rainfall in the Tararua Range. This suggests that a portion of the water flowing in the Mangatarere Stream was groundwater, recharged by surface water infiltration. However, considering that flow in the Mangatarere Stream was not low enough to cause the stream to dry out in the vicinity of Andersons Line (a reach where it often runs dry during very low flows), it is possible that groundwater discharging into the Mangatarere Stream is older but was diluted at the time of sampling by recent rainwater sourced surface water run-off. Further investigation/sampling would be needed to estimate the age of the water at minimum stream flow.

Assuming that water in the Mangatarere Stream during baseflow conditions is at least two years old, this suggests that nutrient contamination in the groundwater is due to relatively recent land use practices.

5.5 Water quality sampling of tributaries and shallow groundwater flowing into Lake Wairarapa

Lake Wairarapa is classified as supertrophic (Perrie 2005), indicating that nutrient concentrations are elevated, water clarity is poor and the algal biomass is high. Results from Greater Wellington’s River State of the Environment monitoring programme indicate that water quality in the two of the lake’s more significant tributaries – Tauherenikau River and Waiorongomai River – is generally good with low nutrient concentrations (Perrie 2009). This suggests that nutrient enrichment of the lake arises from other sources, such as the numerous small streams and drainage schemes that discharge into the lake. Flood flows from the Ruamahanga River that enter the lake via the Oporua Floodway, along with back-flow through the barrage gates are other potential nutrient sources. Also, little is known about the nutrient contribution from shallow groundwater, which may be significant given the intensive landuse in the surrounding catchment area.

Water samples from 15 surface water sites and four shallow groundwater bores were collected on one occasion over 16-17 December 2009 and tested for a range of variables, including dissolved and total nutrients, major ions and *E. coli* bacteria (Figure 5.5). The aim of the investigation was to obtain some initial information on the quality of streams, drains and shallow groundwater entering Lake Wairarapa.

Figure 5.5: A water sample being collected from bore S27/0800 on 16 December 2009 (left), and from the Mangatete Stream on 17 December 2009 (right)

The results suggest that elevated concentrations of nutrients are entering the Lake Wairarapa from drainage and stream networks located on the northern and eastern margins of Lake Wairarapa. General inspection of the catchment indicates that intensive agriculture (dairy, sheep, beef, piggery) tends to dominate land use in the northern and eastern areas of the lake catchment. This intensive land use will be influencing the water quality of shallow (unconfined) groundwater and surface water draining to the lake from these areas. Determining the relative contribution of nutrients from these sources to Lake Wairarapa water quality, as well as further investigation into groundwater and surface water interaction around the lake margins, is required.

6. Summary

Groundwater levels during 2009/10 were generally around average to below average in the Wairarapa, average in the Hutt Valley and above average on the Kapiti Coast. This mirrors rainfall and river flow data for 2009/10 reported by Thompson and Gordon (2010). The drier winter months followed by an unusually wet summer sustained fairly average groundwater levels throughout the region with most aquifers recovering from the 2008/09 drought conditions.

Routine groundwater quality monitoring over 2009/10 indicated that *E. coli* bacteria counts met the Ministry of Health drinking water standard in 29 of the 44 bores monitored[13]. Median nitrate concentrations were low (<3 mg/L) in most bores. However, median concentrations in six bores located in Kapiti and Wairarapa were high (7–11.3 mg/L) and a sample from one bore (T26/0489) exceeded the Ministry of Health drinking water standard on one sampling occasion. Elevated nitrate results were generally seen in shallow bores in areas of intensive farming and horticulture.

During 2009/10, Phase 2 of the Wairarapa Valley groundwater investigation and the Mangatarere Stream catchment water quality investigation were completed. A number of other groundwater-related projects and investigations were also undertaken, including an assessment of ten of the region's wetlands considered to be vulnerable to stress from groundwater abstraction, and one-off testing of water samples from shallow groundwater bores and surface water sites around Lake Wairarapa.

[13] Note that not all of the bores monitored are actually used for drinking water supply.

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Appendix 1: Groundwater monitoring networks

Table A1.1: Greater Wellington's automatic groundwater level monitoring network

Site Name	Site Number	Groundwater Zone	Start Date
Wairarapa Valley			
Simmonds /John	S27/0099	Battersea	10/12/1996
Perry	S26/0490	Greytown	13/08/1990
Hammond	S27/0225	Greytown	06/09/1994
Simmonds - 6E/44/30/I	S27/0309	Kahutara	11/01/2002
Simmonds - 6E/51/18/I	S27/0317	Kahutara	21/12/2001
Green	S27/0467	Kahutara	29/11/2001
Martinborough Golf Club	S27/0571	Martinborough Eastern Terraces	05/10/1998
Duggan	S27/0522	Martinborough Western Terraces	01/12/2000
Blundell	S26/0749	Middle Ruamahanga	17/12/1997
Croad	S27/0202	Moroa	26/04/1988
Luttrell/Shallow	S27/0587	Onoke	07/09/1990
Towgood	S26/0738	Parkvale	03/08/1983
Baring	S26/0743	Parkvale	06/11/1986
Dry River Beef	S27/0481	Pukeo	19/09/1983
Zyzalo	T26/0239	Rathkeale	26/08/1997
Burt	S27/0330	Tauherenikau	30/11/2000
Herrick	S27/0381	Tawaha East	09/03/1984
Smith	S27/0346	Tawaha West	02/12/1983
Wairoria	S27/0434	Te Hopai	02/02/1994
Oliver - deep	T26/0494	Te Ore Ore	27/11/1991
Oliver - shallow	T26/0501	Te Ore Ore	15/07/1983
Robinson	S27/0442	Tuhitarata	30/08/2005
Downing	S26/0033	Upper Plain	30/09/1983
Wairio	S27/0428	Wairio	11/02/1983
Renall Street - deep	S26/1032	Parkvale	29/09/2008
Renall Street - shallow	S26/1033	Parkvale	29/09/2008
Hilton Road - deep	S26/1034	Carterton	14/11/2008
Hilton Road - shallow	S26/1035	Carterton	14/11/2008
Lucas	T26/0814	Te Ore Ore	05/08/2008
Taumata Lagoon - Inner	S27/0881	Middle Ruamahanga	29/08/2009
Taumata Lagoon - Outer	S27/0878	Middle Ruamahanga	04/08/2009
Bicknell	S27/0883	Ahikouka	07/08/2008
Tucker	S27/0884	Riverside	14/08/2008
Didsbury	S27/0885	Riverside	07/08/2008
McNamara - Shallow	S26/1053	Parkvale	21/08/2008
Hutt Valley			
HVMTC	R27/0120	Lower Hutt GW Zone	24/09/1968
McEwan Park Shallow	R27/0122	Lower Hutt GW Zone	03/03/1971
IBM No 1	R27/0320	Lower Hutt GW Zone	14/02/1974
UWA 3	R27/1086	Lower Hutt GW Zone	24/12/1997
Hutt Rec	R27/1115	Lower Hutt GW Zone	15/12/1967
Mitchell Park	R27/1116	Lower Hutt GW Zone	24/09/1968
Taita Intermediate	R27/1117	Lower Hutt GW Zone	24/09/1968
Randwick	R27/1122	Lower Hutt GW Zone	22/07/1975
Somes Island	R27/1171	Lower Hutt GW Zone	28/01/1969
IBM No 2	R27/1265	Lower Hutt GW Zone	16/09/2004
Marsden St	R27/6386	Lower Hutt GW Zone	01/05/2001
South Pacific Tyres	R27/1137	Upper Hutt GW Zone	08/06/2006
Trentham Memorial Park	R27/7004	Upper Hutt GW Zone	25/05/1973

Site Name	Site Number	Groundwater Zone	Start Date
McEwan Park Deep	R27/7153	Lower Hutt GW Zone	14/03/2008
TS Tamatoa Deep	R27/7215	Lower Hutt GW Zone	5/02/2008
TS Tamatoa Shallow	R27/7154	Lower Hutt GW Zone	5/02/2008
Coca Cola/Unibag	R27/6978	Lower Hutt GW Zone	1/08/2006
Kapiti Coast			
Sims Rd Sth	R25/0003	Coastal GW Zone	28/03/1985
Housiaux 2	R26/6879	Coastal GW Zone	23/02/2005
Centrepoint	S25/5208	Hautere GW Zone	19/12/1991
Bettys	S25/5258	Otaki GW Zone	04/03/1993
Waikanae Park	R26/6284	Waikanae GW Zone	14/07/2003
Rangihiroa St	R26/6287	Waikanae GW Zone	16/12/2002
Rutherford Drive	R26/6378	Waikanae GW Zone	13/09/2006
Stevenson	R25/5171	Coastal GW Zone	15/04/2009
Jensen Deep	R25/5262	Coastal GW Zone	26/03/2009
J Abigail & J Anderton	R25/7087	Coastal GW Zone	30/03/2009
Jensen Shallow	R25/7086	Coastal GW Zone	30/03/2009
Estuary Shallow	R26/6566	Waikanae GW Zone	18/02/2005
Waikanae CHP Deep	R26/6594	Waikanae GW Zone	30/05/1994
Taiata St Shallow	R26/6673	Waikanae GW Zone	18/02/2005
Larch Grove	R26/6831	Waikanae GW Zone	01/03/2001
Maclean Park	R26/6833	Waikanae GW Zone	03/04/2001
Te Harakeke No 3	R26/6886	Waikanae GW Zone	18/11/2005
Waikanae CHP Shallow	R26/6916	Waikanae GW Zone	10/08/1994
Taiata St Deep	R26/6955	Waikanae GW Zone	18/02/2005
Estuary Deep	R26/6956	Waikanae GW Zone	18/02/2005
Nga Manu	R26/6991	Waikanae GW Zone	18/11/2005
K6	R26/6992	Waikanae GW Zone	18/11/2005
W1	R26/7025	Waikanae GW Zone	18/11/2005
Taylors	S25/5332	Waitohu GW Zone	23/05/1995

Table A1.2: Greater Wellington's manual groundwater level monitoring network

Site Name	Site No.	Groundwater Zone	Start Date
Wairarapa			
Craig /Deep	S26/0545	Ahikouka	03/08/1983
Craig /Shallow	S26/0547	Ahikouka	03/08/1983
Nicholson	S26/0223	East Taratahi	18/03/1998
East Coast Fert./Dee	S26/0229	East Taratahi	14/05/1984
Oldfield	S26/0236	East Taratahi	03/08/1983
East Coast Fert./Shall	S26/0242	East Taratahi	03/08/1983
McKay	T26/0326	Fern Hill	03/08/1991
Simmonds /Jim	S27/0271	Kahutara	21/04/1982
Awaroa /Deep	S27/0446	Kahutara	11/11/1982
Awaroa /Shallow	S27/0465	Kahutara	20/04/1982
Wither/Craig	S26/0658	Mangatarere	03/08/1983
Wall	S27/0403	Martinborough Eastern Terraces	13/11/2001
Collins/MacCullum	S27/0560	Martinborough Eastern Terraces	01/05/2002
Te Kairanga/Deep	S27/0640	Martinborough Eastern Terraces	01/02/2002
Transport Wairarapa	T26/0429	Masterton	10/02/1986
Wenden	S26/0756	Middle Ruamahanga	29/05/1998
Morrison	S27/0248	Middle Ruamahanga	03/08/1983
Warren	S27/0594	Narrows	18/08/1981
Luttrell /Deep	S27/0576	Onoke	29/11/1982
Tocher/Lawrence	T26/0208	Opaki	26/01/1998

Site Name	Site No.	Groundwater Zone	Start Date
Tulloch /Shallow	S26/0155	Parkvale	03/08/1983
Denbee	S26/0568	Parkvale	17/08/1983
Tulloch /Investigation	S26/0656	Parkvale	03/08/1983
McNamara	S26/0675	Parkvale	30/10/1996
Ness /Deep	S27/0484	Pukeo	07/12/1990
Ness/Shallow	S27/0485	Pukeo	28/11/1995
Stuart	S27/0517	Pukeo	22/09/1989
Windy Farm /House	S27/0009	South Featherston	01/05/2002
Windy Farm /Pig Unit	S27/0012	South Featherston	03/08/1983
Sth Featherston School	S27/0035	Tauherenikau	03/08/1983
Butcher	S27/0542	Tawaha	21/12/1988
Waicon	T26/0232	Te Ore Ore	19/09/1983
List	S27/0572	Huangarua Lower Terraces	
Masterton District Council	T26/0243	Te Ore Ore	26/09/1988
Annear – Lake Ferry	R28/0002	Turanganui	14/11/2001
Lenton	T26/0003	Upper Opaki	02/04/1997
Dick /Investigation	S26/0030	Upper Plain	24/07/1989
Atkinson	S27/0618	Whangaehu / Tuhitarata	16/04/1982
Carlisle	S27/0148	Woodside	03/08/1983
Annear – Homebush	T26/0366	Masterton	08/04/2002
Wairarapa A & P	S26/0837	Parkvale	04/08/2009
Windy Farm - Irrigation	S27/0839	South Featherston	03/11/09
Kells Stream	T26/0709	Upper Plain	15/11/1993
Hutt Valley			
Nevis St	R27/1223	Lower Hutt GW Zone	03/03/1971
Kapiti Coast			
Faith P	R25/5123	Coastal GW Zone	26/02/1993
Quinn	R26/6747	Coastal GW Zone	30/06/1982
Housiaux 1	R26/6861	Coastal GW Zone	25/11/2004
Housiaux 2b	R26/6936	Coastal GW Zone	25/11/2004
Housiaux 3	R26/6880	Coastal GW Zone	25/11/2004
Housiaux 5	R26/6882	Coastal GW Zone	25/11/2004
Housiaux 6	R26/6883	Coastal GW Zone	25/11/2004
Housiaux 4	R26/6881	Coastal GW Zone	22/09/2004
Jamieson	R25/5111	Hautere GW Zone	26/02/1993
Windsor Park	R25/5135	Hautere GW Zone	30/06/1982
Common Property	S25/5200	Hautere GW Zone	12/03/1993
Penray	S25/5256	Hautere GW Zone	26/02/1993
KCDC Rangiuru	R25/5228	Otaki GW Zone	08/04/1993
Lutz C	S25/5212	Otaki GW Zone	23/03/1993
Andrews V	S25/5228	Otaki GW Zone	26/02/1993
Horowhenua Racing Club	S25/5287	Otaki GW Zone	12/03/1993
QE Park No 3	R26/5102	Raumati/Paekak GW Zone	12/09/2001
QE Park No 1	R26/6503	Raumati/Paekak GW Zone	26/02/1993
QE Park No 2	R26/6520	Raumati/Paekak GW Zone	12/12/1994
QE Park No 4	R26/6919	Raumati/Paekak GW Zone	12/09/2001
QE Park No 5	R26/6920	Raumati/Paekak GW Zone	12/09/2001
Weka Park	R26/6521	Waikanae GW Zone	26/02/1993
Mazengarb	R26/6557	Waikanae GW Zone	26/03/1993
NZ Staff College	R26/6569	Waikanae GW Zone	26/02/1993
McLaughlan	R26/6626	Waikanae GW Zone	26/02/1993
McCardle	R26/6738	Waikanae GW Zone	26/02/1993
Te Harakeke Bore 1	R26/6884	Waikanae GW Zone	14/05/2002
Te Harakeke Bore 2	R26/6885	Waikanae GW Zone	14/05/2002
Edhouse D	S25/5322	Waitohu GW Zone	26/03/1993
Laurensen Estate	S25/5329	Waitohu GW Zone	26/03/0993

Table A1.3: Greater Wellington's State of Environment groundwater quality monitoring network

Site No.	Site Name	Groundwater Zone
Wairarapa Valley		
S26/0457	Palmer	Ahikouka
S27/0156	O'neale	Battersea
S26/0705	CDC South	Carterton
S26/0824	CDC North	Carterton
S26/0223	Nicholson	East Taratahi
T26/0332	Taratahi Shallow	Fern Hill
S26/0846	Druzianic	Greytown
S26/0467	Fitzgerald Shallow	Hodders
S27/0681	Te Kairanga Shallow	Huangarua Lower Terraces
S27/0268	Barton	Kahutara
S27/0283	Osbourne	Kahutara
S27/0299	Johnson	Lake Domain
S26/0117	Butcher, G	Mangatarere
S27/0389	Dimittina	Martinborough Eastern Terraces
S27/0571	Mtb Golf	Martinborough Eastern Terraces
S27/0522	Duggan	Martinborough Western Terraces
T26/0413	Seymour	Masterton
T26/0430	Trout Hatchery	Masterton
S26/0439	Rogers	Matarawa
S26/0756	Wendon	Middle Ruamahanga
S26/0762	Schaef	Middle Ruamahanga
S27/0202	Croad	Moroa
S27/0594	Warren	Narrows
S27/0585	Mccreary	Onoke
T26/0099	Butcher, M	Opaki
T26/0206	Thornton	Opaki
S26/0568	Denbee	Parkvale
S26/0576	Mcnamara	Parkvale
S27/0607	Findlayson	Pouawha
S27/0495	Bosch	Pukeo
T26/0259	Opaki Water Supply	Rathkeale
S27/0009	Donderman, A	South Featherston
S27/0070	Sth Fstn School	Tauherenikau
S27/0588	Swdc Pirinoa	Taunui
S27/0396	Swdc Martinborough	Tawaha East
S27/0344	George	Tawaha West
S27/0433	Mapuna Atea	Te Hopai
S27/0442	Robinson Transport	Te Hopai
T26/0489	Duffy	Te Ore Ore
T26/0538	Percy	Te Ore Ore
T26/0003	Lenton	Upper Opaki
T26/0087	Biss	Upper Plain
S27/0435	Wairio	Wairio
R25/5233	Op Trust	Waitohu
S25/5322	Edhouse	Waitohu
S26/0299	Graham	West Taratahi
S27/0602	Weatherstone	Whangaehu / Tuhitarata
S27/0614	Sorenson Southern	Whangaehu / Tuhitarata
S27/0615	Sorenson Northern	Whangaehu / Tuhitarata
S27/0136	Sugrue	Woodside
Riversdale		
T27/0063	Acacia Ave	Riversdale GW Zone

Site No.	Site Name	Groundwater Zone
Hutt, Mangaroa and Wainuiomata Valley		
R27/0320	Ibm 1	Lower Hutt
R27/1171	Somes Island	Lower Hutt
R27/1180	Mahoe St/Willoughby St V	Lower Hutt
R27/1182	Seaview Wools	Lower Hutt
R27/1183	Avalon Studios	Lower Hutt
R27/1265	Ibm 2	Lower Hutt
R27/6833	Mangaroa	Mangaroa
R27/1137	South Pacific Tyres	Upper Hutt
R27/6418	Wainuiomata Golf Club	Wainuiomata River
Kapiti Coast		
R25/5100	O'Malley	Coastal
R25/5164	Card	Coastal
R25/5165	Salter	Coastal
R25/5190	Williams	Coastal
R25/5135	Windsor Park	Hautere
S25/5200	Common Property	Hautere
S25/5256	Penray	Hautere
S25/5125	Bettys/Andrews	Otaki
R26/6503	QE Park	Raumati/Paekakariki
R26/6587	Liddle Nurseries	Waikanae
R26/6624	Boffa	Waikanae

Appendix 2: Groundwater quality variables and analytical methods

Variable	Method Used	Detection Limit
Temperature	Field meter – ExStik DO600 (Extech Imstruments), YSI 550A Meters and WTW350i Meters	0.01 ˚C
Dissolved Oxygen	Field meter – ExStik DO600 (Extech Imstruments), YSI 550A Meters and WTW350i Meters	0.01 mg/L
Conductivity	Field meter – ExStik DO600 (Extech Imstruments), YSI 550A Meters and WTW350i Meters	0.1 µS/cm
pH	Field meter – ExStik DO600 (Extech Imstruments), YSI 550A Meters and WTW350i Meters	0.01 units
pH (lab)	pH meter APHA 4500-H+ B 21st ed. 2005.	0.1 pH units
Electrical Conductivity	Conductivity meter, 25°C APHA 2510 B 21st ed. 2005.	0.1 mS/m, 1 µS/cm
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), Radiometer autotitrator. APHA 2320 B (Modified for alk <20) 21st ed. 2005.	1 mg/L as $CaCO_3$
Free carbon dioxide	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates r bicarbonates. APHA 4500-CO2 D 21st ed. 2005.	1 mg/L at 25°C
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO2 D 21st ed. 2005.	1 mg/L at 25°C
Total Dissolved Solids	Filtration (GF/C, 1.2 µm), filtrate dried at 103 - 105 °C, Gravimetric. APHA 2540 C (modified from 180 °C) 21st ed. 2005.	10 mg/L
Dissolved Calcium	Filtered sample, ICP-MS APHA 3125 B 21st ed. 2005.	0.05 mg/L
Dissolved Magnesium	Filtered sample, ICP-MS APHA 3125 B 21st ed. 2005.	0.02 mg/L
Total Hardness	Calculation: from Dissolved Ca and Dissolved Mg APHA 2340 B 21st ed. 2005.	1 mg/L as $CaCO_3$
Dissolved Sodium	Filtered sample, ICP-MS APHA 3125 B 21st ed. 2005.	0.02 mg/L
Dissolved Potassium	Filtered sample, ICP-MS APHA 3125 B 21st ed. 2005.	0.05 mg/L
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N) APHA 4500-NH_3 F (modified from manual analysis) 21st ed. 2005.	0.01 mg/L
Nitrate-N + Nitrite-N (TON)	Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO3 - I (modified) 21sted. 2005.	0.002 mg/L
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N.	0.002 mg/L
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3 - I (modified) 21st ed. 2005.	0.002 mg/L
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 21st ed. 2005.	0.004 mg/L
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500-Cl- E (modified from continuous-flow analysis) 21st ed. 2005.	0.5 mg/L

Variable	Method Used	Detection Limit
Fluoride	Ion selective electrode APHA 4500-F- C 21st ed. 2005.	0.05 mg/L
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.5 mg/L
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.05 mg/L
Dissolved Boron	Filtered sample. ICP-MS APHA 3125 B 21st ed. 2005.	0.005 mg/L
Reactive Silica	Filtered sample. Heteropoly blue colorimetry. Discrete Analyser. APHA 4500-SiO2 F (modified from flow injection analysis) 21st ed. 2005.	0.1 mg/L as SiO_2
Total Organic Carbon (TOC)	Catalytic oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC -TIC. APHA 5310 B (modified) 21st ed. 2005.	0.05 mg/L
Dissolved Iron	Filtered sample. ICP-MS APHA 3125 B 21st ed. 2005.	0.02 mg/L
Dissolved Manganese	Filtered sample. ICP-MS APHA 3125 B 21st ed. 2005.	0.0005 mg/L
Dissolved Lead	Filtered sample. ICP-MS APHA 3125 B 21st ed. 2005.	0.0001 mg/L
Dissolved Zinc	Filtered sample. ICP-MS APHA 3125 B 21st ed. 2005.	0.001 mg/L
Total Anions	Calculation: sum of anions as mEquiv/L [Includes Alk, Cl, NO_xN & SO_4]	0.07 mEquiv/L
Total Cations	Calculation: sum of cations as mEquiv/L [Includes Ca, Mg, Na, K, Fe, Mn, Zn & NH_4N].	0.06 mEquiv/L
% Difference in Ion Balance	Calculation from Sum of Anions and Cations APHA 1030 E 21st ed. 2005.	0.1 %
Faecal coliforms	APHA 21st Ed. Method 9222 D.	1 cfu/100 mL
E. coli	APHA 21st Ed. Method 9222 G.	1 cfu/100 mL
Dissolved Arsenic	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.001 mg/L
Dissolved Cadmium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.00005 mg/L
Dissolved Chromium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 mg/L
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 mg/L
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.0005 mg/L

Water, air, earth and energy – elements in Greater Wellington's logo that combine to create and sustain life. Greater Wellington promotes **Quality for Life** by ensuring our environment is protected while meeting the economic, cultural and social needs of the community

For more information, contact Greater Wellington:

Wellington office
PO Box 11646
Manners Street
Wellington 6142
T 04 384 5708
F 04 385 6960

Masterton office
PO Box 41
Masterton 5840
T 06 378 2484
F 06 378 2146

facebook.com/GreaterWellington

twitter.com/greaterwgtn

www.gw.govt.nz

Photo
Groundwater flowing from an open hydrant during purging of a bore in the Wairarapa

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