



Annual hydrology monitoring report for the Wellington region, 2010/11

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Main cover photo: The Huangarua River in flood on 23 July 2010, viewed from Hautotora Bridge. GWRC monitoring station visible at left. This flood had an approximate return period of 5 years.

Contents

1.	Introduction	1
2.	Overview of the hydrological monitoring programmes	2
2.1	Surface water hydrology monitoring programme	2
2.2	Groundwater hydrology monitoring programme	6
2.3	Hydrometric network changes in 2010/11	6
3.	Overview of hydrological conditions in 2010/11	8
3.1	Rainfall and river flows	8
3.1.1	Rainfall	8
3.1.2	River flows	10
3.1.3	Background climatic conditions	10
3.2	Lake Wairarapa and Lake Onoke water levels	11
3.3	Soil moisture	13
3.4	Groundwater levels	14
3.4.1	Overview	14
3.4.2	Wairarapa Valley	14
3.4.3	Hutt Valley	15
3.4.4	Kapiti Coast	16
4.	Significant hydrological events of 2010/11	18
4.1	High rainfall and floods	18
4.2	Low rainfall and low flows	22
5.	Hydrological investigations	26
5.1	Wairarapa Valley groundwater allocation	26
5.2	Instream flow investigations	26
5.3	Lake Wairarapa	26
5.4	Wetland investigations	27
	References	28
	Acknowledgements	29
	Appendix 1: Monitoring sites	30
	Appendix 2: Groundwater areas in the Wellington region	39
	Appendix 3: River flood warning alarm levels and occurrences	41

1. Introduction

Freshwater in the Wellington region is highly valued for a variety of uses. Public (city and town) supplies throughout the region rely on high quality abstractions from our large rivers (eg, the Hutt, Waikanae, Wainuiomata, Orongorongo and Waingawa rivers). Groundwater under the Lower Hutt Valley alone supplies about a third of Wellington's water supply while several other towns (eg, Otaki and Martinborough) are also heavily dependent on groundwater for supply. In rural areas of the Kapiti Coast and the Wairarapa, groundwater and surface water are vital 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.

Knowledge of hydrological patterns and trends is vital for achieving sustainable management of water resources. Greater Wellington Regional Council (Greater Wellington) carries out a hydrological monitoring programme that includes a hydrometric network for measuring rainfall, river flows, groundwater levels and lake levels. The information gathered is important for:

- Detecting long and short-term trends in climate and water resources;
- Providing warning of floods and droughts;
- Policy and plan development and review; and
- Resource consent monitoring.

This annual hydrology monitoring report, covering the period 1 July 2010 to 30 June 2011, provides an overview of the patterns in rainfall, river flows, lake, wetland and groundwater levels and notable hydrological events of the year. Note that the inclusion of groundwater level information in this report is a new addition. Groundwater levels were previously reported separately, together with groundwater quality (eg, see Tidswell et al. 2010).

2. Overview of the hydrological monitoring programmes

The objectives of Greater Wellington's surface water and groundwater hydrological monitoring programme are to:

- Provide information on the baseline quantity of fresh water;
- Assist in the detection of spatial and temporal trends in fresh water quantity;
- Provide information to help develop regional plans and assess resource consent applications; and
- Provide information to help determine the effectiveness of regional policies and plans.

2.1 Surface water hydrology monitoring programme

Greater Wellington's surface water hydrometric network as at 30 June 2011 consists of 50 automatic rainfall sites, 45 automatic river level, and 10 automatic lake or wetland level monitoring sites (Figures 2.1 to 2.3; see Appendix 1 for site details). River level is converted to river flow using a rating curve. However, some of the river level monitoring stations have rating curves that are only accurate for high flows or low flows, as indicated in Appendix 1. Some of the rainfall sites are also equipped to monitor climate and soil parameters (such as air temperature, wind speed, soil temperature and soil moisture), and water quality parameters (such as water temperature); the four soil moisture sites shown in Figure 2.3 are those that are regularly reported on by Greater Wellington.

In addition to the 50 rainfall sites referred to above, a further seven rainfall sites in and around Wellington city – that are owned by the city council – are operated by Greater Wellington according to the same hydrometric standards (these additional sites are also shown in Figure 2.1). See Section 2.1 for a list of these sites.

NIWA also operates a network of river flow monitoring sites in the Wellington region, some of which are partly funded by Greater Wellington. Flow data from the co-funded sites are included in this report where appropriate, to provide an indication of regional river flow patterns. Greater Wellington also monitors two stream level/flow sites on behalf of Kapiti Coast District Council. Overall, in addition to the 45 river level/flow sites operated solely by Greater Wellington, a further 10 long term sites are operated in the region. All 55 sites are shown in Figure 2.2.

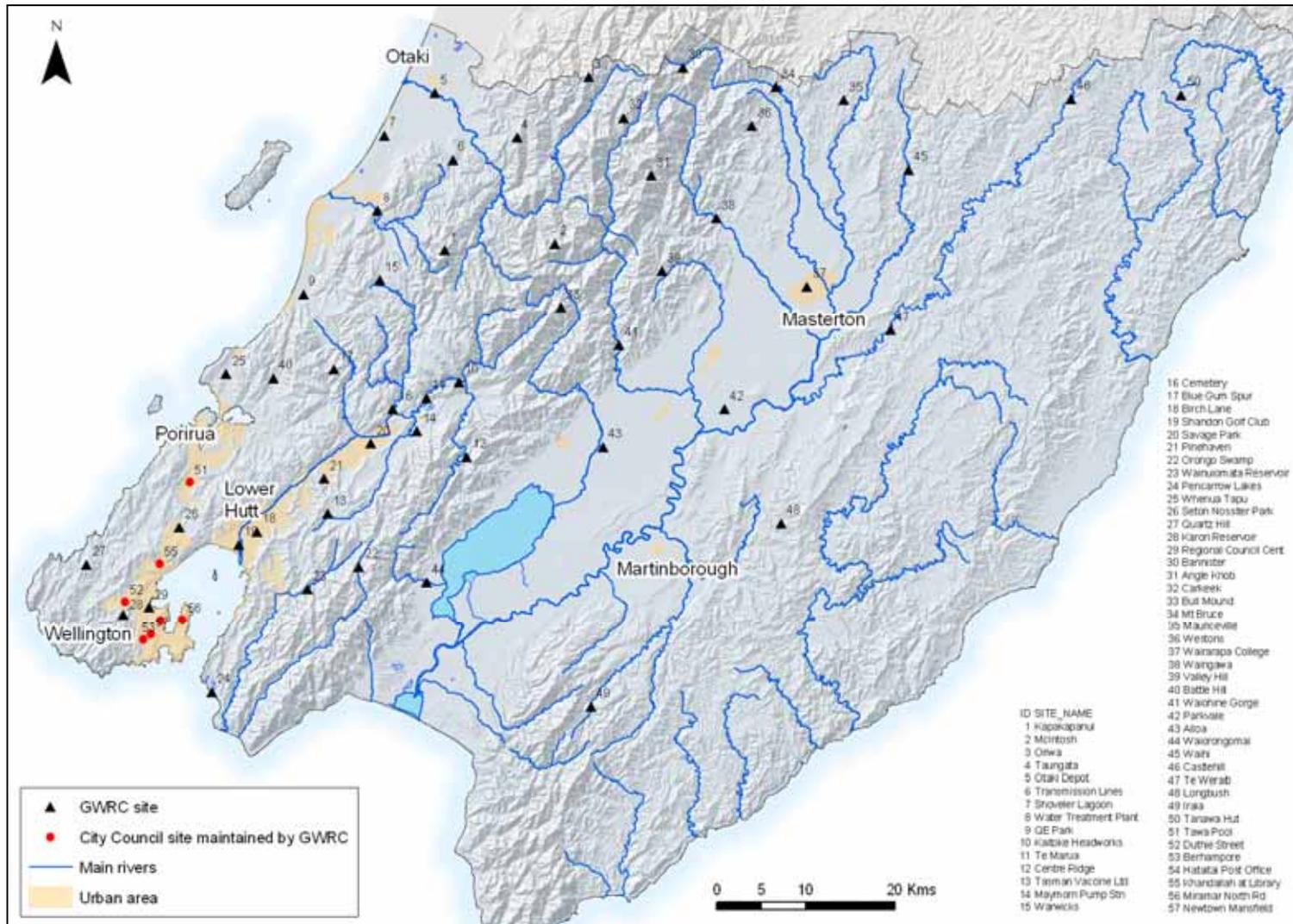
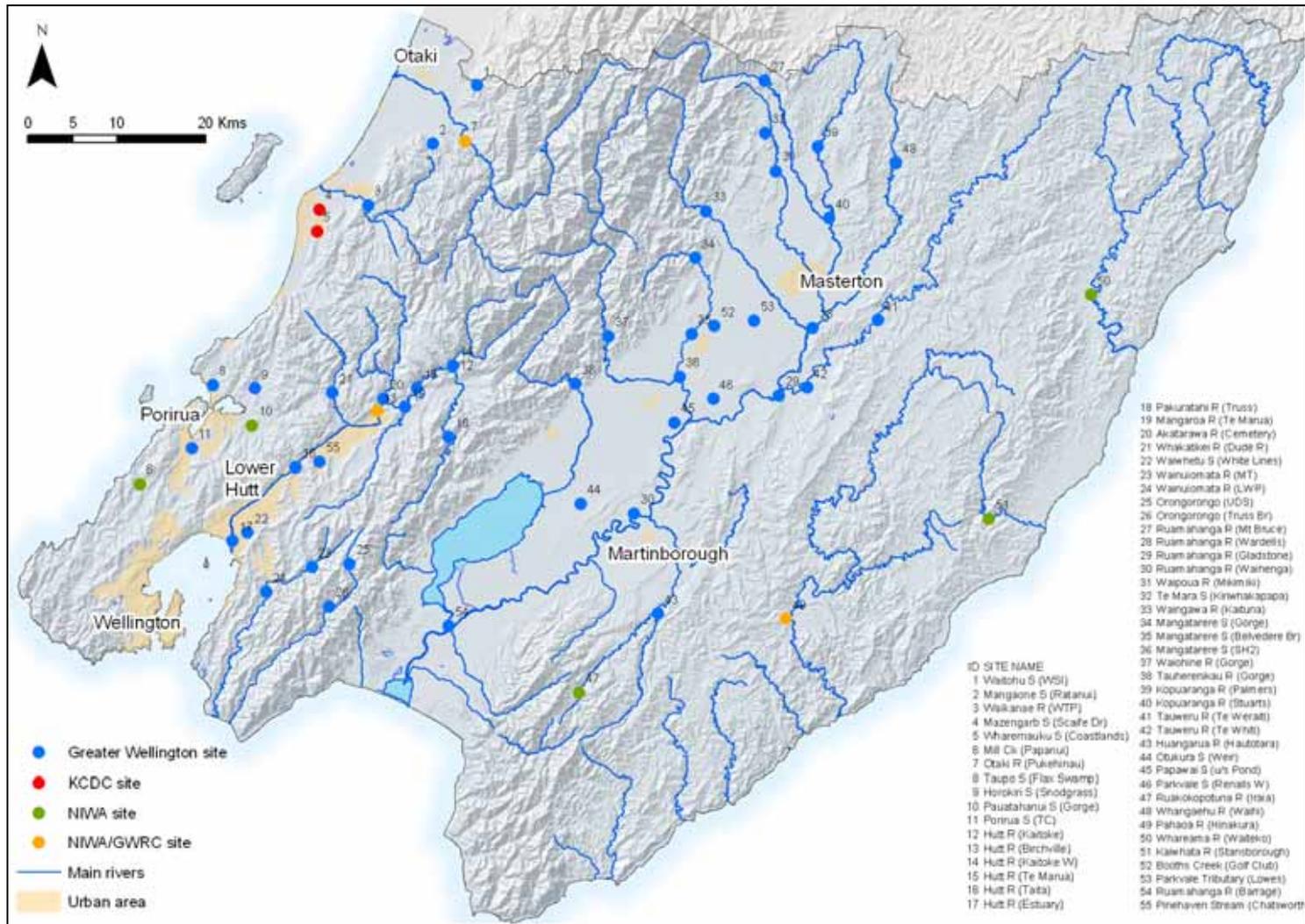


Figure 2.1: Location of Greater Wellington's automatic rainfall monitoring sites



Note: Only water level (stage height) is measured at sites Hutt River at Estuary (ID=17) and Ruamahanga River at Barrage (ID=54). Both these sites are heavily influenced by tides.

Figure 2.2: Greater Wellington's automatic river level/flow monitoring sites

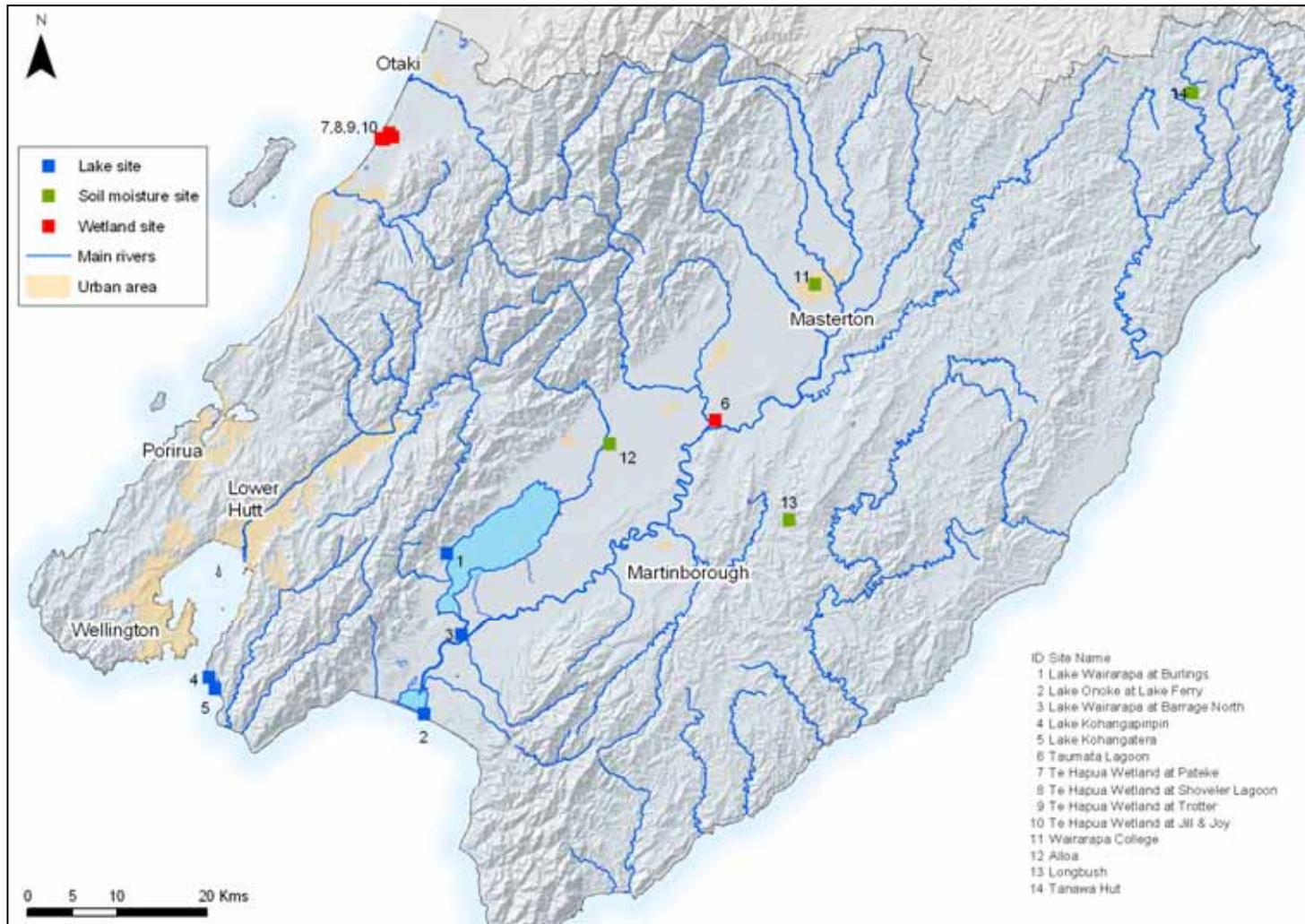


Figure 2.3: Greater Wellington's automatic lake/wetland level monitoring sites and selection of soil moisture monitoring sites that are reported on regularly

2.2 Groundwater hydrology monitoring programme

Greater Wellington monitors groundwater levels in a network of bores across the three principal groundwater areas in the Wellington region (see Appendix 2 for information on these groundwater areas). This network utilises dedicated monitoring bores as well as used¹ and un-used² privately owned bores. The groundwater level network currently consists of 76 automatic and 72 manually dipped³ bores (Figure 2.4 and Appendix 1).

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

2.3 Hydrometric network changes in 2010/11

The following major changes⁴ to Greater Wellington's surface water hydrometric network were made in 2010/11:

- The rainfall stations 'Hutt River at Savage Park' and 'Pinehaven at Pinehaven Reservoir' in the Hutt River catchment were opened in July and August 2010, respectively.
- New stream level/flow sites 'Booths Creek at Golf Club Pond' and 'Parkvale Tributary at Lowes Reserve' opened in December 2010 and March 2011, respectively. These sites are included in Figure 2.2 although their long term viability is not yet known.

The following major changes to Greater Wellington's groundwater hydrometric network were made in 2010/11:

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

¹ Bores that are currently pumped for water supply (this pumping may have short term effects on water level readings).

² Bores previously pumped for supply but no longer utilised for this purpose.

³ Bores are manually dipped to test depth to groundwater, generally on a four or six week rotation.

⁴ Major changes are sites being opened or closed. Other changes such as equipment replacements are not listed here.

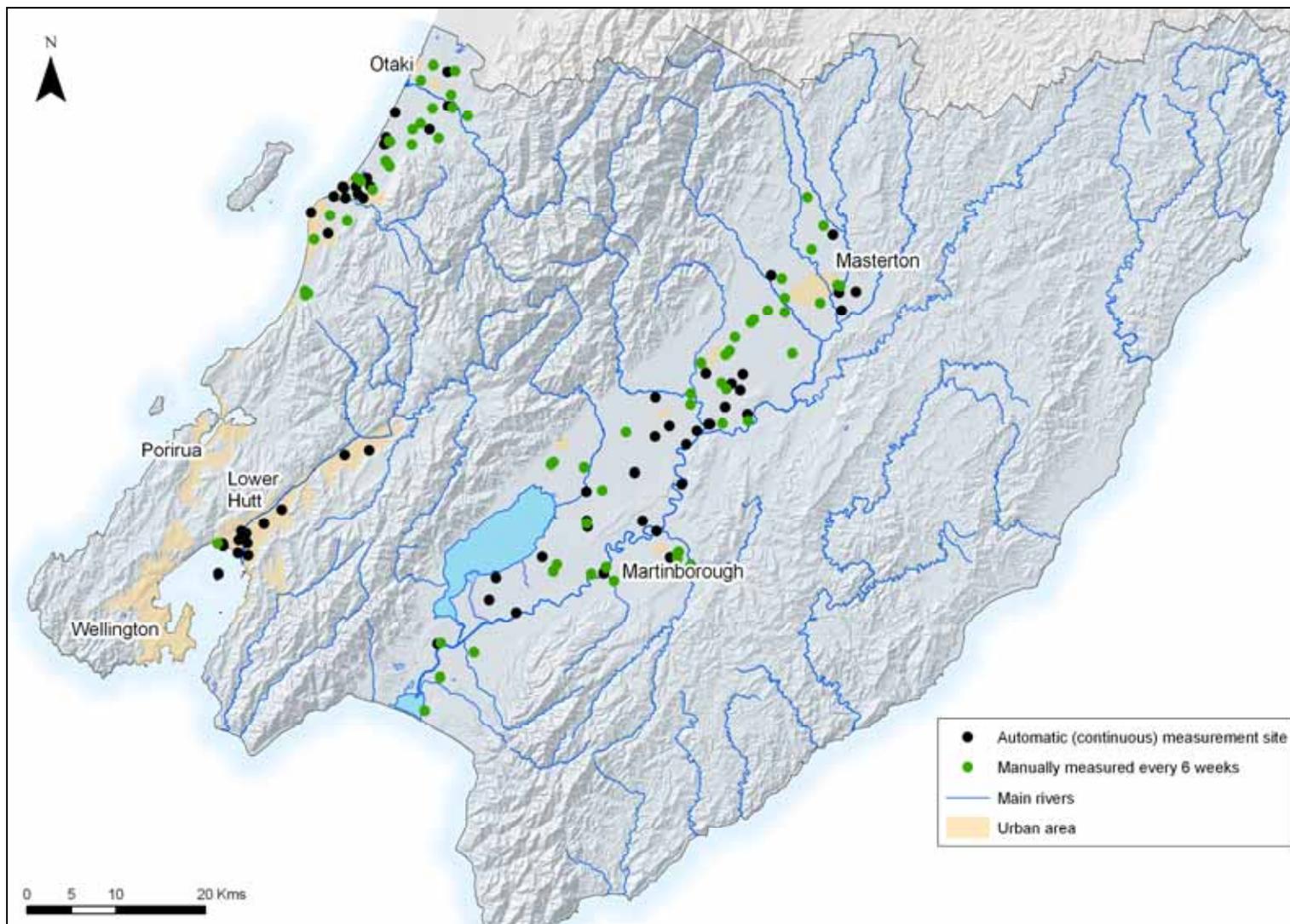


Figure 2.4: Location of groundwater level sites in the Wellington region monitored over 1 July 2010 to 30 June 2011

3. Overview of hydrological conditions in 2010/11

Overall, 2010/11 was wetter than average in most parts of the Wellington region. While there were no particularly significant region-wide droughts or floods, there were some notable wet and dry spells. To indicate how hydrological conditions varied over the year compared to average, the following sections present a summary of rainfall, river flow, soil moisture, lake level and groundwater level data from Greater Wellington's monitoring networks. More detail on hydrological conditions and events in 2010/11 can be found in monthly summaries that are posted on Greater Wellington's website.

3.1 Rainfall and river flows

3.1.1 Rainfall

Table 3.1 and Figure 3.1 summarise seasonal and monthly rainfall totals for a selection of monitoring sites across the region. Key features of the seasonal pattern of rainfall (Table 3.1) include:

- Wetter than average conditions in winter and spring 2010 at most locations (with seasonal rainfall exceeding 120% of the long term average in many places). The exception was eastern Wairarapa where spring was drier than normal.
- A drier than normal summer across most of the region.
- A very wet autumn everywhere except the eastern Wairarapa.

Table 3.1: Seasonal rainfall in 2010/11 (as a percentage of the long term mean) for selected rainfall monitoring sites in the Wellington region. Shading indicates where rainfall departed by more than 10% from the long term mean (blue=higher and orange=lower). No colour indicates rainfall was about average

Sub-region and area		Rainfall as a percentage of the long term mean				
		Winter 2010 (Jun–Aug)	Spring 2010 (Sep–Nov)	Summer 2010/11 (Dec–Feb)	Autumn 2011 (Mar–May)	Overall 2010/11
Kapiti Coast	Waikanae	93%	123%	98%	147%	114%
	Otaki	95%	105%	85%	167%	110%
Hutt Valley	Lower Hutt	124%	129%	103%	200%	134%
	Kaitoke	103%	105%	81%	112%	101%
Wellington	Central city	126%	113%	80%	164%	121%
Wairarapa Plains	Featherston	119%	101%	79%	133%	110%
	Masterton	131%	98%	110%	162%	126%
Eastern Wairarapa	Tanawa Hut (near Tinui)	106%	90%	81%	106%	98%
	Longbush	120%	84%	73%	107%	100%

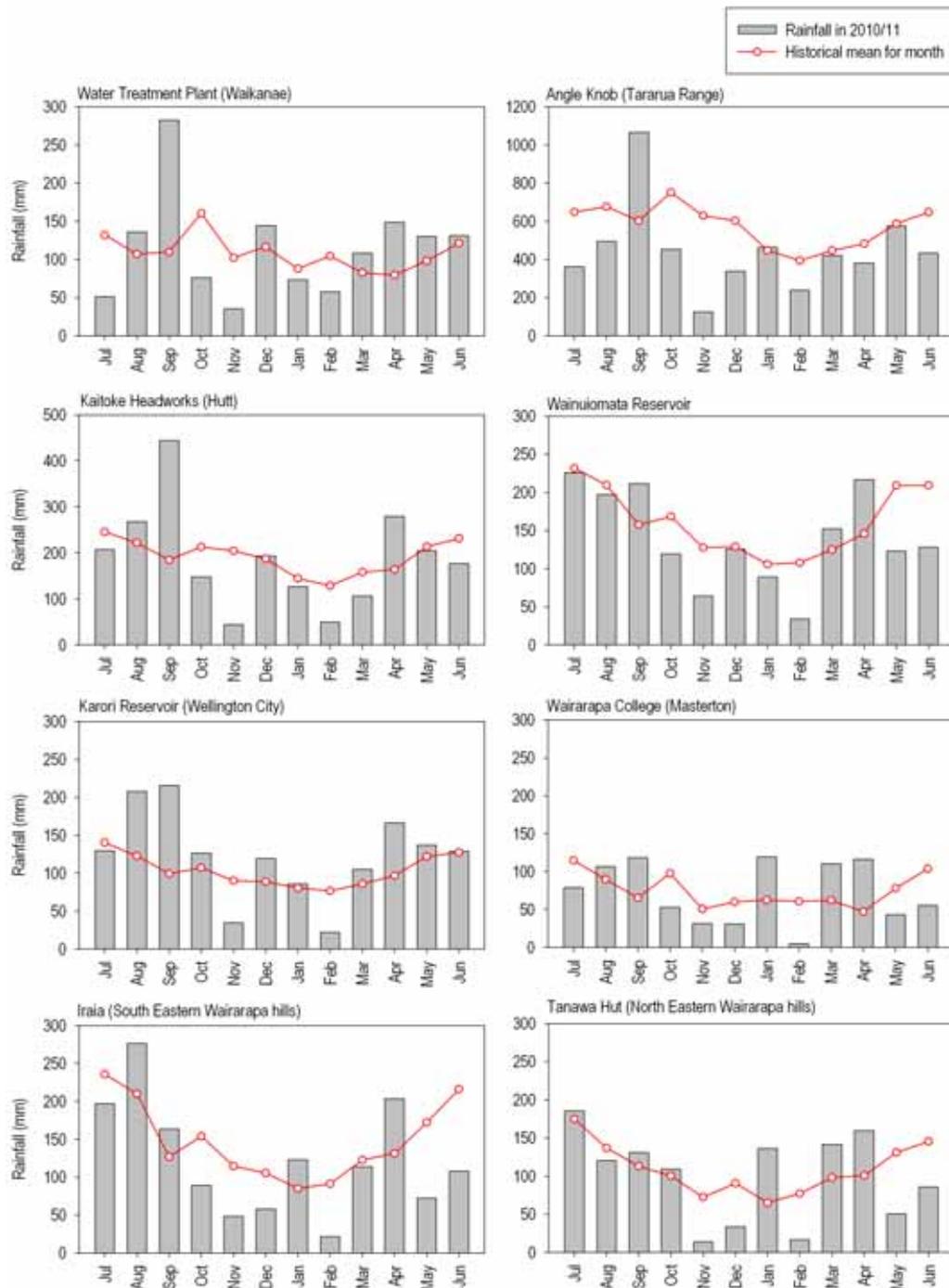


Figure 3.1: Monthly rainfall totals for 2010/11 (grey bars) compared to long term mean monthly rainfall (red line) at selected rainfall monitoring locations in the Wellington region

Taking a closer look, Figure 3.1 provides a monthly breakdown of rainfall at selected stations during 2010/11. There were some notable extremes:

- September was a stormy month with very high rainfall in many places; it was particularly wet in the west with parts of the Kapiti Coast, Hutt Valley and Taranua Range receiving around twice their average rainfall for this month. Several monitoring sites had record high monthly totals for September.

- In contrast, October and, particularly, November were very dry months. Some sites in Wairarapa (eg, 'Castlehill' in the headwaters of the Taueru River catchment) recorded only 10% of the normal November rainfall and more than one third of 36 long term Greater Wellington rainfall sites had record low monthly totals.
- February 2011 was a very dry month across most of the region and the main cause of an overall summer (December to February) rainfall deficit.

3.1.2 River flows

Figure 3.2 shows that mean monthly river flows fell within historical ranges at most sites for most of the time during 2010/11. Extreme highs and lows mirrored the rainfall patterns just described, occurring in September and November respectively. Several sites had mean monthly flows that equalled or just exceeded previous September highs (eg, Waikanae River) and November lows (eg, Ruamahanga River), indicating the significance of the conditions in a historical context.

3.1.3 Background climatic conditions

The El Nino Southern Oscillation (ENSO) is the primary mode of natural climate variability that affects New Zealand's rainfall in the two to seven year timescale (Salinger et al. 2004). The ENSO is a result of cyclic warming and cooling of the surface of the central and eastern Pacific Ocean, and may lead to El Nino or La Nina events. A description of the effects of El Nino and La Nina events on rainfall in the Wellington region is given by Watts (2005). Both El Nino and La Nina events have been found to increase the likelihood of dry periods and low flows in different parts of the Wellington region, compared to during 'neutral' ENSO conditions (Harkness 1998; 1999; 2000). However, droughts may occur that are not linked with either El Nino or La Nina.

2010/11 was characterised by the onset of La Nina conditions in mid-2011. The La Nina strengthened through winter and spring, peaked in summer and persisted, in a weakening state, through autumn 2011. The observed summer rainfall deficit is broadly consistent with what is expected in a strong La Nina; very dry spells, such as that occurring throughout February, punctuated by intermittent but heavy downpours associated with moist easterly airflows originating in the equatorial tropics.

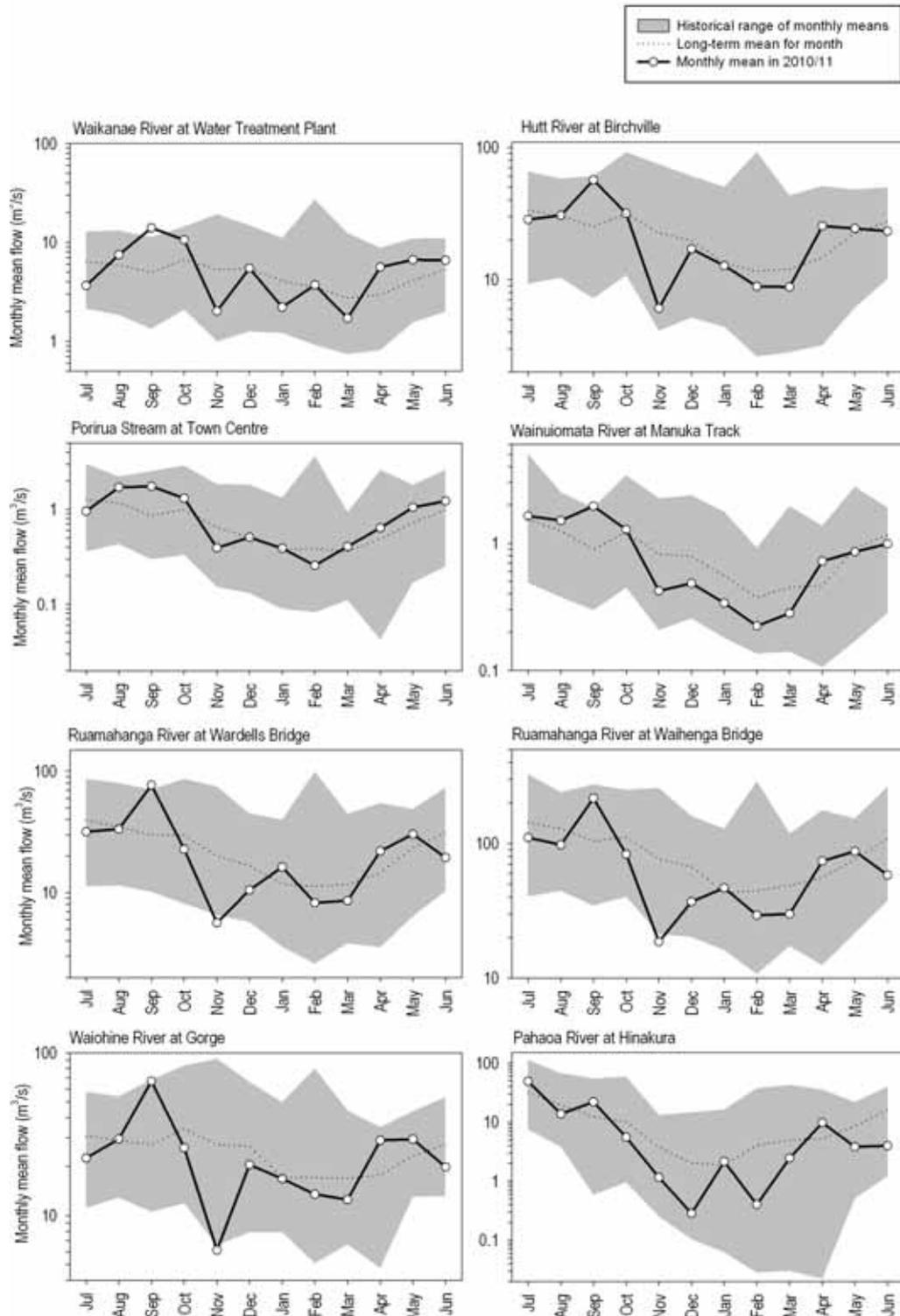


Figure 3.2: Monthly mean river flows for 2010/11 (black line) compared to long term mean monthly river flows (dotted line) at selected monitoring locations in the Wellington region. The grey shaded area represents the historic range of monthly means. Note the logarithmic scale on the vertical axes

3.2 Lake Wairarapa and Lake Onoke water levels

During 2010/11, no record minima or maxima occurred in the monthly mean water levels in Lake Wairarapa or Lake Onoke (Figure 3.3). Generally, water

levels were slightly lower than average in Lake Wairarapa, although the effect of periods of particularly high rainfall (eg, September 2010) can be seen. Slight declines below the seasonal target minimum levels occurred in December and February as a result of reduced tributary input during prolonged dry spells; otherwise target minimum levels were exceeded throughout the year.

Water levels in Lake Onoke were higher than usual throughout the year due to the lake mouth being closed to the sea for longer periods than normal. The exception was February when low rainfall and low flows in the Ruamahanga River, combined with an open lake mouth, saw levels in the lake drop significantly.

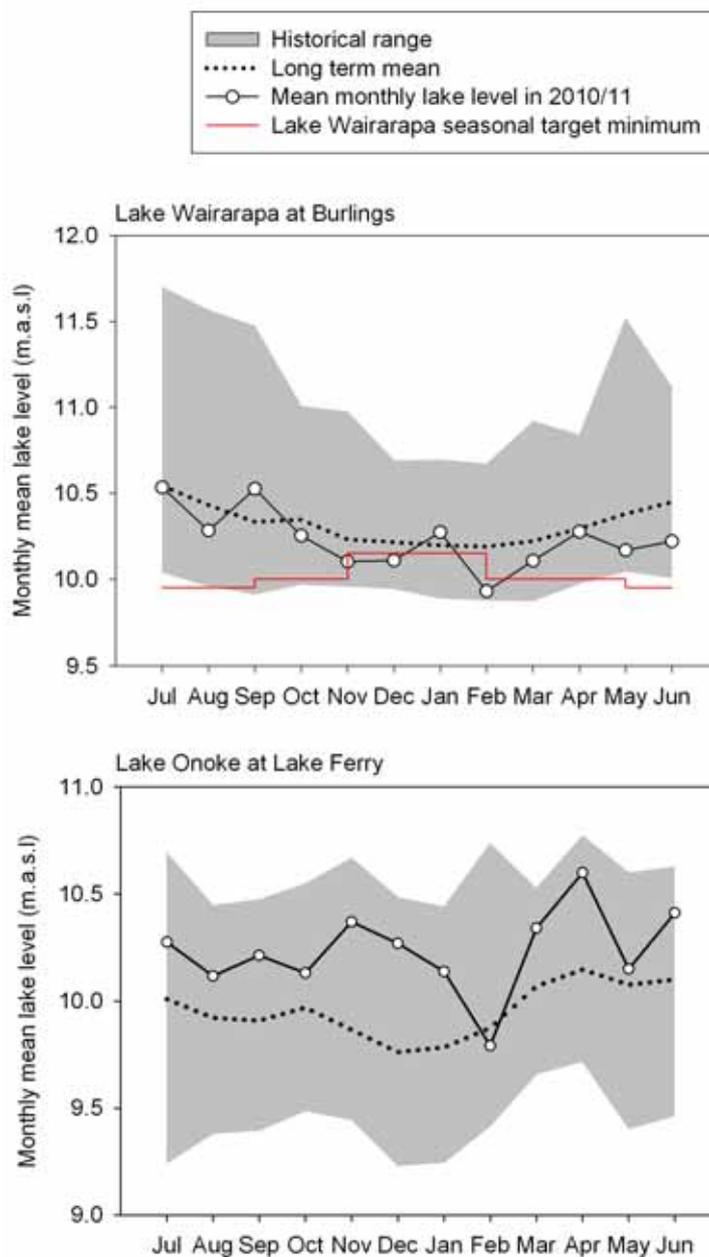


Figure 3.3: Mean monthly water levels in Lake Wairarapa (top) and Lake Onoke (bottom) during 2010/11, compared to long-term monthly mean levels. Seasonal target minimum levels for Lake Wairarapa (specified in the Water Conservation Order for this lake) are also shown

3.3 Soil moisture

Greater Wellington monitors soil moisture at four locations in the Wairarapa. Data from two sites – Alloa (near Featherston) and Tanawa Hut (in the northeastern hill country) – are presented in Figure 3.4 to provide an indication of patterns in soil moisture during 2010/11 compared with recent years.

The very dry spring brought on an unusually early and rapid reduction in soil moisture, such that in late December/early January moisture levels were the lowest in about 10 years of record for these sites. Substantial rainfall in late January provided a reasonable moisture buffer to soils through the very dry February and frequent rainfall thereafter prevented a severe deficit from setting in again.

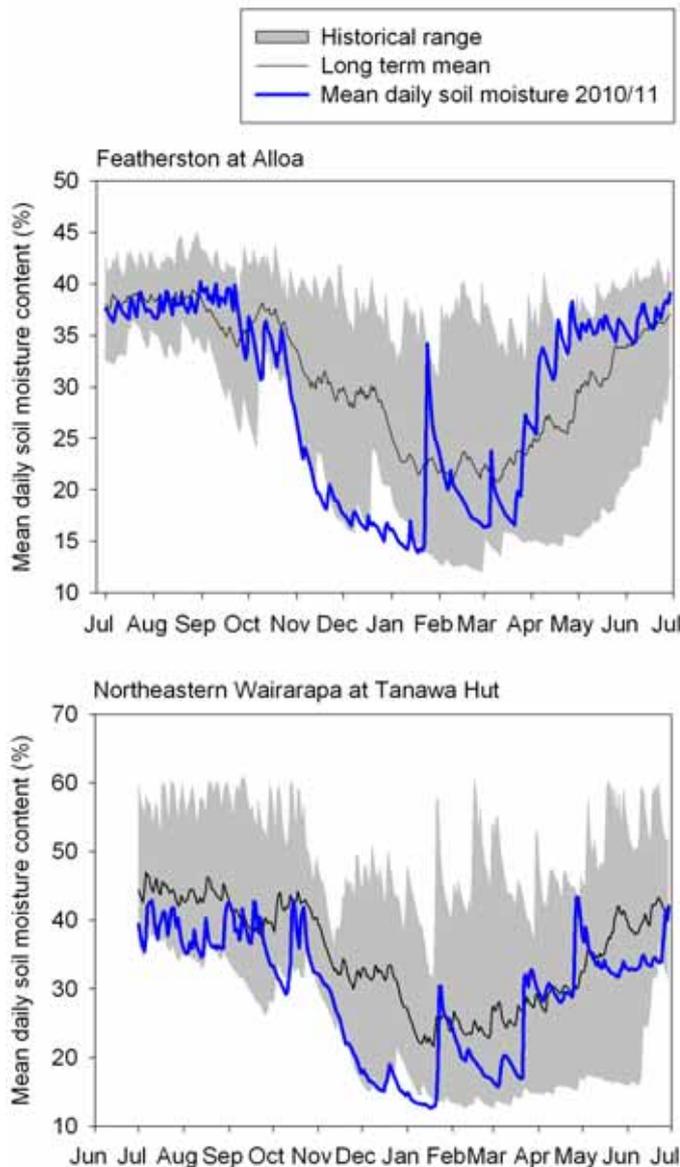


Figure 3.4: Mean daily soil moisture levels during 2010/11 at two monitoring sites in the Wairarapa: Alloa on the Wairarapa Plain near Featherston (top) and Tanawa Hut in the northeastern hill country (bottom). The 2010/11 record is compared to historic mean and range data for each site (the Alloa site has been operating since 2000 and the Tanawa Hut site since 2002)

3.4 Groundwater levels

3.4.1 Overview

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) aquifers⁵.

Groundwater levels during 2010/11 were generally higher than the long term monthly mean during the months of July to late November, and lower than the long term monthly mean from December onwards (Figures 3.5–3.6). This reflects the rainfall patterns shown earlier 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.

3.4.2 Wairarapa Valley

In general, groundwater levels in the Wairarapa Valley fluctuated from at or above the long term mean during winter to below the long term monthly mean during summer at many monitoring sites during 2010/11 (Figure 3.5). Compared to 2009/10, groundwater levels were closer to minimum values during summer 2011. Groundwater levels at many sites showed an increase from April 2011 onwards which coincided with average to above average rainfall sustained over the autumn months of 2011.

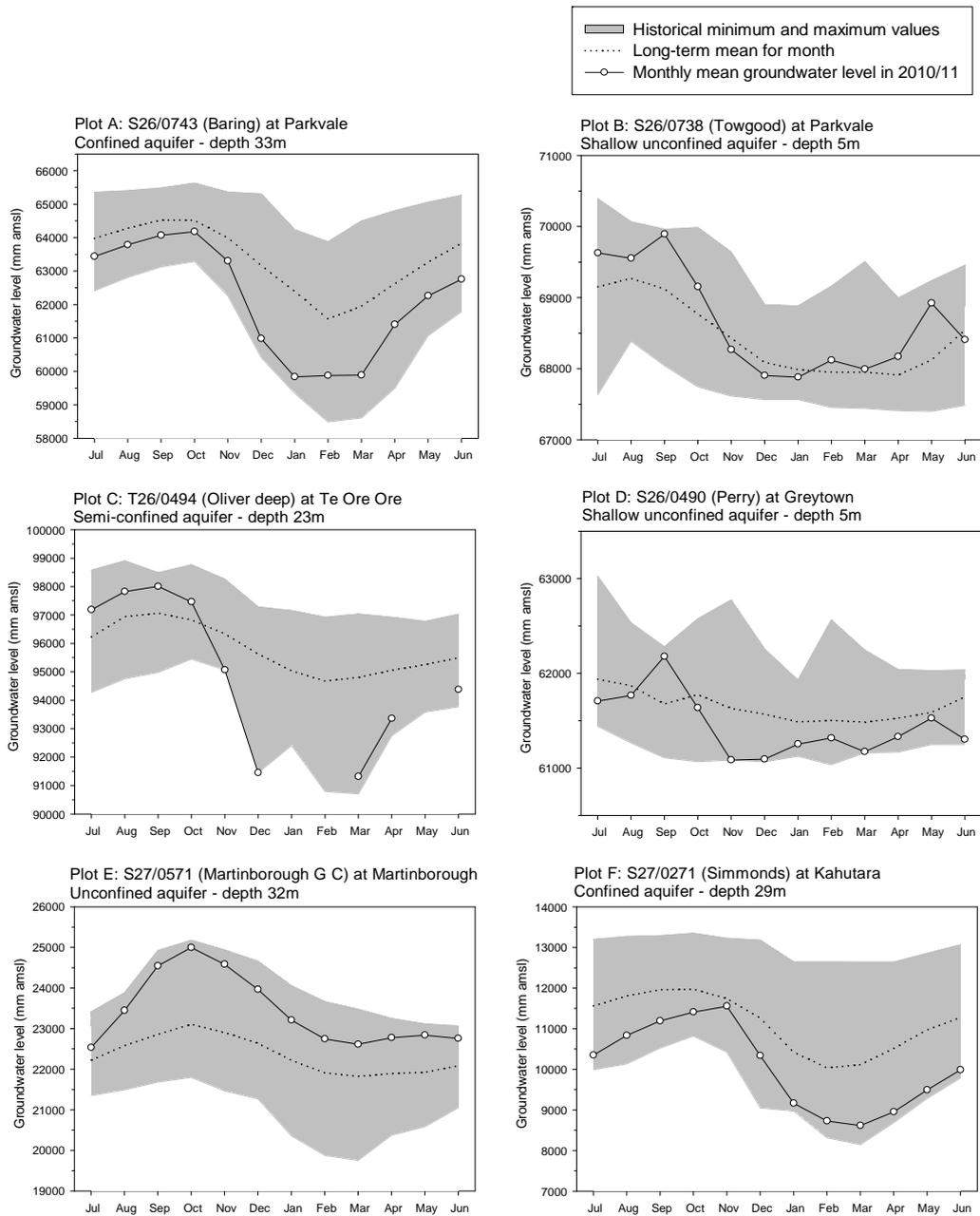
Groundwater levels in confined aquifers and deeper bores were generally just below average due to the drier than average autumn in 2010. Groundwater levels dropped to just above long term minimum values as dry conditions persisted from late November 2010 through to March 2011. Groundwater levels remained below historic monthly means during April (Figure 3.5, Plots A, C and F). Record-low, or near record-low, monthly average water levels were recorded in some monitoring locations (eg, Te Ore Ore and Kahutara in Plots C and F, Figure 3.5) during summer 2010/11.

Groundwater levels in unconfined aquifers, shallow bores and bores recharged by river flow, were generally at or just above the long term monthly mean in winter 2010. Groundwater levels then rose to peak in spring, coinciding with the higher rainfall and river flows detailed in Section 3.1. However, groundwater levels in unconfined aquifers responded rapidly to drier conditions during summer 2010/11, with levels dropping below the long term monthly mean and at times, historic minima.

There was a steady increase in groundwater levels in unconfined aquifers during autumn 2011 (Figure 3.5, Plots B and D) due to higher rainfall. However, levels in the Martinborough Terraces aquifer (Figure 3.5, Plot E), remained well above the long term monthly mean throughout the entire year. This suggests that the higher than average rainfall during the winter months

⁵ Deeper aquifers are recharged through the downward percolation of water from shallow aquifers.

sustained aquifer levels above the long term monthly mean during the summer irrigation season.



* Note missing data points at site T26/0494 are due to equipment failure during January, February and May 2011

Figure 3.5: Monthly mean groundwater levels for 2010/11 (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 historic minimum and maximum monthly mean groundwater levels

3.4.3 Hutt Valley

Groundwater levels were generally below the long term average for the entire year in the Hutt Valley aquifer. The most affected aquifers were the deep artesian aquifers of Lower Hutt where groundwater levels were generally below the long term lowest monthly levels. Shallow artesian aquifers showed

generally below long term average groundwater levels but the levels were higher than lowest monthly levels and remained above warning levels for saline intrusion (Figure 3.6, Plot F).

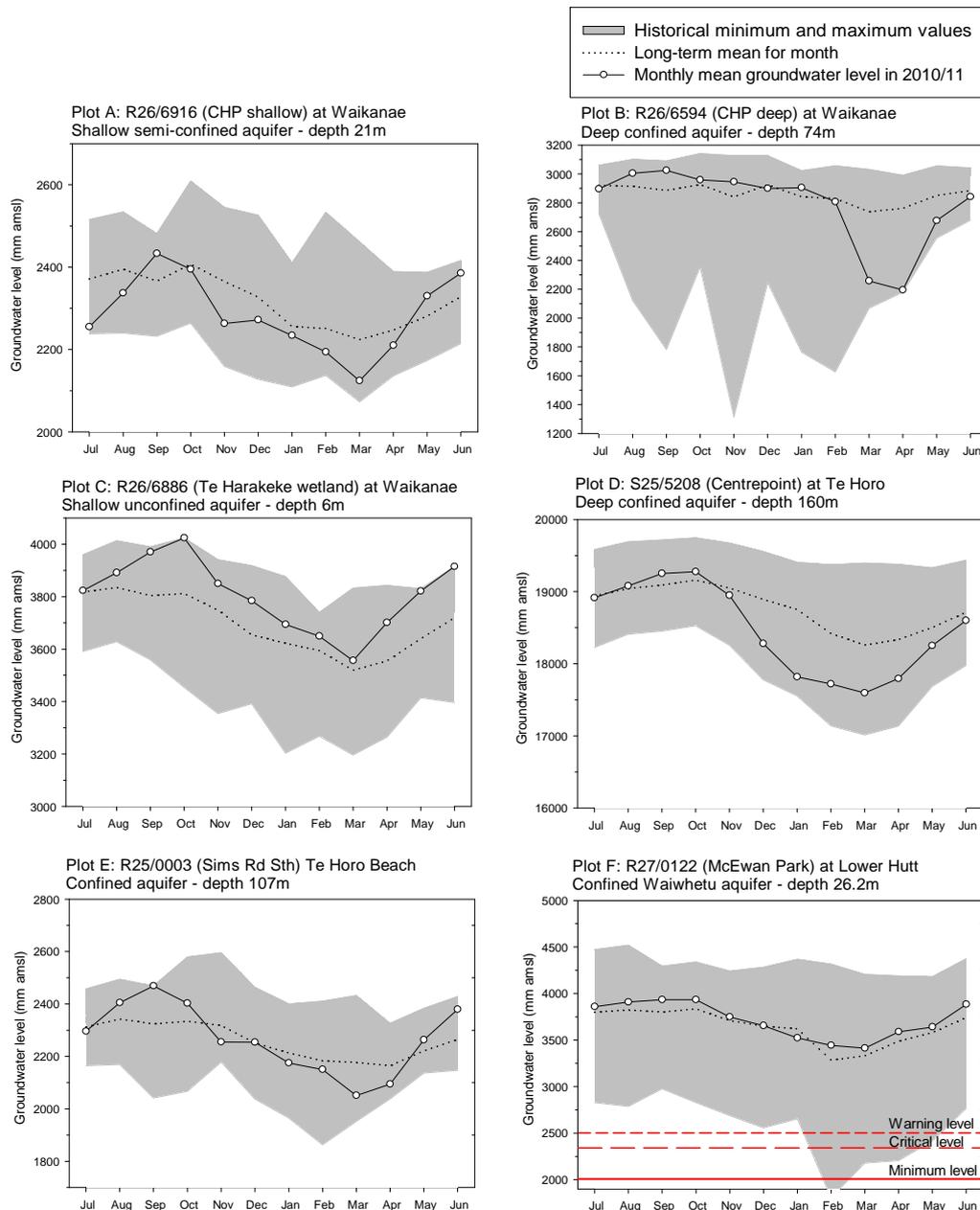


Figure 3.6: Monthly mean groundwater levels for 2010/11 (black line) compared to historical mean monthly groundwater levels (dotted line) at selected sites in Kapiti and Hutt Valley. The grey shaded areas represent the range of historical minimum and maximum monthly mean groundwater levels

3.4.4 Kapiti Coast

Overall, groundwater levels in Kapiti Coast aquifers during 2010/11 were around average or slightly above the historic average, although water levels at some deep monitoring sites dropped below average during late October/early November and didn't recover until May or June 2011 (Figure 3.6). The

shallow semi-confined aquifer at Waikanae (Figure 3.6, Plot A) had groundwater levels at or above historic averages.

Groundwater levels in the Waikanae potable borefield were generally above average, however a significant drop to close to historic minimum levels was observed between the months of February to June 2011 for the deep Waikanae aquifer (Figure 3.6, Plot B).

Groundwater levels in the 160-m deep Centrepoint bore in the Te Horo area were generally around average for the period July 2010 to October 2010, Groundwater levels were below historic monthly averages for the rest of the year (Figure 3.6, Plot D).

4. Significant hydrological events of 2010/11

This section briefly summarises the most prominent hydrological events of 2010/11, with reference to data in Tables 4.1–4.7.

4.1 High rainfall and floods

Tables 4.1 and 4.2 provide details of short (1–12 hour) and long (1–3 day) duration rainfall events recorded at selected monitoring sites during 2010/11. Most events had estimated return periods of less than two or three years. Events with estimated return periods of five years or more included:

- Short duration (1–12 hour) events in the Tararua Range on 6 September and 28 December 2010 in the Tararua Range; almost 300 mm fell at the highest elevation (Angle Knob) site over 12 hours on 28 December.
- A highly localised but extreme short duration (1-hour) event in Lower Hutt on 15 May 2011. The highest 1-hour total on record (32.5 mm) was measured at the Birch Lane site during this event and had an estimated return period of 20 years.
- Long duration events around Wellington city and Porirua in late September 2010 when almost 100 mm of rain was recorded over 24 hours at two sites.
- Long duration (1–3 day) events in the Wairarapa lowlands on 22 and 23 January 2011; almost 130 mm of rain fell in the eastern hill country (Castlehill gauge).

Peak instantaneous river flows were also modest compared with historical floods at most sites during 2010/11. Most estimated return periods were less than two or three years (Table 4.3). More exceptional events were all, bar one, associated with the heavy rainfall events in early and late September 2011. Of particular note were flows in the Ruamahanga River on 6 September that approached those expected, on average, only once every 10 years.

Table A3.2 in Appendix 3 lists the river level flood warning alarms triggered in 2010/11. Of the 85 individual alarms, more than half were associated with events in the stormy September.

Table 4.1: Maximum short-duration rainfall depths during 2010/11 at selected rainfall monitoring stations in the Wellington region. Bolded values indicate a record result

Site (Catchment/area)	1-hour		6 hours		12 hours	
	Depth and start date	Est. return period (years)	Depth and start date	Est. return period (years)	Depth and start date	Est. return period (years)
Water Treatment Plant (Waikanae)	17.5 mm 4 Apr 2011	<2	44.5 mm 30 Sep 2010	2	65.0 mm 30 Sep 2010	2-3
QE Park (Paekakariki) ¹	20.0 mm 15 May 2011	2	37.5 mm 30 Sep 2010	<2	50.5 mm 30 Sep 2010	<2
Warwicks (Akatarawa)	19.5 mm 6 Sep 2010	<2	66.0 mm 5 Sep 2010	2	87.0 mm 30 Sep 2010	<2
Te Marua (Upper Hutt)	19.0 mm 16 May 2011	<2	64.0 mm 28 Dec 2010	2-5	81.0 mm 27 Dec 2010	<2
TVL (Mangaroa / Whitemans Valley)	19.0 mm 15 May 2011	<2	43.5 mm 28 Dec 2010	<2	52.0 mm 27 Dec 2010	<2
Birch Lane (Lower Hutt)	32.5 mm 15 May 2011	20	46.5 mm 15 May 2011	<2	48.0 mm 14 May 2011	<2
Wainuiomata Reservoir (Wainuiomata)	15.5 mm 15 May 2011	<2	44.5 mm 23 Jul 2010	<2	62.0 mm 23 Jul 2010	<2
Seton Nossiter Park (Porirua)	20.5 mm 15 May 2011	2-3	37.0 mm 28 Dec 2010	<2	51.0 mm 30 Sep 2010	<2
Karori Reservoir (Wellington City)	25.4 mm 1 Aug 2010	4	44.2 mm 15 May 2011	2	56.4 mm 30 Sep 2010	2
McIntosh (W Tararua Range)	24.0 mm 6 Sep 2010	<2	108.5 mm 6 Sep 2010	2-3	186.0 mm 5 Sep 2010	6
Angle Knob (E Tararua Range)	54.5 mm 28 Dec 2010	5	211.0 mm 28 Dec 2010	5-6	292.5 mm 28 Dec 2010	4
Waiohine Gorge ²	21.0 mm 28 Dec 2010	2-3	70.5 mm 28 Dec 2010	5	87.5 mm 28 Dec 2010	2-3
Wairarapa College (Masterton) ¹	8.4 mm 9 Sep 2010	<2	34.6 mm 23 Jan 2011	2	56.0 mm 23 Jan 2011	3
Alloa (Featherston)	11.2 mm 17 Sep 2101	<2	29.4 mm 23 Jan 2011	<2	46.2 mm 23 Jan 2011	<2
Castlehill (Tauweru)	10.0 mm 28 Jun 2011	<2	38.5 mm 23 Jan 2011	2-3	62.0 mm 23 Jan 2011	3
Iraia (Huangarua)	12.5 mm 23 Jul 2010	<2	57.0 mm 23 Jul 2010	2-3	89.5 mm 23 Jul 2010	3
Tanawa Hut (Whareama)	10.5 mm 25 Jun 2011	<2	31.0 mm 23 Jan 2011	<2	53.0 mm 23 Jan 2011	<2

¹ Return periods estimated using HIRDS v3.0 (NIWA 2002).

² Return periods estimated using 'Waiohine at Phelps' site that was closed in January 2010.

Table 4.2: Maximum long-duration rainfall depths during 2010/11 at selected rainfall monitoring stations in the Wellington region. Bolded values indicate a record result

Site (Catchment/area)	24 hours		48 hours		72 hours	
	Depth and start date	Est. return period (years)	Depth and start date	Est. return period (years)	Depth and start date	Est. return period (years)
Water Treatment Plant (Waikanae)	92.5 mm 29 Sep 2010	3–4	111.5 mm 29 Sep 2010	4	112.5 mm 28 Sep 2010	2–3
QE Park (Paekakariki) ¹	77.5 mm 29 Sep 2010	<2	87.5 mm 29 Sep 2010	<2	88.0 mm 28 Sep 2010	<2
Warwicks (Akatarawa)	144.0 mm 29 Sep 2010	3	194.0 mm 29 Sep 2010	3–4	198.0 mm 28 Sep 2010	3
Te Marua (Upper Hutt)	92.5 mm 29 Sep 2010	<2	131.0 mm 29 Sep 2010	2	134.0 mm 28 Sep 2010	<2
TVL (Mangaroa / Whitemans Valley)	81.0 mm 29 Sep 2010	<2	107.0 mm 29 Sep 2010	2	109.5 mm 28 Sep 2010	<2
Birch Lane (Lower Hutt)	74.0 mm 29 Sep 2010	<2	87.0 mm 29 Sep 2010	<2	88.0 mm 28 Sep 2010	<2
Wainuiomata Reservoir (Wainuiomata)	65.5 mm 23 Jul 2010	<2	78.5 mm 22 Jul 2010	<2	82.5 mm 24 Apr 2011	<2
Seton Nossiter Park (Porirua)	84.0 mm 29 Sep 2010	5	90.0 mm 29 Sep 2010	3	90.0 mm 28 Sep 2010	<2
Karori Reservoir (Wellington City)	90.4 mm 29 Sep 2010	7	95.2 mm 29 Sep 2010	2	95.2 mm 28 Sep 2010	<2
McIntosh (W Tararua Range)	210.0 mm 5 Sep 2010	2	237.0 mm 5 Sep 2010	<2	260.0 mm 24 Apr 2011	<2
Angle Knob (E Tararua Range)	335.5 mm 5 Sep 2010	2	349.0 mm 5 Sep 2010	<2	371.5 mm 3 Sep 2010	<2
Waiohine at Gorge ²	91.0 mm 23 Jan 2011	<2	117.0 mm 22 Jan 2011	<2	141.0 mm 21 Jan 2010	<2
Wairarapa College (Masterton) ¹	80.8 mm 23 Jan 2011	4	102.4 mm 22 Jan 2011	4	106.6 mm 21 Jan 2010	3
Alloa (Featherston)	73.2 mm 23 Jan 2011	5	85.4 mm 22 Jan 2010	5	88.6 mm 21 Jan 2011	3
Castlehill (Tauweru)	96.0 mm 22 Jan 2011	5	116.5 mm 22 Jan 2011	5	126.5 mm 21 Jan 2011	5
Iraia (Huangarua)	112.0 mm 23 Jul 2010	<2	136.5 mm 22 Jul 2010	<2	138.5 mm 21 Jul 2010	<2
Tanawa Hut (Whareama)	82.0 mm 21 Mar 2011	<2	120.5 mm 24 Apr 2011	<2	137.5 mm 24 Apr 2011	<2

¹ Return periods estimated using HIRDS v3.0 (NIWA 2002).

² Return periods estimated using 'Waiohine at Phelps' site that was closed in January 2010.

Table 4.3: Maximum river and stream flows during 2010/11 at river flow monitoring sites in the Wellington region^{1, 2}

Site	Highest flow in 2010/11 (m ³ /s)	Date of occurrence	Estimated return period (years)
Waitohu S at Water Supply Intake	53	6 Sep 2010	3
Otaki R at Pukehinau ³	1110	6 Sep 2010	3
Mangaone S at Ratanui	16.4	6 Sep 2010	2
Waikanae R at Water Treatment Plant	206	30 Sep 2010	4
Hutt R at Te Marua	348	28 Dec 2010	<2
Hutt R at Birchville ³	605	30 Sep 2010	<2
Hutt R at Taita Gorge	817	30 Sep 2010	3
Pakuratahi R at Truss Bridge	86	28 Dec 2010	<2
Mangaroa R at Te Marua	65	23 Jul 2010	<2
Akatarawa R at Cemetery	265	30 Sep 2010	<2
Whakatikei R at Dude Ranch	91	30 Sep 2010	3
Waiwhetu S at Whites Line East	10.2	15 May 2011	–
Wainuiomata R at Manuka Track	13.4	23 Jul 2010	<2
Wainuiomata R at Leonard Wood Park	32	23 Jul 2010	<2
Orongorongo R at Upper Dam Site	18.6	28 Dec 2010	<2
Taupo S at Flax Swamp	9.3	30 Sep 2010	21
Horokiri S at Snodgrass	42	30 Sep 2010	5 ⁴
Porirua S at Town Centre	36	15 May 2011	3
Ruamahanga R at Mt Bruce	337	6 Sep 2010	3
Ruamahanga R at Wardells Bridge	643	6 Sep 2010	7–8
Ruamahanga R at Gladstone Bridge	1040	6 Sep 2010	8–9
Ruamahanga R at Waihenga Bridge	1344	6 Sep 2010	5–6
Waipoua R at Mikimiki Bridge	132	6 Sep 2010	<2
Waingawa R at Kaituna	272	6 Sep 2010	<2
Mangatarere S at Gorge	73	6 Sep 2010	2–3
Waiohine R at Gorge	839	6 Sep 2010	2
Tauherenikau R at Gorge	307	28 Dec 2010	2–3
Kopuaranga R at Palmers	34	7 Sep 2010	<2
Tauweru R at Te Weraiti	106	8 Jul 2010	<2
Huangarua R at Hautotara	283	23 Jul 2010	5
Pahaoa R at Hinakura ³	346	23 Jul 2010	<2

¹ For sites where the largest flood was within 10% of the second largest, both floods are listed. This accounts for error in flow measurement.

² River level stations that are not rated for high flows are omitted from the table.

³ Data provided by NIWA but frequency analysis performed by Greater Wellington.

⁴ Based on a 10 year record only

4.2 Low rainfall and low flows

Table 4.4 shows that most 2-week and 4-week rainfall minima in the Wellington region during 2010/11 occurred in the very dry spring (October/November). However, the lowest 4-week totals of all sites assessed occurred during February in eastern and southern Wairarapa (10 mm or less was recorded at several sites).

Low flows in the west of the region were not particularly significant in 2010/11, with most sites dropping to flows with estimated return periods of less than two years (Table 4.5). Table 4.6 shows that low flows were more significant in the Wairarapa, particularly during November when events with return periods of four to six years were recorded at several sites (eg, Waingawa at Kaituna).

The number of days in 2010/11 when mean daily flow was lower than the first restriction threshold for rivers (specified in Greater Wellington's Regional Freshwater Plan) was generally higher than the previous summer (2009/10), similar to 2008/09 and much lower than 2007/08 – a particularly warm and dry summer (Table 4.7).

Table 4.4: Lowest rainfall totals during 2010/11 for 14-day and 28-day durations at selected monitoring locations in the Wellington region

Site name	14 days		28 days	
	Rainfall minima (mm)	Start date	Rainfall minima (mm)	Start date
Angle Knob (Tararua Range)	6.5	22 Nov 2010	84	7 Nov 2010
Waikanae Water Treatment Plant	0	22 Nov 2010	16	13 Nov 2010
Kaitoke Headworks (north Upper Hutt)	0	22 Nov 2010	21.5	22 Oct 2010
Shandon Golf Club (Petone)	0	6 Nov 2010 22 Nov 2010 28 Dec 2010	14	22 Oct 2010
Wainuiomata Reservoir	0	6 Nov 2010 22 Nov 2010	16	6 Nov 2010
Karori Reservoir (Wellington)	0	6 Nov 2010	13	22 Oct 2010
Waiohine Gorge (Tararua foothills – Wairarapa)	1.5	22 Oct 2010	22.5	22 Oct 2010
Wairarapa College (Masterton)	0	22 Oct 2010 22 Nov 2010 7 Mar 2011	5	29 Jan 2011
Alloa (Featherston)	0	22 Oct 2010	11.8	29 Jan 2011
Tanawa Hut (NE Wairarapa)	0.5	7 Mar 2011	8.5	20 Dec 2010
Iraia (SE Wairarapa)	0	22 Nov 2010	10.5	6 Nov 2010

Table 4.5: Lowest 7-day and 28-day mean river flows during 2010/11 at monitoring stations in the western Wellington region. A return period of two years is generally equal to mean annual low flow (MALF), the average of the low flows on record

Site name	7-day duration			28-day duration		
	Lowest mean flow in 2010/11 (m ³ /s)	Start date	Estimated return period	Lowest mean flow in 2010/11 (m ³ /s)	Start date	Estimated return period
Waitohu S at WSI	0.162	28 Jan 2011	<2	0.247	7 Jan 2011	<2
Otaki R at Pukehinau ¹	4.844	4 Dec 2010	<2	9.124	16 Nov 2010	<2
Mangaone S at Ratanui	0.097	19 Mar 2010	<2	0.118	26 Feb 2011	<2
Waikanae R at WTP	1.036	19 Mar 2011	2	1.415	26 Feb 2011	<2
Hutt at Birchville ^{1,2}	3.078	4 Dec 2010	<2	4.222	16 Nov 2010	2
Hutt R at Taita Gorge ²	3.813	4 Dec 2010	<2	5.333	16 Nov 2010	2
Pakuratahi R at Truss Bridge	0.252	30 Nov 2010	<2	0.321	16 Nov 2010	2
Mangaroa R at Te Marua	0.418	23 Feb 2011	<2	0.572	16 Feb 2011	<2
Akatarawa R at Cemetery	1.118	4 Dec 2010	<2	1.416	16 Nov 2010	MALF
Whakatikei R at Dude Ranch	0.421	4 Dec 2010	<2	0.525	16 Nov 2010	<2
Wainuiomata R at Manuka Track	0.156	23 Feb 2011	3	0.201	15 Feb 2011	3
Wainuiomata R at LWP ²	0.437	6 Dec 2010	<2	0.561	19 Nov 2010	<2
Orongorongo R at UDS	0.035	11 Jan 2011	MALF	0.059	16 Nov 2010	MALF
Taupo S at Flax Swamp	0.022	2 Dec 2010	n/a	0.030	16 Nov 2010	n/a
Horokiri S at Snodgrass	0.107	9 Mar 2011	n/a	0.128	7 Mar 2011	n/a
Porirua S at Town Centre	0.175	15 Feb 2011	<2	0.248	25 Jan 2011	<2

¹ Data provided by NIWA but frequency analysis performed by Greater Wellington.

² Low flow likely to have been significantly affected by upstream abstraction.

Table 4.6: Lowest 7-day and 28-day mean river flows during 2010/11 at monitoring stations¹ in the Wairarapa. A return period of two years is generally equal to mean annual low flow (MALF), the average of the low flows on record.

Site name	7-day duration			28-day duration		
	Lowest mean flow in 2010/11 (m ³ /s)	Start date	Estimated return period	Lowest mean flow in 2010/11 (m ³ /s)	Start date	Estimated return period
Ruamahanga R at Mt Bruce	1.024	30 Nov 2010	5	1.792	13 Nov 2010	4
Ruamahanga R at Wardells ²	2.746	15 Mar 2011	2–3	4.169	13 Nov 2010	2–3
Ruamahanga R at Waihenga Br ²	7.531	4 Dec 2010	5	12.884	13 Nov 2010	4
Waipoua R at Mikimiki ⁴	0.307	11 Jan 2011 15 Mar 2011	3	0.402	19 Nov 2010	5
Waingawa R at Kaituna	1.177	4 Dec 2010	4	1.633	13 Nov 2010	6–7
Mangatarere S at Gorge	0.135	15 Mar 2011	3	0.206	23 Nov 2010	3
Waiohine R at Gorge	3.239	30 Nov 2010	2–3	5.206	13 Nov 2010	3–4
Tauherenikau R at Gorge	1.335	30 Nov 2010	< 2	1.675	13 Nov 2010	3
Kopuaranga R at Palmers ²	0.293	14 Mar 2011	2	0.358	22 Feb 2011	2
Otukura S at Weir ²	0.035	16 Jan 2011	4	0.053	22 Feb 2011	4
Papawai S u/s Oxi Pond ²	0.091	5 Jan 2011	–	0.130	1 Feb 2011	–
Pahaoa R at Hinakura ³	0.053	10 Jan 2011	2–3	0.088	26 Dec 2010	3

¹ Only the river level sites that are rated for low flows are shown in the table.

² Low flow likely to have been significantly affected by upstream abstraction.

³ Data provided by NIWA.

⁴ Short record site.

Table 4.7: Number of days in 2010/11 (and the previous two years) where mean daily flow was lower than the first restriction threshold for rivers specified in Greater Wellington's Regional Freshwater Plan

Part of the region	River and site	First low flow restriction threshold (m ³ /s)	Number of days below threshold			
			2007/08	2008/09	2009/10	2010/11
Kapiti Coast	Waitohu Stream	0.18	89	23	0	17
	Otaki River	4.375	20	14	0	1
	Mangaone Stream	0.045	0	0	2	0
Wairarapa	Ruamahanga River	9.8	53	27	0	18
	Waiohine River	3.04	5	6	0	2
	Tauherenikau River	1.35	55	7	0	4
	Waingawa River	1.9	92	46	17	51
	Kopuaranga River	0.27	72	2	0	0
	Waipoua River	0.3	54	20	0	10
	Mangatarere Stream	0.33	116	90	46	96
Central and south	Hutt River	1.45	0	0	0	0
	Wainuiomata River	0.36	79	37	41	0

5. Hydrological investigations

In addition to routine hydrological monitoring, Greater Wellington also undertakes specific investigation work to better understand and manage aspects of the region's freshwater resources.

5.1 Wairarapa Valley groundwater allocation

The Wairarapa Valley groundwater investigation drew to a close in 2009/10, following the completion of numerical groundwater flow models for three modelling areas (upper, middle and lower Wairarapa Valley). As noted in previous annual reports (eg, McAlister & Tidswell 2008; Thompson & Gordon 2010), the Wairarapa Valley groundwater investigation was initiated in response to increasing demand for groundwater for irrigation in the Wairarapa.

Over the past year, the findings of the investigation have been used to develop proposals for sustainable groundwater allocation in the Wairarapa Valley. This work has involved modelling different water abstraction scenarios to test for effects on nearby rivers and streams (ie, 'streamflow depletion' effects) and culminated in a report published in June 2011 (Hughes & Gyopari 2011). The report sets out proposals for groundwater management that account for stream flow depletion (as outlined in Appendix 2) and will be used to inform recommendations Greater Wellington's next Regional Plan.

5.2 Instream flow investigations

Assessment of instream values and minimum flows for waterways in the Wellington region is an ongoing work programme. The focus in 2010/11 was on assembling results from investigations completed to date into a summary document that can be used to help develop policy options for the next Regional Plan. The report will provide recommendations on both revised minimum flow values for selected rivers and streams as well as further analyses needed to identify core allocation options.

In addition to technical assessments by Greater Wellington staff, work continues on a project to establish flow-related values for Wairarapa waterways from a tangata whenua perspective. An external consultant has visited several catchments and met with iwi representatives. A final report is expected in late 2011.

5.3 Lake Wairarapa

Work continues to improve our understanding of aspects of the hydrology and water quality of Lake Wairarapa. Water levels in Lake Wairarapa are potentially vulnerable to the impacts of over-abstraction. However, little is known about the lake's water balance and this leads to some uncertainty in managing allocation. Work in 2010/11 focussed on trying to refine some aspects of the water balance based on flow gaugings undertaken while the barrage gates were continuously open (for painting) in February and March. Early results confirm that tidally-influenced backflow from Lake Onoke – when the Onoke mouth is open to the sea – plays an important role in the Lake Wairarapa water balance.

Six shallow groundwater and open water (lagoon and lake) level monitoring points were established in March 2011 at the north-eastern end of the lake (between Barton's Lagoon and the Tauherenikau River mouth). These sites are being monitored to help provide information on the interaction between the hydrology of the lake, the Tauherenikau River and marginal wetlands, and therefore, what the implications of water level alteration (by abstraction, lake level manipulation and drainage) might be.

5.4 Wetland investigations

During 2010/11 a consultant continued work documenting assessments made during early 2010 of the condition of 10 wetlands in the region thought to be vulnerable to water abstraction. As reported by Tidswell et al. (2010), the assessments looked at wetland hydrology, vegetation condition and water quality. This information gained from the assessments will be useful for developing a planning framework for wetlands.

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Appendix 1: Monitoring sites

Sites listed in the following tables are those that are part of Greater Wellington's long term monitoring network. Monitoring sites established as part of short term investigations are not listed.

Note: Easting and northing map references for all sites in the following tables are in the 'NZ Trans Mercator' (TM) format.

Table A1.1: Rainfall monitoring sites

Site name	Catchment/Location	Altitude (m)	Start date	Easting (TM)	Northing (TM)
Wairarapa					
Mangatarere at Valley Hill	Mangatarere (Carterton)	483	21/04/1997	1806451	5464852
Kopuaranga at Mauriceville	Mauriceville	228	07/05/2008	1826879	5483853
Parkvale Stream at Renalls Weir	Parkvale (Carterton)	50	08/01/2008	1813496	5449490
Ruakokopatuna at Iraia	Ruakokopatuna	260	09/04/1969	1798384	5416434
Ruamahanga River at Mt Bruce	Ruamahanga	300	30/07/1984	1819318	5485239
Ruamahanga River at Wairarapa College	Ruamahanga (Masterton)	100	29/05/2002	1822753	5463166
Ruamahanga River at Bannister Basin	Ruamahanga (Tararua Range)	1,006	30/09/1974	1808833	5487428
Waikoukou at Longbush	Southern Whangaehu	250	01/11/2006	1819836	5436843
Taueru at Castlehill	Taueru	250	10/04/1991	1852368	5483979
Taueru River at Te Weraiti	Taueru	90	09/09/1997	1832112	5458262
Tauherenikau at R/course & Tauherenikau at Alloa ¹	Tauherenikau (Featherston)	40	04/07/2007	1799488	5445146
		40	18/08/1999	1799870	5445286
Tauherenikau at Bull Mound	Tauherenikau (Tararua Range)	1005	23/05/1976	1795128	5460805
Waingawa River at Kaituna	Waingawa (Lower Tararua Range)	240	09/05/1994	1812555	5470757
Waingawa River at Angle Knob	Waingawa (Tararua Range)	1200	27/12/1974	1805258	5475462
Waiohine River at Gorge	Waiohine (Lower Tararua Range)	140	02/02/2006	1801812	5456651
Waiohine River at Carkeek	Waiohine (Tararua Range)	1158	30/09/1974	1802385	5482185
Waiorongomai at Matthews	Waiorongomai	25	18/05/2009	1780017	5430263
Waipoua at Westons	Waipoua	470	08/11/2007	1816567	5480958
Whangaehu River at Waihi	Whangaehu	175	10/01/2001	1834120	5476086
Whareama River at Tanawa Hut	Whareama	280	01/01/1956	1864716	5484384
Central (Hutt and Wainuiomata)					
Akatarawa River at Cemetery	Akatarawa	100	29/03/1988	1776280	5449591
Akatarawa River at Warwicks	Akatarawa	345	16/06/1980	1775149	5463808

Site name	Catchment/Location	Altitude (m)	Start date	Easting (TM)	Northing (TM)
Pencarrow Lakes (Lake Kohangatara)	Gollans/Pencarrow Lakes	5	22/08/2007	1755922	5418015
Horokiri Steam at Battle Hill	Horokiri	60	30/03/2010	1762848	5452927
Hutt River at Kaitoke Headworks	Hutt	190	01/04/1951	1783717	5452461
Hutt River at Savage Park	Hutt	70	12/07/2010	1773805	5445685
Hutt River at Te Marua	Hutt	150	22/07/1993	1780104	5450417
Hutt River at Birch Lane	Hutt (Lower Hutt)	10	25/07/2001	1761032	5435863
Mangaroa River at Tasman Vaccine Limited	Hutt (Lower Hutt)	229	03/05/1968	1768976	5437852
Pinehaven Stream at Pinehaven Reservoir	Hutt (Lower Hutt)	150	03/08/2010	1768529	5441785
Hutt River at Shandon Golf Club	Hutt (Petone)	4	3/04/2000	1758994	5434444
Mangaroa River at Maymorn Pump Station	Hutt (Upper Hutt)	130	20/01/2005	1778980	5447039
Orongorongo River at Orongo Swamp	Orongorongo	420	03/10/1980	1772386	5431972
Pakuratahi River at Centre Ridge	Hutt (Upper Hutt)	480	06/04/1984	1784715	5444105
Porirua Stream at Seton Nossiter Park	Porirua	100	06/07/1992	1752279	5436387
Porirua Stream at Tawa Pool*	Porirua Stream (Tawa)	20	29/08/1996	1753456	5441339
Taupo Stream at Whenua Tapu	Taupo	40	17/04/1991	1757470	5453313
Wainuiomata River at Wainui Reservoir	Wainuiomata	125	01/01/1890	1766690	5429549
Whakatikei River at Blue Gum Spur	Tararua Range	335	13/10/1981	1769680	5453885
Wellington city					
Kaiwharawhara Stream at Karori Reservoir	Kaiwharawhara	140	02/01/1879	1746801	5427468
Makara Stream at Quartz Hill Wind Farm	Makara	275	03/09/2007	1741915	5432265
Berhampore at Nursery*	Wellington city	40	29/07/1996	1748271	5423847
Hataitai at Old Post Office*	Wellington city	30	25/02/1997	1750195	5425963
Karori Stream at Duthie Street*	Wellington city	190	08/10/1990	1746180	5428176
Khandallah at Library*	Wellington city	170	29/08/1996	1750041	5432297
Miramar at Miramar North Road*	Wellington city	25	04/10/2004	1752751	5426102
Newtown at Mansfield Street*	Wellington city	40	11/09/1996	1749045	5424519
Wellington at Regional Council Centre	Wellington city	30	26/07/1996	1748885	5427456

Site name	Catchment/Location	Altitude (m)	Start date	Easting (TM)	Northing (TM)
Kapiti Coast					
Mangaone Stream at Transmission Lines	Mangaone	140	13/10/1992	1783024	5477205
East Waitewaewae at Oriwa	Otaki	1,085	08/09/1991	1798235	5486338
Otaki River at Depot	Otaki	15	18/07/1984	1780982	5484663
Penn Creek at McIntosh	Otaki	1,286	26/09/1991	1794483	5467883
Waitatapia Stream at Taungata	Otaki	912	06/09/1991	1790352	5479866
Sth Waiotauru River at Kapakapanui	Tararua Range	1,102	06/09/1991	1782184	5467064
Te Hapua Wetland at Shoveller Lagoon	n/a Te Hapua Wetland	3	30/03/2009	1775288	5479884
Waikanae River at Water Treatment Plant	Waikanae	40	09/02/1995	1774586	5471372
Whareroa Stream at QE Park (McKays Crossing)	Whareroa (Paekakariki)	8	12/09/2001	1766239	5462294

¹ There are two sites ('Alloa' and 'Racecourse') in close proximity to each other that are being run concurrently until sufficient length of record is available to properly correlate (at which point one will be dropped)

* These sites are maintained by Greater Wellington but owned by Wellington City Council.

Table A1.2: River level/flow monitoring sites

Site name	Start date	Catchment area (km ²)	Easting (TM)	Northing (TM)	Comments
Wairarapa					
Booths Creek at Golf Club Pond	20/12/2010	0.9	1813632	5457701	
Huangarua at Hautotara	01/01/1968	140	1807216	5425383	Rated for high flows only
Kaiwhata at Stansborough	28/07/1988	84	1844584	5436070	NIWA site
Kopuaranga at Palmers Bridge	15/03/1985	100.3	1825333	5477907	
Kopuaranga River at Stuarts	28/08/2009	166	1826760	5469569	
Mangatarere at Belvedere Bridge	26/01/2004	55.8	1811046	5456798	Rated for low flows only
Mangatarere River at Gorge	09/02/1999	33.3	1811469	5465421	
Mangatarere River at SH 2	01/09/2009	119	1809768	5452160	
Otukura Stream at Weir	17/12/1997	51.4	1798544	5437750	
Pahaoa River at Hinakura	04/09/1986	563	1821678	5424774	NIWA/GWR C co-funded
Papawai Stream at u/s Oxi Pond conf.	06/12/2005	6.6	1809149	5446809	
Parkvale Stream at Renalls Weir	15/01/2002	50.5	1813496	5449490	
Parkvale tributary at Lowes Reserve	17/03/2011		1818094	5458352	Catchment area not defined
Ruakokopatuna at Iraia	29/05/1969	15.54	1798384	5416434	NIWA site
Ruamahanga River at Barrage South	01/01/1974	3,341	1783641	5423998	

Site name	Start date	Catchment area (km ²)	Easting (TM)	Northing (TM)	Comments
Ruamahanga River at Gladstone Br	06/06/1992	1,315	1820883	5449878	Rated for high flows only
Ruamahanga River at Mt Bruce	01/01/1975	76.5	1819318	5485239	
Ruamahanga River at Waihenga Br	31/12/1956	2340	1804604	5436519	
Ruamahanga River at Wardells	10/11/1954	637	1824745	5457268	
Taueru River at Te Weraiti	10/12/1969	373	1832112	5458262	Rate for high flows only
Taueru River at Te Whiti Rd Bridge	28/03/2002	497	1824184	5450777	
Tauherenikau at Gorge	30/03/1976	112	1798066	5451001	
Te Mara Stream at Kiriwhakapapa	28/11/2008	11.9	1819413	5479407	
Waingawa River at Kaituna	14/05/1976	79	1812555	5470757	
Waiohine River at Gorge	27/12/1954	180	1801812	5456651	
Waipoua River at Mikimiki Bridge	05/02/1979	80.3	1820657	5475132	
Whangaehu River at Waihi	10/05/1967	36.3	1834120	5476086	NIWA site
Whareama at Waiteko	09/04/1970	398	1856073	5461248	NIWA site
Central (Hutt and Wainuiomata)					
Akatarawa River at Cemetery	19/02/1979	113.5	1776280	5449591	
Horokiri Stream at Snodgrass	15/02/2002	28.68	1761804	5450652	
Hutt River at Birchville	07/09/1970	427	1775575	5448016	NIWA/GWR C co-funded
Hutt River at Estuary Bridge	28/09/1976	614	1759317	5433619	River level only (tidal site)
Hutt River at Kaitoke	21/12/1967	88.84	1784150	5453267	NIWA/GWR C co-funded
Hutt River at Kaitoke Weir	03/02/2004	86.8	1784210	5453157	
Hutt River at Taita Gorge	16/03/1979	547	1766532	5441959	
Hutt River at Te Marua	05/03/1984	191	1780104	5450417	
Mangaroa River at Te Marua	20/05/1977	102.3	1778726	5448590	
Orongorongo River at Truss Bridge	12/03/1998	31.7	1770185	5426275	
Orongorongo River at Upper Dam Site	09/10/1980	26.3	1772477	5430984	
Pauatahanui Stream at Gorge	30/05/1975	–	1761480	5446486	NIWA site
Pakuratahi River at Truss Bridge	22/05/1978	37.2	1783807	5445152	
Porirua Stream at Town Centre	08/09/1965	44.8	1754669	5443961	
Mill Creek at Papanui	24/04/1969	–	1748880	5439987	NIWA site
Taupo Stream at Flax Swamp	21/11/1979	8.2	1757073	5451057	Funded by PCC
Wainuiomata River at Leonard Wood Park	14/04/1977	77.5	1763077	5427886	
Wainuiomata River at Manuka Track	10/06/1982	25.2	1768301	5430792	
Waiwhetu Stream at Whites Line East	31/05/1978	11.62	1760977	5434510	

Site name	Start date	Catchment area (km ²)	Easting (TM)	Northing (TM)	Comments
Whakatikei River at Dude Ranch	08/09/1976	46	1770535	5450171	
Kapiti Coast					
Mangaone Stream at Ratanui	13/01/1993	9.23	1781860	5478162	
Mazengarb Drain at Scaife Drive	17/05/1995	4.5	1769065	5471011	Funded by KCDC
Otaki River at Pukehinau	17/07/1980	306	1785491	5478669	NIWA/GWR C co-funded
Pinehaven Stream opp Chatsworth Rd	15/08/2008	4	1769113	5442443	
Waikanae River at Water Treatment Plant	03/03/1975	124.5	1774586	5471372	
Waitohu Stream at Water Supply Intake	17/10/1994	19.24	1786883	5484786	
Wharemauku Stream at Coastlands	16/12/1980	7.77	1768842	5468427	Funded by KCDC

Table A1.3: Lake and wetland level monitoring sites

Site name	Start date	Easting (TM)	Northing (TM)
Wairarapa			
Lake Onoke at Lake Ferry	27/04/1953	1779174	5415284
Lake Wairarapa at Barrage North	01/01/1974	1783641	5423998
Lake Wairarapa at Burlings	18/09/1953	1781732	5433108
Taumata Oxbow Lagoon	01/09/2005	1811485	5447885
Central (Hutt and Wainuiomata)			
Lake Kohangatera	19/09/2007	1755922	5418015
Lake Kohangapiripiri	19/09/2007	1755213	5419272
Kapiti Coast			
Te Hapua Wetland at Shoveler Lagoon	30/03/2009	1775288	5479884
Te Hapua Wetland at Jill and Joys	03/04/2009	1774344	5479298
Te Hapua Wetland at Pateke	07/04/2009	1775764	5479452
Te Hapua Wetland at Trotter	04/06/2009	1774724	5479152

Table A1.4: Greater Wellington's automatic groundwater level monitoring network

Site name	Site no.	Groundwater zone	Start date	Easting (TM)	Northing (TM)
Wairarapa					
Bicknell	S27/0883	Ahikouka	07/08/2008	1810184	5447188
Simmonds	S27/0099	Battersea	10/12/1996	1803170	5442510
Hilton Road Deep	S26/1034	Carterton	14/11/2008	1811188	5453628
Hilton Road Shallow	S26/1035	Carterton	14/11/2008	1811188	5453628
Perry	S26/0490	Greytown	13/08/1990	1805492	5450976
Hammond	S27/0225	Greytown	6/09/1994	1807071	5447719
Simmonds	S27/0309	Kahutara	11/01/2002	1797877	5436461
Simmonds	S27/0317	Kahutara	21/12/2001	1797799	5437083
Green	S27/0467	Kahutara	13/11/2001	1792820	5433065
M/B Golf Club	S27/0571	Martinborough Eastern Terraces	05/10/1988	1807158	5433014
Duggan	S27/0522	Martinborough Western Terraces	01/12/2000	1803032	5431324
Taumata Lagoon – Inner	S27/0881	Middle Ruamahanga	01/09/2005	1811485	5447885
Taumata Lagoon – Outer	S27/0878	Middle Ruamahanga	01/09/2005	1811485	5447885
Blundell	S26/0749	Middle Ruamahanga	17/12/1997	1815842	5449088
Didsbury	S27/0885	Riverside	14/08/2008	1808967	5445646
Croad	S27/0202	Moroa	26/04/1988	1805461	5446520
Luttrell Shallow	S27/0587	Onoke	07/02/1990	1781042	5423379
Towgood	S26/0738	Parkvale	03/08/1983	1815311	5453577
Baring	S26/0743	Parkvale	06/11/1986	1815028	5451785
Renall Deep	S26/1032	Parkvale	29/09/2008	1813337	5449868
Renall Shallow	S26/1033	Parkvale	29/09/2008	1813337	5449868
Mcnamara Shallow	S26/1053	Parkvale	21/08/2008	1814051	5452481
Dry River Beef	S27/0481	Pukio	19/09/1989	1799718	5431317
Zyzalo	T26/0239	Rathkeale	26/08/1997	1825441	5469001
Tucker	S27/0884	Riverside	14/08/2008	1808478	5441241
Burt	S27/0330	Tauherenikau	30/11/2001	1797767	5440421
Herrick	S27/0381	Tawaha East	09/03/1984	1805651	5435941
Smith	S27/0346	Tawaha West	02/12/1983	1804059	5437102
Wairoria	S27/0434	Te Hopai	02/02/1994	1786852	5428337
Himona	T26/0246	Te Ore Ore	10/03/2009	1827679	5464157
Oliver Deep	T26/0494	Te Ore Ore	27/11/1981	1828039	5462681
Oliver Shallow	T26/0501	Te Ore Ore	15/07/1983	1826098	5462612
Lucas	T26/0814	Te Ore Ore	05/08/2008	1826428	5460584
Robinson Transport	S27/0442	Tuhitarata	30/08/2005	1789891	5426884
Downing Recorder	S26/0033	Upper Plain	30/09/1983	1818493	5464562
Wairio	S27/0428	Wairio	11/02/1983	1787618	5430809
Central (Hutt Valley)					
H.V.M.T.C	R27/0120	Lower Hutt	24/09/1968	1758778	5434956

Site name	Site no.	Groundwater zone	Start date	Easting (TM)	Northing (TM)
McEwan Park	R27/0122	Lower Hutt	03/03/1971	1758748	5433546
McEwan Park Deep	R27/7153	Lower Hutt	14/03/2008	1758681	5433523
IBM No 1	R27/0320	Lower Hutt	22/09/1992	1756996	5434508
IBM No 2	R27/1265	Lower Hutt	2/06/1991	1756998	5434516
UWA 3	R27/1086	Lower Hutt	24/12/1997	1759813	5433246
Hutt Rec	R27/1115	Lower Hutt	15/12/1967	1759588	5435716
Mitchell Park	R27/1116	Lower Hutt	24/09/1968	1761599	5436816
Taita Int. School	R27/1117	Lower Hutt	24/09/1968	1763574	5438391
Randwick Reserve	R27/1122	Lower Hutt	24/06/1975	1759757	5434602
Somes Island	R27/1171	Lower Hutt	28/01/1969	1756493	5431227
Marsden Street	R27/6386	Lower Hutt	01/05/2000	1759039	5435971
TS Tamatoa Shallow	R27/7154	Lower Hutt	05/02/2008	1757020	5434294
TS Tamatoa Deep	R27/7215	Lower Hutt	05/02/2008	1757022	5434298
South Pacific Tyres	R27/1137	Upper Hutt	09/06/2006	1773406	5444956
Coca Cola/Unibag	R27/6978	Upper Hutt	01/08/2006	1772082	5444732
Trentham Memorial Park	R27/7004	Upper Hutt	25/05/1973	1770649	5444445
Kapiti Coast					
Sims Road South	R25/0003	Coastal	28/03/1985	1776328	5482692
Jensens Deep	R25/5262	Coastal	26/03/2009	1775470	5479412
Jensens Shallow	R25/7086	Coastal	30/03/2009	1775295	5479894
Jill and Joys	R25/7087	Coastal	30/03/2009	1774698	5479298
Housiaux 2	R26/6879	Coastal	25/11/2004	1775707	5479424
Centrepont	S25/5208	Hautere	19/12/1991	1780182	5480785
Bettys*	S25/5258	Otaki	4/03/1993	1782227	5483430
Waikanae Park	R26/6284	Waikanae	14/07/2003	1772736	5473167
Rangihiroa St	R26/6287	Waikanae	16/12/2002	1770587	5474307
KCDC Rutherford Dr	R26/6378	Waikanae	13/09/2006	1771995	5475389
Larch Grove	R26/6831	Waikanae	13/10/2000	1768770	5469188
Maclean Park	R26/6833	Waikanae	13/10/2000	1766872	5471508
KCDC K6 Observation	R26/6992	Waikanae	18/11/2005	1773140	5475374
Te Harakeke Bore 3	R26/6886	Waikanae	14/05/2002	1771939	5474425
Waikanae CHP Shallow	R26/6916	Waikanae	10/08/1994	1770722	5473136
Waikanae CHP Deep	R26/6594	Waikanae	30/05/1994	1770722	5473136
Taiata St Shallow	R26/6673	Waikanae	18/02/2005	1770439	5474422
Taiata St Deep	R26/6955	Waikanae	18/02/2005	1770439	5474422
Estuary Shallow	R26/6566	Waikanae	18/02/2005	1769407	5473310
Estuary Deep	R26/6956	Waikanae	18/02/2005	1769407	5473310
GWRC Nga Manu	R26/6991	Waikanae	18/11/2005	1773517	5474443
KCDC W1	R26/7025	Waikanae	18/11/2005	1772141	5473628
Taylors	S25/5332	Waitohu	14/08/1995	1782183	5487286

* Site closed in February 2011.

Table A1.5: Greater Wellington's manual groundwater level monitoring network

Site name	Site no.	Groundwater zone	Start date	Easting (TM)	Northing (TM)
Wairarapa					
Craig Deep	S26/0545	Ahikouka	03/08/1983	1809483	5451390
Craig Shallow	S26/0547	Ahikouka	03/08/1983	1809453	5450175
Nicholson	S26/0223	East Taratahi	18/03/1998	1816203	5459285
East Coast Fert Shallow	S26/0242	East Taratahi	03/08/1983	1816553	5459603
East Coast Fert Deep	S26/0229	East Taratahi	14/05/1984	1816546	5459589
Oldfield	S26/0236	East Taratahi	03/08/1983	1818120	5460574
Mckay	T26/0326	Fern Hill	02/08/1991	1820860	5455804
List	S27/0572	Huangarua Lower Terraces	30/11/2000	1809440	5432047
Simmonds	S27/0271	Kahutara	21/04/1982	1797796	5437060
Awaroa Deep	S27/0446	Kahutara	11/11/1982	1794482	5432237
Awaroa Shallow	S27/0465	Kahutara	20/04/1982	1794056	5431529
Wither	S26/0658	Mangatarere	03/08/1983	1810633	5454760
Wall	S27/0403	Martinborough Eastern Terraces	13/11/2001	1807960	5433462
MacCullum	S27/0560	Martinborough Eastern Terraces	03/11/2000	1807965	5432882
Te Kairanga Deep	S27/0640	Martinborough Eastern Terraces	01/05/2002	1808122	5433651
Annear Nursery Rd	T26/0366	Masterton	8/04/2002	1823982	5461416
Trans.Wai.	T26/0429	Masterton	10/02/1986	1820022	5461986
Stevenson (Ex Wenden)	S26/0756	Middle Ruamahanga	29/05/1998	1815919	5448296
Morrison	S27/0248	Middle Ruamahanga	03/08/1983	1813058	5448004
Warren	S27/0594	Narrows	18/08/1981	1781351	5419721
Luttrell Deep	S27/0576	Onoke	29/11/1982	1781419	5423507
Tocher	T26/0208	Opaki	12/01/1984	1823048	5467347
Tulloch Shallow	S26/0155	Parkvale	03/08/1983	1813828	5456110
Tulloch Invest	S26/0656	Parkvale	12/05/1982	1813362	5455652
Denbee	S26/0568	Parkvale	17/08/1983	1813487	5451921
McNamara	S26/0675	Parkvale	30/10/1996	1812924	5452588
Wairarapa A&P Clareville	S26/0837	Parkvale	04/08/2009	1814435	5457638
Ness Deep	S27/0484	Pukio	07/12/1990	1798305	5431172
Ness Shallow	S27/0485	Pukio	28/11/1995	1798305	5431172
Stuart	S27/0517	Pukio	22/09/1989	1800865	5430454
Windy Farm House	S27/0009	South Featherston	01/05/2002	1793895	5443482
Windy Farm Pig Unit	S27/0012	South Featherston	03/08/1983	1793778	5443400
Windy Farm Deep New Irrigation	S27/0839	South Featherston	03/11/2009	1794106	5443659
Sth Featherston School	S27/0035	Tauherenikau	03/08/1983	1797506	5443107
Butcher	S27/0542	Tawaha	21/12/1988	1799989	5431940
Wacon	T26/0232	Te Ore Ore	19/09/1983	1825940	5463448

Site name	Site no.	Groundwater zone	Start date	Easting (TM)	Northing (TM)
Mast. Boro	T26/0243	Te Ore Ore	26/09/1988	1826226	5463379
Annear Lake Ferry	R28/0002	Turanganui	11/06/1994	1779603	5416045
Lenton	T26/0003	Upper Opaki	02/04/1997	1822559	5473236
Dick Invest	S26/0030	Upper Plain	17/01/1983	1819666	5464185
Kells Stream	T26/0709	Upper Plain	15/11/1993	1820021	5460426
Atkinson	S27/0618	Whangaehu / Tuhitarata	16/04/1982	1785168	5422471
Carlisle	S27/0148	Woodside	03/08/1983	1802221	5447044
Central (Hutt and Wainuiomata)					
Nevis Street	R27/1223	Lower Hutt	03/03/1971	1756414	5434542
Kapiti Coast					
Faith	R25/5123	Coastal	26/02/1993	1778282	5480785
Quinn	R26/6747	Coastal	30/06/1982	1775247	5477235
Housiaux 1	R26/6861	Coastal	25/11/2004	1775689	5479431
Housiaux 5	R26/6882	Coastal	25/11/2004	1775630	5479498
Housiaux 6	R26/6883	Coastal	25/11/2004	1775695	5479458
Housiaux 2b	R26/6936	Coastal	23/02/2005	1775707	5479422
Jamieson	R25/5111	Hautere	26/02/1993	1778182	5479085
Windsor Park	R25/5135	Hautere	30/06/1982	1779152	5481483
Common Property	S25/5200	Hautere	12/03/1993	1781182	5479785
Penray	S25/5256	Hautere	26/02/1993	1780491	5483154
KCDC Rangioru	R25/5228	Otaki	08/04/1993	1779182	5486286
Lutz	S25/5212	Otaki	26/03/1993	1784454	5482334
Andrews	S25/5228	Otaki	26/02/1993	1782737	5483246
Horowhenua Racing Club	S25/5287	Otaki	12/03/1993	1782583	5484686
QE Park No. 3	R26/5102	Raumati/Paekak	12/09/2001	1766541	5462545
QE Park No. 1	R26/6503	Raumati/Paekak	26/02/1993	1766253	5462295
QE Park No. 2	R26/6520	Raumati/Paekak	12/12/1994	1766365	5462470
QE Park No. 4	R26/6919	Raumati/Paekak	12/09/2001	1766543	5462545
QE Park No. 5	R26/6920	Raumati/Paekak	12/09/2001	1766226	5462840
KCDC Weka Park	R26/6521	Waikanae	26/02/1993	1767208	5468481
KCDC Mazengarb	R26/6557	Waikanae	26/03/1993	1768981	5471083
NZ Staff College	R26/6569	Waikanae	26/02/1993	1770929	5470578
McLauchlan	R26/6626	Waikanae	26/02/1993	1773782	5474085
McCardle	R26/6738	Waikanae	26/02/1993	1775682	5476685
Te Harakeke Bore 1	R26/6884	Waikanae	14/05/2002	1772093	5475388
Te Harakeke Bore 2	R26/6885	Waikanae	14/05/2002	1772488	5475034
Edhouse	S25/5322	Waitohu	26/03/1993	1782983	5487486
Laurensen Estate	S25/5329	Waitohu	26/03/1993	1780583	5487986

Appendix 2: Groundwater areas in the Wellington region

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 A2.1). These zones are currently used as a framework to help manage the region's groundwater resources. Although there are currently 44 groundwater management zones within the region, a recent re-evaluation of hydrogeology and geology in the Wairarapa Valley (Gyopari & McAlister 2010a; 2010b; 2010c) has led to a proposed revision of the zone boundaries in this area, reducing their total number from 29 to 17 (Hughes & Gyopari 2011) (Figure A2.2).

The revised zone boundaries divide groundwater into three categories – A, B and C – which represent a ranging degree of hydraulic connectivity with surface water (direct, moderate and very little, respectively). It is proposed that groundwater takes in category A will be managed under surface water allocation policy and takes in category C under groundwater allocation policy. Category B takes will be managed under a combination of both surface and groundwater allocation policy (Hughes & Gyopari 2011).

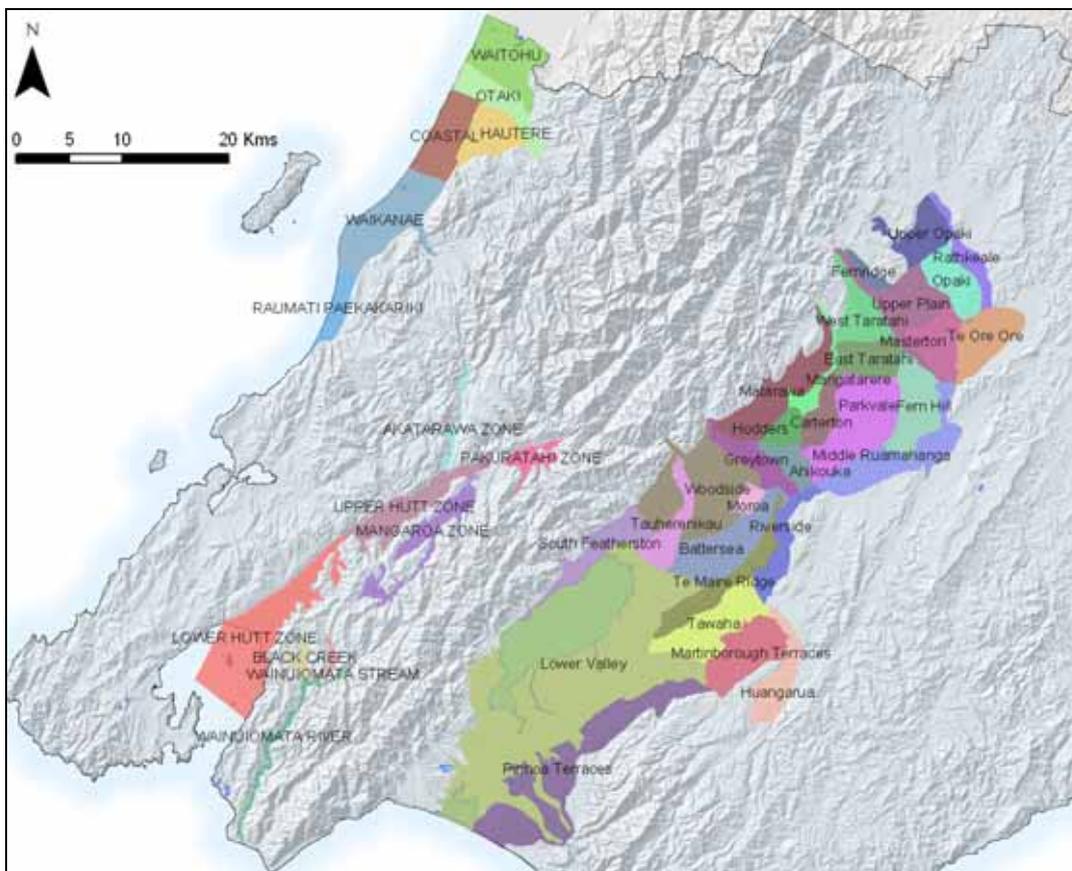


Figure A2.1: Groundwater management zones in the Wellington region as defined in the existing Regional Freshwater Plan (WRC 1999)

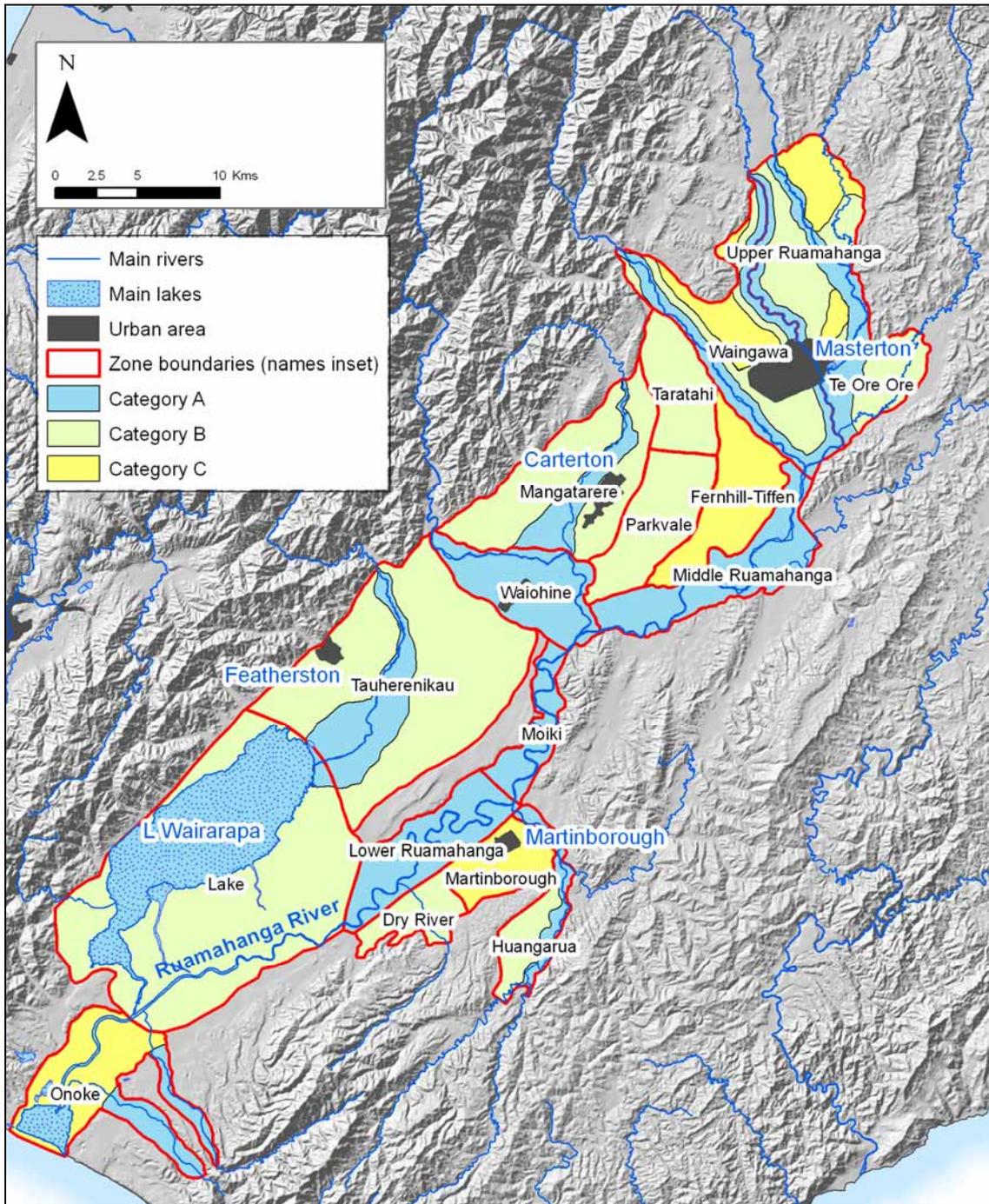


Figure A2.2: Proposed new groundwater management zones for the Wairarapa Valley (Hughes & Gyopari 2011)

Appendix 3: River flood warning alarm levels and occurrences

Table A3.1: Greater Wellington river flood warning alarm levels

Site	Flood warning alarm level (mm)	Comments
Waitohu S at Water Supply Intake	900	
Otaki Rat Pukehinau	4,500	
Mangaone S at Ratanui	1,700	
Waikanae R at Water Treatment Plant	3,200	
Hutt R at Te Marua	3,800	
Hutt R at Birchville	3,500	
Hutt R at Taita Gorge	28,000	
Mangaroa R at Te Marua	2,500	
Akatarawa R at Cemetery	2,000	
Waiwhetu S at Whites Line East	1,300	Initial alarm level
Wainuiomata R at Manuka Track	2,000	
Wainuiomata R at Leonard Wood Park	1,500	
Porirua S at Town Centre	900	
Ruamahanga R at Mt Bruce	4,000	
Ruamahanga R at Wardells Bridge	3,000	Initial alarm level
Ruamahanga R at Gladstone Bridge	2,000	
Ruamahanga R at Waihenga Bridge	3,350	Initial alarm level
Waipoua R at Mikimiki Bridge	1,800	Initial alarm level
Waingawa R at Kaituna	2,800	Initial alarm level
Mangatarere S at Gorge	1,800	
Waiohine R at Gorge	2,500	Initial alarm level
Tauweru R at Te Weraiti	9,000	
Huangarua R at Hautotara	3,400	

Table A3.2: River level flood warning alarms triggered during 2010/11

Event date	Alarm levels triggered
8 July 2010	Taueru River at Te Weraite
23 July 2010	Hutt River at Birchville Hutt River at Kaitoke Weir Hutt River at Te Marua Huangarua River at Hautotara Ruamahanga River at Waihenga
1 August 2010	Porirua Stream at Town Centre
14 August 2010	Porirua Stream at Town Centre
17 August 2010	Hutt River at Kaitoke Weir Otaki River at Pukehinau Waitohu Stream at Water Supply Intake Ruamahanga River at Gladstone Ruamahanga River at Waihenga Ruamahanga River at Wardells Waiohine River at Gorge
31 August 2010	Ruamahanga River at Waihenga
2 September 2010	Hutt River at Kaitoke Weir Ruamahanga River at Gladstone Ruamahanga River at Waihenga Ruamahanga River at Wardells
6 September 2010	Akatarawa River at Cemetery Hutt River at Birchville Hutt River at Kaitoke Weir Hutt River at Te Marua Mangaone Stream at Ratanui Otaki River at Pukehinau Waikanae River at Water Treatment Plant Waitohu Stream at Water Supply Intake Mangatarere Stream at Gorge Ruamahanga River at Gladstone Ruamahanga River at Waihenga Ruamahanga River at Wardells Waiohine River at Gorge Waipoua River at Mikimiki 1.3 & 1.8
9–10 September 2010	Waipoua River at Mikimiki 1.3 Ruamahanga River at Gladstone Ruamahanga River at Waihenga Ruamahanga River at Wardells
18–20 September 2010	Ruamahanga River at Waihenga Waipoua River at Mikimiki 1.3 Ruamahanga River at Gladstone Ruamahanga River at Waihenga

Event date	Alarm levels triggered
18–20 September 2010 (cont.)	Ruamahanga River at Wardells Ruamahanga River at Gladstone Ruamahanga River at Waihenga Waipoua River at Mikimiki 1.3
23 September 2010	Waipoua River at Mikimiki 1.3
30 September 2010	Akatarawa River at Cemetery Hutt River at Birchville Hutt River at Kaitoke Weir Hutt River at Taita Gorge Hutt River at Te Marua Mangaone Stream at Ratanui Otaki River at Pukehinau Porirua Stream at Town Centre Waikanae River at Water Treatment Plant Waitohu Stream at Water Supply Intake Ruamahanga River at Gladstone Ruamahanga River at Waihenga Ruamahanga River at Wardells Waiohine River at Gorge
9 October 2010	Porirua Stream at Town Centre
21 December 2010	Hutt River at Kaitoke Weir
28 December 2010	Akatarawa River at Cemetery Hutt River at Birchville Hutt River at Kaitoke Weir Hutt River at Te Marua Ruamahanga River at Gladstone Ruamahanga River at Waihenga Ruamahanga River at Wardells Waiohine River at Gorge Waipoua River at Mikimiki 1.3
23 January 2011	Ruamahanga River at Gladstone Ruamahanga River at Waihenga Ruamahanga River at Wardells
7 February 2011	Otaki River at Pukehinau
27 March 2011	Porirua Stream at Town Centre
15–16 May 2011	Porirua Stream at Town Centre Waipoua River at Mikimiki 1.3
26 May 2011	Hutt River at Kaitoke Weir Otaki River at Pukehinau Waikanae River at Water Treatment Plant Ruamahanga River at Gladstone Ruamahanga River at Waihenga Ruamahanga River at Wardells

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