



# Annual hydrology monitoring report for the Wellington region, 2007/08

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## 1. Introduction

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 2007 to 30 June 2008, describes the existing surface water hydrometric network and major changes to the network during the year. It also provides an overview of the trends in rainfall, river flows and lake levels and notable hydrological events of the year. A report containing an analysis of long-term trends is produced every six years (e.g., Watts 2005). This 2007/08 annual report covers surface water only; for information on the groundwater monitoring programme and trends in groundwater levels during 2007/08 see McAlister & Tidswell (2008).

## 2. Overview of the hydrological monitoring programme

The objectives of Greater Wellington's hydrological monitoring programme are to:

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

The monitoring network consists of 46 automatic rainfall, 39 automatic river level, and six automatic lake level monitoring sites (Figures 2.1 to 2.3; see Appendix 1 for site details). Some of these sites also have equipment that monitors climate and soil parameters (such as air temperature, wind speed, soil temperature and soil moisture), and water quality parameters (such as turbidity and water temperature).

The 46 rainfall sites shown in Figure 2.1 are those that are operated according to hydrometric standards. Greater Wellington has an additional four rain gauges that are not operated to these standards, which are generally for short-term investigations or indicative rainfall monitoring purposes. These rain gauges are at Castlepoint, Papawai (east of Greytown, called 'Tilsons Creek'), Te Horo ('Centrepont') and in the Horokiri catchment ('Snodgrass'). Although the data from these sites are not presented, the data were used in the background analysis for this report.

Greater Wellington has real-time access to rainfall data collected by the National Rural Fire Authority (NRFA). Rainfall data from MetService and the National Institute of Water and Atmospheric Research (NIWA) are able to be accessed through the National Climate Database. The automatic rainfall sites operated by these organisations are shown in Figure 2.4. The data from these sites, along with data from manually-read Wairarapa farm rain gauges, were obtained from the National Climate Database for the drought analysis in Section 5.

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. NIWA also operates a network of river flow monitoring sites in the Wellington region, some of which are partly funded by Greater Wellington (Figure 2.2). Flow data from the co-funded sites are included in this report where appropriate, to provide an indication of regional river flow patterns.



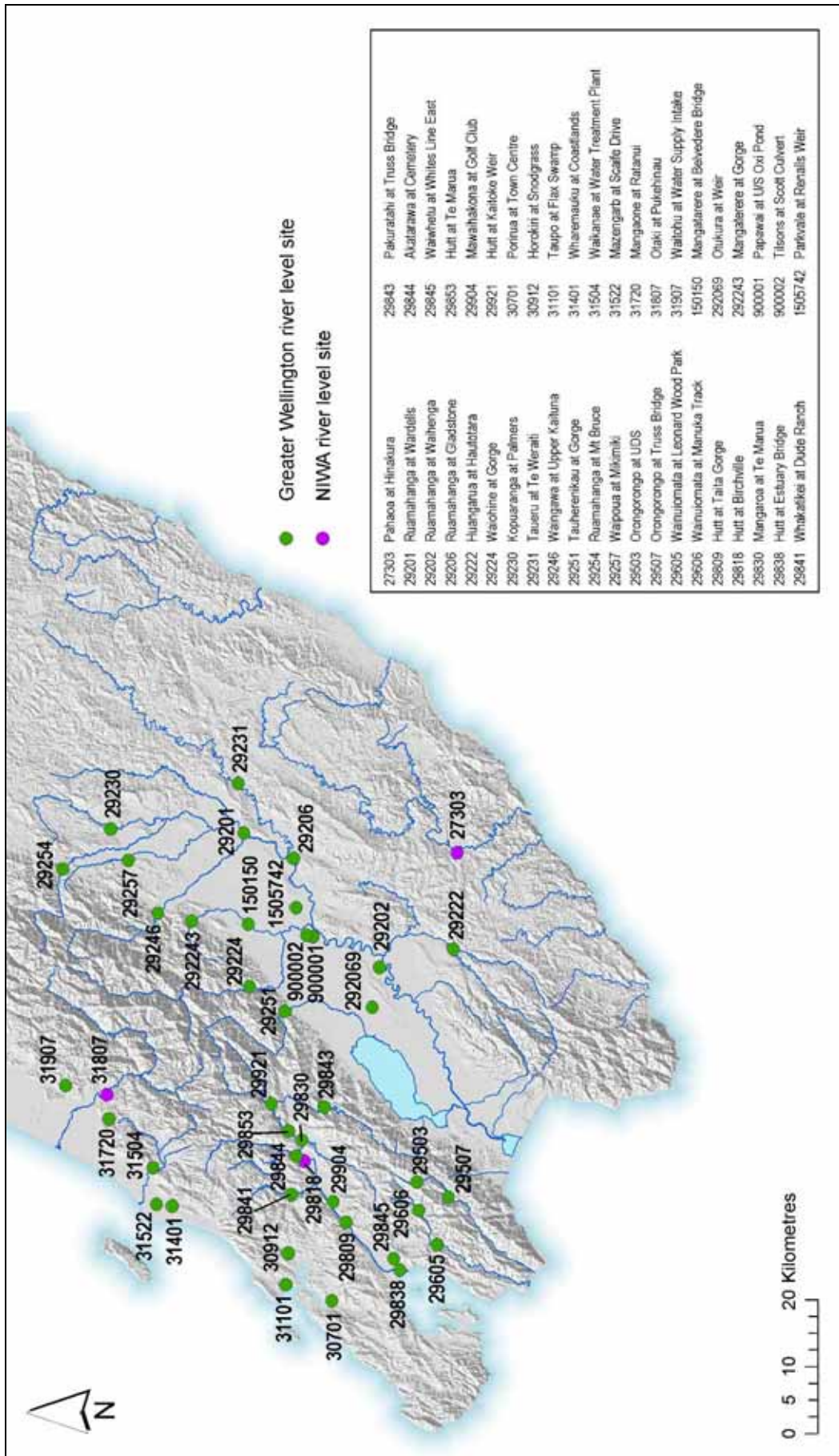


Figure 2.2: Location of automatic river level monitoring sites

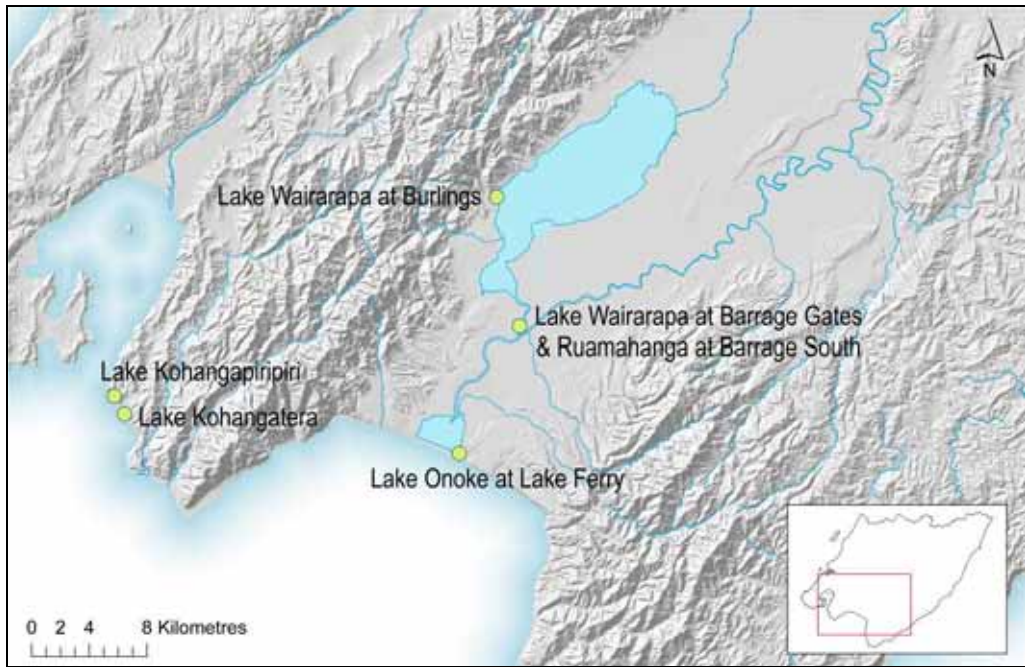


Figure 2.3: Greater Wellington's automatic lake level monitoring sites

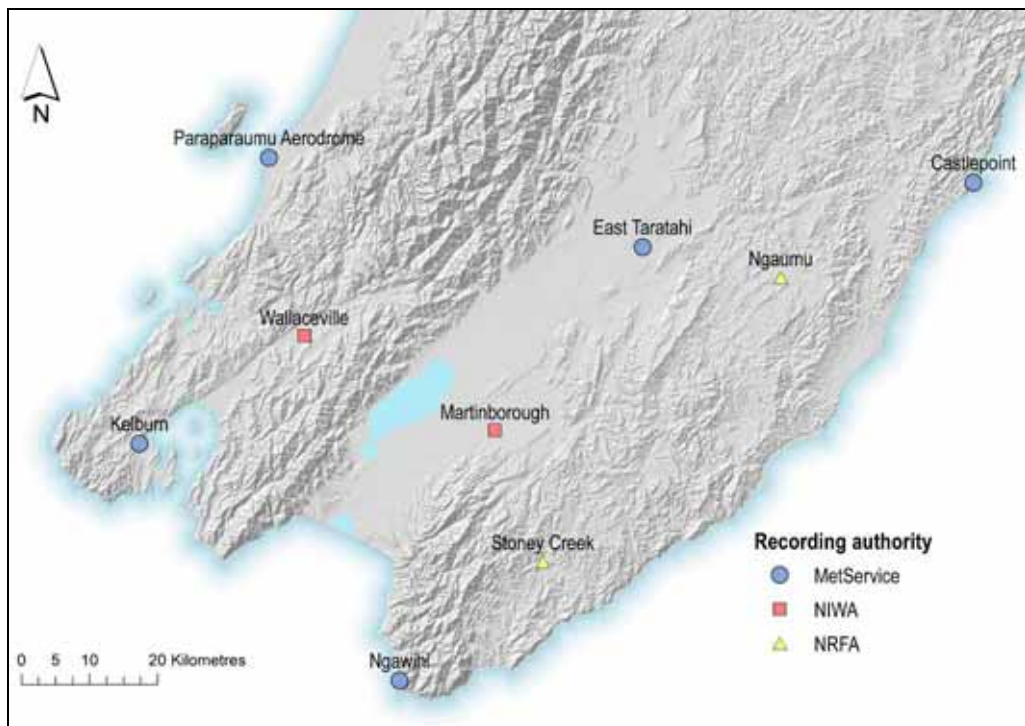


Figure 2.4: Location of automatic rainfall sites operated by external agencies

## 2.1 Hydrometric network changes in 2007/08

The following major changes<sup>1</sup> to Greater Wellington's surface water hydrometric network were made in 2007/08:

- The 'Transmission Lines' and 'Masterton Office' rainfall sites were temporarily closed (in October 2007 and March 2008 respectively);
- New rainfall sites were installed in the Makara ('Quartz Hill'), Waipoua ('Westons'), Kopuaranga ('Mauriceville') and Parkvale catchments;
- Automatic lake level monitoring equipment and a rain gauge were installed at the Pencarrow Lakes (Lake Kohangatera and Lake Kohangapiripiri); and
- The river level monitoring site 'Waipoua River at Mikimiki' was moved a short distance downstream to a location more conducive to measuring low flows.

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<sup>1</sup> Major changes are sites being opened or closed. Other changes such as equipment replacements are not listed here.

### 3. Summary of hydrological conditions in 2007/08

Overall, 2007/08 was a year of below-average rainfall in the Wellington region. To indicate how general hydrological conditions compared to ‘normal’, the monthly rainfall totals and monthly mean river flows and lake levels are tabulated along with the long-term means in Appendix 2. The graphs in Figures 3.1 to 3.3 summarise the results for selected monitoring stations.

#### 3.1 Rainfall and river flows

Following an extremely dry autumn in 2007, winter 2007 was also relatively dry in many parts of the Wellington region. Predominant north-easterly airflows brought rain to north-eastern Wairarapa in July 2007, although rainfall remained below average on the Kapiti Coast and in Wainuiomata. Similarly, August 2007 was dry throughout the region – except in the Tararua Range – due to predominant south-westerly weather conditions.

Spring 2007 had an unusual start, with settled weather in September due to light easterly winds. Rainfall was lower than average – particularly on the Kapiti Coast and in Wellington City. As a result, river flows were low for the time of the year, with fewer ‘freshes’ compared to normal. Spring conditions arrived in October, with strong westerly winds and unsettled weather. Rainfall was high for the month, particularly in the Tararua Range and on the Kapiti Coast, resulting in overall average to above-average flows in the major rivers fed from the range. In many parts of the region it was the first month of 2007 without below-average rainfall. However, the wet conditions of spring were short-lived. November 2007 saw a return to settled weather and below-average rainfall throughout the Wellington region. In many places rainfall was less than half the long-term average for the month. It was particularly dry on the Wairarapa plains, with only 17 mm of rainfall recorded in Masterton. Although river flows were also low, the base flows from the rains of October prevented the rivers from dropping to extreme lows during November.

The summer of 2007/08 (December to February) was very dry in most of the Wellington region, particularly in the east, due to La Nina conditions. The very low rainfall during summer, combined with the overall low rainfall of autumn, winter and spring 2007, led to very low river flows and soil moisture conditions that tended to occur earlier in the summer than usual. For example, many of the region’s main rivers (e.g., Hutt, Wainuiomata, Tauherenikau, Waiohine, Waingawa and Ruamahanga rivers) had the lowest mean flow for December on record. The lack of winter recharge also had implications for groundwater levels, with extreme low levels in some of the region’s aquifers (McAlister & Tidswell 2008). A more detailed hydrological analysis of the drought can be found in Section 5.

The anomaly of summer was a storm on 7-8 January that affected the Kapiti Coast (see Section 4.1). The high rainfall associated with this event meant that January 2008 was the wettest January at our monitoring site ‘Waikanae Water Treatment Plant’ since records began in 1970 (with 190.5 mm recorded). In contrast, it was the second driest January in Masterton since 1926 (Salinger &

Renwick 2008), with only 10 mm recorded at our monitoring station ‘Wairarapa College’.

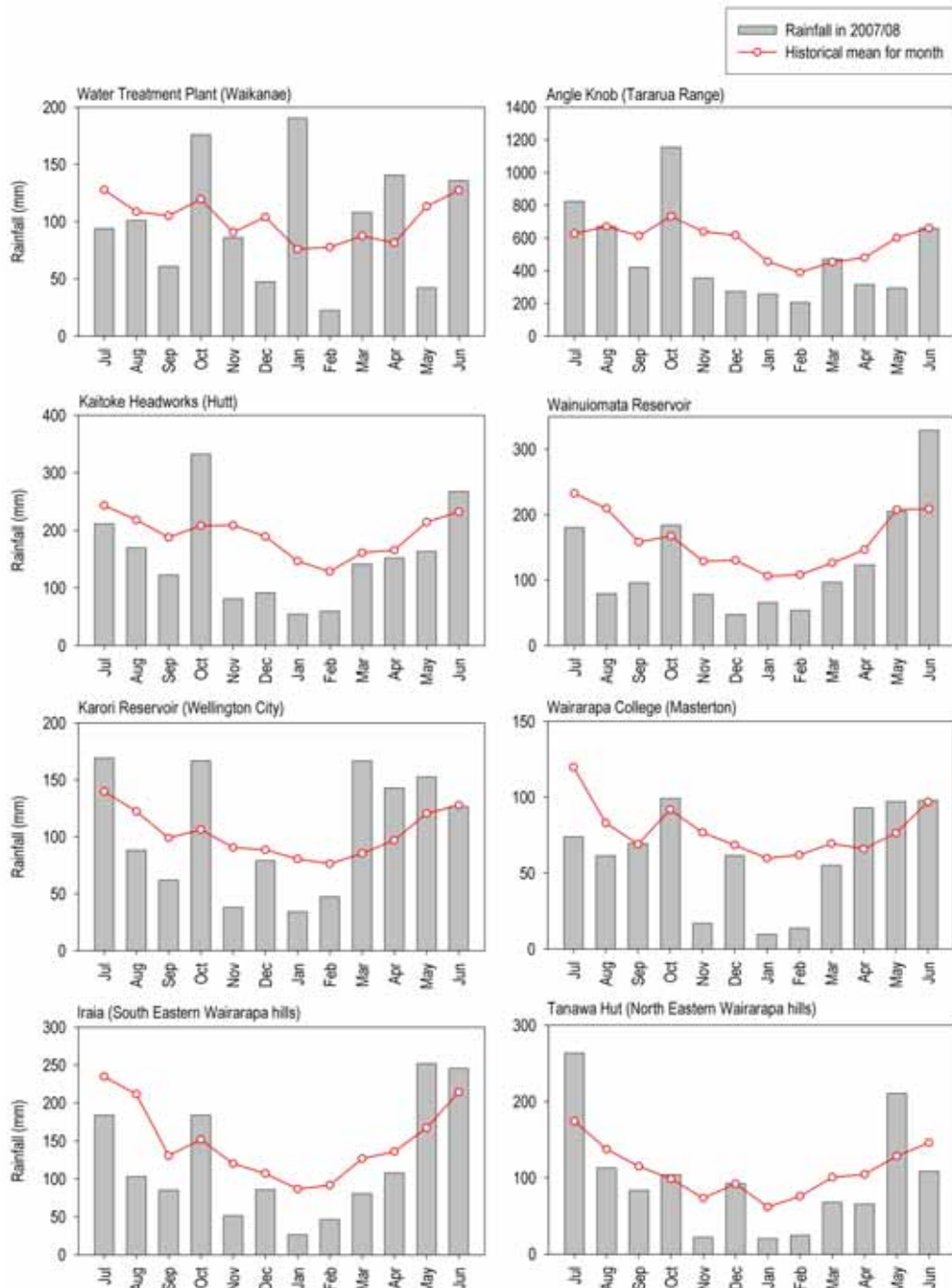


Figure 3.1: Monthly rainfall totals for 2007/08 (grey bars) compared to long-term mean monthly rainfall (red line) at selected rainfall monitoring locations in the Wellington region

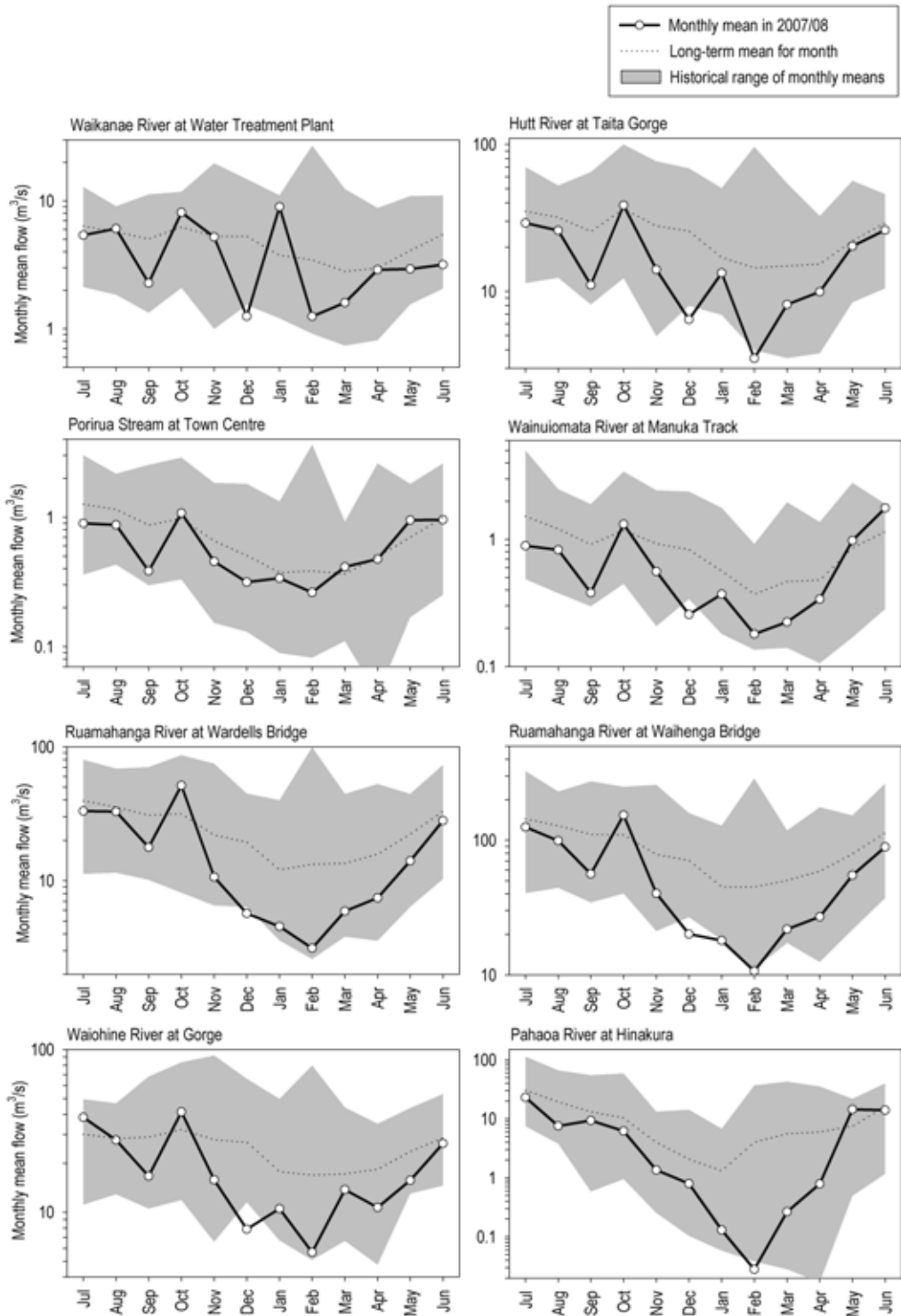


Figure 3.2: Monthly mean river flows for 2007/08 (black line) compared to long-term mean monthly river flows (dotted line) at selected monitoring locations in the Wellington region. Grey shaded area represents the historic range of monthly means. Note the logarithmic scale on y-axes.

The drought was broken by rainfall in many parts of the Wellington region during late March 2008, although autumn brought mixed conditions. On the Kapiti Coast, March and April were wetter than average but May had less than half the long-term average rainfall for the month. Conversely, eastern

Wairarapa, parts of the Hutt catchment, and Wainuiomata remained drier than average through until May 2008. By June 2008, river flows and soil moisture conditions had generally returned to about average for the time of the year, coinciding with a weakening of the La Nina.

### 3.2 Lake Wairarapa

The monthly mean lake levels in Lake Wairarapa were below average for the first few months of the reporting period (Figure 3.3), due to the low river and stream flows entering the lake during late winter and spring. Following average levels in October and November, the lake experienced low levels in December and January, once again due to the low inflows. The mean level of 9.95 m in December 2007 is the lowest December level since the Lower Wairarapa Valley Development Scheme was completed, and corresponds with the lowest average December flows in the Tauherenikau River (the lake's main tributary) since monitoring began in 1976. However, lake levels for late summer and autumn were above average for the time of the year, and rose to relatively high levels in June 2008.

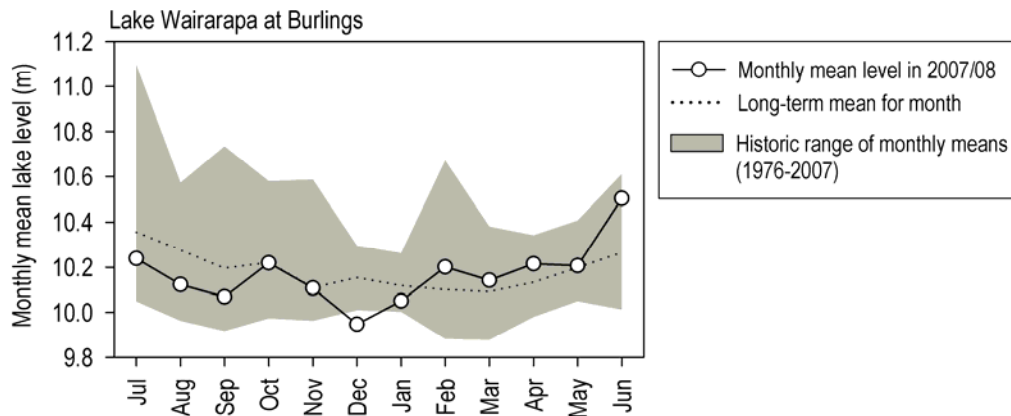


Figure 3.3: Mean monthly levels in Lake Wairarapa during 2007/08, compared to long-term monthly mean levels (dotted lines)

### 3.3 Lake Onoke

In contrast to the levels in Lake Wairarapa, monthly mean levels in Lake Onoke were relatively high throughout spring and summer 2007/08 (Figure 3.4). The lake levels are predominantly governed by the interaction of sea swell conditions and flows in the Ruamahanga River. The combination of high seas and low river flows results in the closure of the sand bar at Lake Onoke, blocking the river flow to the sea, which leads to a rise in lake level. The high levels experienced overall in 2007/08 are a result of generally low river flows and a lack of floods during summer. The lake levels during January and February were particularly notable, being the highest average levels for that time of the year since the Lower Wairarapa Valley Development Scheme was completed. This corresponded with very low flows in the Ruamahanga River (Figure 3.2) leading to the lake being blocked. By May, Lake Onoke levels returned to about average for the time of the year, following some 'freshes' through the Ruamahanga River.

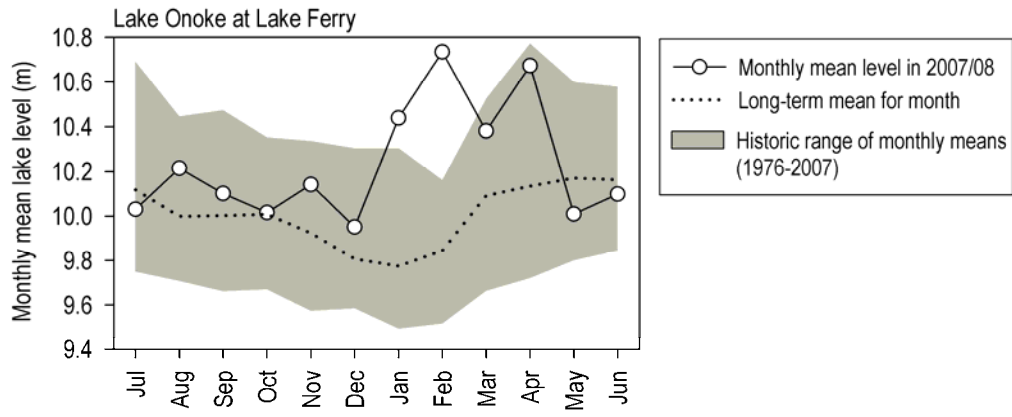


Figure 3.4: Mean monthly levels in Lake Onoke during 2007/08, compared to long-term monthly mean levels (dotted lines)

## 4. Heavy rainfall and floods of 2007/08

Statistics for the heaviest rainfall events during 2007/08 are provided in Tables 4.1 and 4.2 at the end of this section. The highest river flows during 2007/08 and the estimated return periods of these flows are shown in Table 4.3.

Greater Wellington operates a flood warning service for some of the major catchments of the region. Alarms are triggered when rainfall exceeds a certain depth over a certain duration (e.g., 20 mm within 2 hours), or when a certain river level is reached (see Table A3.1, Appendix 3). The river level alarms that were triggered during the year are listed in Table A3.2, Appendix 3. In general the 2007/08 year was a relatively 'quiet' one for floods; there were 13 events that triggered river level flood warning alarms, compared to 20 in 2006/07.

The first storm of note in 2007/08 occurred on 11 August 2007, when a north-westerly airflow brought relatively heavy rain to the eastern Tararua Range. The initial flood warning alarm was triggered in the Ruamahanga River (at both 'Wardells' and 'Waihenga').

Although frequent westerly-type rainfall events usually occur in October and November in the Wellington region, there were relatively few in spring 2007. The most significant occurred on 7-8 October, when there was 250 mm of rainfall in 24 hours in parts of the Tararua Range. This produced the largest flood for the year in the Orongorongo River, the Hutt River, and the eastern Hutt tributaries (Pakuratahi and Mangaroa rivers). Flood warning alarms were triggered in the Hutt, Otaki, Waiohine, Mangatarere and Ruamahanga rivers. In addition, thunderstorms caused heavy rain and surface flooding in parts of the Hutt Valley and Kapiti Coast.

A storm on 17 October was more significant in the eastern Tararua Range than the earlier October event. The resulting flood in the Waipoua River, which had an estimated return period of six years, caused some flooding of low-lying farmland and surface flooding across Paierau Road (the main road bypass around Masterton). The 17 October event also caused the largest flood of 2007/08 in the Ruamahanga River.

### 4.1 7-8 January 2008

An "extraordinary" meteorological event occurred on the Kapiti Coast on 7-8 January 2008 (Revell<sup>2</sup> pers. comm. 2008). A moist north-westerly airflow brought rain to the coast and western Tararua foothills that persisted for more than 48 hours. Very high rainfall totals were recorded in Paraparaumu, in the foothills (at our monitoring sites 'Water Treatment Plant' and 'Warwicks'), and at the low-elevation western Tararua Range monitoring locations ('Taungata' and 'Kapakapanui'). The event was unusual both in its long duration and because it lacked forcing to carry the rain further into the Tararua Range or over to the Hutt Valley. For example, the two-day rainfall totals for 7-8 January were 350 mm and 303 mm at 'Taungata' and 'Warwicks'

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<sup>2</sup> Cliff Revell, New Zealand Meteorological Society

respectively – significantly higher than totals over the same period recorded at ‘Angle Knob’ (144 mm) and ‘Kaitoke Headworks’ (44 mm).

At ‘Taungata’, ‘Kapakapanui’ and ‘Warwicks’ this storm produced the highest rainfall depths on record for durations of 24 and 48 hours. However, rainfall records for the Tararua Range are relatively short (beginning in 1991) and therefore there is low confidence in estimating return periods. At ‘Warwicks’ the event had an estimated return period of up to 40 years. The rainfall was prolonged but was generally not as heavy as during the storm of 5 January 2005.

The storm caused large floods in the smaller rivers and streams of the Kapiti Coast – the most significant floods of 2007/08 in the Wellington region. The Waikanae River at Water Treatment Plant had its sixth largest flood since records began in 1975, with an estimated return period of eight years (Figure 4.1). Due to the unusually heavy rainfall in the foothills, very significant floods occurred in the Waitohu and Mangaone streams, with reports of considerable storm damage in those catchments. The flood in the Mangaone Stream at Ratanui was about the same size as that experienced on 6 January 2005, but was not as high as the flood of 21 October 1998. The flood recorded in the Waitohu Stream at Water Supply Intake appears to be the second largest since the site was installed in 1994 (the largest flood was on 20 February 1996), although there have been problems with measuring floods at this site.



Figure 4.1: High flow in the Waikanae River at Otaihanga on 8 January 2008

## **4.2 29 April – 1 May 2008**

Two storm events occurred in succession in late April and early May 2008, resulting in significant surface flooding in some parts of the western Wellington region. A northerly airflow brought heavy rainfall to the Kapiti Coast and western Tararua Range overnight on 29-30 April, producing the highest rainfall depths for short durations (up to six hours) recorded on the Kapiti Coast during the 2007/08 year. The rainfall caused surface flooding in Raumati, and triggered flood warning alarms for the Akatarawa, Hutt and Waikanae rivers.

The following night, a southerly front stalled over Wellington producing sustained and moderately heavy rainfall over Wellington City and Porirua. The event caused surface flooding in urban areas and produced an estimated three-year return period flood in the Porirua Stream. The rainfall was the heaviest for the 2007/08 year in these areas, with 'Karori Reservoir' recording 80 mm of rainfall in the eight hours through until 4 am on 1 May. This is the second heaviest rainfall recorded since the automatic gauge was installed there in 1984.

## **4.3 29 June 2008**

A southerly front on 29 June 2008 brought sustained rainfall to parts of the region that are exposed to the south – in particular, the Hutt Valley, Wainuiomata and southern Wairarapa. This was the most significant long-duration storm of the year in these parts of the region. The rainfall caused the largest floods for the year in the Wainuiomata River and Waiwhetu Stream – the most significant flood in these catchments since October 2006, and estimated to be a four-year return period flood in the Wainuiomata River at Leonard Wood Park.

**Table 4.1: Maximum short-duration rainfall depths during 2007/08, at selected rainfall monitoring stations in the Wellington region**

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)*	25.5 mm 30 Apr 2008	4	48 mm 29 Apr 2008	3	74.5 mm 8 Jan 2008	4
QE Park (Paekakariki)*	22.5 mm 30 Apr 2008	5	38 mm 29 Apr 2008	<2	44 mm 29 Jun 2008	<2
Warwicks (Akatarawa)	32 mm 30 Apr 2008	15	86.5 mm 8 Jan 2008	8	135.5 mm 8 Jan 2008	10
Te Marua (Upper Hutt)	27 mm 30 Apr 2008	3	47 mm 1 Oct 2007 8 Oct 2007	<2	58.5 mm 8 Oct 2007	<2
TVL (Mangaroa)	16 mm 30 Apr 2008	<2	32 mm 8 Oct 2007	<2	51 mm 29 Jun 2008	<2
Shandon Golf Club (Petone)	21 mm 11 Feb 2008	5	45 mm 30 Apr 2008 <sup>#</sup>	2	58 mm 30 Apr 2008 <sup>#</sup>	2
Wainuiomata Reservoir (Wainuiomata)	18 mm 11 Feb 2008	<2	48.5 mm 29 Jun 2008	2	88.5 mm 29 Jun 2008	3
Seton Nossiter Park (Porirua)	22.5 mm 13 Nov 2007	5	52.5 mm 30 Apr 2008 <sup>#</sup>	5	65.5 mm 30 Apr 2008 <sup>#</sup>	4
Karori Reservoir (Wellington City)	23 mm 30 Apr 2008 <sup>#</sup>	2	76.4 mm 30 Apr 2008 <sup>#</sup>	15	93.8 mm 30 Apr 2008 <sup>#</sup>	25
McIntosh (W Tararua Range)	19.5 mm 29 Aug 2007 8 Oct 2007	<2	81 mm 8 Oct 2007	<2	115 mm 8 Jan 2008	<2
Angle Knob (E Tararua Range)	36mm 8 Oct 2007	<2	145.5 mm 8 Oct 2007	<2	211.5 mm 8 Oct 2007	<2
Phelps (Waiohine, foothills)	14.4 mm 5 Mar 2008	<2	44 mm 17 Oct 2007	<2	56.5 mm 8 Oct 2007 16 Oct 2007	<2
Wairarapa College (Masterton)*	8.4 mm 10 May 2008	<2	31 mm 29 Apr 2008	<2	32 mm 29 Apr 2008 9 May 2008	<2
Alloa (Featherston)*	16.4 mm 5 Mar 2008	2	31.2 mm 9 May 2008	<2	43.2 mm 9 May 2008	<2
Castlehill (Tauweru)	15 mm 9 May 2008	2	27.5 mm 9 May 2008	<2	38.5 mm 29 Apr 2008	<2
Iraia (Huangarua)	34.5 mm 9 Dec 2007	15	45 mm 9 Dec 2007	<2	57 mm 28 Jun 2008	<2
Tanawa Hut (Whareama)	13 mm 9 May 2008	<2	30.5 mm 17 Jul 2007 9 May 2008	<2	50 mm 17 Jul 2007	<2

\*Return periods estimated using HIRDS v2.0 (NIWA 2002)

<sup>#</sup>Rainfall totals were recorded during the event overnight on 30 April / 1 May, not during the event of the previous night

**Table 4.2: Maximum long-duration rainfall depths during 2007/08, at selected rainfall monitoring stations in the Wellington region**

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)*	136 mm 7 Jan 2008	25	188.5 mm 7 Jan 2008	25+	188.5 mm 6 Jan 2008	25+
QE Park (Paekakariki)*	74 mm 28 Jun 2008	4	82.5 mm 7 Jan 2008	3	100 mm 27 Jun 2008	2
Warwicks (Akatarawa)	250.5 mm 7 Jan 2008	35	315 mm 7 Jan 2008	40	316.5 mm 6 Jan 2008	25
Te Marua (Upper Hutt)	68 mm 7 Oct 2007	<2	82 mm 29 Apr 2008	<2	109.5 mm 7 Oct 2007	<2
TVL (Mangaroa)	95 mm 29 Jun 2008	3	113 mm 28 Jun 2008	2	126 mm 27 Jun 2008	2
Shandon Golf Club (Petone)	66.5 mm 28 Jun 2008	<2	88.5 mm 29 Apr 2008	2	98.5 mm 29 Apr 2008	2
Wainuiomata Reservoir (Wainuiomata)	147.5 mm 29 Jun 2008	5	166 mm 28 Jun 2008	2	176 mm 27 Jun 2008	<2
Seton Nossiter Park (Porirua)	70 mm 30 Apr 2008	2	99 mm 29 Apr 2008	4	108 mm 29 Apr 2008	3
Karori Reservoir (Wellington City)	94.6 mm 30 Apr 2008	10	123 mm 29 Apr 2008	9	137 mm 29 Apr 2008	8
McIntosh (Otaki, Tararua Range)	199 mm 8 Jan 2008	<2	251 mm 7 Jan 2008	<2	253.5 mm 7 Jan 2008	<2
Angle Knob (Waingawa, Tararua Range)	250 mm 7 Oct 2007	<2	287.5 mm 1 Jul 2007	<2	338 mm 5 Oct 2007	<2
Phelps (Waiohine, foothills)	67 mm 7 Oct 2007	<2	78 mm 16 Oct 2007	<2	104.5 mm 7 Oct 2007	<2
Wairarapa College (Masterton)*	43.4 mm 18 Dec 2007	<2	50 mm 17 Dec 2007	<2	52.6 mm 17 Dec 2007	<2
Alloa (Featherston)*	47.8 mm 9 May 2008	<2	58.6 mm 29 Apr 2008	<2	69 mm 30 Apr 2008	<2
Castlehill (Tauweru)	57.5 mm 18 Dec 2007	<2	65 mm 17 Dec 2007	<2	69.5 mm 16 Jul 2007	<2
Iraia (Huangarua)	100.5 mm 28 Jun 2008	<2	121 mm 28 Jun 2008	<2	143.5 mm 27 Jun 2008	<2
Tanawa Hut (Whareama)	90.5 mm 17 Jul 2007	2.5	112 mm 17 Jul 2007	2	134 mm 16 Jul 2007	2

\*Return periods estimated using HIRDS v2.0 (NIWA 2002)

**Table 4.3: Maximum river and stream flows during 2007/08 at river flow monitoring sites in the Wellington region<sup>3</sup>**

Site	Highest flow in 2007/08 (m <sup>3</sup> /s)	Date of occurrence	Estimated return period (years)
Waitohu S at Water Supply Intake	83	8 Jan 2008	15
Otaki R at Pukehinau*	762	8 Jan 2008	<2
Mangaone S at Ratanui	26	8 Jan 2008	10
Waikanae R at Water Treatment Plant	240	8 Jan 2008	8
Mazengarb S at Scaife Drive	0.9	30 Apr 2008	<2
Hutt R at Te Marua	332	8 Oct 2007	<2
Hutt R at Birchville*	515	8 Oct 2007	<2
Hutt R at Taita Gorge	500	8 Oct 2007	<2
Pakuratahi R at Truss Bridge	92	8 Oct 2007	2
Mangaroa R at Te Marua	77	8 Oct 2007	<2
Akatarawa R at Cemetery	226	8 Jan 2008	<2
Whakatikei R at Dude Ranch	92	8 Jan 2008	<2
Waiwhetu S at Whites Line East	10.6	29 Jun 2008	<2
Wainuiomata R at Manuka Track	26	29 Jun 2008	2
Wainuiomata R at Leonard Wood Pk.	74	29 Jun 2008	4
Orongorongo R at Upper Dam Site	21	8 Oct 2007	<2
Taupo S at Flax Swamp	4.8	1 May 2008	2
Horokiri S at Snodgrass	15	29 Jun 2008	n/a <sup>#</sup>
Porirua S at Town Centre	35	1 May 2008	3
Ruamahanga R at Mt Bruce	200	7 Jun 2008	<2
Ruamahanga R at Wardells Bridge	475	17 Oct 2007	2
Ruamahanga R at Gladstone Bridge	685	17 Oct 2007	3
Ruamahanga R at Waihenga Bridge	771	17 Oct 2007	<2
Waipoua R at Mikimiki Bridge	185	17 Oct 2007	6
Waingawa R at Kaituna	202	17 Oct 2007	<2
Mangatarere S at Gorge	34	17 Oct 2007	<2
Waiohine R at Gorge	570	8 Oct 2007	<2
Tauherenikau R at Gorge	216	8 Oct 2007	<2
Kopuaranga R at Palmers	496	17 Oct 2007	2
Tauweru R at Te Weraiti	76	18 Jul 2007	<2
Huangaaru R at Hautotara	100	29 Jun 2008	<2
Otukura S at Weir	4.6	29 Jun 2008	<2
Pahaoa R at Hinakura*	167	18 Jul 2007	<2

\*Data provided by NIWA but frequency analysis performed by Greater Wellington

<sup>#</sup>Record not long enough for analysis

<sup>3</sup> River level stations that are not rated for high flows are omitted from the table

## 5. The drought of 2007/08

The most notable hydrological event of 2007/08 was the drought experienced during summer and autumn. The summer climate was dominated by a strong La Nina, which produced more anticyclones south-east of the South Island and mild north-easterly winds over New Zealand (Salinger 2008). These conditions led to well below average rainfall from November 2007 through until at least March 2008.

As mentioned in Section 3, rainfall was also, overall, below average during winter and spring 2007. This followed on from a seasonal drought in autumn 2007 (Watts & Gordon 2007), during El Nino conditions. Although this report analyses the short-term hydrological conditions of 2007/08 (e.g., the lowest rainfall and flows experienced during the year), it should be kept in mind that the low rainfall earlier in 2007 exacerbated the situation through below-average recharge to groundwater (McAlister 2007; McAlister & Tidswell 2008), and the effects on farming were compounded by two droughts in relatively quick succession.

This section presents an analysis of the rainfall, soil moisture deficits and river flows during the 2007/08 drought. For comparative purposes, the following recent droughts are referred to in the analysis:

- 1972/73 – a drought during El Nino conditions, that occurred from about mid-spring 1972 through until early autumn 1973. This was soon after a La Nina-related drought in 1970/71.
- 1997/98 – a particularly strong El Nino episode which led to drought in the Wairarapa.
- 2000/01 – a drought during La Nina conditions, which mainly affected the Hutt Valley, Wainuiomata and Wairarapa, particularly during autumn 2001.
- 2003 – an El Nino-related drought that affected much of the Wellington region, particularly the Kapiti Coast and the Wairarapa plains, during January to March 2003.

### 5.1 Rainfall

The drought conditions experienced in summer 2007/08 were partly due to dry, settled weather of summer starting earlier than usual. Although October 2007 had average or above-average rainfall throughout the Wellington region, November had very low rainfall compared to normal for the time of the year. As mentioned in Section 3, the November rainfall was less than half the long-term average in many parts of the Wellington region. Overall, for the period 1 November 2007 to 31 March 2008 the area with the lowest rainfall was the eastern Wairarapa valley, from about Masterton east to Ngaumu and south to Longbush valley and Martinborough (Figure 5.1), where rainfall was as low as 150 mm for the five-month period. More than half of the Wellington region received less than 300 mm of rainfall over this period, including the eastern Wairarapa hills, the Wairarapa plains, the Hutt Valley, the Kapiti Coast and Wellington City.

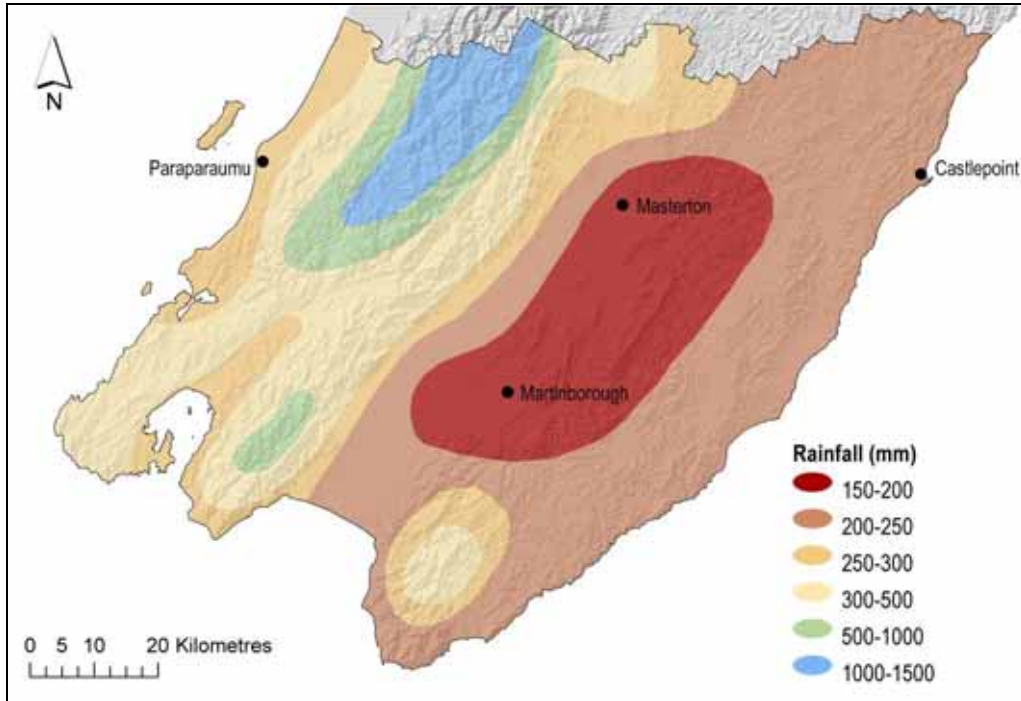


Figure 5.1: Approximate rainfall during November 2007 to March 2008

In terms of conditions compared to ‘normal’, rainfall during November 2007 to March 2008 was between about 50% and 60% of the long-term average in the eastern Wairarapa hills and the eastern foothills of the Tararua Range (Figure 5.2). The Wairarapa plains were also much drier than average, as were northern and eastern parts of the Hutt and Wainuiomata catchments.

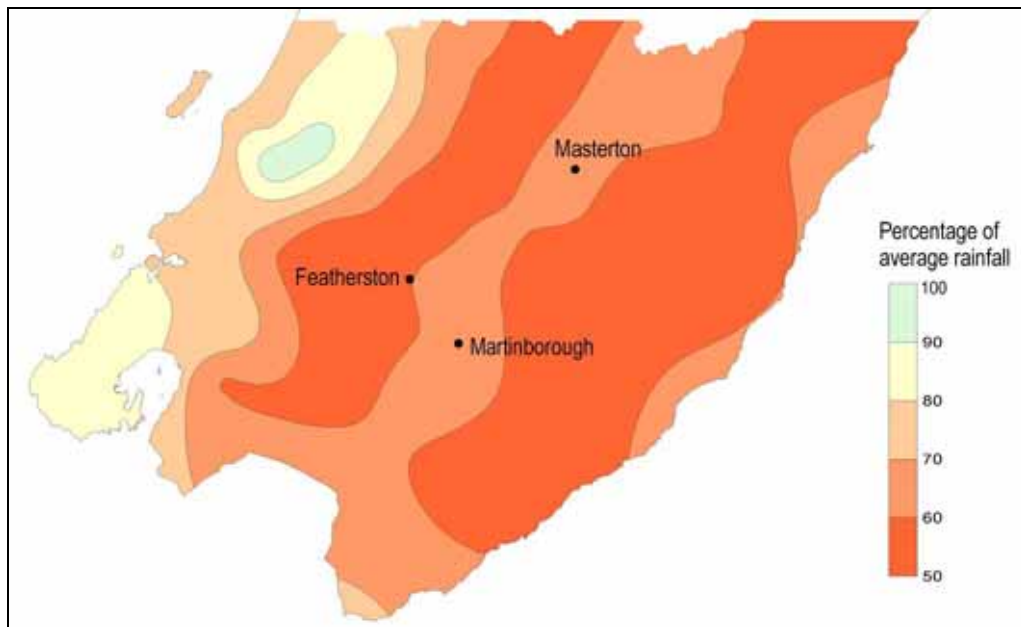


Figure 5.2: Rainfall during November 2007 to March 2008 as an estimated percentage of the long-term average rainfall

As indicated by the minimum rainfall totals recorded during 2007/08 in the Wellington region (Table 5.1), the driest 28-day period tended to be from mid-November to mid-December 2007 or in January 2008. This highlights the relatively early start to the drought; usually the driest months of the year are January to March. The rainfall minima for three-month and six-month durations tended to begin in October or November 2007.

**Table 5.1: Lowest rainfall totals during 2007/08 for 28-day, 3 month and 6 month durations, at selected monitoring locations in the Wellington region**

Site Name	28 days		3 months		6 months	
	Rainfall minima (mm)	Start date	Rainfall minima (mm)	Start date	Rainfall minima (mm)	Start date
Angle Knob (Tararua Range)	47.5	16/11/2007	661	15/11/2007	2075	12/10/2007
Waikanae Water Treatment Plant	4	12/01/2008	167	12/01/2008	507.8	18/10/2007
Kaitoke Headworks (nth Upper Hutt)	17	13/01/2008	181.5	14/11/2007	482	17/10/2007
Shandon Golf Club (Petone)	2.5	9/01/2008	119	5/11/2007	325	14/10/2007
Wainuiomata Reservoir	6	16/11/2007	156.5	16/11/2007	394.5	19/10/2007
Karori Reservoir (Wellington)	3.2	16/11/2007	144.6	5/11/2007	425.2	20/08/2007
Phelps (Tararua foothills – Wairarapa)	12.5	16/11/2007	152.5	16/11/2007	420.5	17/10/2007
East Taratahi (Near Masterton)*	2.4	17/11/2007	71	29/12/2007	216.7	18/10/2007
Alloa (Featherston)	10.8	8/01/2008	99.8	16/11/2007	291.8	17/10/2007
Tanawa Hut (North-east Wairarapa)	9.5	28/12/2007	100.5	28/12/2007	269.5	27/10/2007
Iraia (South-east Wairarapa)	7	9/01/2008	126	28/12/2007	349	18/10/2007

The estimated return periods of the three-month rainfall depths are most significant for the Tararua Range (15 years), eastern Tararua foothills (eight years), Wairarapa plains (five years), eastern Wairarapa hills (five years), Wainuiomata (12 years), and the northern and eastern Hutt catchment (e.g., 15 years at Kaitoke). Analysis of the rainfall during the 2007/08 drought in different parts of the Wellington region shows that:

- On the Kapiti Coast, although the driest 28-day period was significant (approximately a five-year return period) the three-month and six-month rainfall minima were not significant. In other words, the period of low rainfall was not prolonged, and records show that during the drought of 2002/03 there was less rainfall on the Kapiti Coast. Similarly, in

Wellington City and Petone/Lower Hutt the 28-day duration rainfall minima were significant (up to 10 year return period), but overall the summer and autumn of 2000/01 was drier.

- In the north-eastern Hutt and Wainuiomata catchments the three-month and six-month rainfall minima were significant, with estimated return periods of 10-15 years. However, in general the rainfall was not as low as during the droughts of 1970/71, 1972/73, 2000/01, and 2002/03 (although there is variation depending on location).
- In the Tararua Range there was a clear west-east division, with the rainfall minima for 2007/08 being more significant in the eastern range (partly due to the storm of 7-8 January affecting the western range). At 'Angle Knob' the three month period from 15 November 2007 is the driest on record (records begin in 1982). However, it was not the most significant six-month period, with drier phases in the 1980s and 2000/01. This indicates that the eastern Tararua Range experienced a moderate duration drought during 2007/08, not as prolonged as that of 2000/01. The same trend occurred in the foothills of the eastern Tararua Range (e.g., at the monitoring sites 'Mt Bruce', 'Kaituna' and 'Valley Hill').
- On the Wairarapa plains and in the eastern Wairarapa hills the three-month rainfall minima for 2007/08 have an estimated return period of about five years. For the six-month duration there was less rainfall on the Wairarapa plains during the droughts of 1972/73, 1997/98, 2002/03, and autumn 2007. In the eastern hills the droughts of 1970/71, 1972/73, 1997/98 and 2000/01 tended to be more prolonged, with less rainfall over the six-month duration. In north-east Wairarapa the drought during autumn 2007 produced less rainfall than the summer 2007/08 drought.

## 5.2 Soil moisture deficit

Greater Wellington monitors soil moisture at several locations, although generally the records are short and therefore are not suitable for long-term analysis. The longest-running monitoring location is 'Alloa' (near Featherston), where soil moisture has been monitored since 2000. The data for 2007/08 shows that soil moisture declined sharply in November 2007 – earlier than usual – and remained well below average through until March 2008 (Figure 5.3). However, by May 2008 soil moisture conditions were back to about average for the time of the year. This is indicative of conditions on the Wairarapa plains during 2007/08, and monitoring of soil moisture in the eastern Wairarapa hills shows a similar trend for the year.

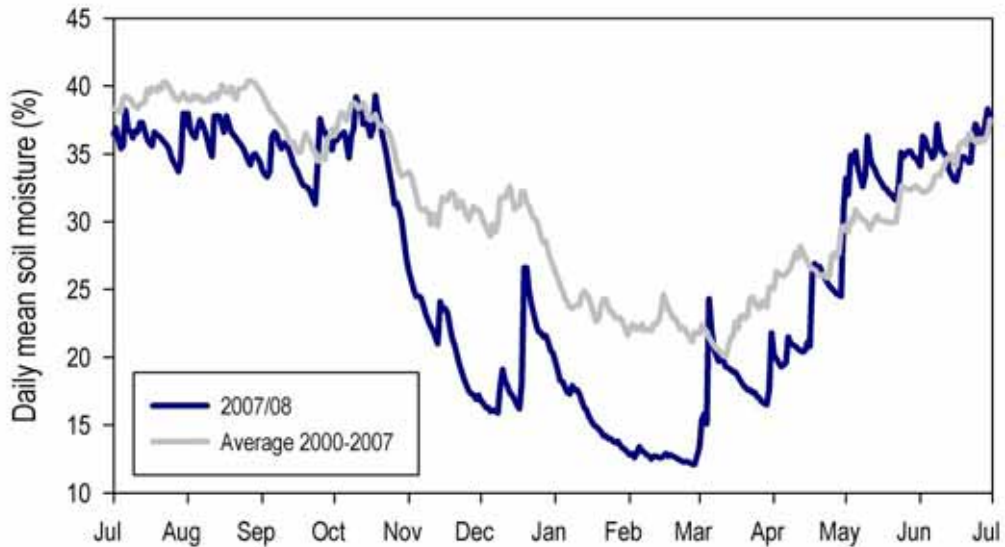


Figure 5.3: Soil moisture at Alloa (near Featherston) during 2007/08 compared to the long-term average

One way of classifying or ranking droughts is by their effects, which are often related to the soil moisture deficit<sup>4</sup>. The severity and duration of soil moisture deficit is a function of the soil's available water capacity, rainfall and evapotranspiration. Therefore, modelled soil moisture deficits for an 'average' soil type (with an available water capacity of 150 mm) can be used to compare droughts by reflecting both the rainfall and the climate conditions that affect evapotranspiration.

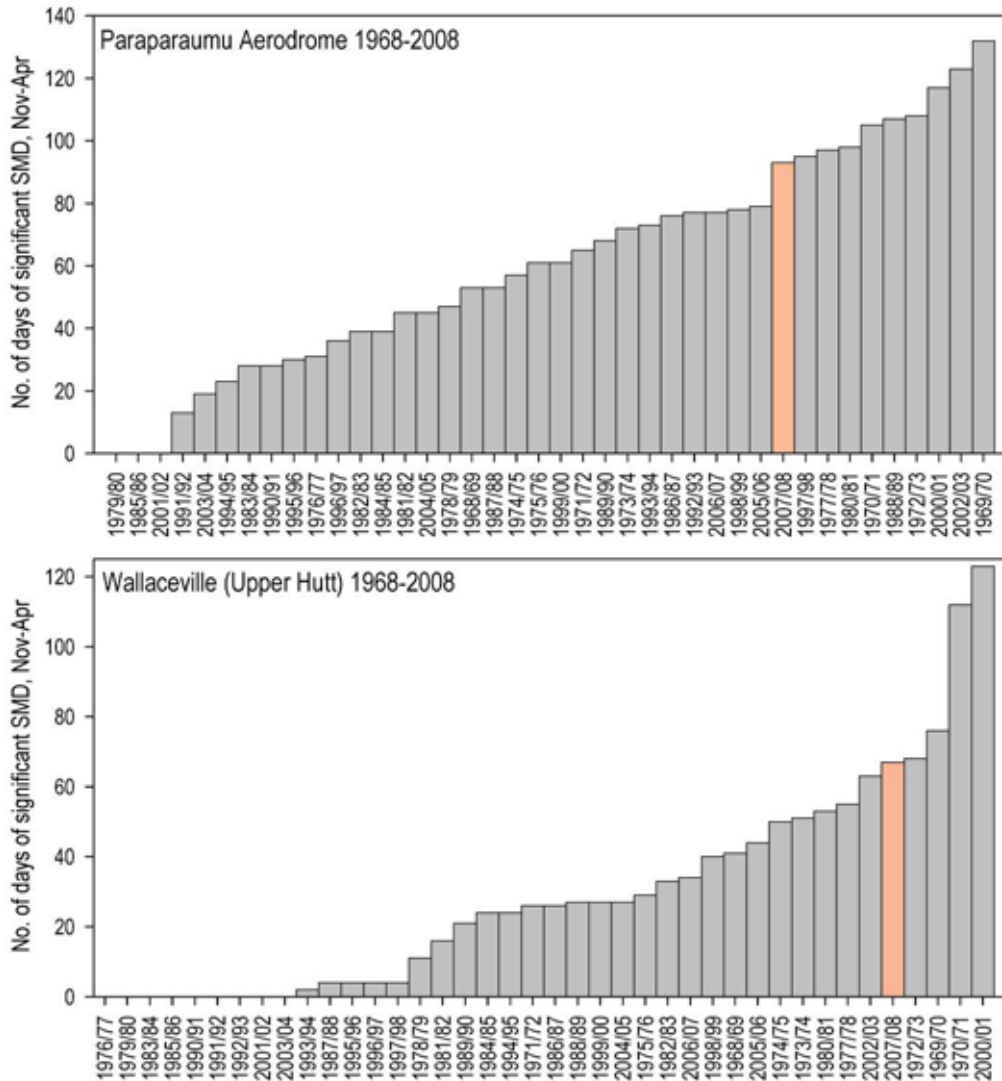
Modelled soil moisture deficit data were obtained from NIWA for four long-running monitoring locations. The data were used to calculate the estimated number of days per year within the period November to April with a significant soil moisture deficit (SSMD)<sup>5</sup>. As shown in Figure 5.4, on the Kapiti Coast (indicated by 'Paraparaumu Aerodrome') 2007/08 was not overly significant in terms of the number of days with SSMD, with this year ranking 10<sup>th</sup> in 40 years of data. A higher number of days with SSMD were experienced in several drought periods of the early 1970s and in 2002/03. In the Hutt Valley, the 2007/08 drought ranks about fourth equal (with 1972/73) in 40 years of data from 'Wallaceville'. The droughts of 1970/71 and 2000/01 – also during La Nina conditions – appear to have caused a considerably higher number of days with SSMD in the Hutt Valley compared to 2007/08. The ranking is roughly consistent with the estimated return period of about 15 years assigned to the three-month rainfall minima for 2007/08 at 'Kaitoke Headworks'.

In the Wairarapa, the drought of 2007/08 produced a higher number of days with SSMD than in the west of the region (Figure 5.5). On the Wairarapa plains (as indicated by 'East Taratahi' near Masterton) there were 120 days of SSMD, which ranks fourth equal with 1972/73 and 1977/78 in 31 years of data.

<sup>4</sup> The amount of rainfall required to return the soil to field capacity

<sup>5</sup> A significant soil moisture deficit is taken to be 110 mm or greater, a commonly-used threshold for defining an agricultural drought

In this location, the El Nino-related droughts of 2002/03 and 1997/98 appear to have produced more severe soil moisture deficits. The analysis shows that this year's drought in the eastern Wairarapa hills ranks third highest in 40 years of data, after 1997/98 and 2000/01 (a similar La Nina year). This is consistent with the rainfall analysis which generally shows less rainfall during these droughts in the eastern hills. Although the autumn 2007 drought was significant in the eastern Wairarapa hills it does not rank high for days of SSMD; this is because potential evapotranspiration tends to be lower in late autumn than in summer.



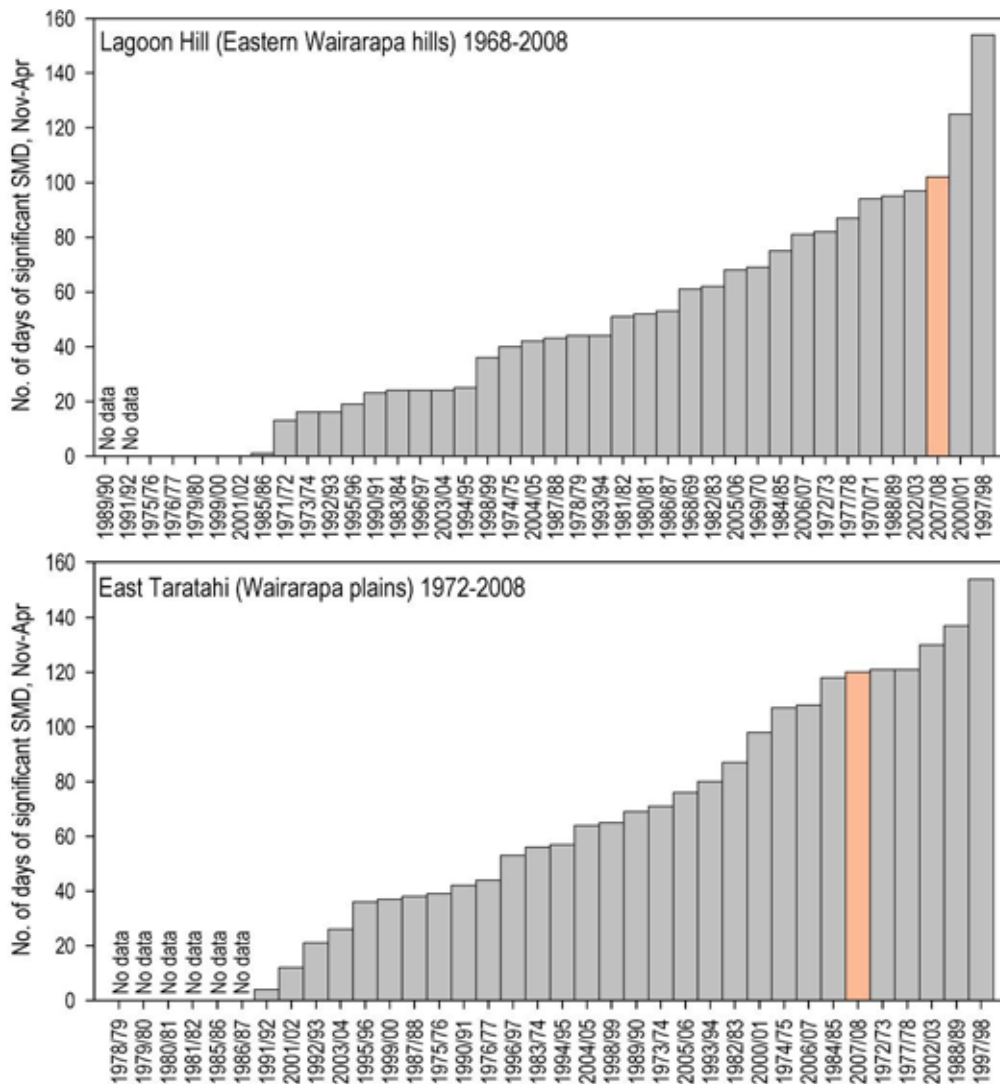


Figure 5.5: Number of days per year (November to April) with soil moisture deficit greater than 110 mm (for a soil type with available water capacity of 150 mm) in the Wairarapa. Data obtained from the NIWA National Climate Database.

### 5.3 River flows

Low river flows were experienced early in the 2007/08 summer, with the mean flows for December being the lowest on record in many of the major rivers of the region (as noted in Section 3). This was a result of both the unusually dry November and December in the Tararua Range (meaning there were fewer ‘freshes’ than usual) and low baseflow in the rivers following overall low rainfall during winter and spring.

In the western part of the region the lowest 7-day mean flows of the year occurred in March (Table 5.2). The rivers and streams of the Kapiti Coast had significant 7-day low flows but over the longer durations the river flows were not particularly significant, highlighting that in this part of the region the drought was not as prolonged as in 2002/03 (when lower flows were recorded).

In the Hutt catchment, the longer duration low flows were more significant, with estimated return periods of up to eight years for the 28-day duration low

flows and about 10 years for three-month duration low flows (not shown in Table 5.2). This is consistent with the rainfall analysis which found the drought was significant for three- and six-month durations in this part of the region. Lower flows in the Hutt River were recorded during the drought of 2000/01. Similarly, the flow in the Wainuiomata River was not as low as that recorded in autumn 2001 and in late summer 1989 (another La Nina event).

**Table 5.2: Lowest 7-day and 28-day mean river flows during 2007/08 at monitoring stations in the western Wellington region**

Site Name	7-day duration			28-day duration		
	Lowest mean flow in 2007/08 (m <sup>3</sup> /s)	Start date	Estimated return period (years)	Lowest mean flow in 2007/08 (m <sup>3</sup> /s)	Start date	Estimated return period (years)
Waitohu S at WSI	0.089	26 Mar 2008	12	0.172	2 Mar 2008	3
Otaki R at Pukehinau*	3.577	22 Mar 2008	15	6.217	27 Nov 2007	4
Mangaone S at Ratanui	0.054	22 Mar 2008	5	0.078	1 Mar 2008	3
Waikanae R at WTP	0.679	22 Mar 2008	12	0.925	1 Mar 2008	6
Hutt at Birchville*#	1.883	22 Mar 2008	3	2.611	2 Feb 2008	5
Hutt R at Taita Gorge#	2.330	22 Mar 2008	8	3.480	2 Feb 2008	7
Pakuratahi R at Truss Bridge	0.139	22 Mar 2008	15	0.214	2 Feb 2008	8
Mangaroa R at Te Marua	0.211	19 Mar 2008	6	0.331	2 Mar 2008	5
Akatarawa R at Cemetery	0.770	22 Mar 2008	8	1.074	2 Feb 2008	4
Whakatikei R at Dude Ranch	0.217	22 Mar 2008	8	0.280	1 Mar 2008	5
Wainuiomata R at Manuka Track	0.132	22 Mar 2008	4	0.171	2 Mar 2008	3
Wainuiomata R at LWP#	0.185	22 Mar 2008	4	0.289	14 Jan 2008	3
Orongorongo R at UDS	0.018	22 Mar 2008	12	0.038	14 Jan 2008	4
Taupo S at Flax Swamp	0.005	22 Mar 2008	3	n/a (missing data)	n/a	n/a
Horokiri S at Snodgrass	0.055	22 Mar 2008	n/a	0.075	1 Mar 2008	n/a
Porirua S at Town Centre	0.137	22 Mar 2008	2	0.180	13 Jan 2008	2

\*Data provided by NIWA but frequency analysis performed by Greater Wellington

#Low flow likely to have been significantly affected by upstream abstraction

In the Wairarapa, the lowest river flows of the year were recorded slightly earlier than in the western part of the region, generally commencing in January or February (Table 5.3). The Wairarapa low flows of 2007/08 were significant at all of the monitoring locations, with estimated return periods generally in the order of five to 15 years.

**Table 5.3: Lowest 7-day and 28-day mean river flows during 2007/08 at monitoring stations<sup>6</sup> in the Wairarapa**

Site Name	7-day duration			28-day duration		
	Lowest mean flow in 2007/08 (m <sup>3</sup> /s)	Start date	Estimated return period (years)	Lowest mean flow in 2007/08 (m <sup>3</sup> /s)	Start date	Estimated return period (years)
Ruamahanga R at Mt Bruce	0.93	4 Feb 2008	11	1.44	20 Nov 2007	9
Ruamahanga R at Wardells <sup>#</sup>	1.92 <sup>‡</sup>	5 Feb 2008	10	2.51 <sup>‡</sup>	15 Jan 2008	11
Ruamahanga R at Waihenga Bridge <sup>#</sup>	5.77 <sup>‡</sup>	4 Feb 2008	35	8.40 <sup>‡</sup>	14 Jan 2008	18
Waipoua R at Mikimiki	0.16	23 Mar 2008	9	0.24	14 Jan 2008	15
Waingawa R at Kaituna	1.10	4 Feb 2008	6	1.60	14 Jan 2008	8
Mangatarere S at Gorge	0.08	23 Feb 2008	11	0.14	14 Jan 2008	16
Waiohine R at Gorge	3.01	3 Feb 2008	4	4.43	20 Nov 2007	7
Tauherenikau R at Gorge	1.06	23 Feb 2008	4	1.30	14 Jan 2008	8
Kopuaranga R at Palmers <sup>#</sup>	0.20	23 Mar 2008	6	0.23	9 Mar 2008	9
Otukura S at Weir <sup>#</sup>	0.04	24 Jan 2008	3	0.05	13 Jan 2008	4
Papawai S at U/S Oxi Pond <sup>#</sup>	0.07	28 Jan 2008	n/a	0.08	15 Jan 2008	n/a
Tilsons Ck at Scott Culvert <sup>#</sup>	0.11	29 Jan 2008	n/a	0.12	21 Jan 2008	n/a
Pahaoa R at Hinakura <sup>*</sup>	0.02	25 Feb 2008	7	0.03	6 Feb 2008	8

<sup>\*</sup>Data provided by NIWA

<sup>#</sup>Low flow likely to have been significantly affected by upstream abstraction

<sup>‡</sup> Record adjusted to 'remove' the impact of an alleged unauthorised abstraction from the Ruamahanga River in early February, upstream of the monitoring site

<sup>6</sup> Only the river level sites that are rated for low flows are shown in the table

Of the Ruamahanga River tributaries, the most extreme low flows (in terms of return period) occurred in rivers and streams with the majority of their catchments in the eastern Tararua foothills (e.g., Mangatarere Stream and Waipoua River, Figure 5.6). The low flows in these waterways were approximately a 15-year return period – a result of particularly low rainfall in the foothills (as identified in Section 5.1). However, in general the low flows experienced in the Ruamahanga River tributaries were not as low as those recorded in 1977/78, 1985, and 1988/89 (and autumn 2001 in some of the waterways).



Figure 5.6: By January 2008 the Waipoua River upstream of Paierau Road had dried up into a series of pools. The river began flowing further downstream.

The main stem of the Ruamahanga River experienced extremely low flows in 2007/08, particularly at the most downstream recording site ‘Waihenga’. These were the lowest 7-day and 28-day duration low flows in that river since 1985. However, more extreme longer duration low flows occurred in the Ruamahanga River in autumn 2001.

The very low flows (for up to 28-day durations) recorded in the Ruamahanga River in 2007/08 were a result of particularly low rainfall in the eastern Tararua Range and foothills during spring and summer. In addition, the low rainfall over winter and spring 2007 meant that groundwater levels were very low during summer 2007/08 (McAlister & Tidswell 2008); the Ruamahanga River has significant interaction with groundwater systems and the low groundwater levels may have led to reduced groundwater inflow to the river system.

In the rivers of the eastern Wairarapa hills (indicated by Pahaoa River at Hinakura) the lowest flows of 2007/08 were about a seven to eight year return period. Lower river flows were recorded in the Pahaoa River in 1989, 1997/98 and 2001.

#### **5.4 Key points**

- The onset of the drought occurred early, with particularly low rainfall in November 2007. This meant that soil moisture and river flows had dropped to low levels by December.
- The areas with lowest rainfall compared to average for November 2007 to March 2008 were the eastern Wairarapa hills and eastern foothills of the Tararua Range.
- The three-month rainfall minima during the drought had an estimated return period of five to 15 years in various parts of the Wellington region.
- In general, the drought was not as severe or prolonged as that of 2000/01. Comparison of soil moisture deficits indicates that the 2007/08 drought was the equal fourth worst in 30-40 years in the Hutt Valley and Wairarapa valley, and third worst in 40 years in eastern Wairarapa.
- The drought resulted in prolonged low river flows, particularly in the Hutt catchment and Wairarapa. The Ruamahanga River experienced its lowest flows in more than 20 years.

## 6. Summary

Analysis of hydrological events and trends of 2007/08 showed that in much of the Wellington region, rainfall and river flows were below average for most of the year, until May 2008. There were relatively few floods during the year, with the most significant floods being caused by a storm that affected the Kapiti Coast and western Tararua Range on 7-8 January 2008.

The year was notable for the significant La Nina-related drought that started in late spring and persisted through until early autumn, and had its worst impacts in the east of the region. Overall, rainfall and river flows were below average during July, August and spring 2007 (with the exception of October), meaning that river baseflow and soil moisture were lower than normal at the start of summer. Continued low rainfall over summer resulted in significant soil moisture deficits and low river flows.

Very low rainfall occurred during spring and summer 2007/08 in the eastern Tararua Range and its foothills, the Wairarapa plains, eastern Wairarapa, and the Hutt Valley. In these locations, the three-month rainfall minima have estimated return periods of five to 15 years. Particularly low flows were recorded in the Hutt River and its tributaries, the eastern Wairarapa rivers, and in the Ruamahanga catchment – notably in the Ruamahanga ‘foothill catchment’ tributaries. Flows in the Ruamahanga River were the lowest in more than 20 years, although more prolonged low flows occurred during the drought of autumn 2001.

Analysis and comparison with other recent droughts found that, in general, less rainfall and more prolonged significant soil moisture deficits occurred during the droughts of 1970/71 (Hutt Valley, Wainuiomata and Kapiti Coast), 1972/73 (Wairarapa and Kapiti Coast), 1997/98 (Wairarapa), 2001 (eastern Wairarapa, Wainuiomata, Hutt and Kapiti Coast catchments), and 2002/03 (Kapiti Coast and Wairarapa plains). While the drought was therefore not the worst on record, the impacts on human activities – such as municipal water supply and farming – during the 2007/08 drought are likely to have been exacerbated by other factors such as the timing of its onset (in late spring, a vital time for grass growth) and because it occurred so soon after the significant autumn drought of 2007. Similarly, the extreme low flows observed in the Ruamahanga River were a result of low baseflow at the start of summer and low groundwater levels in the Wairarapa valley, following on from the drier than normal winter and spring of 2007.

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## **Acknowledgements**

Most of the data presented in this report were collected via Greater Wellington's hydrometric network, which is operated by the Environmental Monitoring Team. Greater Wellington hydrological data are supplemented by data from NIWA, as indicated in the report. In addition, some of the rainfall data obtained from NIWA's National Climate Database were collected by MetService and Wairarapa landowners; this information was vital for the analysis of the 2007/08 drought.

## Appendix 1: Monitoring site details

Table A1.1: Rainfall monitoring sites

Site Name	Catchment/Location	Altitude (m)	Start date	Easting	Northing
Kapakapanui	Otaki (Tararua Range)	1090	06/09/1991	2692100	6028900
McIntosh	Otaki (Tararua Range)	1020	26/09/1991	2704500	6029600
Oriwa	Otaki (Tararua Range)	1050	08/09/1991	2708300	6048100
Taungata	Otaki (Tararua Range)	980	06/09/1991	2700200	6041400
Otaki Depot	Otaki	17	18/07/1984	2691000	6046300
Transmission Lines	Mangaone	140	13/10/1992	2693000	6038900
Water Treatment Plant	Waikanae	40	02/08/1969	2684600	6033300
QE Park	Whareroa (Paekakariki)	15	12/09/2001	2676258	6024009
Kaitoke Headworks	Hutt	223	02/01/1991	2693700	6014200
Te Marua	Hutt	150	22/07/1993	2690100	6012400
Centre Ridge	Pakuratahi	510	06/04/1984	2694600	6005900
Tasman Vaccine Ltd	Mangaroa	229	03/05/1968	2679000	5999600
Warwicks	Akatarawa	345	16/06/1980	2684800	6025600
Cemetery	Akatarawa	100	29/03/1988	2686300	6011200
Blue Gum Spur	Whakatikei	335	13/10/1981	2679700	6015600
Birch Lane	Hutt (Lower Hutt)	10	25/04/2001	2671000	5997600
Shandon Golf Club	Hutt (Petone)	4	03/04/2000	2669020	5996170
Orongo Swamp	Orongorongo	420	03/10/1980	2682500	5993700
Wainuiomata Reservoir	Wainuiomata	125	01/01/1890	2676700	5991200
Pencarrow Lakes	Gollans / Pencarrow Lakes	8	22/08/2007	2665946	5979727
Whenua Tapu	Taupo	45	17/04/1991	2667600	6015100
Seton Nossiter Park	Porirua	150	06/07/1992	2662300	5998100
Quartz Hill	Makara	270	03/09/2007	2651936	5993977
Karori Reservoir	Kaiwharawhara	141	02/01/1879	2656100	5988400
Regional Council Centre	n/a (Wellington city)	30	26/07/1996	2658900	5989200
Bannister	Ruamahanga (Tararua Range)	1000	30/09/1974	2718847	6049143
Angle Knob	Waingawa (Tararua Range)	1200	27/12/1974	2715273	6037178
Carkeek	Waiohine (Tararua Range)	1158	30/09/1974	2712181	6043585
Bull Mound	Tauherenikau (Tararua Range)	1000	23/03/1976	2705146	6022522
Mt Bruce	Ruamahanga	300	30/07/1984	2729290	6047000
Mauriceville	Kopuaranga	230	07/05/2008	2736890	6045570
Westons	Waipoua	470	08/11/2007	2726580	6042674
Masterton Office	Ruamahanga (Masterton)	120	18/08/2000	2734068	6025323
Wairarapa College	Ruamahanga (Masterton)	115	29/05/2002	2732767	6024886
Waingawa	Waingawa	240	09/05/1994	2722560	6032448
Valley Hill	Mangatarere	483	21/04/1997	2716500	6026600
Phelps	Waiohine	125	02/01/1974	2711649	6017328
Waiohine Gorge	Waiohine	140	02/02/2006	2711700	6018300

Site Name	Catchment/Location	Altitude (m)	Start date	Easting	Northing
Parkvale	Parkvale (Carterton)	100	08/01/2008	2723514	6011211
Alloa	Tauherenikau (Featherston)	40	01/03/1963	2709890	6007005
Waihi	Whangaehu	175	10/01/2001	2744120	6037795
Castlehill	Tauweru	240	10/04/1991	2762370	6045690
Te Weraiti	Tauweru	80	09/09/1997	2742125	6019985
Longbush	Southern Whangaehu	255	01/11/2006	2729856	5998567
Iraia	Ruakokoputuna	260	09/04/1969	2708410	5978155
Tanawa Hut	Whareama	280	01/01/1956	2774715	6046105

Table A1.2: River level/flow monitoring sites

Site Name	Start date	Catchment area (km <sup>2</sup> )	Easting	Northing	Comments
Waitohu Stream at Water Supply Intake	17/10/1994	19.2	2696903	6046500	
Mangaone Stream at Ratanui	13/01/1993	9.2	2691891	6039889	
Waikanae River at Water Treatment Plant	03/03/1975	125	2684589	6033100	
Mazengarb Stream at Scaife Drive	03/05/1995	4.5	2679099	6032582	Funded by KCDC
Wharemauku Stream at Coastlands	16/12/1980	7.8	2678860	6030142	Funded by KCDC
Hutt River at Kaitoke Weir	03/02/2004	86.8	2694200	6015000	River level only
Hutt River at Te Marua	05/03/1984	191	2690100	6012400	
Hutt River at Taita Gorge	16/03/1979	556	2676431	6003512	
Hutt River at Estuary Bridge	28/09/1976	623	2669300	5995300	River level only (tidal site)
Pakuratahi River at Truss Bridge	22/05/1978	37.2	2693700	6006900	
Mangaroa River at Te Marua	20/05/1977	102	2688773	6010299	
Akatarawa River at Cemetery	19/02/1979	114	2686308	6011215	
Whakatikei River at Dude Ranch	08/09/1976	46	2680600	6011900	
Mawaihakona 1 Stream at Golf Club	24/08/2006	-	2679500	6005500	Catchment area not defined (spring)
Waiwhetu Stream at Whites Line East	31/05/1978	11.6	2671018	5996214	
Wainuiomata River at Manuka Track	10/06/1982	27.1	2678249	5992347	
Wainuiomata River at Leonard Wood Park	14/04/1977	77.5	2673115	5989539	
Orongorongo River at Upper Dam Site	09/10/1980	7.1	2682500	5992700	
Orongorongo River at Truss Bridge	12/03/1998	31.7	2680182	5987879	
Taupo Stream at Flax Swamp	17/08/1979	8.2	2667093	6012771	Funded by Porirua City Council
Horokiri Stream at Snodgrass	15/02/2002	28.8	2671800	6012400	
Porirua Stream at Town Centre	08/09/1965	44.8	2664697	6005684	
Ruamahanga River at Mt Bruce	01/01/1975	76.5	2729300	6047000	
Ruamahanga River at Wardells	10/11/1954	637	2734700	6019200	

Site Name	Start date	Catchment area (km <sup>2</sup> )	Easting	Northing	Comments
Ruamahanga River at Gladstone Bridge	06/06/1992	1315	2730900	6011600	Rated for high stage only
Ruamahanga River at Waihenga Bridge	31/12/1956	2340	2714600	5998400	
Waipoua River at Mikimiki Bridge	05/02/1979	80.5	2730600	6036900	
Waingawa River at Kaituna	14/05/1976	79	2722700	6032400	
Mangatarere Stream at Gorge	09/02/1999	33.3	2721485	6027140	
Mangatarere Stream at Belvedere Bridge	26/01/2004	55.9	2721063	6018518	Rated for low flows only
Waiohine River at Gorge	27/12/1954	180	2711700	6018300	
Tauherenikau River at Gorge	30/03/1976	112	2708000	6012900	
Kopuaranga River at Palmers	15/03/1985	100	2735300	6039600	
Tauweru River at Te Weraiti	10/12/1969	373	2742100	6020100	Rated for high stage only
Huangarua River at Hautotara	01/01/1968	140	2717300	5987100	Rated for high stage only
Otukura Stream at Weir	17/12/1997	36.2	2708600	5999500	
Papawai Stream at U/S Oxi Pond	06/12/2005	-	2719168	6008530	Catchment area not defined (spring)
Tilsons Creek at Scott Culvert	03/11/2005	-	2719350	6009560	Catchment area not defined (spring)
Parkvale Stream at Renalls Weir	15/01/2002	-	2723514	6011211	Catchment area not defined
Otaki River at Pukehinau	17/07/1980	306	2695500	6040200	NIWA site partly funded by GW
Hutt River at Birchville	07/09/1970	427	2685600	6009900	NIWA site partly funded by GW
Pahaoa River at Hinakura	04/09/1986	563	2731700	5986500	NIWA site partly funded by GW

Table A1.3: Lake level monitoring sites

Site Name	Start date	Easting	Northing
Lake Wairarapa at Burlings	18/09/1953	2691800	5994800
Lake Onoke at Lake Ferry	27/04/1953	2689200	5977000
Lake Wairarapa at Barrage North	01/01/1974	2693400	5985800
Ruamahanga River at Barrage South	01/01/1974	2693400	5985800
Lake Kohangapiripiri	20/08/2007	2665237	5980984
Lake Kohangatera	17/08/2007	2665946	5979727

## Appendix 2: Monthly hydrological data summary

Table A2.1: Monthly rainfall totals (mm) for July to December 2007 and long-term (LT) mean monthly totals at Greater Wellington rainfall stations

Site	July		August		September		October		November		December	
	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean
Kapakapanui	199.5	191.2	209	189.6	126	232.9	257.5	259.1	204	213	83	266.7
McIntosh	588.5	472.2	449	412.1	303	476.3	608	593.8	323.5	516	217.5	482.7
Oriwa	381	361	389.5	344.4	213	486.6	511	575.5	409	511.3	160	562.6
Taungata	213	227.5	212	197.4	122	280.2	240.5	338.2	290.5	296	103.5	322.1
Otaki Depot	80.5	92.4	61	81.1	53	86	113.5	93.3	64.5	87.9	N/A	86.1
Transmission Lines	120	143	114.5	122.4	N/A	151	N/A	182.1	N/A	150.3	N/A	171
Water Treatment Plant	94	127.7	101	109	61	105.5	176	120.1	86	95.5	47.5	105.4
QE Park	95	N/A	91	N/A	32	N/A	132.5	N/A	N/A	N/A	37	N/A
Kaitoke Headworks	211.5	243.3	169.5	218.3	122.5	187.9	332.5	208.4	81	209	91.5	189.3
Te Marua	172	197.7	145.5	155.5	77.5	146.9	301	240.4	75	184.3	68	150.4
Centre Ridge	138	225.2	N/A	200.5	N/A	159.3	263	210.6	82	187.9	105.5	157.5
Tasman Vaccine Ltd	130.5	181	105	146.1	56.5	123.6	179.5	162.3	81.5	117.5	70	118.6
Warwicks	167	189.9	200	188.3	90.5	192.1	229	264.5	171	210.8	78.5	227.4
Cemetery	153.5	150.8	129	152.9	64.5	142.4	272.5	206.4	85.5	145	67.5	149.5
Blue Gum Spur	205	177.7	138	165.7	68	162	226	222	147	192.5	63.5	197
Birch Lane	127	161.2	88.5	163.8	38.5	84.8	157	147.2	47.5	106	68	123.4
Shandon Golf Club	83.5	115	63.5	103.3	34.5	57.8	147.5	99.9	43	73.4	58	83.5
Orongo Swamp	245	307.8	140	241.8	122.5	180.4	256.5	277.1	117.5	223.8	84.5	207.3
Wainuiomata Res.	180.5	232.6	79.5	209.5	96	158.2	184	167.5	78.5	128.9	47.5	130.3
Pencarrow Lakes	N/A	N/A	N/A	N/A	53.5	N/A	134	N/A	11	N/A	47.5	N/A
Whenua Tapu	116	101.4	77.5	90.4	35.5	93.7	133.5	112.9	34	87.2	39.5	77.6
Seton Nossiter Park	185.2	135.3	76.6	113.8	57.6	97	141	135.5	63	99	<u>70</u>	95.6
Quartz Hill	N/A	N/A	N/A	N/A	N/A	N/A	137	N/A	42.5	N/A	58	N/A
Karori Reservoir	169.4	139.8	88.2	122.3	62	99.1	166.8	106.3	38	90.7	79.2	88.6
Regional Council	137.8	107.3	75.6	84.6	50.6	61.1	122	96.9	25.2	73.3	69.2	65.8
Bannister	766	592.2	654	526.5	353.5	561.6	843.5	594.6	378.5	526	219	543.5
Angle Knob	824.5	626.3	670.5	669.9	420.5	613.3	1156	730.9	356.5	639.4	272.5	615.9
Carkeek	565.5	468.7	440.5	471.3	294	452.9	612	481.9	245.5	393.3	182.5	422.1
Bull Mound	534	486	372.5	449.3	283	403.5	563	476.1	169	408.7	232	390.2
Mt Bruce	229.5	238.9	<u>190</u>	230.7	136.5	206.5	459.5	272.1	92	224.3	126.5	190.2
Mauriceville	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Westons	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	128.5	N/A
Wairarapa College	74	121.4	61.4	92.9	69.6	67.7	99.2	99.8	17	73.8	61.6	79.3
Waingawa	189.5	233	183.5	181	116.5	166.3	342	239.1	49	187.1	90.5	145.4
Valley Hill	307.5	270.7	272	251.4	198	247.1	476	392.2	105	276.1	152	256.8
Phelps	171	220.9	128	209.6	110	167.8	299.5	206.3	42	182.3	99.5	156.6
Waiohine Gorge	191.5	N/A	154	N/A	121	N/A	333.5	N/A	44.5	N/A	101.5	N/A
Parkvale	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Site	July		August		September		October		November		December	
	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean
Alloa	89.2	118.9	64.2	104.7	70.4	86.3	134.6	99.5	29.6	89.7	75.8	82.7
Waihi	125	138.3	79	117.4	118	85.7	111.5	132.9	22.5	78.7	117	93.3
Castlehill	199	151.5	102.5	104.4	81	86.6	99.5	99.6	14	98.5	87.5	72.3
Te Weraiti	75.5	112.9	47.5	87.5	84.5	48.4	72	88.4	20.5	59.8	53.5	66.2
Longbush	99.5	N/A	47	N/A	63.5	N/A	82.5	N/A	29	N/A	39.5	N/A
Iraia	184	234.7	103	211.6	85	130.8	184	151.7	51.5	120.1	86	107.1
Tanawa Hut	263.5	172.4	113	138	83.5	115.7	104	98.6	22	74.3	92.5	92

Notes:

Numbers in italics and underlined indicate that monthly mean rainfall has been estimated from another rainfall station.

**Table A2.2: Monthly rainfall totals (mm) for January to June 2008 and long-term (LT) mean monthly totals at Greater Wellington rainfall stations**

Site	January		February		March		April		May		June	
	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean
Kapakapanui	350.5	147.3	61.5	161.5	210	164.4	219.5	144	49	210.1	279.5	226.4
McIntosh	365.5	344.1	154.5	346.2	357	365.3	N/A	319.4	N/A	415.6	528	462.7
Oriwa	431.5	303.8	150	314.3	300	309.6	258.5	281.8	81	402.3	458	414.9
Taungata	436.5	178	88.5	218.2	169.5	192	190.5	169.9	43.5	234.9	271.5	221.8
Otaki Depot	N/A	68.6	16	84.3	95	59.5	107.5	65.2	N/A	83	<u>117</u>	106.9
Transmission Lines	N/A	94.5	N/A	107.4	N/A	101.8	N/A	96.6	N/A	135.3	N/A	162.6
Water Treatment Plant	190.5	79.7	22.5	78.5	108	88.6	140.5	80.7	42.1	112.3	135.7	127
QE Park	84.5	N/A	17.5	N/A	115.5	N/A	112	N/A	44.5	N/A	176	N/A
Kaitoke Headworks	54.5	146.6	59.5	128.4	141	161.2	152	165.8	163.5	214.4	268	232.3
Te Marua	48.5	106	56.5	114.5	103	115.5	125	109.5	89	136.4	201.5	184.3
Centre Ridge	57.5	123.7	51.5	150.1	105.5	153.9	146	141.9	205.5	172.6	N/A	201.2
Tasman Vaccine Ltd	84.5	92.6	55.5	82	104.5	95.9	124.5	103.1	108.5	148.5	233	173.1
Warwicks	345	156.5	54.5	135	230	161.5	204.5	130.5	85.5	177.1	209	211.7
Cemetery	75.5	120.5	34	105.6	96.5	121.2	98	98.5	N/A	118.2	N/A	162.7
Blue Gum Spur	268.5	151.7	28.5	107.1	181.5	105.4	166	117.9	73.5	148.1	N/A	179.5
Birch Lane	37	94	44	116.5	104.5	63.1	98.5	68.7	74	88.9	202	138.8
Shandon Golf Club	29	55.8	52.5	58.6	101	40.1	112	47.9	89.5	67.7	156	115.4
Orongo Swamp	117.5	149.9	76	121	151.5	187.6	160	151.9	254	230.6	376	269.4
Wainuiomata Res.	65.5	106	53.5	108.3	96.5	126.3	123	146.7	205	207.6	329	209
Pencarrow Lakes	24	N/A	47.5	N/A	96.5	N/A	102	N/A	127.5	N/A	93.5	N/A
Whenua Tapu	79.5	71.5	31	88.8	106.5	62.9	108	53.6	57	84.1	128.5	103.5
Seton Nossiter Park	46.5	75.9	45	81.3	133.5	74.2	125.5	83.5	122	99.4	150.5	130.4
Quartz Hill	36.5	N/A	47	N/A	156.5	N/A	121.5	N/A	109.5	N/A	113	N/A
Karori Reservoir	34.2	80.5	47.2	76.4	166.6	85.5	143	97	152.8	120.6	126.6	127.9
Regional Council	23	67.9	43	60.2	123.6	55.7	96.4	53.2	119.6	78.6	N/A	99.8
Bannister	299	387.8	185	366.3	449	446.8	302.5	420.6	209	496.7	654	541.8
Angle Knob	257	456.1	206	389.1	471	452.6	315	479.8	293.5	601	662.5	660.3

Site	January		February		March		April		May		June	
	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean
Carkeek	214	293	129	274.8	313.5	333.4	257	290.3	188	411.9	467	445.8
Bull Mound	118.5	275.8	140	267	319	330.1	231.5	308.4	289.5	405.8	446	443.7
Mt Bruce	27.5	171.4	46.5	161.5	109.5	155	88	156.2	147.5	184.4	239	243.3
Mauriceville	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	165	N/A
Westons	31	N/A	45.5	N/A	127.5	N/A	137.5	N/A	117	N/A	241	N/A
Wairarapa College	9.6	58.6	13.6	61.1	55.2	66	93	48.4	96.6	69.9	98	104.9
Waingawa	16.5	118	43	127.1	122	122.2	106	134.5	111	138.6	206	210.7
Valley Hill	50	176.1	83	166.1	242.5	198.8	109.5	158.5	169	216	343	290.1
Phelps	21.5	115.3	42.5	123.6	137	149.4	117.5	145	171	183.4	209.5	212.2
Waiohine Gorge	26.5	N/A	51	N/A	158.5	N/A	126	N/A	175	N/A	N/A	N/A
Parkvale	N/A	N/A	29	N/A	43.5	N/A	84	N/A	88.5	N/A	105	N/A
Alloa	13.2	63.7	15.8	67.5	104.6	81.5	90.2	78.7	138.8	95.2	140.6	111.3
Waihi	31.5	60.1	11	81	77	63.3	187	56.9	N/A	72.2	N/A	127.1
Castlehill	21.5	69.8	30	69.0	67.5	73.2	102	81.9	143.5	84.6	116	115.8
Te Weraiti	17.5	53.4	12	47.3	37.5	55.5	104.5	48.3	130	61.7	101	80.7
Longbush	9.5	N/A	14.5	N/A	51	N/A	83.5	N/A	147.5	N/A	119	N/A
Iraia	26.5	86.6	46.5	91.7	80.5	126.7	108	135.8	252	167.3	245.5	214.3
Tanawa Hut	20.5	62.6	24.5	76.9	67	100.7	65.5	104.5	210.5	128.3	108.5	146

Notes:

Numbers in italics and underlined indicate that monthly mean rainfall has been estimated from another rainfall station.

**Table A2.3: Monthly mean river flows (m<sup>3</sup>/s) for July to December 2007 and long-term (LT) mean monthly flows at Greater Wellington river monitoring stations**

Site	July		August		September		October		November		December	
	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean
Otaki R at Pukehinau*	31.02	33.16	30.10	33.73	18.15	34.84	44.11	44.93	27.98	37.16	7.20	39.84
Waitohu S at Water Supply Intake	0.97	0.92	0.87	0.73	0.47	0.89	1.09	1.39	1.35	1.17	0.22	1.11
Mangaone S at Ratanui	0.34	0.40	0.30	0.36	0.14	0.36	0.40	0.59	0.51	0.42	0.12	0.40
Waikanae R at WTP	5.39	6.34	6.06	5.73	2.28	5.03	8.11	6.23	5.21	5.27	1.25	5.26
Mazengarb S at Scaife Drive	0.14	0.19	0.14	0.16	0.12	0.15	0.16	0.17	0.20	0.18	0.16	0.18
Wharemauku S at Coastlands	0.05	0.27	0.10	0.22	0.02	0.21	0.14	0.12	0.04	0.15	0.02	0.08
Hutt R at Kaitoke Weir	N/A – water level only											
Hutt R at Birchville*	28.48	33.01	23.40	29.69	9.55	25.95	37.79	30.97	12.67	23.05	5.20	20.08
Hutt R at Te Marua	19.17	15.68	14.08	13.59	6.74	11.93	21.74	17.76	6.14	11.16	2.84	10.66
Hutt R at Taita Gorge	29.14	35.00	25.94	31.82	11.05	25.54	38.47	36.35	14.04	27.82	6.43	25.67
Pakuratahi R at Truss Bridge	2.61	3.22	1.83	2.63	1.20	2.02	3.43	2.72	1.01	2.18	0.61	2.07
Mangaroa R at Te Marua	3.41	6.00	3.27	4.88	1.34	3.67	5.51	4.85	1.50	3.39	0.75	2.86
Akatarawa R at Cemetery	6.02	6.99	6.19	6.82	2.29	5.67	8.19	8.69	4.29	5.95	1.45	5.07

Site	July		August		September		October		November		December	
	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean
Whakatikei R at Dude Ranch	1.29	2.00	1.85	1.96	0.58	1.65	2.18	2.48	1.33	1.99	0.48	1.77
Mawaihakona 1 S at Golf Club	0.19	N/A	0.22	N/A	0.16	N/A	0.20	N/A	0.16	N/A	0.10	N/A
Waiwhetu S at Whites Line East	0.28	0.44	0.26	0.34	0.11	0.34	0.35	0.40	0.14	0.29	0.07	0.25
Wainuiomata R at Manuka Track	0.89	1.52	0.83	1.21	0.38	0.91	1.32	1.18	0.56	0.92	0.26	0.83
Wainuiomata R at LWP	2.06	4.46	2.06	3.43	0.76	2.76	2.97	2.99	1.06	2.36	0.51	1.92
Orongorongo R at Upper Dam Site	0.50	0.65	0.36	0.51	0.17	0.36	0.58	0.59	0.26	0.40	0.07	0.38
Orongorongo R at Truss Bridge	2.70	N/A	1.76	N/A	1.00	N/A	3.30	N/A	1.13	N/A	0.27	N/A
Taupo S at Flax Swamp	0.08	0.15	0.12	0.13	0.02	0.09	0.15	0.11	0.02	0.07	0.01	0.05
Horokiri S at Snodgrass	0.33	N/A	0.56	N/A	0.17	N/A	0.72	N/A	<u>0.18</u>	N/A	0.11	N/A
Porirua S at Town Centre	0.90	1.26	0.87	1.15	0.38	0.87	1.08	0.98	0.45	0.65	0.32	0.51
Ruamahanga R at Mt Bruce	16.43	12.68	14.75	12.24	7.77	12.14	20.72	13.14	6.68	10.75	3.25	10.41
Ruamahanga R at Wardells	33.12	39.20	32.85	34.07	17.72	28.06	51.44	32.11	10.64	21.86	5.69	18.61
Ruamahanga R at Gladstone Br	N/A – river level only											
Ruamahanga R at Waihenga Br	125.35	141.75	99.22	127.02	56.16	108.65	154.01	110.89	40.30	77.19	19.86	69.05
Waipoua R at Mikimiki Br	7.25	N/A	6.35	N/A	2.62	N/A	11.27	N/A	1.06	N/A	0.88	N/A
Waingawa R at Kaituna	16.41	13.04	12.85	12.75	6.43	12.32	17.94	13.20	5.11	10.39	3.13	10.40
Mangatarere S at Gorge	2.76	2.54	2.14	2.34	1.09	1.63	3.39	2.75	0.64	1.82	0.45	1.64
Waiohine R at Gorge	38.27	30.63	27.81	28.08	16.67	27.69	41.37	33.80	15.79	27.73	7.86	26.90
Tauherenikau R at Gorge	12.93	13.08	8.86	11.81	5.01	10.23	15.82	11.83	4.10	8.56	2.98	8.69
Kopuaranga R at Palmers	4.00	4.88	4.35	4.09	2.43	3.29	5.55	3.72	0.69	2.30	0.62	1.47
Tauweru R at Te Weraiti	N/A – river level only											
Huangaaru R at Hautotara	N/A – river level only											
Otukura S at Weir	0.27	0.97	0.33	1.00	0.24	0.70	0.55	0.89	0.20	0.43	0.19	0.40
Papawai S at U/S Oxi Pond	0.27	N/A	0.28	N/A	0.26	N/A	0.36	N/A	N/A	N/A	0.15	N/A
Tilsons Ck at Scott Culvert	0.19	N/A	0.18	N/A	0.17	N/A	N/A	N/A	N/A	N/A	0.13	N/A
Parkvale S at Renalls Weir	0.48	N/A	0.76	N/A	0.60	N/A	1.08	N/A	0.49	N/A	0.22	N/A
Pahaoa R at Hinakura*	23.09	30.69	7.58	19.26	9.35	13.12	6.21	10.36	1.35	3.98	0.80	2.11

Notes:

\*Data provided by NIWA

Numbers in italics and underlined indicate some missing data during the month, and so monthly mean is estimated

**Table A2.3: Monthly mean river flows (m<sup>3</sup>/s) for January to June 2008 and long-term (LT) mean monthly flows at Greater Wellington river monitoring stations**

Site	January		February		March		April		May		June	
	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean
Otaki R at Pukehinau*	27.01	22.97	6.68	18.65	12.70	19.78	15.26	19.55	13.45	27.42	28.63	33.87
Waitohu S at Water Supply Intake	2.00	0.56	0.21	0.62	0.27	0.46	0.42	0.46	0.24	0.64	0.67	0.83
Mangaone S at Ratanui	0.90	0.23	0.12	0.27	0.12	0.17	0.19	0.16	0.14	0.21	0.20	0.38
Waikanae R at WTP	9.00	3.74	1.25	3.45	1.60	2.80	2.89	2.98	2.93	4.08	3.17	5.47
Mazengarb S at Scaife Drive	0.15	0.16	0.14	0.15	0.14	0.12	0.14	0.11	0.12	0.13	0.12	0.16
Wharemauku S at Coastlands	0.08	0.06	0.02	0.03	0.03	0.03	0.07	0.03	0.08	0.06	0.08	0.10
Hutt R at Kaitoke Weir	N/A – water level only											
Hutt R at Birchville*	10.81	13.30	2.62	11.82	6.57	12.37	9.24	15.19	17.59	22.39	23.52	27.86
Hutt R at Te Marua	3.76	6.53	1.23	7.88	3.81	6.75	4.78	7.33	11.02	9.49	13.91	13.22
Hutt R at Taita Gorge	13.33	16.98	3.49	14.44	8.14	14.87	9.91	15.30	20.30	21.97	26.07	29.19
Pakuratahi R at Truss Bridge	1.01	1.23	0.21	1.29	0.55	1.59	1.11	1.39	2.89	2.03	3.12	2.66
Mangaroa R at Te Marua	1.03	1.87	0.35	1.63	0.44	1.38	0.92	2.23	2.36	3.42	3.84	4.68
Akatarawa R at Cemetery	5.38	3.64	1.09	3.48	2.39	3.08	3.28	3.50	3.42	4.97	4.85	6.17
Whakatikei R at Dude Ranch	2.72	1.34	0.40	1.14	0.72	1.02	1.00	1.12	1.14	1.56	1.36	1.93
Mawaihakona 1 S at Golf Club	0.11	N/A	0.10	N/A	0.08	N/A	0.10	N/A	0.14	N/A	0.14	N/A
Waiwhetu S at Whites Line East	0.06	0.21	0.06	0.23	0.08	0.18	0.13	0.19	0.19	0.25	0.45	0.34
Wainuiomata R at Manuka Track	0.37	0.57	0.18	0.37	0.22	0.47	0.34	0.48	0.98	0.85	1.77	1.15
Wainuiomata R at LWP	0.66	1.49	0.34	1.45	0.47	1.25	0.72	1.38	2.02	2.20	3.84	3.37
Orongorongo R at Upper Dam Site	0.26	0.24	0.05	0.25	0.13	0.24	0.22	0.26	0.48	0.44	0.78	0.54
Orongorongo R at Truss Bridge	1.01	N/A	0.18	N/A	0.62	N/A	0.93	N/A	3.80	N/A	5.49	N/A
Taupo S at Flax Swamp	0.04	0.04	0.01	0.05	0.03	0.03	0.05	0.04	0.11	0.07	0.13	0.11
Horokiri S at Snodgrass	0.42	N/A	0.08	N/A	0.17	N/A	0.29	N/A	0.43	N/A	0.63	N/A
Porirua S at Town Centre	0.34	0.37	0.26	0.38	0.41	0.36	0.48	0.49	0.95	0.70	0.95	1.00
Ruamahanga R at Mt Bruce	3.53	7.16	2.33	6.61	5.07	7.41	4.75	7.45	5.02	9.68	11.65	12.01
Ruamahanga R at Wardells	4.55	11.41	3.16	13.13	5.92	13.13	7.43	15.50	14.06	21.48	28.08	31.44
Ruamahanga R at Gladstone Br	N/A – river level only											
Ruamahanga R at Waihenga Br	17.99	45.06	10.75	44.32	21.82	48.02	27.00	56.82	54.92	77.43	89.16	111.99
Waipoua R at Mikimiki Br	0.31	N/A	0.26	N/A	0.57	N/A	N/A	N/A	2.27	N/A	4.68	N/A
Waingawa R at Kaituna	2.60	6.78	2.17	6.84	4.67	7.20	3.79	7.72	6.04	9.77	10.59	12.12
Mangatarere S at Gorge	0.18	0.97	0.16	1.16	0.67	1.05	0.42	0.97	N/A	1.61	2.41	2.77
Waiohine R at Gorge	10.52	17.19	5.67	16.78	13.74	17.32	10.70	18.01	15.69	22.60	26.46	27.63

Site	January		February		March		April		May		June	
	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean
Tauherenkau R at Gorge	2.19	5.29	1.51	5.10	4.03	6.00	3.78	6.60	8.75	9.10	9.95	11.79
Kopuaranga R at Palmers	0.32	0.92	0.24	1.57	0.25	1.13	0.41	1.48	1.79	2.39	3.60	4.04
Tauweru R at Te Weraiti	N/A – river level only											
Huangarua R at Hautotara	N/A – river level only											
Otukura S at Weir	0.07	0.22	0.07	0.25	0.09	0.23	0.20	0.26	0.65	0.31	0.94	0.45
Papawai S at U/S Oxi Pond	0.11	N/A	0.09	N/A	0.13	N/A	0.22	N/A	0.28	N/A	0.33	N/A
Tilsons Ck at Scott Culvert	0.12	N/A	0.13	N/A	0.15	N/A	0.18	N/A	0.21	N/A	0.22	N/A
Parkvale S at Renalls Weir	0.07	N/A	0.07	N/A	0.10	N/A	0.15	N/A	0.69	N/A	1.14	N/A
Pahaoa R at Hinakura*	0.13	1.33	0.03	4.01	0.27	5.57	0.79	5.96	14.41	7.47	13.99	16.12

Notes:

\*Data provided by NIWA

Numbers in italics and underlined indicate some missing data during the month, and so monthly mean is estimated

**Table A2.5: Monthly mean lake levels (mm) for July to December 2007 and long-term (LT) mean levels at Greater Wellington lake level monitoring stations**

Site	July		August		September		October		November		December	
	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean	2007	LT mean
Lake Onoke at Lake Ferry	10030	10117	10214	9998	10101	10001	10015	10007	10141	9922	9950	9806
Lake Wairarapa at Burlings	10239	10355	10123	10276	10069	10196	10219	10221	10107	10109	9947	10154
Lake Wairarapa at Barrage North	10190	10289	10094	10212	9997	10161	10293	10172	10066	1010	9985	10183
Ruamahanga River at Barrage South	10211	10401	10370	10293	10147	10224	10220	10209	10158	10069	9939	9945
Lake Kohangapiripiri	N/A	N/A	N/A	N/A	N/A	N/A	1431	N/A	1257	N/A	1156	N/A
Lake Kohangatera	N/A	N/A	N/A	N/A	N/A	N/A	288	N/A	355	N/A	298	N/A

**Table A2.6: Monthly mean lake levels (mm) for January to June 2008 and long-term (LT) mean levels at Greater Wellington lake level monitoring stations**

Site	January		February		March		April		May		June	
	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean	2008	LT mean
Lake Onoke at Lake Ferry	10438	9774	10734	9843	10381	10091	10672	10134	10009	10170	10625	10162
Lake Wairarapa at Burlings	10051	10118	10201	10101	10142	10092	10215	10133	10207	10198	10503	10266
Lake Wairarapa at Barrage North	10123	10139	10255	10095	10202	10081	10206	10117	10073	10195	10474	10244
Ruamahanga River at Barrage South	10428	9906	10737	9959	10368	10170	10695	10262	10088	10325	10764	10383
Lake Kohangapiripiri	1091	N/A	963	N/A	960	N/A	1054	N/A	1446	N/A	1364	N/A
Lake Kohangatera	235	N/A	151	N/A	258	N/A	407	N/A	468	N/A	712	N/A

### 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 at Water Supply Intake	900	
Otaki at Pukehinau	4500	
Mangaone at Ratanui	1700	
Waikanae at Water Treatment Plant	3200	
Hutt at Te Marua	3800	
Hutt at Birchville	3500	
Hutt at Taita Gorge	28000	
Mangaroa at Te Marua	2500	
Akatarawa at Cemetery	2000	
Waiwhetu at Whites Line East	1300	
Wainuiomata at Manuka Track	2000	
Wainuiomata at Leonard Wood Park	1500	
Porirua at Town Centre	900	
Ruamahanga at Mt Bruce	4000	
Ruamahanga at Wardells Bridge	3000	Initial alarm level
Ruamahanga at Gladstone Bridge	2000	
Ruamahanga at Waihenga Bridge	3350	Initial alarm level
Waipoua at Mikimiki Bridge	1500	Initial alarm level
Waingawa at Kaituna	2800	Initial alarm level
Mangatarere at Gorge	1800	
Waiohine at Gorge	2500	Initial alarm level
Tauweru at Te Weraiti	9000	
Huangerua at Hautotara	3400	

**Table A3.2: River level flood warning alarms triggered during 2007/08**

Event date	Alarm levels triggered	
2 July 2007	Ruamahanga at Waihenga	
12 August 2007	Ruamahanga at Wardells Ruamahanga at Waihenga	Ruamahanga at Gladstone
8 October 2007	Mangaroa at Te Marua Hutt at Birchville Otaki at Pukehinau Ruamahanga at Wardells Ruamahanga at Waihenga	Hutt at Te Marua Hutt at Taita Gorge Waiohine at Gorge Ruamahanga at Gladstone
17 October 2007	Waipoua at Mikimiki Ruamahanga at Gladstone	Ruamahanga at Wardells Ruamahanga at Waihenga
4 November 2007	Mangaone at Ratanui Otaki at Pukehinau	Waitohu at Water Supply Intake
14 November 2007	Porirua at Town Centre	
4 December 2007	Waitohu at Water Supply Intake	
7-8 January 2008	Waitohu at Water Supply Intake Waikanae at Water Treatment Plant Akatarawa at Cemetery	Mangaone at Ratanui Otaki at Pukehinau Hutt at Birchville
11 February 2008	Porirua at Town Centre	
29-30 April 2008	Waikanae at Water Treatment Plant Hutt at Birchville	Akatarawa at Cemetery Hutt at Te Marua
1 May 2008	Porirua at Town Centre	
8 June 2008	Ruamahanga at Wardells Ruamahanga at Waihenga	Ruamahanga at Gladstone
29 June 2008	Wainuiomata at Manuka Track Waiwhetu at Whites Line East	Wainuiomata at LW Park Huangarua at Hautotara