

Hydrology and meteorology of the Paekakariki storm 3 October 2003

Prepared by:
Laura Watts
Resource Investigations Department
Greater Wellington Regional Council

Contents

1.	Introduction	1
2.	Synoptic situation	1
3.	Rainfall analysis	1
3.1	When did it rain?	1
3.2	Rainfall distribution within the Wellington region	4
3.3	How much rain fell in Paekakariki?	5
3.4	Rainfall depth-duration-frequency	6
4.	River flow analysis	9
5.	Summary	11
	References	12
	Acknowledgements	12
	Appendix 1 – Severe weather warnings	13
	Appendix 2 – Telemetry alarms during the event	18
	Appendix 3 – Daily rainfall totals	19

1. Introduction

This report summarises the meteorology and hydrology of the 3 – 4 October 2003 storm event in the Wellington region. The report gives an overview of the synoptic weather patterns, quantifies rainfall and river flows, and provides a frequency analysis of the event using data from Greater Wellington's environmental monitoring network.

During the storm landslides and flooding caused extensive damage in Paekakariki and surrounding areas. This report does not describe the damage that occurred. For a description of the flooding and landslide activity the reader is referred to Duffill Watts & Tse (2003).

2. Synoptic situation

MetService Ltd provided the following description of the situation:

On Friday 3 October 2003, a strong moist north-westerly air stream covered New Zealand ahead of an active front and trough in the Tasman Sea. A broad rain band associated with the front brought rain to most the North Island and northern South Island. Over the southern North Island, a localised convergent wind zone embedded within the broad rain band brought a narrow band of very heavy rain to the Paekakariki area in the evening. This zone was a result of convergence between strong north to north-easterly winds over the Kapiti area, and strong north-westerly winds over Wellington.

Severe weather warnings were issued on October 2, 3 and 4, as shown in Appendix 1.

3. Rainfall analysis

Greater Wellington operates a network of 44 automatic rainfall stations. The key stations referred to in this report are shown in Figure 1. Note that although Greater Wellington has a rainfall station at Paekakariki, problems with this station experienced during the storm mean the data for 3 October 2003 is irretrievable.

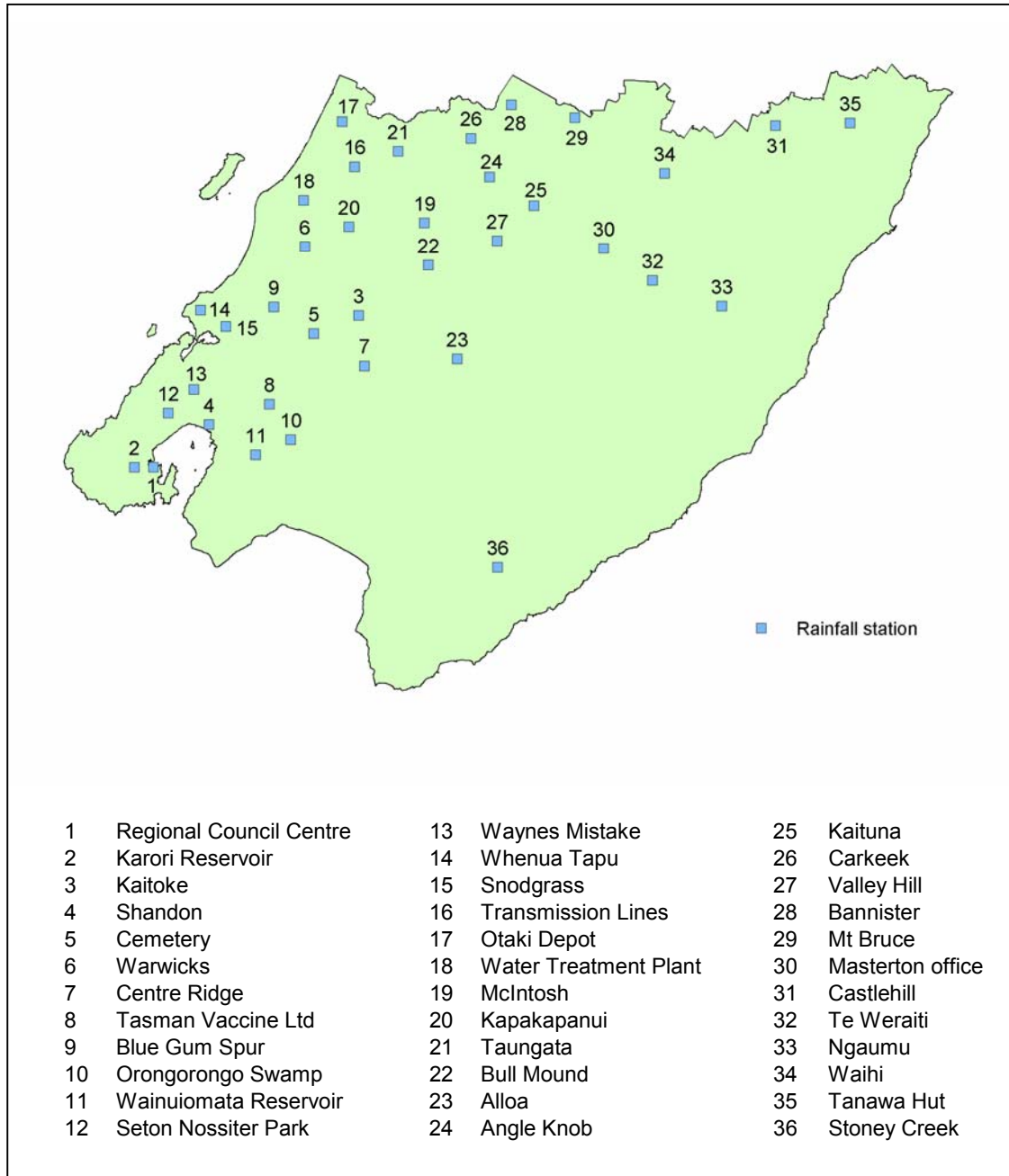
3.1 When did it rain?

The temporal pattern of the rainfall is illustrated in Figure 2, which shows the rainfall at four Greater Wellington rainfall stations. In most parts of the Wellington region rain started to fall between 5 and 6 am on 3 October, and continued steadily until about 10 pm. Rain commenced again at about 1 to 3 am on 4 October and continued until about 3 pm. The most intense rainfall was between 7 and 10 pm on 3 October. In the Tararua ranges, rainfall continued steadily throughout 3 October and through the morning of 4 October (as shown by the McIntosh rainfall graph in Figure 2).

Appendix 2 shows when Greater Wellington's rainfall alarms were triggered during the event. Note that many of the rainfall alarms were received between

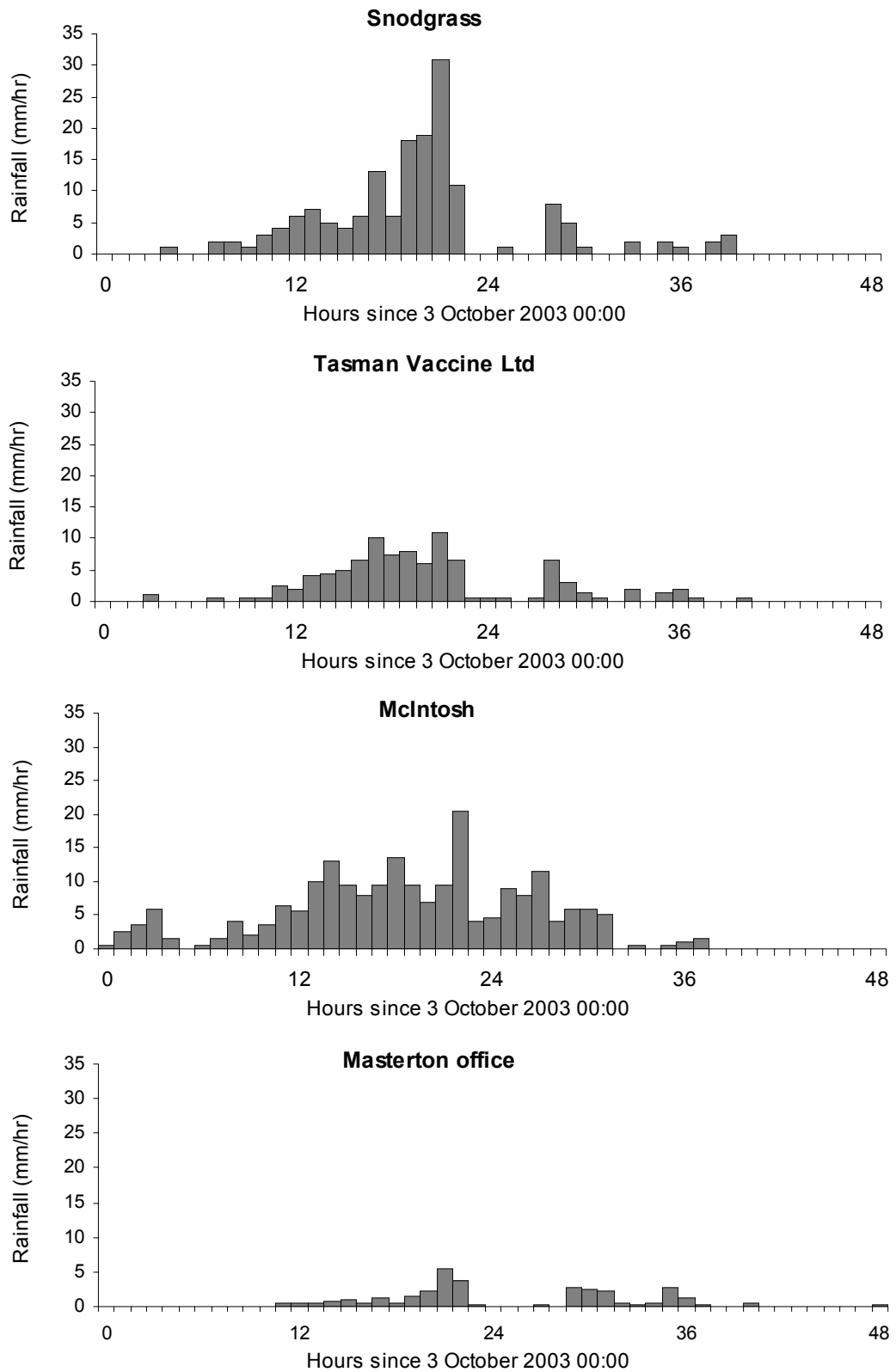
9 and 10 pm on 3 October, and by 4 October the rainfall had eased was generally not intense enough to trigger alarms.

Figure 1: Selected Greater Wellington rainfall stations¹



¹ Note the Ngaumu and Stoney Creek rainfall stations are National Rural Fire Authority (NRFA) stations but are included in this report to improve spatial coverage of the data.

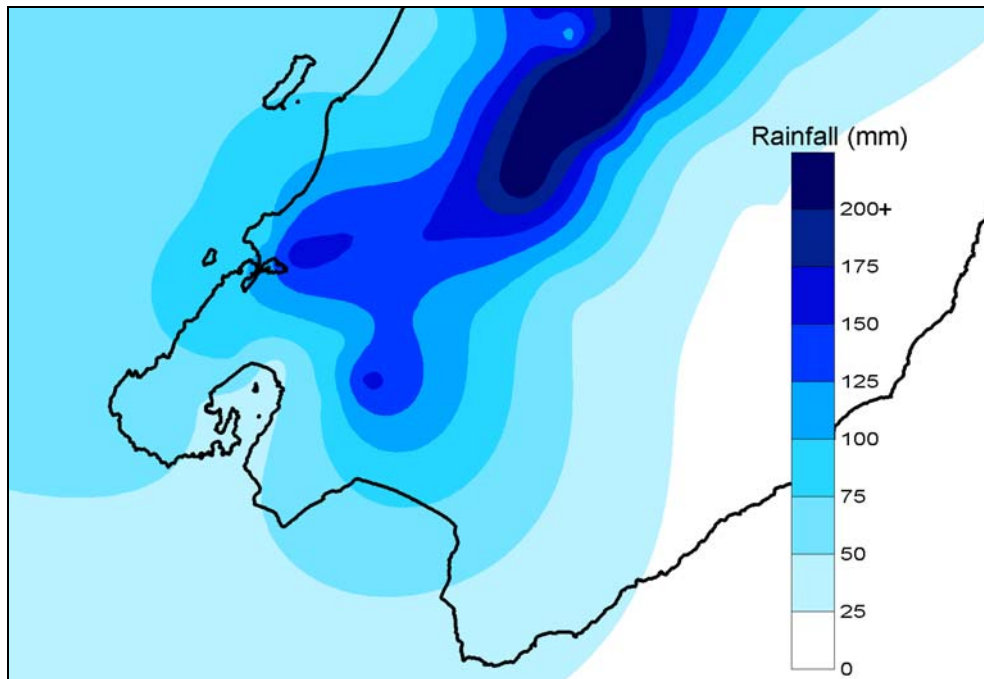
Figure 2: Rainfall distribution during 3 and 4 October, at selected rainfall stations



3.2 Rainfall distribution within the Wellington region

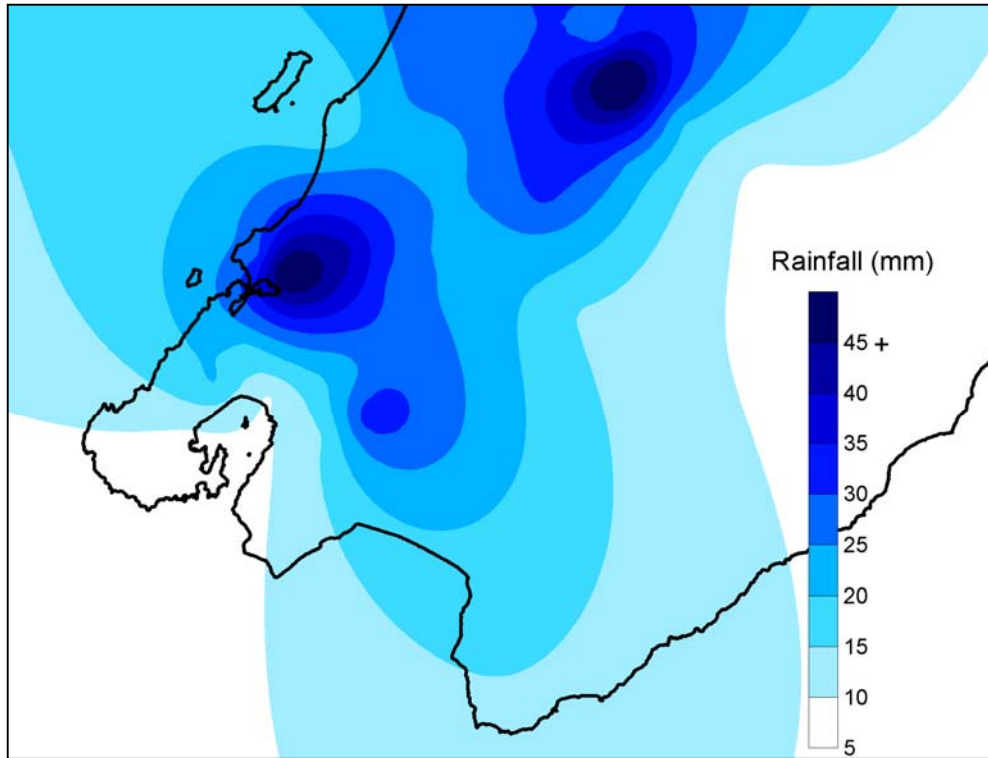
Figure 3 shows how the total rainfall on 3 and 4 October was distributed across the Wellington region. The Tararua ranges received the most rain, with well over 200 mm at some stations. Other areas of high rainfall include the Orongorongo ranges and the area inland of Paekakariki (measured at our Snodgrass and Blue Gum Spur rainfall stations).

Figure 3: Total rainfall during 3 – 4 October 2003



During this event a relatively short period of intense rainfall resulted in the flooding in Paekakariki. Figure 4 shows isohyets based on the maximum 2-hour rainfall totals from the stations shown in Figure 1. The map shows two areas of particularly heavy rainfall over two hours – one area in the Tararua ranges, and one area concentrated inland from Paekakariki, but also spilling over into the Hutt catchment.

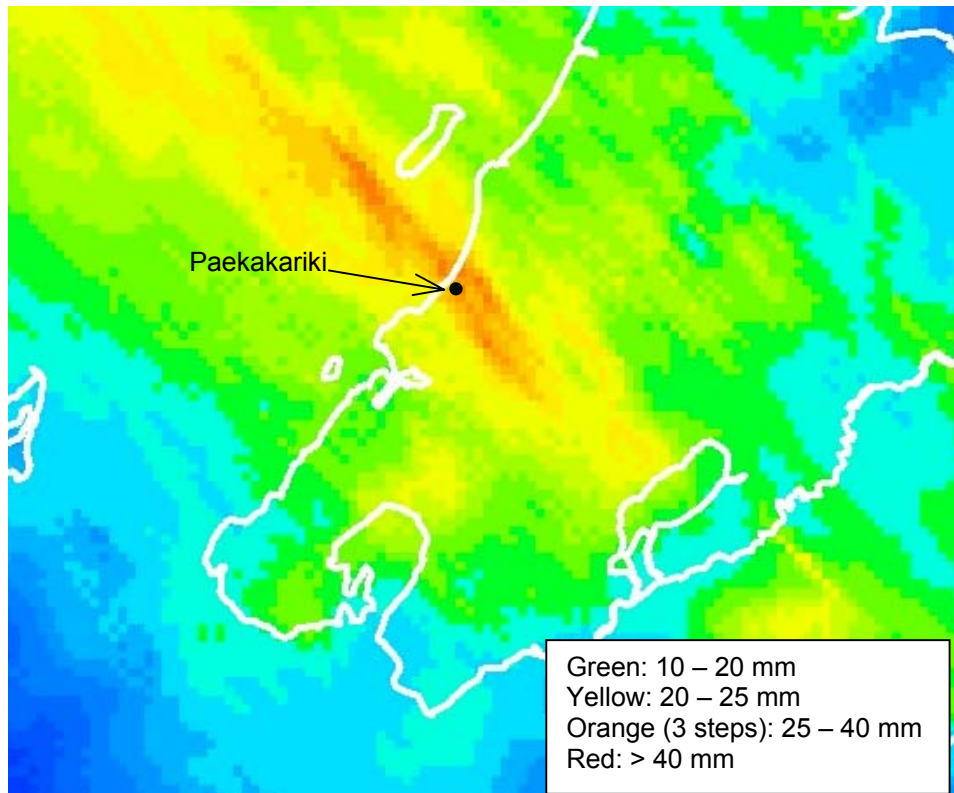
Figure 4: Maximum rainfall received within 2 hours, 3 – 4 October 2003



3.3 How much rain fell in Paekakariki?

The rainfall isohyets in Figures 3 and 4 were derived using data from Greater Wellington's rainfall stations, with rainfall being interpolated between stations. However, a rainfall station network may not detect localised heavy rainfall. Figure 5 shows the rainfall accumulation on the evening of 3 October, as measured by the MetService weather radar. The radar image shows that, in the 3-hour period between 7 and 10 pm, the heaviest rain fell in a band 3 to 4 kilometres wide stretching from Kapiti Island to Upper Hutt. The darkest red of the radar image shows the highest rainfall accumulation was in the hills behind Paekakariki.

Figure 5: Radar-derived rainfall accumulation image for 3 October 2003, 7 to 10 pm². Image provided by MetService Ltd.



The image in Figure 5 has been calibrated using the measurements of rainfall during the same period at Blue Gum Spur (51 mm) and Snodgrass (62 mm). A preliminary estimate of the rainfall in the hills immediately behind Paekakariki for the period 7 to 10 pm on 3 October is 70 – 75 mm (Crouch J., 2003, Pers. Comm.). This confirms that significantly more rain fell in Paekakariki than at the Greater Wellington rainfall stations during the period that resulted in flooding.

3.4 Rainfall depth-duration-frequency

To give an indication of the return period of the rainfall, a depth duration frequency analysis was carried out for each rainfall station with a sufficient length of record. The moving duration maximums were assigned a return period using the EV1 distribution and the L-moments method of fitting. If an unsatisfactory fit was obtained using EV1, the GEV distribution was used (providing the data record was longer than about 20 years). For rainfall stations with records less than 10 years the return period has been estimated using HIRDS (NIWA, 2002); these estimates should be treated with caution. The results of this analysis are shown in Table 1, with the significant return periods (greater than two years) highlighted.

² The image probably underestimates the rain that fell in the Taranui ranges, due to attenuation of the radar.

As shown by Table 1, the return period of the rainfall varied across the region. The nearest Greater Wellington rainfall station to Paekakariki for which data is available for this event is Snodgrass. The return period of the rainfall at this station is estimated to be between 20 years and 120 years for the various durations, with the highest return period assigned to the 6 hour period between 3:25 and 9:25 pm on 3 October.

The radar-derived rainfall accumulation image (Figure 5) and information provided by MetService Ltd indicate that more rain fell in the hills behind Paekakariki than at Snodgrass. Therefore the return period of the rainfall at Paekakariki may be equal to or greater than 120 years (for a 6 hour duration). Although this should be treated with caution due to the reliance on HIRDS for return period estimation, it is consistent with other work to estimate the rainfall intensity around Paekakariki (Duffill Watts & Tse, 2003).

The rainfall was also significant compared to events on record for the other stations near the band of heavy rainfall (Whenua Tapu, Blue Gum Spur and Waynes Mistake), Kaitoke, Wainuiomata / Orongorongo, and Otaki. In these areas the rainfall had a return period of between 3 and 8 years.

In most parts of the Tararua ranges and in the Wairarapa the rainfall was not significant compared to other events on record. However, in the Waingawa catchment (Angle Knob and Kaituna) and at Bull Mound the rainfall over a 12 to 24 hour period was of a 3 to 4 year return period.

Table 1: Rainfall depths and return periods at Greater Wellington rainfall stations, 3 – 4 October 2003 (significant return periods highlighted)

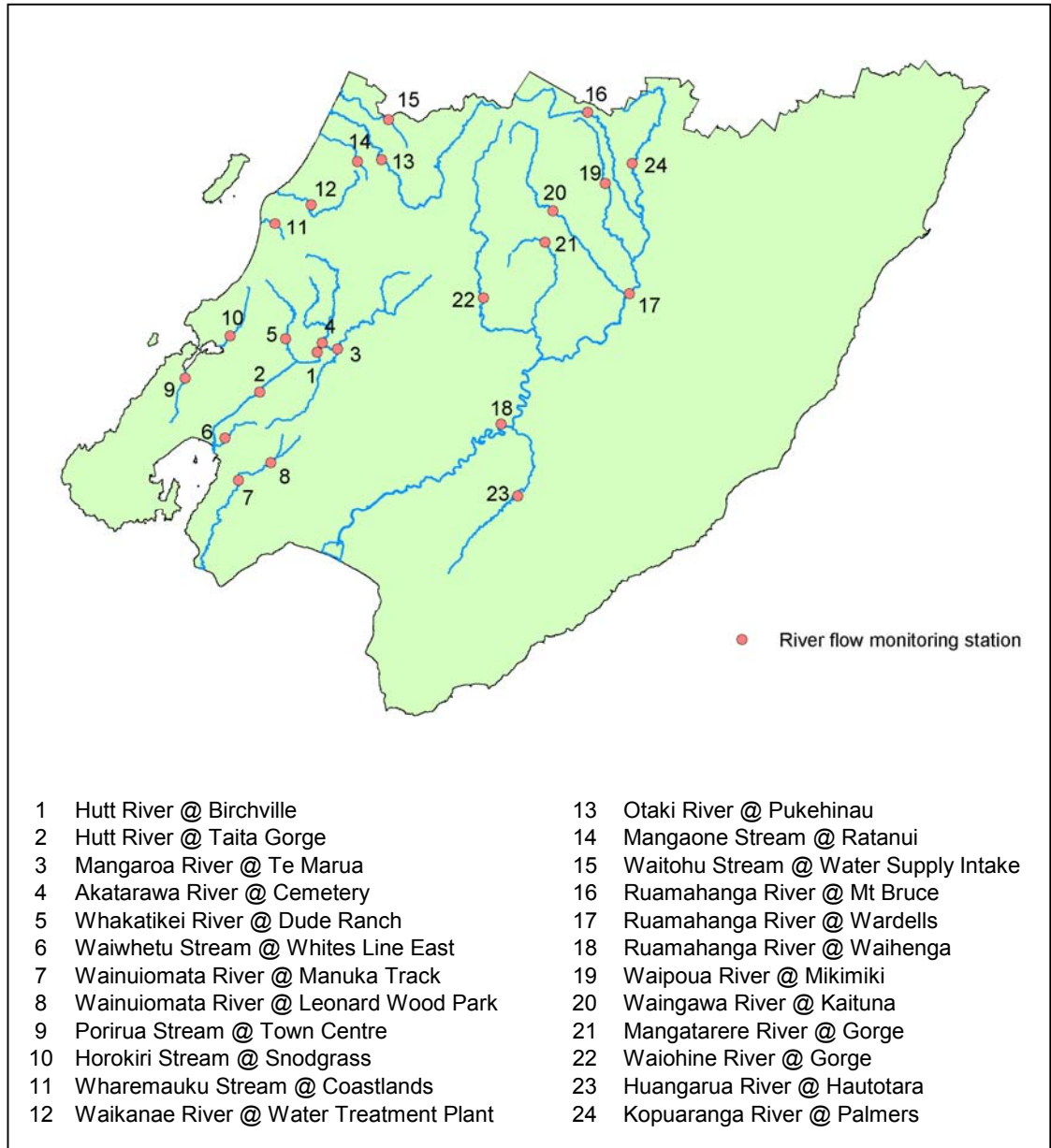
Rainfall station		Duration				
		30 mins	1 hr	6 hrs	12 hrs	24 hrs
Karori Reservoir	Depth (mm)	5	7	20.5	36	46
	Return period	< 2	< 2	< 2	< 2	< 2
Kaitoke	Depth (mm)	8.5	12.5	58.5	99.5	138.5
	Return period	2	3	5	6 – 7	4
Warwicks	Depth (mm)	9	14	59.5	92.5	126.5
	Return period	< 2	< 2	< 2	< 2	2
Centre Ridge	Depth (mm)	13	17.5	43	66	99
	Return period	2	< 2	< 2	< 2	< 2
Tasman Vaccine Ltd	Depth (mm)	11	14	51.5	74	88
	Return period	< 2	< 2	2	2 – 3	2 – 3
Blue Gum Spur	Depth (mm)	14	23.5	86	111.5	143
	Return period	2	3	8	6	6
Orongorongo Swamp	Depth (mm)	11	18.5	82.5	125	147
	Return period	< 2	< 2	6 – 7	8 – 10	3
Wainuiomata Reservoir	Depth (mm)	4.5	8.5	41.0	65.5	70.5
	Return period	5	5	4	2	< 2
Seton Nossiter Park	Depth (mm)	9.6	14.4	41.2	59.8	70.4
	Return period [‡]	< 2	< 2	2	< 2	< 2
Waynes Mistake	Depth (mm)	6.6	11	40.6	66.6	77.6
	Return period	< 2	< 2	< 2	3 – 4	2 – 3
Whenua Tapu	Depth (mm)	9	18	55	73	82.5
	Return period	< 2	< 2	5	6 – 7	5
Snodgrass	Depth (mm)	20	32	100	131	153
	Return period [‡]	20	30	120	90	45
Transmission Lines	Depth (mm)	16.5	21.5	53	70	86
	Return period	2	< 2	< 2	2	< 2
Otaki Depot	Depth (mm)	17.5	22.5	46	57.5	66.5
	Return period	6	6	6	6	4
Water Treatment Plant	Depth (mm)	7.0	13.5	45.5	61	75.5
	Return period	< 2	< 2	2	2	3
McIntosh	Depth (mm)	17.5	23.5	71.5	122.5	189.5
	Return period	< 2	< 2	< 2	< 2	< 2
Kapakapanui	Depth (mm)	7.5	12.5	40	64	94.5
	Return period	< 2	< 2	< 2	< 2	< 2
Bull Mound	Depth (mm)	10.5	17	84	138	203
	Return period	< 2	< 2	< 2	2.5	3
Alloa	Depth (mm)	5	8.8	23	38	53
	Return period [‡]	< 2	< 2	< 2	< 2	< 2
Angle Knob	Depth (mm)	17	31.5	157.5	259.5	345.5
	Return period	< 2	< 2	2	4	4
Kaituna	Depth (mm)	6	11.5	51.5	86	107.5
	Return period	< 2	< 2	3	4	3
Carkeek	Depth (mm)	9	16	48.5	73	100
	Return period	< 2	< 2	< 2	< 2	< 2
Valley Hill	Depth (mm)	7	13.5	55	88	114.5
	Return period [‡]	< 2	< 2	< 2	n/a	< 2
Mt Bruce	Depth (mm)	10.5	15	64.5	109.5	149
	Return period	< 2	< 2	< 2	< 2	3
Masterton Office	Depth (mm)	4	5.4	14.6	19.8	30.2
	Return period [‡]	< 2	< 2	< 2	< 2	< 2
Castlehill	Depth (mm)	4.5	8	16	26.5	37
	Return period [‡]	< 2	< 2	< 2	< 2	< 2

[‡] Based on a depth-duration-frequency derived using HIRDS v2.00 (NIWA, 2002)

4. River flow analysis

Greater Wellington operates a network of automatic river flow monitoring stations. The key stations used in this report are shown in Figure 6.

Figure 6: Selected Greater Wellington river flow monitoring stations



The storm event resulted in increased river flows at all the monitoring stations shown in Figure 6, with the peak flows generally occurring late on 3 October. Table 2 shows the peak flows recorded at each station and the corresponding return period. The return periods were estimated using an at-a-site analysis, by fitting an EV1 distribution to the annual maximum series (as recommended by Pearson & Davies (1997)).

Table 2: Peak flows at Greater Wellington river flow monitoring stations, 3 – 4 October 2003

Station	Date and time of peak flow	Peak flow (m ³ /s)	Estimated return period (years)
Hutt River @ Birchville	3/10 23:00	912	4
Hutt River @ Taita Gorge	3/10 24:00	1137	4
Mangaroa River @ Te Marua	3/10 22:15	230	11
Akatarawa River @ Cemetery	3/10 22:25	269	< 2
Whakatikei River @ Dude Ranch	3/10 22:00	180	60
Waiwhetu Stream @ Whites Line East	3/10 22:30	14	4
Wainuiomata River @ Manuka Track	3/10 22:45	22	< 2
Wainuiomata River @ Leonard Wood Park	3/10 22:00	72	3
Porirua Stream @ Town Centre	3/10 18:00	33.5	2
Horokiri Stream @ Snodgrass	3/10 21:45	67	n/a ³
Wharemauku Stream @ Coastlands	3/10 22:15	7.9	3
Waikanae River @ Water Treatment Plant	3/10 23:35	193	4 – 5
Otaki River @ Pukehinau	3/10 23:30	673	< 2
Mangaone Stream @ Ratanui	3/10 22:15	12.6	< 2
Waitohu Stream @ Water Supply Intake	3/10 22:15	37	< 2
Ruamahanga River @ Mt Bruce	3/10 20:30	183	< 2
Ruamahanga River @ Wardells	4/10 02:15	633	5
Ruamahanga River @ Waihenga	4/10 10:15	1350 ⁴	7
Waipoua River @ Mikimiki	3/10 22:15	260	n/a ³
Waingawa River @ Kaituna	3/10 18:30	220	< 2
Mangatarere River @ Gorge	3/10 23:15	51	< 2
Waiohine River @ Gorge	3/10 23:15	696	< 2
Huangarua River @ Hautotara	4/10 05:30	59	< 2
Kopuaranga River @ Palmers	4/10 11:00	45	< 2

The estimated return period of the peak river flows varied across the region. The Hutt River experienced a peak flow with approximately a 4 year return period. The Mangaroa River, one of the main tributaries of the Hutt River, had one of its highest flows since records began in 1977. This high flow is probably a result of some localised heavy rainfall due to the rain band shown in Figure 5.

Another tributary of the Hutt River, the Whakatikei River, experienced its highest flow since records began in 1976. The estimated return period of the flow is 60 years. The catchment of the Whakatikei River is located on the eastern side of the hills behind Paekakariki, within the area of heaviest rainfall as shown in Figures 4 and 5.

The Horokiri Stream, which also has its headwaters on the eastern side of the Paekakariki hill, had a flood flow that caused some damage. The return period

³ Return period cannot be estimated due to the short record at this site.

⁴ Total flow derived through a gauging of Waihenga (970 m³/s) and Jenkins Dip floodway (380 m³/s)

of this flow cannot be estimated due to the short record at this site (monitoring began in February 2002). However, the Horokiri Stream flow record correlates well with the Whakatikei River flow record. As the headwaters of both these waterways received heavy rainfall on 3 October, a return period of 60 years for the Horokiri Stream peak flow could be assumed.

On the Kapiti Coast, the Otaki River, Mangaone Stream and Waitohu Stream recorded insignificant flow peaks compared to other floods on record. However, the Waikanae River and Wharemauku Stream, which are nearer to the band of heavy rainfall that occurred over Paekakariki, had flow peaks with return periods between 3 and 5 years.

In general the high flows that occurred in the monitored Wairarapa rivers were less significant. However, due to sustained rainfall in the Tararua ranges, a significant peak flow occurred in the Ruamahanga River, particularly in its lower reaches (approximately a 7-year return period at Waihenga).

Greater Wellington does not monitor flow in the small streams above Paekakariki that resulted in the flooding on 3 October. The nearest monitored waterways are the Whakatikei River and the Horokiri Stream, which both have their headwaters on the eastern side of the hills behind Paekakariki. As discussed above, a return period of 60 years has been assigned to the peak flow that occurred in the Whakatikei River on 3 October.

5. Summary

On 3 and 4 October 2003, a storm event occurred in the Wellington region caused by a trough of low pressure over the North Island. A convergence zone embedded within the system caused a narrow band of heavy rainfall stretching south-east over Paekakariki during the evening of 3 October. Although the most rainfall over the two days occurred in the Tararua ranges, very intense rainfall over a short period occurred around Paekakariki due to that convergence zone.

The rainfall depth over a 6 hour duration (100 mm) was approximately a 120 year return period at the Snodgrass rainfall station (the nearest operative Greater Wellington rainfall station to Paekakariki). However, the return period of the rainfall that occurred in the hills behind Paekakariki may be greater than this. In some other parts of the Wellington region (Wainuiomata, Mangaroa, Kaitoke and Otaki) rainfall was significant but had a lower return period (2 to 8 years). Even though the rainfall was heavy in the Tararua ranges, it was generally not significant compared to other events on record.

Significantly high river flows were measured in Hutt River (and its tributaries the Mangaroa and Whakatikei Rivers), Waiwhetu Stream, Wainuiomata River, Horokiri Stream, Waikanae River and Ruamahanga River. The highest river flow return periods for the 3 October event were assigned to the Mangaroa River (11 year return period) and the Whakatikei River (60 year return period). This latter river has its headwaters within the area of heaviest rainfall that occurred behind Paekakariki, and is the best available indicator of the return period of the 3 October storm flows in that area.

References

Duffill Watts & Tse, 2003: Preliminary Review of the Background Causes of the Flooding Emergency at Paekakariki on 3 October 2003. Report prepared for Kapiti Coast District Council.

NIWA, 2002: HIRDS V2.0 – High Intensity Rainfall Design System.

Pearson, C & Davies, T., 1997: Stochastic Methods. In Mosley, M and Pearson, C., 1997: Floods and Droughts the New Zealand Experience. NZ Hydrological Society, Wellington.

Acknowledgements

John Crouch (MetService) provided the radar-derived rainfall accumulation image and the description of the synoptic situation.

Mike Gordon (Resource Investigations, Wairarapa Division) provided statistical analysis of the Wairarapa rainfall and river flow data contained in this report.

Appendix 1 – Severe weather warnings

SEVERE WEATHER WARNING. ISSUED BY MetService AT 12:01 pm 02-Oct-2003
DEEPENING LOW EXPECTED TO BRING WIDESPREAD HEAVY RAIN AND SEVERE NORTHERLY
GALES OVER NORTHERN AND CENTRAL NEW ZEALAND ON FRIDAY

MetService is warning of widespread heavy, driving rain and severe northerly gales over northern and central New Zealand on Friday. 100 to 150mm of rain is likely near the ranges of Buller and Nelson including the Richmond Range, Marlborough Sounds, Tararua Ranges, north Taranaki and the hill country of Taumarunui, Taupo and Waikato also Bay of Plenty and northern Gisborne. People in or near these areas should expect creeks and rivers to rise.

Forecasters are also warning of the likelihood of widespread gales. North to northwest winds could gust to between 120 and 140 km/h at times in exposed parts of Taranaki, Taumarunui, Taihape, Wellington, Wairarapa, Marlborough and north Canterbury at times on Friday and on Friday evening or overnight in exposed areas of Northland, Auckland, Coromandel Peninsula, Bay of Plenty, Gisborne and Hawkes Bay. These gusts coupled with the rain are likely to make driving hazardous especially for motorcyclists, large trucks and motorists towing caravans, and would damage trees and power lines. Motorists are advised to take extreme care tomorrow and boat owners should check moorings today before the winds get up.

FOR THE LATEST WEATHER AND FORECAST CHARTS PLEASE GO TO
<http://www.metservice.co.nz/maps/index.asp>
MORE DETAILED INFORMATION FOR EMERGENCY MANAGERS AND TECHNICAL USERS
FOLLOWS:

=====

HEAVY RAIN WARNING.

=====

AREA/S AFFECTED: RANGES OF BULLER NELSON MARLBOROUGH INCLUDING THE RICHMOND
RANGE AND SOUNDS, TARARUA RANGE, TARANAKI AND THE HIGHER SLOPES OF TAUMARUNUI
TAUPO, WAIKATO ALSO BAY OF PLENTY AND GISBORNE FROM ABOUT TOKOMARU BAY
NORTHWARDS

FORECAST:
RANGES OF BULLER, NELSON, MARLBOROUGH INCLUDING THE RICHMOND RANGE AND
SOUNDS ALSO TARARUA RANGE
In the 18 to 21 hours starting about 4am Friday in Buller and northwest Nelson and about 6am in other
areas expect 100 to 120mm of rain.

HIGHER PARTS OF MT TARANAKI, TAUMARUNUI, TAUPO AND WAIKATO INCLUDING
HEADWATERS OF THE WANGANUI RIVER
In the 21 hours from about 6am Friday, expect 120 to 150 mm of rain and 50 to 70mm at lower levels.

BAY OF PLENTY AND GISBORNE FROM ABOUT TOMARU BAY NORTHWARDS
In the 21 hours from about 9am Friday, 150mm of rain likely near the ranges and 50 to 70mm at low levels.

FREEZING LEVEL/SNOW CONDITIONS: Freezing level rising above 2400 metres on Friday morning.

=====

STRONG WIND WARNING.

=====

AREA/S AFFECTED: TARANAKI TAUMARUNUI TAIHAPE WELLINGTON WAIRARAPA
MARLBOROUGH NORTH CANTERBURY NORTHLAND AUCKLAND COROMANDEL PENINSULA
BAY OF PLENTY GISBORNE HAWKES BAY

FORECAST:
North to northwest winds are expected to pick up to 70 km/h gusts 120 km/h at times in exposed places on
Friday morning in Taranaki, Taumarunui, Taihape, Wellington, Wairarapa, Marlborough and north
Canterbury. Winds should ease in north Canterbury in the afternoon but gusts could peak at 140 km/h in
the other areas in the evening and spread to exposed areas of Northland, Auckland, Coromandel
Peninsula, Bay of Plenty, Gisborne and Hawkes Bay.

NEXT SEVERE WEATHER WARNING WILL BE ISSUED AT OR BEFORE 9:00pm Thursday 02-Oct-2003
Forecast prepared by: Ian Miller
A service provided through a contract with the Crown
(C) Copyright Meteorological Service of New Zealand Ltd 2003

SEVERE WEATHER WARNING. ISSUED BY MetService AT 8:32 pm 02-Oct-2003

HEAVY RAIN AND GALES ON THE WAY.

MetService is warning of widespread rain and northerly gales over northern and central New Zealand for Friday. Forecasters expect a low to deepen as it tracks towards the South Island. An active front, preceded by very strong northerly winds is likely to bring widespread rain, with heaviest falls about the central North Island high country from Taranaki to Bay of Plenty and northern Gisborne, also the Tararua Ranges, and the ranges of northern Marlborough, Nelson and Buller. In these areas 100 to 120mm of rain could fall in a 15 to 21 hour period in the ranges and 50 to 70mm lower down. People in these areas should be alert to rising creeks and rivers. In addition, north to northwest winds may rise to gale force in many exposed parts of the North Island and northern South Island, with gusts to 120 km/h. The windiest places are likely to be Taranaki and the central North Island high country, eastern parts from Gisborne to Wairarapa and about Wellington, eastern Marlborough and north Canterbury. The strongest winds are likely to be early evening in North Island areas and mid Friday in Marlborough and northern Canterbury. These gusts could be strong enough to damage trees and power lines and make driving hazardous for large vehicles and motorcycles.

FOR THE LATEST WEATHER AND FORECAST CHARTS PLEASE GO TO
<http://www.metservice.co.nz/maps/index.asp>

MORE DETAILED INFORMATION FOR EMERGENCY MANAGERS AND TECHNICAL USERS
FOLLOWS:

=====
HEAVY RAIN WARNING.
=====

AREAS AFFECTED: THE RANGES OF BULLER, NELSON AND NORTHERN MARLBOROUGH
THE TARARUA RANGES MT TARANAKI AND THE CENTRAL NORTH ISLAND HIGH COUNTRY FROM
EASTERN TARANAKI TO TAUPO INCLUDING THE HEADWATERS OF THE WHANGANUI RIVER
THE RANGES OF EASTERN BAY OF PLENTY AND NORTHERN GISBORNE

FORECAST:
RANGES OF BULLER, NELSON AND NORTHERN MARLBOROUGH INCLUDING THE RICHMOND
RANGE AND THE SOUNDS

In the 15 hours from 6am to 9pm on Friday 100 to 120mm of rain possible in the ranges in strong north to northwest winds. Peak intensities of 15 to 20mm per hour expected in the afternoon. In lower lying areas, 40 to 50mm possible.

HIGHER PARTS OF MT TARANAKI, TAUMARUNUI, TAUPO AND SOUTHWEST WAIKATO INCLUDING
HEADWATERS OF THE WHANGANUI RIVER

In the 15 to 18 hours from about 6am Friday, expect 100 to 120 mm of rain with intensities of 6 to 10mm at first, peaking at 15 to 20mm per hour for a time in the evening. On northern slopes of Mt Taranaki, up to 180mm possible with peak intensities 20 to 25mm per hour. At lower levels 40 to 60mm of rain is likely in some places.

THE TARARUA RANGES

In the 21 hours from 6am Friday to about 3am Saturday, 120 to 150mm possible on high parts of the ranges from about Otaki southwards and 60 to 80mm on lower western slopes. Heaviest falls are likely to be about Friday evening.

BAY OF PLENTY EAST OF ROTORUA AND THE GISBORNE RANGES FROM ABOUT
TOKOMARU BAY NORTHWARDS

In the 18 hours from about noon on Friday to 6am Saturday, 100 to 120mm of rain possible in the ranges and 40 to 60mm at lower levels in the west.

FREEZING LEVEL/SNOW CONDITIONS: Freezing level rising above
2400 metres on Friday morning.

=====
STRONG WIND WARNING.
=====

AREAS AFFECTED:
NORTHLAND AUCKLAND TARANAKI TAUMARUNUI TAIHAPE GISBORNE HAWKES BAY
WAIRARAPA WELLINGTON EASTERN MARLBOROUGH AND NORTH CANTERBURY FORECAST:

NORTHLAND AND AUCKLAND

Northerly winds rising to gale in exposed places Friday evening, with a few gusts reaching 100 to 120 km/h. Winds should die down by midnight Friday.

TARANAKI TAUMARUNUI TAIHAPE

Northerly winds increasing to 70 km/h by early afternoon on Friday with peak gusts reaching 130 km/h at times in exposed places, especially in the evening. Winds should then ease overnight.

GISBORNE HAWKES BAY WAIRARAPA WELLINGTON

Northwest winds are expected to rise to 70 km/h occasionally gusting 130 km/h between about 3pm and 10pm on Friday. Winds then easing overnight.

EASTERN MARLBOROUGH AND NORTH CANTERBURY

A burst of northwest gales 70kt gusting to 130 km/h is likely between 9am and late afternoon on Friday, with strongest winds about the middle of the day.

**NEXT SEVERE WEATHER WARNING WILL BE ISSUED AT OR BEFORE
9:00am Friday 03-Oct-2003**

Forecast prepared by: Bob Lake

For further information after 9pm contact Duty Forecaster Gerard Barrow

A service provided through a contract with the Crown

(C) Copyright Meteorological Service of New Zealand Ltd 2003

**SEVERE WEATHER WARNING. ISSUED BY MetService AT 8:22 am 03-Oct-2003
HEAVY RAIN AND GALES TODAY FOR PARTS OF THE NORTH ISLAND AND NORTHERN
SOUTH ISLAND.**

MetService is warning of widespread rain and northerly gales over northern and central New Zealand today. Forecasters expect a deep low to cross the South Island. An active front, preceded by very strong northerly winds is likely to bring widespread rain, with heaviest falls about the central North Island high country from Taranaki to Bay of Plenty and northern Gisborne, also the Tararua Ranges, and the ranges of northern Marlborough, Nelson and Buller. In these areas 100 to 120mm of rain could fall in a 15 to 21 hour period in the ranges and 50 to 70mm lower down. People in these areas should be alert to rising creeks and rivers. In addition, north to northwest winds may rise to gale force in many exposed parts of the North Island and northern South Island, with gusts to 120 kilometre/h. The windiest places are likely to be Taranaki and the central North Island high country, eastern parts from Eastern Bay of Plenty, and Gisborne to Wairarapa and about Wellington, eastern Marlborough and north Canterbury. The strongest winds are likely to be this afternoon or evening in North Island areas and about the middle of the day in Marlborough and northern Canterbury. These gusts could be strong enough to damage trees and power lines and make driving hazardous for large vehicles and motorcycles.

**FOR THE LATEST WEATHER AND FORECAST CHARTS PLEASE GO TO
<http://www.metservice.co.nz/maps/index.asp>**

**MORE DETAILED INFORMATION FOR EMERGENCY MANAGERS AND TECHNICAL USERS
FOLLOWS:**

=====

HEAVY RAIN WARNING.

=====

AREAS AFFECTED:

THE RANGES OF BULLER, NELSON AND NORTHERN MARLBOROUGH THE TARARUA RANGES
MT TARANAKI AND THE CENTRAL NORTH ISLAND HIGH COUNTRY FROM EASTERN TARANAKI TO
TAUPO INCLUDING THE HEADWATERS OF THE WHANGANUI RIVER THE RANGES OF EASTERN
BAY OF PLENTY AND NORTHERN GISBORNE

FORECAST:

THE RANGES OF BULLER, NELSON AND NORTHERN MARLBOROUGH INCLUDING THE
RICHMOND RANGE AND THE SOUNDS

In the 10 hours from 8am to 6pm today up to 100 mm of rain possible in the ranges in strong north to
northwest winds. Peak intensities of 15 to 20mm per hour expected in the afternoon. In lower lying areas,
30 to 40mm possible.

HIGHER PARTS OF MT TARANAKI, TAUMARUNUI, TAUPO AND SOUTHWEST WAIKATO INCLUDING
HEADWATERS OF THE WHANGANUI RIVER

In the 15 hours from 9am to midnight today, expect 100 to 120 mm of rain with intensities rising to 6 to
10mm per hour in the afternoon and peaking at 15 to 20mm per hour for a time in the evening. On
northern slopes of Mt Taranaki, up to 180mm possible with peak intensities 20 to 25mm per hour. At lower
levels 40 to 60mm of rain is likely in some places.

THE TARARUA RANGES

In the 15 hours from 9am to midnight today, 100 to 120mm possible on high parts of the ranges from about
Otaki southwards and 40 to 60mm on lower western slopes. Heaviest falls are likely to be from mid
afternoon to this evening.

BAY OF PLENTY EAST OF ROTORUA AND THE GISBORNE RANGES FROM ABOUT TOKOMARU BAY NORTHWARDS

In the 18 hours from about noon today to 6am Saturday, 100 to 120mm of rain possible in the ranges and 40 to 60mm at lower levels in the west.

FREEZING LEVEL/SNOW CONDITIONS: Freezing level rising above 2400 metres on Friday morning.

=====
STRONG WIND WARNING.
=====

AREAS AFFECTED:

NORTHLAND AUCKLAND TARANAKI TAUMARUNUI TAIHAPE BAY OF PLENTY GISBORNE HAWKES BAY WAIRARAPA WELLINGTON EASTERN MARLBOROUGH AND NORTH CANTERBURY
FORECAST:

NORTHLAND, AUCKLAND AND EASTERN BAY OF PLENTY

Northerly winds rising to gale in exposed places this evening, with a few gusts reaching 100 to 120 km/h. Winds should die down by midnight.

TARANAKI TAUMARUNUI TAIHAPE

Northerly winds increasing to 70 km/h by early this afternoon with peak gusts reaching 120 km/h at times in exposed places, especially late afternoon and early evening. Winds should then ease overnight.

GISBORNE HAWKES BAY WAIRARAPA WELLINGTON

Northwest winds are expected to rise to 70 km/h occasionally gusting 130 km/h between about 3pm and 10pm today. Winds then easing overnight.

EASTERN MARLBOROUGH AND NORTH CANTERBURY

A burst of northwest gales 70kt gusting to 130 km/h is likely between about 11am and 3pm today, then easing later in the afternoon.

NEXT SEVERE WEATHER WARNING WILL BE ISSUED AT OR BEFORE

9:00pm Friday 03-Oct-2003

Forecast prepared by: Bob Lake

A service provided through a contract with the Crown
(C) Copyright Meteorological Service of New Zealand Ltd 2003

SEVERE WEATHER WARNING.

ISSUED BY MetService AT 8:56 pm 03-Oct-2003

HEAVY RAIN AND GALES STILL EXPECTED TONIGHT FOR PARTS OF THE NORTH ISLAND WHILE WIND AND RAIN HAVE EASED IN THE UPPER SOUTH ISLAND.

The rain has eased on Mt Taranaki, in the ranges of Buller, Nelson and northern Marlborough and so the warnings for those areas are lifted.

However, over the rest of the northern half of the North Island east of Taranaki, a period of heavy rain and northerly gales is expected tonight. The heaviest falls are expected about the central North Island high country from Taranaki to Bay of Plenty and northern Gisborne. In these areas a further 50 to 60 mm may fall on the central plateau and 80 to 100mm further east in the Bay of Plenty ranges.

In addition, north to northwest gales are still likely in many exposed parts of the North Island, with gusts to 120 km/h. The windiest places are likely to be the central North Island high country, eastern parts from Eastern Bay of Plenty, and in the ranges of Gisborne and Hawkes Bay. Both rain and strong winds are expected to ease from the west during the night.

FOR THE LATEST WEATHER AND FORECAST CHARTS PLEASE GO TO

<http://www.metservice.co.nz/maps/index.asp>

MORE DETAILED INFORMATION FOR EMERGENCY MANAGERS AND TECHNICAL USERS
FOLLOWS: =====

HEAVY RAIN WARNING.
=====

AREA/S AFFECTED:

THE TARARUA RANGE THE CENTRAL NORTH ISLAND HIGH COUNTRY FROM TAUMARUNUI TO TAUPO INCLUDING THE HEADWATERS OF THE WHANGANUI RIVER THE RANGES OF EASTERN BAY OF PLENTY AND NORTHERN GISBORNE
FORECAST:

THE HIGHER PARTS OF TAUMARUNUI, TAUPO AND SOUTHWEST WAIKATO INCLUDING HEADWATERS OF THE WHANGANUI RIVER
In the 7 to 10 hours from 8pm Friday, expect a further 40 to 60mm.

THE TARARUA RANGES
The heaviest rainfall is likely now over but expect a further 40 to 60 mm about higher slopes in an east to northeasterly flow in the 4hours from 8pm until midnight.

BAY OF PLENTY EAST OF ROTORUA AND THE GISBORNE RANGES FROM ABOUT TOKOMARU BAY NORTHWARDS
In the 10 to 13 hours from 8pm today to 6am Saturday, expect a further 80 to 100mm of rain in the ranges and 30 to 50mm at lower levels in the west.

FREEZING LEVEL/SNOW CONDITIONS: Freezing level above 2600 metres.

=====
STRONG WIND WARNING.
=====

AREAS AFFECTED:
NORTHLAND AUCKLAND TARANAKI TAUMARUNUI TAIHAPE BAY OF PLENTY GISBORNE HAWKES BAY
FORECAST:

NORTHLAND AND AUCKLAND
Northerly gales in exposed places, with a few gusts reaching 100 to 120 km/h. Winds should die down from about midnight.

TARANAKI TAUMARUNUI TAIHAPE
North to northeasterly gales with gusts reaching 120 km/h at times in exposed places are expected to die down by midnight.

EASTERN BAY OF PLENTY, GISBORNE AND HAWKES BAY
Northwest winds are expected to rise to 70 km/h occasionally gusting 120 km/h in exposed areas next few hours and ease again by dawn Saturday morning.

=====
WARNINGS NO LONGER IN FORCE
=====

HEAVY RAIN WARNINGS. HAVE BEEN LIFTED FOR: THE RANGES OF BULLER, NELSON AND NORTHERN MARLBOROUGH, MT TARANAKI.
NO FURTHER WARNINGS WILL BE ISSUED FOR THIS EVENT FOR THE ABOVE AREAS.

STRONG WIND WARNINGS. HAVE BEEN LIFTED FOR: WAIRARAPA WELLINGTON EASTERN MARLBOROUGH AND NORTH CANTERBURY
NO FURTHER WARNINGS WILL BE ISSUED FOR THIS EVENT FOR THE ABOVE AREAS.

NEXT SEVERE WEATHER WARNING WILL BE ISSUED AT OR BEFORE
9:00am Saturday 04-Oct-2003

Forecast prepared by: PAUL MALLINSON
For further information after 9PM contact Duty Forecaster GEOFF SANDERS
A service provided through a contract with the Crown
(C) Copyright Meteorological Service of New Zealand Ltd 2003

Appendix 2 – Telemetry alarms during the event

Type	Station	Catchment	Alarm trigger	Date & time alarm received
Rainfall	Angle Knob	Waingawa	17.5 mm / 60 min	3/10 12:58
Rainfall	Angle Knob	Waingawa	25.5 mm / 60 min	3/10 13:58
Rainfall	Bull Mound	Tauherenikau	15.5 mm / 60 min	3/10 15:12
Rainfall	Orongorongo Swamp	Orongorongo	25 mm / 120 min	3/10 15:36
Rainfall	Warwicks	Akatarawa	15 mm / 120 min	3/10 16:54
Rainfall	Te Marua	Hutt	20 mm / 120 min	3/10 17:03
Rainfall	Tasman Vaccine Ltd	Mangaroa	21.5 mm / 120 min	3/10 18:25
Rainfall	Water Treatment Plant	Waikanae	20 mm / 120 min	3/10 20:55
Rainfall	Kapakapanui	Sth Waiotauru	20 mm / 120 min	3/10 21:02
Rainfall	Taugata	Waitatapia	20 mm / 120 min	3/10 21:18
Rainfall	Transmission Lines	Mangaone	23 mm / 120 min	3/10 21:19
Rainfall	Otaki Depot	Otaki	25 mm / 120 min	3/10 21:21
Rainfall	McIntosh	Penn Creek	32.5 mm / 120 min	3/10 21:41
Rainfall	Oriwa	Otaki	31.5 mm / 120 min	3/10 21:42
Rainfall	Centre Ridge	Pakuratahi	25.5 mm / 120 min	3/10 21:43
River level	Gorge	Waiohine	2584 mm	3/10 15:26
River level	Gorge	Waiohine	2903 mm	3/10 15:56
River level	Town Centre	Porirua	937 mm	3/10 16:30
River level	Birchville	Hutt	3512 mm	3/10 16:45
River level	Whites Line East	Waiwhetu	1504 mm	3/10 18:00
River level	Te Marua	Hutt	3805 mm	3/10 18:10
River level	Wardells	Ruamahanga	3019 mm	3/10 18:17
River level	Cemetery	Akatarawa	2008 mm	3/10 18:55
River level	Wardells	Ruamahanga	3365 mm	3/10 19:17
River level	Pukehinau	Otaki	4502 mm	3/10 19:45
River level	Te Marua	Mangaroa	2673 mm	3/10 19:45
River level	Water Treatment Plant	Waikanae	3214 mm	3/10 20:05
River level	Taita Gorge	Hutt	28041 mm	3/10 20:05
River level	Mikimiki	Waipoua	2429 mm	3/10 20:32
River level	Waihenga	Ruamahanga	3429 mm	3/10 20:55
River level	Waihenga	Ruamahanga	3513 mm	3/10 21:10
River level	Water Supply Intake	Waitohu	903 mm	3/10 21:30
River level	Mikimiki	Waipoua	2705 mm	3/10 22:17
River level	Waihenga	Ruamahanga	3819 mm	3/10 22:25
River level	Wardells	Ruamahanga	4008 mm	3/10 22:32
River level	Manuka Track	Wainuiomata	2004 mm	3/10 22:45
River level	Gorge	Waiohine	3666 mm	3/10 22:56
River level	Gorge	Mangatarere	1815 mm	3/10 23:35
River level	Waihenga	Ruamahanga	4234 mm	4/10 00:55
River level	Gorge	Waiohine	2807 mm	4/10 03:57
River level	Cemetery	Akatarawa	2028 mm	4/10 05:50
River level	Te Marua	Hutt	3814 mm	4/10 06:15
River level	Gorge	Waiohine	2501 mm	4/10 06:57
Lake level	Ferry	Onoke	10622 mm	4/10 11:32
Lake level	Ferry	Onoke	10614 mm	5/10 12:03

Appendix 3 – Daily rainfall totals

Station	Catchment	3/10/03	4/10/03	Total during event
Regional Council Centre	Wellington	25.8	13.6	39.4
Karori Reservoir	Karori	38.5	23.0	61.5
Kaitoke	Hutt	111.0	39.5	150.5
Shandon	Hutt	35.0	7.0	42.0
Cemetery	Akatarawa (Hutt)	104.0	36.5	140.5
Warwicks	Akatarawa (Hutt)	103.5	27.5	131.0
Centre Ridge	Pakuratahi (Hutt)	70.0	39.0	109.0
Tasman Vaccine Ltd	Mangaroa (Hutt)	77.0	19.0	96.0
Blue Gum Spur	Whakatikei (Hutt)	119.5	31.0	150.5
Orongorongo Swamp	Orongorongo	133.0	28.0	161.0
Wainuiomata Reservoir	Wainuiomata	68.5	12.0	80.5
Seton Nossiter Park	Porirua	64.6	17.8	82.4
Waynes Mistake	Porirua	74.4	13.4	87.8
Whenua Tapu	Taupo Swamp	79.0	8.5	87.5
Snodgrass	Horokiri Stream	139.0	25.0	164.0
Transmission Lines	Mangaone	78.0	11.5	89.5
Otaki Depot	Otaki	63.0	4.5	67.5
Water Treatment Plant	Waikanae	68.5	10.0	78.5
McIntosh	Penn Creek	155.5	53.0	208.5
Kapakapanui	Sth Waiotauru	72.5	29.5	102.0
Taungata	Waitatapia	79.5	29.5	109.0
Bull Mound	Tauherenikau	165.5	60.0	225.5
Alloa	Tauherenikau	32.8	24.0	56.8
Angle Knob	Waingawa	306.0	61.0	367.0
Kaituna	Waingawa	92.0	23.5	115.5
Carkeek	Waiohine	76.5	30.0	106.5
Valley Hill	Mangatarere	97.5	25.0	122.5
Bannister	Ruamahanga	146.5	65.5	212.0
Mt Bruce	Ruamahanga	123.5	33.0	156.5
Masterton Office	Masterton	18.2	13.6	31.8
Castlehill	Taueru	17.5	20.5	38.0
Te Weraiti	Taueru	11.8	14.0	25.8
Ngaumu	Wainuioru	10.0	7.8	17.8
Waihi	Whangaehu	31.6	13	44.8
Tanawa Hut	Whareama	10.5	15.0	25.5
Stoney Creek	Awhea	16.2	14.0	30.2