AGENDA ITEM NO: 8(b)	SUBJECT: **How might climate change influence our already presented assessment of the environmental effects/risks of continuing to defer implementation of HWRRP minimum flows?**
AUTHORS: Suzanne Gabites, Jeanine Topélen	DATE OF MEETING: 20 November 2017

Action required

- Zone committee members gain a good understanding of the effect of climate change on the assessment of the environmental implications of delaying the implementation of the HWRRP minimum flows, as already presented at the committee meeting on 16 October 2017.

Work undertaken

We have pulled together information available from various organisations such as Hadley Centre for Climate Change, NIWA, Stats NZ and MfE around climate change and predictions for New Zealand climate. We used this information and flow records from the Waiau River at Marble Point and the Hurunui at Mandamus in a desktop assessment of the influence of climate change on the environmental risk of a further delay in fully implementing the HWRRP flow regimes.

Summary of results

- New Zealand's climate entered a positive phase of Interdecadal Pacific Oscillation (IPO) (a climate cycle of up to 30 years) and is currently experiencing a weak La Niña (part of a 3-7 year ENSO climate cycle).
- Seasonal and interannual variability in combination with ENSO/IPO phases are superimposed on climate change, making quantitative assessments extremely difficult and uncertain.
- Given the information available we would expect our assessed environmental effects of delaying implementation of HWRRP minimum flows (already presented) to be similar or slightly worse in the next 15 years all other factors remaining equal.

Background and purpose

This paper will discuss the likely effect of climate change on the environmental risks of continuiing to defer the implementation of HWRRP minimum flows. It is not a full assesment of climate change implications for the Hurunui River and Waiau River catchments and or the HWRRP flow regimes in general.

It is important to note that climate conditions in the upper catchment of both rivers affect flow restrictions and climate conditions on the plains are the main driver for demand.

The maximum time period of interest is 15 years (2033) because this is the duration of AIC's existing consent and is therefore the longest period of delay to full implementation of HWRRP flows if there was no consent review. Shorter time periods are of interest within that (e.g., 2 years and 5 years out), however our assessment does not suggest any detectable difference from what we've presented earlier as a result of climate change over these shorter periods. This is because seasonal and inter annual climate variablity are often greater than the long-term underlying climate change.

El Niño – Southern Oscillation (ENSO) and Interdecadal Pacific Oscillation (IPO) drive natural climate fluctuations which also causes long-term climate change to be less apparent. ENSO (El Niño/La Niña) events occur irregularly, from 3 to 7 years, and last for up to 18 months, whereas IPO events can last for three decades. The strength and intensity of these climatic cycles can vary significantly. In terms of the impact of these on river flows in the Hurunui and Waiau rivers: during an El Niño phase in summer westerly winds generally occur more often, with typically drier conditions in the east. The winter offers more and colder southerly winds. During a La Niña phase north- easterlies predominate, with higher precipitation in the east. IPO has a negative phase, with an increased tendency of El Niño events and a positive phase, with an increased tendency of La Niña events.
It is reported in MfE (2016) that there is high confidence that the ENSO/IPO will remain the dominant mode of natural climate variability in the 21st century, however there is less confidence in the amplitude and fluctuations.

Question 1: Where is New Zealand currently at with regard to the ENSO and IPO cycles? and therefore would we expect generally wetter or drier conditions from that in the coming 2, 5 and 15 years?

Data from the Hadley Centre for Climate Change suggests we have entered a positive IPO phase in 2014 (see Figure 1.). NIWA provides a plot with the Southern Oscillation Index over the last ten years (Figure 2.), showing we are currently experiencing a weak La Niña. NIWA has predicted that this is likely to strengthen in the coming months.

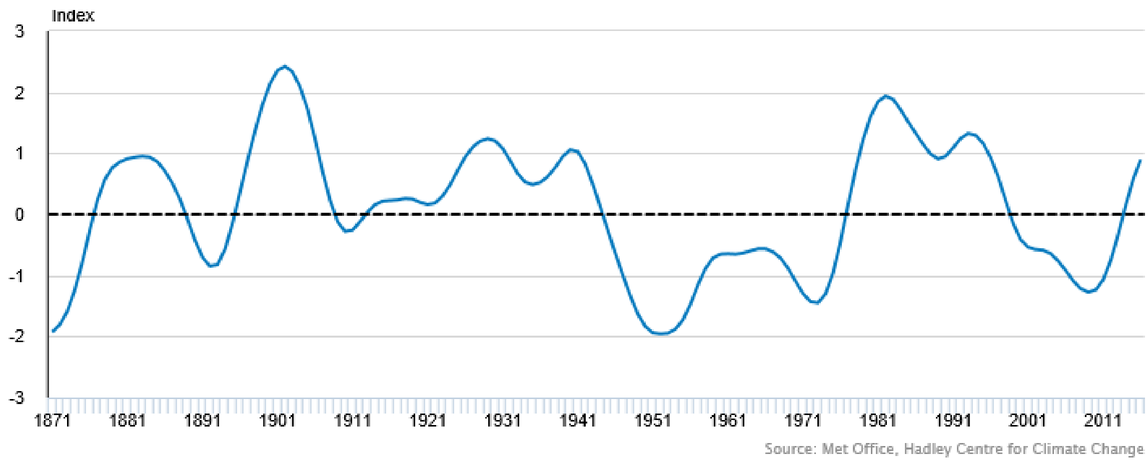
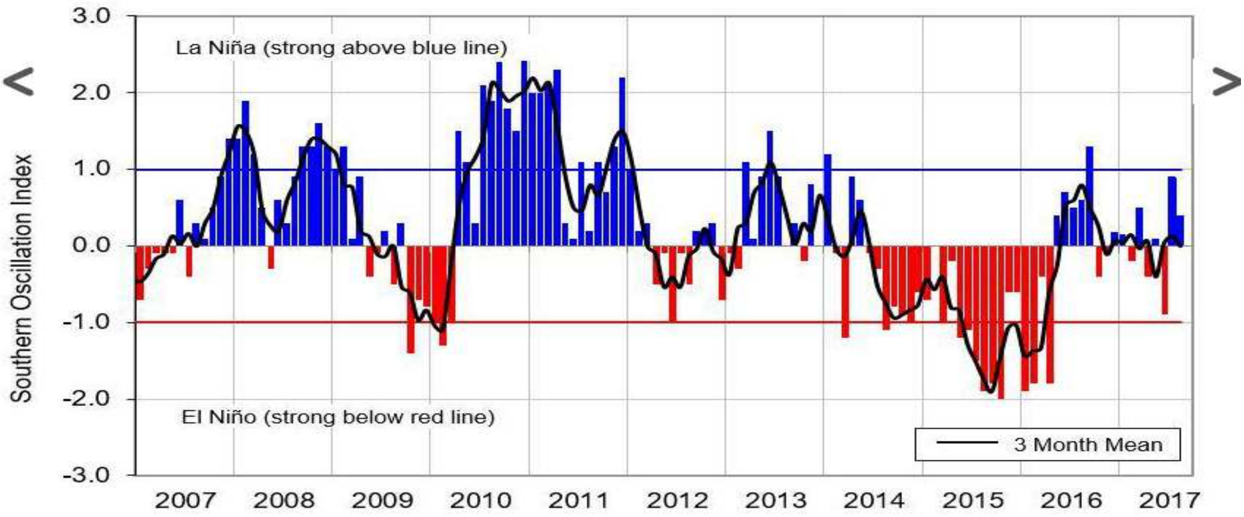


Figure 1. Annual Average Interdecadal Pacific Oscillation Index 1871-2016 (Hadley Centre for Climate Change)



Monthly values of the Southern Oscillation Index (SOI), a measure of changes in atmospheric pressures across the Pacific, and the 3-month mean (black line). SOI mean values: August SOI 0.4; June-August average 0.1.

Figure 2. Monthly values of Southern Oscillation Index from 2007 to 2017 (NIWA)

When comparing the monthly median flows for the Waiau River at Marble Point and the Hurunui River at Mandamus against the IPO index for the last two phases, we found that:

- During the positive phase (1977 to 1998) flows in both rivers in general tend to be higher than in the following negative phase (1999 to 2013).
- Very low monthly flows occur mainly in late winter and early spring during the positive phase (1977 to 1998).
- Very low monthly flows can occur from early spring to late autumn during the negative phase (1999-2013).

The New Zealand climate has entered a positive phase, which suggests flows are likely to be higher than in the 1999 to 2013 period. The last three years however (2014 to 2016) have not been in line with this.

When comparing the monthly median flows for the Waiau River at Marble Point and the Hurunui River at Mandamus for the last ten years against the ENSO events, we found that:

- The lowest spring flows occurred in 2011, more so in the Waiau River, (strong La Niña), 2014 (El Niño), 2015 (strong El Niño) and 2016 (weak El Niño).
- The lowest summer and autumn flows occurred in 2008 (strong La Niña), 2013 (weak La Niña), and 2015 (strong El Niño).

This indicates that low flows can happen under either La Niña or El Niño conditions and we cannot make any comments on shorter term expectations in terms of wetter or drier conditions based on that.

Question 2: What are the long term underlying climate change predictions for the Waiau River and the Hurunui River?

We have taken information from NIWA's 'Our Future Climate New Zealand' Tool. They provide data projections from six models. As the results from the models vary, we have worked with the information from the 'Six-model-average' scenarios (shown in Figure 3 to 6 in Appendix A).

We have included outputs from the low and the high Representative Concentration Pathway (RCP). 'Low' refers to small increase in greenhouse gas concentrations in the atmosphere and therefore small increase in overall global temperature. 'High' refers to large increase in greenhouse gas concentrations in the atmosphere and therefore large increase in overall global temperature.

We have only considered the near-future scenarios (covering 2016 to 2035) as these are relevant to the question asked.

It is worth noting the figures in Appendix A show predicted change in the mean seasonal rainfall; they do not provide information about daily variability, frequency and intensity of events. Changes in precipitation frequency and intensity can cause significant changes in river flow (occurence and duration), which could impact our identified environmental values.
Rainfall frequency and intensity is expected to increase for Canterbury, which suggests the time between events will be shorter but drier.

The Ministry for the Environment (MfE) has some information showing a similar picture to the graphs in Appendix A. Flows in the predominately alpine fed upper catchments would generally follow predictions expected as per Hokitika on the West Coast (Table 10 MfE, 2016) of the South Island which shows increases in predicted rainfall through all four seasons, while the eastern part of the catchment, (closest modelled location is Christchurch), show decreases in rainfall especially in winter (recharge) months (MfE, 2016). This would suggest slightly higher flows in the main stem, but drier on the plains.

Question 3: What are the likely effects of climate change in the next 15 years on the environmental risks of deferring the consent review in the Hurunui and Waiau zone?

Having considered long-term climate change predictions alongside shorter term ENSO cycles and even shorter term seasonal variability, it is clear that making accurate predictions for the next 15 years is difficult and fraught with uncertainty. We can make the following qualitative comments from the information available:

- Overall changes in the months critical for identified environmental values (August to April) are likely to be small.
- Precipitation will be more frequent and more intense throughout the seasons, with shorter but drier periods in between. Therefore low flow events might occur more often too, but will last for shorter periods of time and will have lower flows.
- The critical low flow thresholds might be reached more often, but for shorter periods of time.

Question 4: Where does our current assessment of environmental effects of delaying HWRRP minimum flows sit with regard to the above points?

Our current assessment was based on 10 years (2007- date) of data for the Hurunui River which experienced some very flows during this period. Of the 10 years used the Hurunui had 8 annual low flows (ALF) less than the long-term mean (7DMALF), 1 year was about equal to, and 1 year was slightly higher, which tells us that the 10 years used are likely to be more conservative than if we had used a longer period with more varied flows. However, accurate river flows in the lower part of the catchment are not available before 2007 and given that we wanted to show the risks to the river, we feel this was a useful exercise with the best dataset.

For the Waiau River we used data from 2010 – date, which had 5 annual low flows (ALF) less than the long-term mean (7DMALF), 1 year was about equal to, and 1 year was slightly higher, which tells us that the 7 years used are likely to be more conservative than if we had used a longer period with more varied flows. However, accurate river flows in the lower part of the catchment are not available before 2010 and given that we wanted to show the risks to the river, we feel this was a useful exercise with the best dataset.

Given the information available we would expect our assessed effects (already presented) to be similar or slightly worse in the near future all other factors remaining equal.

References:

MfE (June 2016) Climate Change Projections for New Zealand Atmospheric projections based on simulations undertaken for the IPCC 5th Assessment

https://www.niwa.co.nz/climate/information-and-resources/elnino/elnino-impacts-on-newzealand

http://www.mfe.govt.nz/publications/climate-change/coastal-hazards-and-climate-change-guidance-manual-local-government-ne-7

Hadley Centre

http://www.stats.govt.nz/browse_for_stats/environment/environmental-reporting-series/environmental-indicators/Home/Atmosphere-and-climate.aspx

https://researcharchive.lincoln.ac.nz/bitstream/handle/10182/5436/mohssen_modsim_11.pdf;sequence=1

http://www.stats.govt.nz/browse_for_stats/environment/environmental-reporting-series/environmental-indicators/Home/Atmosphere-and-climate/interdecadal-pacific-oscillations.aspx

https://ofcnz.niwa.co.nz/#/nationalMaps

https://www.ncdc.noaa.gov/teleconnections/enso/indicators/soi/

https://www.stats.govt.nz

Appendix A: Graphs of long-term climate change predictions

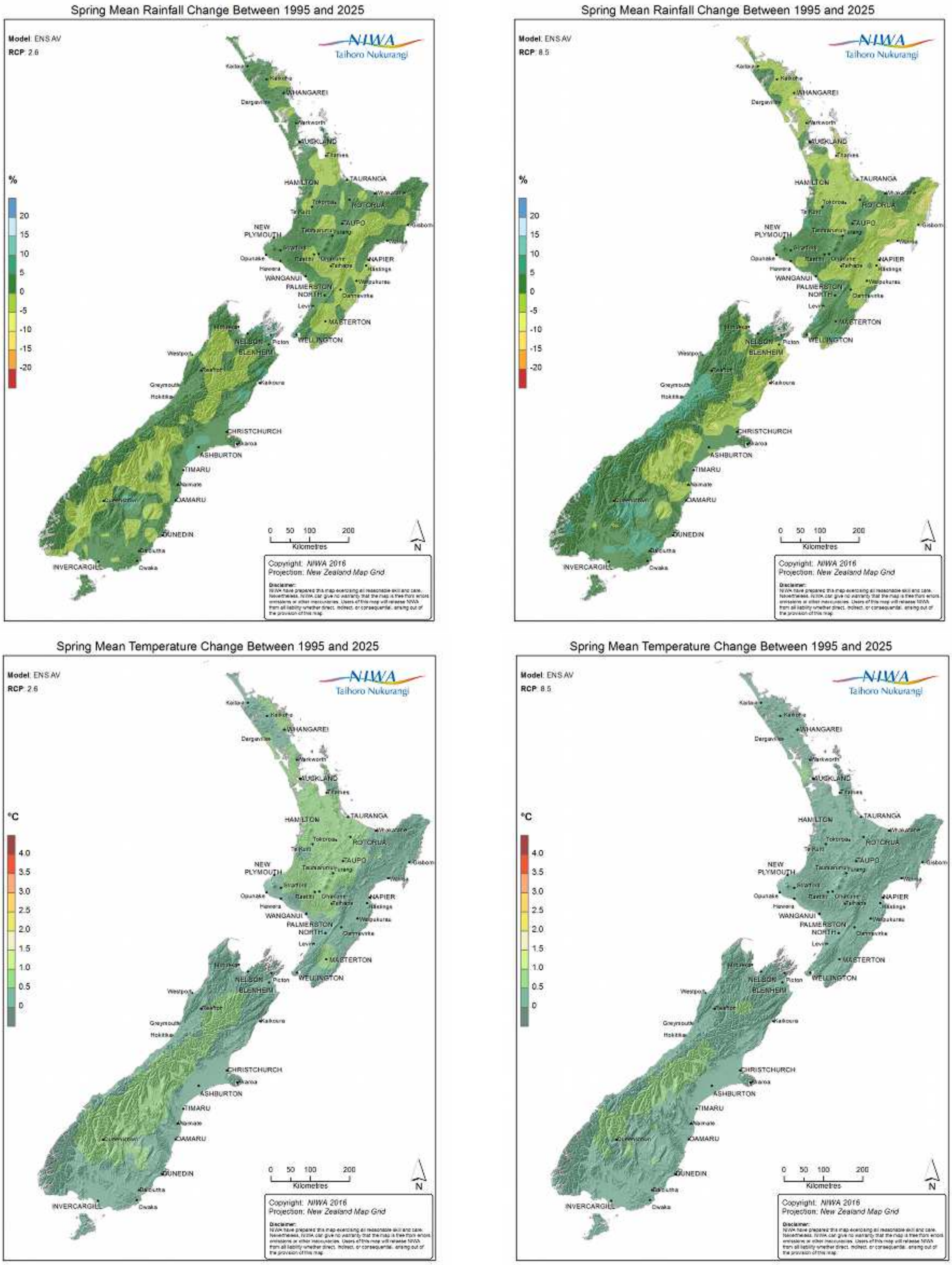


Figure 3. Change in mean spring rainfall (top) and temperature (bottom) comparing 1986-2005 to 2016-2035

Figure 3 shows no to a slight decrease in spring rainfall in the upper catchment of the Waiau and Hurunui Rivers under the low RCP scenario, which could result in slightly lower flows in the mainstems of both rivers. The scenario suggests a slight to moderate increase in rainfall on the plains, which would result in slightly higher tributary flow contribution and posibly lower irrigation demand. The high RCP scenario however, shows the opposite. Changes in temperature vary from 0 to 1 degree. This may result in higher evapotranspiration rates, which could indicate slightly lower flows.

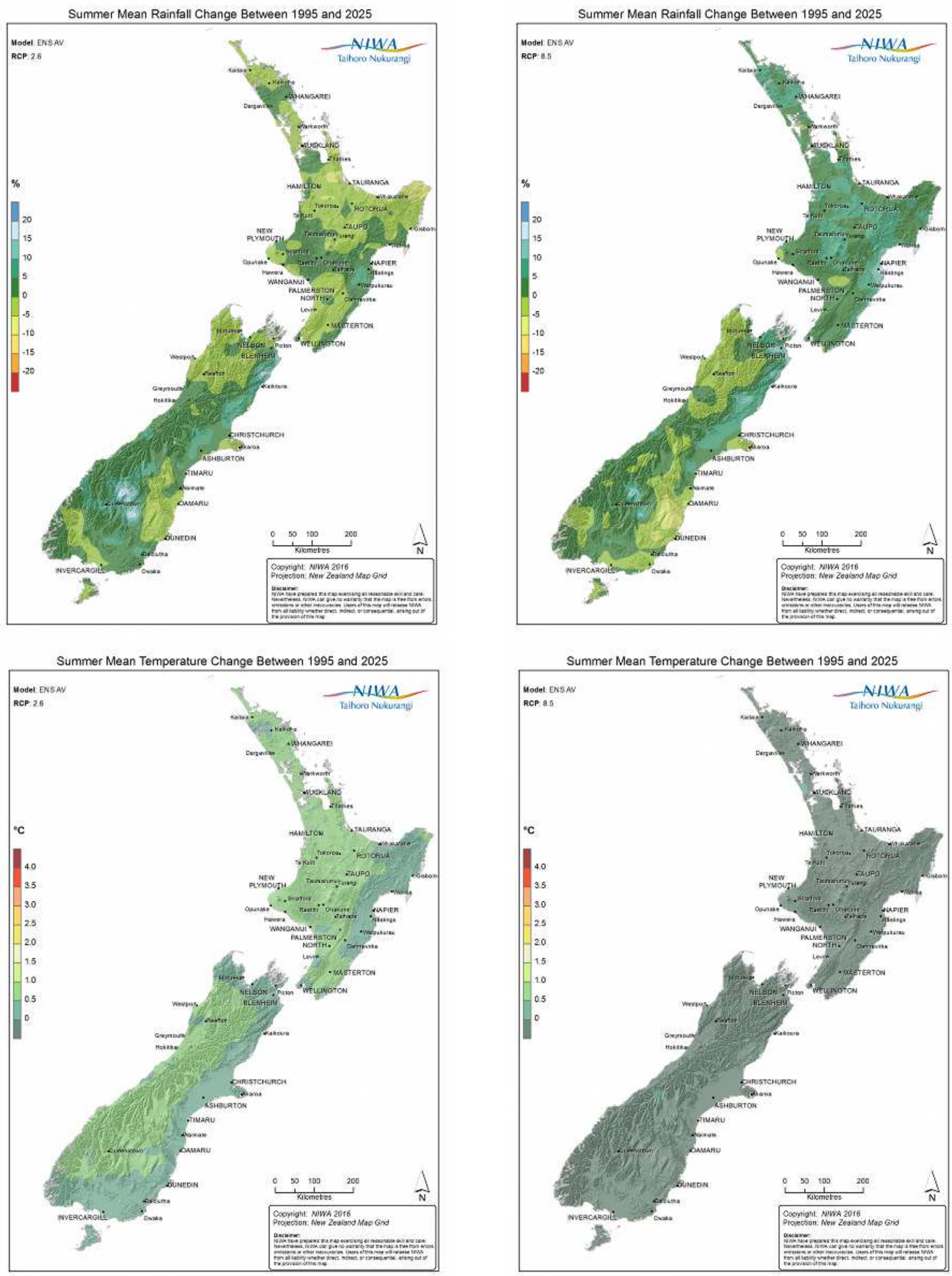


Figure 4. Change in mean summer rainfall (top) and temperature (bottom) comparing 1986-2005 to 2016-2035

Figure 4 shows no to a slight decrease in mean summer rainfall for the northern part of the upper catchment of the Waiau River and no to a slight increase for the southern part of the upper catchment of the Waiau and the upper catchment of the Hurunui river under the low RCP scenario. The plains would see no to a moderate increase in summer rainfall. This could result in a lower demand. The high RCP scenario shows a similar but more extreme picture, with the upper catchment of the Hurunui receiving less rainfall over summer too. Changes in temperature vary from 0 to 1 degree. This may result in higher evapotranspiration rates, which could indicate slightly lower flows.

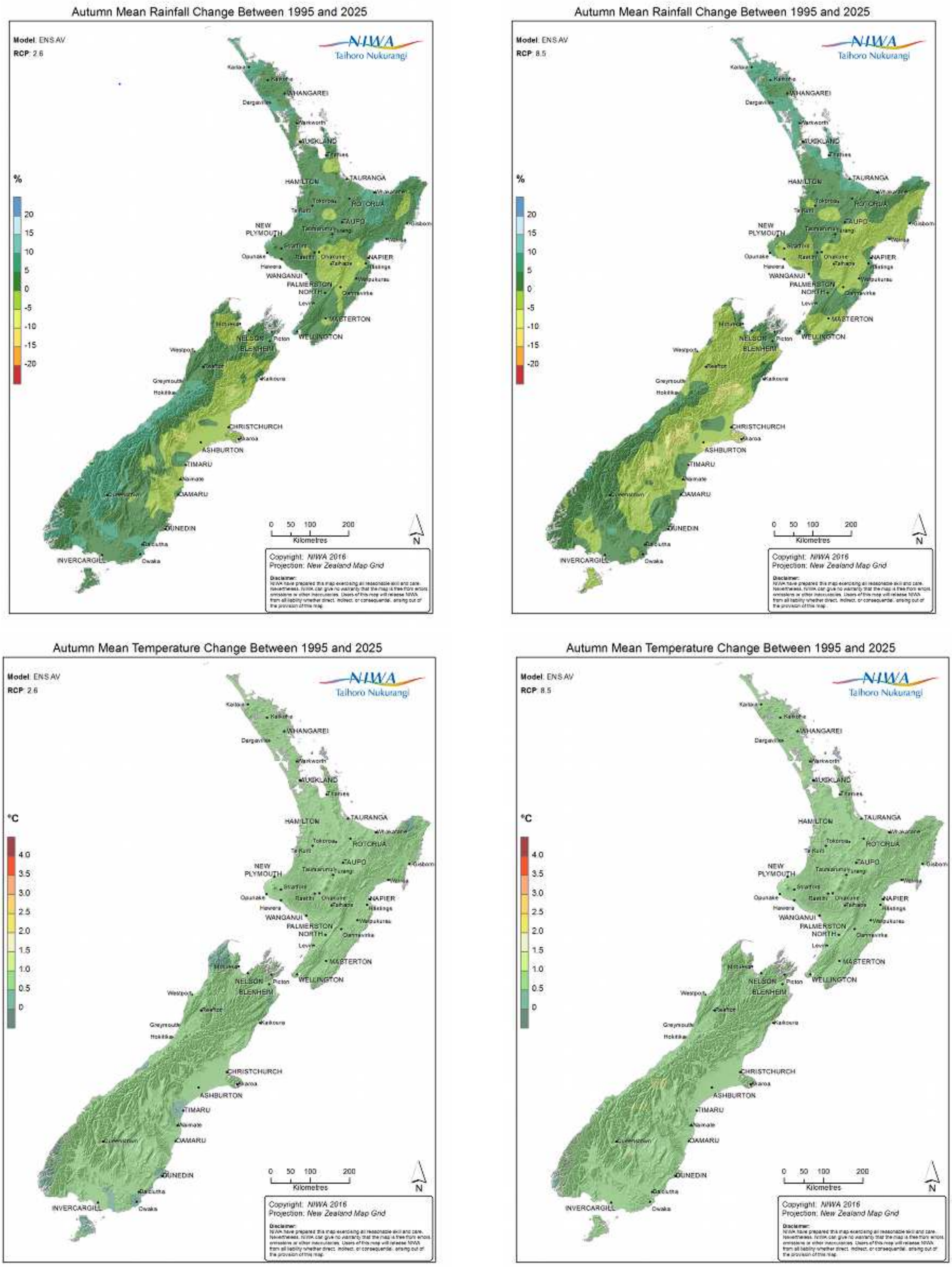


Figure 5. Change in mean autumn rainfall (top) and temperature (bottom) comparing 1986-2005 to 2016-2035

Figure 5 shows no to a slight increase in mean autumn rainfall for the highest part of the upper catchment of both rivers and no to a slight decrease for the lower part of the upper catchment under the low RCP scenario. The plains would see a slight to moderate decrease in autumn rainfall. This could result in a higher demand. The high RCP scenario shows a similar but more extreme picture, with the highest part of the Waiau river upper catchment receiving less rainfall over autumn too. Changes in temperature vary from 0.5 to 1 degree. This may result in higher evapotranspiration rates, which could indicate slightly lower flows.

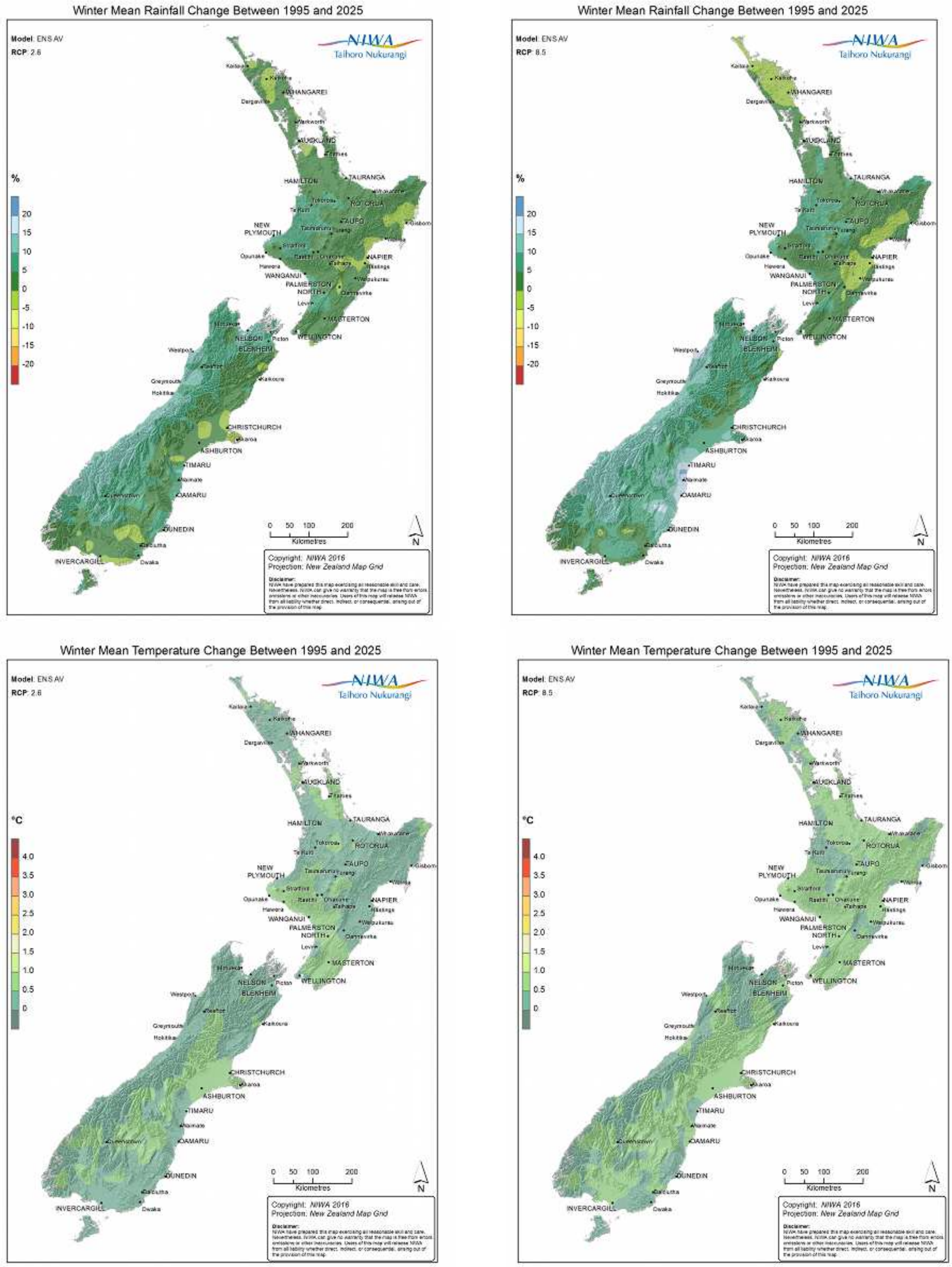


Figure 6. Change in mean winter rainfall (top) and temperature (bottom) comparing 1986-2005 to 2016-2035

Figure 6 shows a slight increase in mean winter rainfall for the plains to a moderate/high increase in the upper of both rivers under the low RCP scenario. The high RCP scenario shows a similar but more extreme picture, with the plains receiving a moderate increase in winter rainfall and the upper catchments receiving more rainfall over winter too. Changes in temperature vary from 0 to 1 degree. This may result in higher evapotranspiration rates, which could indicate slightly lower flows.

Appendix B Monthly median flows (m^3/s) per year for the Waiau River at Marble Point

year	January	February	March	April	May	June	July	August	September	October	November	December	annual
1967										67.0	233.9	111.6	
1968	50.3	60.0	52.5	87.2	76.2	60.6	70.5	63.3	75.1	162.0	173.6	126.9	88.2
1969	76.9	40.3	37.2	52.1	60.2	45.7	43.1	49.7	96.5	54.3	49.0	41.2	53.8
1970	49.5	28.3	39.6	39.2	36.2	48.2	69.5	63.7	213.8	122.4	81.1	55.8	70.6
1971	39.6	26.1	21.9	21.5	31.8	60.0	38.5	62.1	119.4	225.6	120.1	72.9	69.9
1972	49.0	40.0	55.1	69.6	103.9	65.1	95.6	57.7	134.7	134.3	93.6	68.6	80.6
1973	41.5	24.7	23.4	35.2	104.6	70.0	39.8	81.5	74.4	67.5	130.2	53.9	62.2
1974	46.9	55.5	47.8	167.6	75.1	79.3	108.2	82.5	122.5	127.7	93.0	55.6	88.5
1975	41.2	53.5	72.8	84.3	97.5	103.4	80.1	114.5	118.0	141.0	124.0	82.9	92.8
1976	59.4	106.4	48.8	40.1	70.3	88.9	101.1	81.0	74.8	113.3	106.1	134.5	85.4
1977	115.3	66.2	49.4	36.3	71.2	78.6	80.7	57.6	94.9	114.5	113.6	86.8	80.4
1978	61.9	34.9	25.9	57.2	46.2	74.4	101.0	109.8	139.0	103.2	90.9	72.7	76.4
1979	42.2	48.4	49.3	98.9	101.0	62.8	71.8	70.6	153.7	129.8	114.5	143.8	90.6
1980	148.3	109.0	119.9	89.7	56.5	89.0	72.8	87.1	179.5	133.7	133.5	94.7	109.5
1981	46.0	43.0	52.1	69.9	86.1	94.0	80.9	67.8	116.5	144.2	87.1	80.7	80.7
1982	71.9	46.6	30.3	32.6	94.3	77.9	58.1	75.3	89.6	77.0	160.9	123.9	78.2
1983	124.1	45.8	39.7	79.3	167.1	104.0	84.1	83.0	150.3	181.8	93.0	95.2	103.9
1984	59.3	62.0	57.8	45.1	55.6	52.0	103.3	78.8	58.2	106.6	96.3	109.0	73.7
1985	77.8	42.5	31.5	25.1	35.9	55.0	77.9	81.8	83.0	73.3	76.0	110.1	64.1
1986	65.0	42.6	45.6	60.9	58.0	79.4	63.9	101.5	112.1	158.2	105.6	68.4	80.1
1987	80.1	61.1	81.5	74.3	69.1	98.0	57.2	68.4	67.8	125.6	82.1	96.8	80.2
1988	59.0	65.7	66.1	48.3	93.0	104.6	155.9	125.0	130.1	266.0	122.5	74.5	109.2
1989	43.4	35.9	48.5	48.3	37.9	106.4	60.9	42.8	48.2	80.7	59.5	72.8	57.1
1990	65.7	42.3	38.5	52.2	134.0	69.5	57.4	106.3	62.0	66.1	84.5	84.4	71.9
1991	73.8	82.9	36.8	69.8	57.8	73.0	63.0	140.3	96.9	97.7	112.9	84.7	82.5
1992	70.8	50.2	76.8	45.0	38.0	41.7	68.5	115.3	84.2	127.7	117.1	86.7	76.8
1993	96.9	59.0	39.9	47.3	50.0	117.5	52.0	35.8	68.6	118.1	72.4	104.6	71.9
1994	128.5	36.8	43.0	35.8	80.3	99.0	109.2	93.2	95.1	87.6	377.7	103.1	107.4
1995	66.7	54.3	73.3	63.0	68.2	96.6	99.6	97.4	174.5	185.7	141.4	91.4	101.0
1996	58.8	53.9	45.3	97.2	72.3	66.9	80.1	76.6	126.0	149.5	172.7	97.4	91.4
1997	59.6	71.6	66.1	76.1	54.4	63.5	59.9	82.5	52.6	72.5	111.0	168.7	78.2
1998	72.4	50.5	54.0	59.5	44.1	53.7	136.5	108.7	93.5	194.1	110.0	54.4	85.9
1999	29.7	22.0	41.5	57.4	52.9	79.0	68.6	66.7	67.4	132.7	131.9	54.5	67.0
2000	49.0	38.4	33.6	69.9	68.1	119.2	61.6	100.9	115.2	189.5	67.8	59.7	81.1
2001	56.3	33.0	25.0	28.7	28.8	68.5	54.7	69.4	53.6	70.6	100.6	115.4	58.7
2002	106.2	50.1	56.5	47.7	43.6	157.6	69.9	66.0	116.7	114.6	148.7	126.0	92.0
2003	74.7	58.4	42.9	56.2	65.7	109.7	82.4	57.6	151.2	156.7	119.7	68.7	87.0
2004	79.3	119.4	72.1	49.1	77.3	148.0	67.9	90.9	111.3	123.9	82.4	84.4	92.2
2005	56.9	44.4	46.0	36.5	40.3	46.9	53.5	55.5	45.2	54.0	42.2	41.9	46.9
2006	65.9	34.5	30.5	96.2	62.6	74.7	89.2	69.8	93.0	127.6	223.4	110.2	89.8
2007	59.5	43.5	30.7	28.8	45.0	52.7	46.2	52.6	55.6	222.2	70.5	51.1	63.2
2008	39.5	51.3	35.3	26.9	26.6	31.0	91.6	105.8	149.9	116.4	114.2	68.6	71.4
2009	45.9	51.7	37.3	33.0	100.7	59.0	57.1	88.0	88.9	115.3	87.3	106.8	72.6
2010	78.9	37.7	30.6	36.6	47.6	109.1	64.0	98.1	193.3	145.2	76.1	53.0	80.8
2011	61.0	46.6	42.4	59.5	112.3	70.6	78.2	59.9	70.7	94.7	126.1	95.2	76.4
2012	54.5	36.6	40.6	30.0	50.4	79.9	72.7	94.5	98.1	147.8	67.0	63.6	69.7
2013	100.8	37.9	24.7	33.4	59.0	88.5	109.5	77.7	107.0	179.8	68.7	57.1	78.7
2014	74.0	33.0	36.3	67.8	89.3	119.0	65.1	82.9	72.2	84.5	126.5	81.6	77.7
2015	38.7	28.8	24.7	43.1	87.9	104.4	71.0	78.5	61.9	80.3	56.7	52.6	60.7
2016	65.4	39.2	41.9	38.7	123.6	86.6	88.4	70.0	84.9	78.9	93.6	83.8	74.6
2017	92.8	65.8	39.0										
long-term average	**67.4**	**50.2**	**46.0**	**56.1**	**69.6**	**81.3**	**76.2**	**80.5**	**102.9**	**124.9**	**112.9**	**85.7**	**79.3**

NB. Colour scale from green to red
showing annual monthly median flows above overall average in green
showing annual monthly median flows around the overall average in yellow
showing annual monthly median flows below overall average in red

Appendix C Monthly median flows (m^3/s) per year for the Hurunui River at Mandamus

year	January	February	March	April	May	June	July	August	September	October	November	December	annual
1956										53.1	72.1	52.6	
1957	33.6	27.9	35.1	59.2	70.6	47.7	52.9	27.6	24.3	82.5	91.4	138.7	57.6
1958	67.7	49.9	45.2	37.0	110.7	50.1	33.4	46.6	36.5	43.6	34.8	38.3	49.5
1959	26.4	17.6	22.8	23.5	33.2	39.4	26.0	42.8				37.6	
1960	21.5	31.0	30.9	21.0	21.8	32.3	30.0	31.4	57.1	32.2	27.7	23.9	30.1
1961	16.8	27.5	36.2	40.7	34.6	36.6	57.2	58.5	50.4	66.8	68.1	34.7	44.0
1962	42.4	21.4	11.2	12.9	34.1	37.7	43.5	32.0	55.8	70.1	46.5	21.0	35.7
1963	18.2	18.6	29.9	23.5	38.1	47.1	34.1	44.1	57.6	33.2	66.1	31.3	36.8
1964	86.3	25.3	46.0	30.8	69.8	32.3	57.9	66.0	63.5	69.3	59.3	54.5	55.1
1965	31.0	32.8	21.5	22.6	39.9	51.4	39.7	47.3	50.4	65.9	89.7	50.9	45.3
1966	37.6	34.8	24.7	28.4	33.6	28.3	35.0	31.3	29.5	28.8	38.7	42.6	32.8
1967	29.2	32.7	38.8	43.9	49.3	26.1	28.5	50.2	32.5	36.2	145.3	72.7	48.8
1968	31.6	40.0	31.7	40.0	41.1	33.7	44.2	35.3	44.7	109.1	87.8	58.1	49.8
1969	30.6	21.2	24.5	39.4	30.3	25.7	26.5	34.7	61.6	29.5	24.5	22.3	30.9
1970	33.5	20.1	20.7	22.7	20.0	26.8	35.7	41.9	148.9	65.3	45.0	32.1	42.7
1971	18.3	11.7	9.5	9.8	10.4	37.7	27.5	33.2	62.6	115.3	53.4	32.9	35.2
1972	30.0	18.4	28.1	31.8	62.7	33.7	46.7	25.6	76.8	70.1	50.1	32.0	42.2
1973	23.5	14.3	12.7	18.6	63.3	46.4	20.1	49.0	45.6	37.8	81.0	34.1	37.2
1974	25.8	36.9	28.7	89.7	31.7	30.9	48.6	36.6	44.2	56.3	53.6	30.6	42.8
1975	20.5	27.5	41.1	45.1	51.5	62.3	60.8	65.0	66.1	64.7	64.9	45.6	51.3
1976	34.8	42.8	24.2	19.3	39.0	63.0	51.9	44.7	39.9	58.8	48.6	51.5	43.2
1977	64.4	34.6	26.9	21.1	33.6	34.9	36.8	25.6	31.6	43.2	50.7	40.8	37.0
1978	30.0	16.6	12.2	39.6	37.0	34.2	52.7	67.9	74.1	63.1	41.6	36.0	42.1
1979	30.1	28.7	29.3	43.6	90.5	36.6	34.4	41.0	59.3	71.6	51.1	76.0	49.4
1980	77.8	57.1	54.1	38.2	31.8	48.1	33.7	63.0	119.0	74.0	75.1	48.5	60.0
1981	20.2	28.0	29.0	39.7	47.7	49.1	40.0	33.1	65.2	95.6	60.1	50.6	46.5
1982	43.5	29.4	23.2	16.3	39.8	37.9	32.2	47.6	51.9	35.6	97.3	87.9	45.2
1983	69.6	26.9	21.2	57.9	89.6	59.4	54.5	51.1	94.7	94.0	59.1	61.4	61.6
1984	36.7	37.2	32.1	25.6	35.1	34.1	63.1	59.5	34.0	69.9	74.2	77.5	48.3
1985	49.3	22.3	15.7	12.8	20.0	35.7	39.0	35.1	48.6	36.7	35.9	53.5	33.7
1986	38.9	24.8	30.6	38.1	35.3	53.8	38.2	65.5	63.4	78.2	42.2	30.3	45.0
1987	50.2	36.8	36.8	47.9	40.1	67.4	36.1	37.7	38.6	81.4	43.4	54.1	47.5
1988	32.2	23.7	37.5	27.1	57.7	68.6	98.5	85.1	87.2	113.8	71.3	46.4	62.4
1989	28.1	21.3	29.7	30.8	24.1	64.6	35.2	25.8	32.2	42.9	34.2	35.0	33.7
1990	42.4	23.6	21.3	25.8	76.1	30.2	28.2	57.4	29.1	31.7	36.3	57.8	38.3
1991	48.0	61.1	18.9	36.0	31.1	33.4	25.8	98.5	55.5	51.8	47.7	38.3	45.5
1992	39.8	34.2	43.9	22.9	19.4	24.4	51.2	77.7	49.1	53.3	46.5	34.0	41.4
1993	69.2	40.5	19.4	25.7	25.2	77.3	32.1	21.9	31.7	79.9	36.7	59.0	43.2
1994	98.6	25.5	26.1	17.5	34.5	56.9	80.0	66.0	63.5	49.2	182.1	43.7	62.0
1995	36.1	23.7	46.7	39.2	39.0	46.0	52.6	57.0	102.9	109.5	69.7	55.6	56.5
1996	33.4	34.2	28.1	100.2	45.6	45.6	49.7	41.3	68.9	122.6	104.5	54.7	60.7
1997	29.3	35.7	40.5	52.6	34.1	38.0	35.8	55.7	28.0	39.2	72.6	143.3	50.4
1998	38.3	31.1	38.4	41.6	30.3	29.3	93.5	72.5	51.5	120.6	36.9	37.5	51.8
1999	21.4	14.4	25.5	36.1	34.4	51.3	40.6	30.0	32.0	88.0	91.5	27.7	41.1
2000	23.6	23.3	17.0	50.4	35.2	75.7	30.3	65.0	104.1	141.1	36.7	26.2	52.4
2001	31.2	20.0	11.0	20.8	15.0	42.7	27.0	34.6	25.0	30.2	64.9	82.7	33.8
2002	72.3	21.3	26.6	25.7	20.9	131.0	47.3	39.2	98.3	70.6	78.5	61.1	57.7
2003	42.1	32.2	23.5	22.4	43.4	62.2	39.4	24.5	38.3	90.2	63.7	34.5	43.0
2004	39.6	57.3	44.2	27.7	42.0	96.6	28.9	49.2	67.9	70.5	45.4	40.1	50.8
2005	31.3	21.7	34.3	22.6	24.9	26.0	38.2	36.5	32.3	35.4	21.4	23.1	29.0
2006	53.8	21.6	18.7	52.6	30.2	36.9	31.0	33.3	51.4	74.5	144.2	66.2	51.2
2007	32.8	20.4	16.7	17.5	27.2	36.7	33.0	33.5	35.4	135.2	35.8	25.1	37.4
2008	21.8	21.2	19.2	13.2	13.2	20.7	56.8	58.5	82.4	60.2	56.4	38.9	38.6
2009	25.7	15.3	27.3	21.8	68.6	32.9	30.6	59.3	52.9	58.3	37.7	57.8	40.7
2010	49.6	19.9	17.0	25.1	38.2	49.6	35.5	59.5	112.7	77.0	35.4	21.9	45.1
2011	48.6	40.6	23.2	29.5	66.1	32.8	43.9	31.1	33.6	68.4	83.5	54.0	46.3
2012	31.0	19.7	23.5	17.6	27.3	52.9	45.0	64.6	49.9	102.8	40.2	29.8	42.0
2013	77.2	16.3	11.1	13.5	26.5	60.4	60.0	39.8	83.4	122.6	48.7	30.9	49.2
2014	40.3	15.5	15.4	24.3	52.0	73.4	39.6	60.3	38.4	50.8	75.6	38.6	43.7
2015	21.2	17.5	16.2	30.4	58.6	70.5	49.0	52.3	35.8	45.8	29.8	30.9	38.2
2016	40.7	26.3	22.1	19.4	83.4	59.0	61.5	41.2	60.3	51.1			
long-term average	**39.5**	**27.9**	**27.0**	**32.2**	**41.8**	**46.8**	**43.0**	**47.4**	**57.0**	**68.9**	**61.0**	**47.4**	**45.1**

NB. Colour scale from green to red
showing annual monthly median flows above overall average in green
showing annual monthly median flows around the overall average in yellow
showing annual monthly median flows below overall average in red