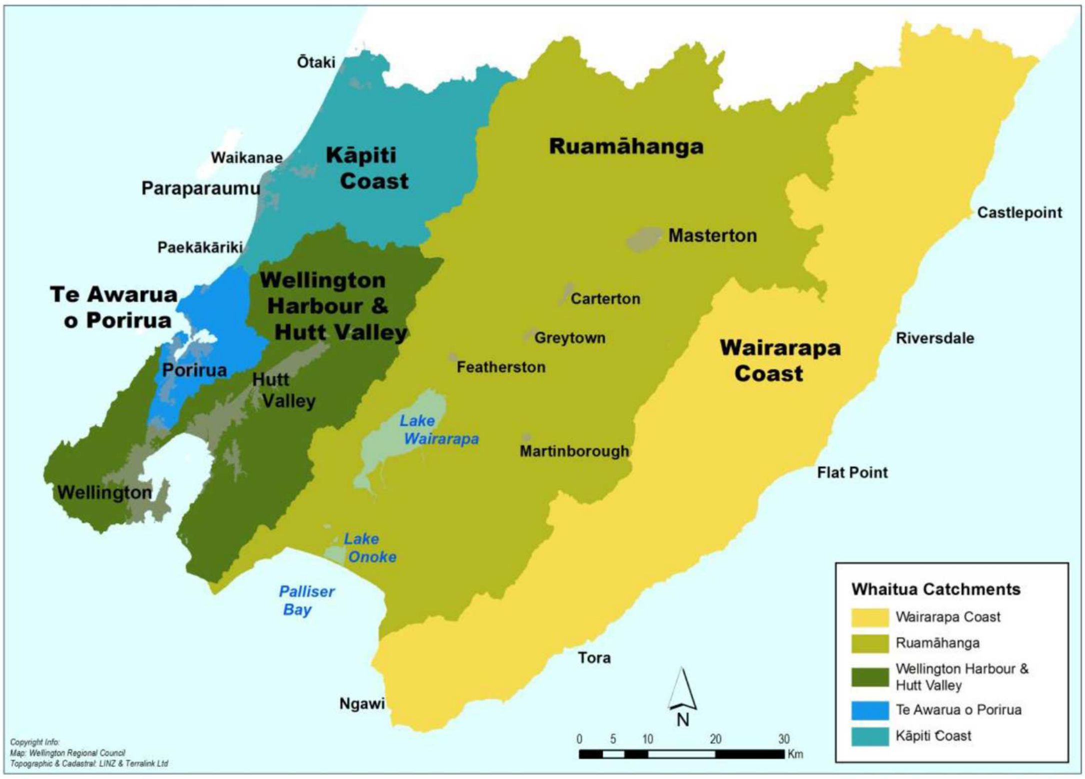
<u>**Whaitua Catchments Climate Change parameters** </u>**(Updated December 2020)**

All parameters were extrapolated based on the most recent NIWA regional climate change report (2017) and Climate Change Extremes and Implications report (2019) for the Wellington Region, available from www.gw.govt.nz/climate-change

Wellington Region whaitua

As pictured on the map below, the Wellington Region has been split into five whaitua (catchments) with a committee in each making decisions on the future of land and water management in that whaitua.

For more info visit: http://www.gw.govt.nz/whaitua-committees/



Changes that have already happened (verified by measurements): As of 2020, our region has already warmed by about 0.8 degrees in total, i.e., since the industrial revolution. Over a third of this warming (about 0.3 degrees) has happened since 1995, which is the reference baseline year representing the middle of the 1986-2005 period against which the IPCC models calculate their projections. This overall warming has been associated with several additional climatic changes, including increases in weather extremes and a significant disruption of weather patterns and displacement of the seasons (e.g. winters starting late). Insurance data confirms a marked increase of weather-related claims in New Zealand over the last decade.

Predicted changes (estimated by climate models): At least a third of the warming predicted for mid-century has already happened since the 1995 baseline. If emissions are reduced by half this decade, and further reduced to net negative by mid-century, most of the high-end projections for late century can be avoided (i.e., a total warming capped by 1.5-2.0 degrees).

<u>**Climate Change mapping online:**</u> https://mapping1.gw.govt.nz/gw/ClimateChange/

Te Awarua-o-Porirua whaitua			
Variable/period	**2040**	**2090**	**Commentary**
Average annual Temperature	+0.5C to 1C above the 1995 baseline (+1.0C to +1.5 C above pre-industrial)	+1C to +2.7C above the 1995 baseline (+1.5C to +3.2C above pre-industrial)	Maximum warming in autumn and winter, least in spring Note reference to 'above the 1995 baseline' versus 'pre-industrial': About 0.5C of warming has already happened from pre-industrial to the 1995 baseline (1880-1909 compared to the 1986-2005 model baseline, centered in 1995). Uncertainty range: lower range for significant emissions reduction (Paris agreement targets met), and upper range for high emissions
Average annual rainfall	0% to 5% increase	0% to 10% increase	There is a large uncertainty in the range of changes due to model differences and emission scenarios. Changes against emission scenarios are not necessarily linear. Greater likelihood of increases in autumn, winter and spring.
Amount of rain falling during heavy rainfall days (> 99th percentile of daily rainfall, equivalent to heavy rainfall days seen every year, i.e., not too extreme)	0% to 15% increase	5% to 25% increase	There is a large uncertainty in the range of changes due to model differences and emission scenarios. Changes against emission scenarios are not necessarily linear. Greater likelihood of increases in autumn, winter and spring.
Extreme rainfall magnitude: 6-12 hour duration, 100 year Average Recurrence Interval (normally used as reference for flooding design, referring to very extreme, infrequent rainfall events)	6% to 12% increase	12% to 32% increase	Although the uncertainty in average rainfall range is high, extreme rainfall increases are more certain due to the increased amount of water vapour that the atmosphere can hold as it gets warmer (about 8% increase in saturation vapour per degree of warming). The figures for extreme rainfall are given as an average of different IPCC models used to inform the HIRDS system, which is the national reference for Flood Protection (https://hirds.niwa.co.nz/).
Sea level rise	0.12 to 0.24 metres above the 1995 baseline (0.38 to 0.5 metres above pre-industrial)	0.68 to 1.75 metres above the 1995 baseline (0.94 to 2 metres above pre-industrial)	The projected sea level rise for 2090 is based on IPCC AR5 plus an estimated additional contribution from Antarctica, based on papers published in *Nature* in 2018. As such, the upper range appears slightly higher than the RCP8.5 H+ from the MFE Coastal Guidance (2017). Note the difference between the 1995 baseline and pre-industrial, as we have already had about 26cm of sea level rise prior to 1995. More regular storm events in the fragile coastal environment may also mean faster and more significant coastal retreat. See the link below for climate change, sea level rise and storm surge maps for the Region: https://mapping1.gw.govt.nz/gw/ClimateChange/

Number of hot days (above 25C) per year	Up to 10 days increase	Up to 30 days increase	
Number of frost nights (below 0C) per year	Up to 5 days reduction	Up to 15 days reduction	
Change in the intensity of wind during windy days (>99th percentile of daily mean)	1% to 2% increase	1% to 3% increase	
Change in annual number of windy days	2 to 4 days increase	2 to 10 days increase	
Change in annual growing degree days base 10	Increase between 200 and 300 GDD units	Increase between 300 and 900 GDD units	Measures potential for crop and pasture growth
Change in annual potential evapotranspiration deficit (mm)	Increase between 60 and 100 mm	Increase between 60 and 120 mm	Measures drought intensity
Change in rivers mean annual low flow discharge (MAL)	Decrease up to 40%	Decrease up to 40%	Measures water shortage in the catchments
Change in rivers mean annual flood discharge (MAF)	Increase up to 40%	Increase up to 80%	Measures flood potential in the catchments
Changes in number of days of very high and extreme forest fire danger	50% to 100% increase	100% to 150% increase	These figures are given by IPCC model averages. Individual models can show much higher increases of up to 700%
Key environmental impacts	Increased flood intensity Increased coastal inundation (some areas to become permanently inundated) Increased erosion Reduced soil fertility Decreased water quality Groundwater quality and availability pressures Salt water intrusion Ground water intrusion Increased pressure on water storage Biodiversity losses Increased pests such as wasps and rodents Ocean acidification Decline in fish population Increased wildfire Increased allergies (e.g. pollen)		

Wellington Harbour & Hutt Valley whaitua			
Variable/period	**2040**	**2090**	**Commentary**
Average annual Temperature	+0.5C to 1C above the 1995 baseline (+1.0C to +1.5 C above pre-industrial)	+1C to +2.5C above the 1995 baseline (+1.5C to +3.0C above pre-industrial)	Maximum warming in summer and autumn, least in spring and winter Note reference to 'above the 1995 baseline' versus 'pre-industrial': About 0.5C of warming has already happened from pre-industrial to the 1995 baseline (1880-1909 compared to the 1986-2005 model baseline, centered in 1995). Uncertainty range: lower range for significant emissions reduction (Paris agreement targets met), and upper range for high emissions
Average annual rainfall	5% decrease to 10% increase	5% decrease to 10% increase	There is a large uncertainty in the range of changes due to model differences and emission scenarios. Changes against emission scenarios are not necessarily linear. Greater likelihood of increases in autumn, winter and spring.
Amount of rain falling during heavy rainfall days (> 99th percentile of daily rainfall, equivalent to heavy rainfall days seen every year, i.e., not too extreme)	5% to 15% increase	5% to 30% increase	There is a large uncertainty in the range of changes due to model differences and emission scenarios. Changes against emission scenarios are not necessarily linear. Greater likelihood of increases in autumn, winter and spring.
Extreme rainfall magnitude: 6-12 hour duration, 100 year Average Recurrence Interval (normally used as reference for flooding design, referring to very extreme, infrequent rainfall events)	6% to 12% increase	12% to 30% increase	Although the uncertainty in average rainfall range is high, extreme rainfall increases are more certain due to the increased amount of water vapour that the atmosphere can hold as it gets warmer (about 8% increase in saturation vapour per degree of warming). The figures for extreme rainfall are given as an average of different IPCC models used to inform the HIRDS system, which is the national reference for Flood Protection (https://hirds.niwa.co.nz/).
Sea level rise	0.12 to 0.24 metres above the 1995 baseline (0.38 to 0.5 metres above pre-industrial)	0.68 to 1.75 metres above the 1995 baseline (0.94 to 2 metres above pre-industrial)	The projected sea level rise for 2090 is based on IPCC AR5 plus an estimated additional contribution from Antarctica, based on papers published in *Nature* in 2018. As such, the upper range appears slightly higher than the RCP8.5 H+ from the MFE Coastal Guidance (2017). Note the difference between the 1995 baseline and pre-industrial, as we have already had about 26cm of sea level rise prior to 1995. More regular storm events in the fragile coastal environment may also mean faster and more significant coastal retreat. See the link below for climate change, sea level rise and storm surge maps for the Region: https://mapping1.gw.govt.nz/gw/ClimateChange/

Number of hot days (above 25C) per year	Up to 10 days increase	Up to 40 days increase	
Number of frost nights (below 0C) per year	Up to 5 days reduction	Up to 10 days reduction	
Change in the intensity of wind during windy days (>99th percentile of daily mean)	1% to 2% increase	1% to 4% increase	
Change in annual number of windy days	2 to 6 days increase	2 to 12 days increase	
Change in annual growing degree days base 10	Increase between 0 and 300 GDD units	Increase between 200 and 800 GDD units	Measures potential for crop and pasture growth
Change in annual potential evapotranspiration deficit (mm)	Increase between 40 and 100 mm	Increase between 40 and 140 mm	Measures drought intensity
Change in rivers mean annual low flow discharge (MAL)	Decrease up to 40%	Decrease up to 40%	Measures water shortage in the catchments
Change in rivers mean annual flood discharge (MAF)	Increase up to 40%	Increase up to 100%	Measures flood potential in the catchments
Changes in number of days of very high and extreme forest fire danger	50% to 100% increase	100% to 150% increase	These figures are given by IPCC model averages. Individual models can show much higher increases of up to 700%
Key environmental impacts	Increased flood intensity Increased coastal inundation (some areas to become permanently inundated) Increased erosion Reduced soil fertility Decreased water quality Groundwater quality and availability pressures Saltwater intrusion Ground water intrusion Increased pressure on water storage Biodiversity losses Increased pests such as wasps and rodents Ocean acidification Decline in fish population Increased wildfire Increased allergies (e.g. pollen)		

Kāpiti Coast whaitua			
Variable/period	2040	2090	Commentary
Average annual Temperature	+0.5C to 1C above the 1995 baseline (+1.0C to +1.5 C above pre-industrial)	+1C to +2.7C above the 1995 baseline (+1.5C to +3.2C above pre-industrial)	Maximum warming in autumn and winter, least in spring Note reference to 'above the 1995 baseline' versus 'pre-industrial': About 0.5C of warming has already happened from pre-industrial to the 1995 baseline (1880-1909 compared to the 1986-2005 model baseline, centered in 1995). Uncertainty range: lower range for significant emissions reduction (Paris agreement targets met), and upper range for high emissions
Average annual rainfall	0% to 5% increase	0% to 10% increase	There is a large uncertainty in the range of changes due to model differences and emission scenarios. Changes against emission scenarios are not necessarily linear. Greater likelihood of increases in autumn, winter and spring.
Amount of rain falling during heavy rainfall days (> 99th percentile of daily rainfall, equivalent to heavy rainfall days seen every year, i.e., not too extreme)	0% to 10% increase	0% to 15% increase	There is a large uncertainty in the range of changes due to model differences and emission scenarios. Changes against emission scenarios are not necessarily linear. Greater likelihood of increases in autumn, winter and spring.
Extreme rainfall magnitude: 6-12 hour duration, 100 year Average Recurrence Interval (normally used as reference for flooding design, referring to very extreme, infrequent rainfall events)	6% to 12% increase	12% to 32% increase	Although the uncertainty in average rainfall range is high, extreme rainfall increases are more certain due to the increased amount of water vapour that the atmosphere can hold as it gets warmer (about 8% increase in saturation vapour per degree of warming). The figures for extreme rainfall are given as an average of different IPCC models used to inform the HIRDS system, which is the national reference for Flood Protection (https://hirds.niwa.co.nz/).
Sea level rise	0.12 to 0.24 metres above the 1995 baseline (0.38 to 0.5 metres above pre-industrial)	0.68 to 1.75 metres above the 1995 baseline (0.94 to 2 metres above pre-industrial)	The projected sea level rise for 2090 is based on IPCC AR5 plus an estimated additional contribution from Antarctica, based on papers published in *Nature* in 2018. As such, the upper range appears slightly higher than the RCP8.5 H+ from the MFE Coastal Guidance (2017). Note the difference between the 1995 baseline and pre-industrial, as we have already had about 26cm of sea level rise prior to 1995. More regular storm events in the fragile coastal environment may also mean faster and more significant coastal retreat. See the link below for climate change, sea level rise and storm surge maps for the Region: https://mapping1.gw.govt.nz/gw/ClimateChange/
Number of hot days (above 25C) per year	Between 5 and 10 days increase	Between 5 and 50 days increase	
Number of frost nights (below 0C) per year	Up to 5 days reduction	Up to 15 days reduction	

Change in the intensity of wind during windy days (>99th percentile of daily mean)	Up to 2% increase	Up to 3% increase	
Change in annual number of windy days	Up to 4 days increase	Up to 6 days increase	
Change in annual growing degree days base 10	Increase between 0 and 300 GDD units	Increase between 200 and 900 GDD units	Measures potential for crop and pasture growth
Change in annual potential evapotranspiration deficit (mm)	Increase between 40 and 80 mm	Increase between 40 and 100 mm	Measures drought intensity
Change in rivers mean annual low flow discharge (MAL)	Decrease up to 40%	Decrease up to 40%	Measures water shortage in the catchments
Change in rivers mean annual flood discharge (MAF)	Between 20% decrease and 60% increase depending on catchment	Increase up to 60%	Measures flood potential in the catchments
Changes in number of days of very high and extreme forest fire danger	50% to 100% increase	100% to 150% increase	These figures are given by IPCC model averages. Individual models can show much higher increases of up to 700%
Key environmental impacts	Increased flood intensity Increased coastal inundation (some areas to become permanently inundated) Increased erosion Reduced soil fertility Decreased water quality Groundwater quality and availability pressures Saltwater intrusion Ground water intrusion Increased pressure on water storage Biodiversity losses Increased pests such as wasps and rodents Ocean acidification Decline in fish population Increased wildfire Increased allergies (e.g. pollen)		

Ruamāhanga whaitua			
Variable/period	2040	2090	Commentary
Average annual Temperature	+0.7C to 1C above the 1995 baseline (+1.2C to +1.5 C above pre-industrial)	+1.2C to +3C above the 1995 baseline (+1.7C to +3.5C above pre-industrial)	Maximum warming in autumn and summer, least in winter Note reference to 'above the 1995 baseline' versus 'pre-industrial': About 0.5C of warming has already happened from pre-industrial to the 1995 baseline (1880-1909 compared to the 1986-2005 model baseline, centered in 1995). Uncertainty range: lower range for significant emissions reduction (Paris agreement targets met), and upper range for high emissions
Average annual rainfall	5% decrease to 5% increase	0% to 10% decrease	There is a large uncertainty in the range of changes due to model differences and emission scenarios. Changes against emission scenarios are not necessarily linear. Greater likelihood of decreases in summer.
Amount of rain falling during heavy rainfall days (> 99^{th} percentile of daily rainfall, equivalent to heavy rainfall days seen every year, i.e., not too extreme)	0% to 10% increase	0% to 20% increase	There is a large uncertainty in the range of changes due to model differences and emission scenarios. Changes against emission scenarios are not necessarily linear. Greater likelihood of increases in autumn, winter and spring.
Extreme rainfall magnitude: 6-12 hour duration, 100 year Average Recurrence Interval (normally used as reference for flooding design, referring to very extreme, infrequent rainfall events)	8% to 12% increase	14% to 36% increase	Although the uncertainty in average rainfall range is high, extreme rainfall increases are more certain due to the increased amount of water vapour that the atmosphere can hold as it gets warmer (about 8% increase in saturation vapour per degree of warming). The figures for extreme rainfall are given as an average of different IPCC models used to inform the HIRDS system, which is the national reference for Flood Protection (https://hirds.niwa.co.nz/).
Sea level rise	0.12 to 0.24 metres above the 1995 baseline (0.38 to 0.5 metres above pre-industrial)	0.68 to 1.75 metres above the 1995 baseline (0.94 to 2 metres above pre-industrial)	The projected sea level rise for 2090 is based on IPCC AR5 plus an estimated additional contribution from Antarctica, based on papers published in *Nature* in 2018. As such, the upper range appears slightly higher than the RCP8.5 H+ from the MFE Coastal Guidance (2017). Note the difference between the 1995 baseline and pre-industrial, as we have already had about 26cm of sea level rise prior to 1995. More regular storm events in the fragile coastal environment may also mean faster and more significant coastal retreat. See the link below for climate change, sea level rise and storm surge maps for the Region: https://mapping1.gw.govt.nz/gw/ClimateChange/
Number of hot days (above 25C) per year	Up to 30 days increase	Up to 80 days increase	

Number of frost nights (below 0C) per year	Up to 15 days reduction	Up to 40 days reduction	
Change in the intensity of wind during windy days (>99th percentile of daily mean)	Up to 3% increase	1% to 4% increase	
Change in annual number of windy days	Up to 4 days increase	Up to 12 days increase	
Change in annual growing degree days base 10	Increase between 0 and 300 GDD units	Increase between 200 and 1000 GDD units	Measures potential for crop and pasture growth
Change in annual potential evapotranspiration deficit (mm)	Increase between 20 and 120 mm	Increase between 0 and 180 mm	Measures drought intensity
Change in rivers mean annual low flow discharge (MAL)	Decrease up to 60%	Decrease up to 80%	Measures water shortage in the catchments
Change in rivers mean annual flood discharge (MAF)	Between 20% decrease and 40% increase depending on catchment	Between 20% decrease and 60% increase depending on catchment	Measures flood potential in the catchments
Changes in number of days of very high and extreme forest fire danger	100% to 150% increase	100% to 150% increase	These figures are given by IPCC model averages. Individual models can show much higher increases of up to 700%
Key environmental impacts	Increased flood intensity Increased coastal inundation (some areas to become permanently inundated) Increased erosion Reduced soil fertility Decreased water quality Groundwater quality and availability pressures Saltwater intrusion Increased in drought frequency and intensity Increased pressure on water storage Biodiversity losses Increased pests such as wasps and rodents High potential for fruit fly establishment Ocean acidification Decline in fish population Increased wildfire Increased allergies (e.g. pollen)		

Wairarapa Coast whaitua			
Variable/period	2040	2090	Commentary
Average annual Temperature	+0.5C to 1C above the 1995 baseline (+1.0C to +1.5 C above pre-industrial)	+1C to +3C above the 1995 baseline (+1.5C to +3.5C above pre-industrial)	Maximum warming in autumn and summer, least in spring Note reference to 'above the 1995 baseline' versus 'pre-industrial': About 0.5C of warming has already happened from pre-industrial to the 1995 baseline (1880-1909 compared to the 1986-2005 model baseline, centered in 1995). Uncertainty range: lower range for significant emissions reduction (Paris agreement targets met), and upper range for high emissions
Average annual rainfall	5% decrease to 5% increase	10% decrease to 5% increase	There is a large uncertainty in the range of changes due to model differences and emission scenarios. Changes against emission scenarios are not necessarily linear. Greater likelihood of decreases in summer.
Amount of rain falling during heavy rainfall days (> 99th percentile of daily rainfall, equivalent to heavy rainfall days seen every year, i.e., not too extreme)	0% to 15% increase	0% to 30% increase	There is a large uncertainty in the range of changes due to model differences and emission scenarios. Changes against emission scenarios are not necessarily linear. Greater likelihood of increases in autumn, winter and spring.
Extreme rainfall magnitude: 6-12 hour duration, 100 year Average Recurrence Interval (normally used as reference for flooding design, referring to very extreme, infrequent rainfall events)	6% to 12% increase	12% to 36% increase	Although the uncertainty in average rainfall range is high, extreme rainfall increases are more certain due to the increased amount of water vapour that the atmosphere can hold as it gets warmer (about 8% increase in saturation vapour per degree of warming). The figures for extreme rainfall are given as an average of different IPCC models used to inform the HIRDS system, which is the national reference for Flood Protection (https://hirds.niwa.co.nz/).
Sea level rise	0.12 to 0.24 metres above the 1995 baseline (0.38 to 0.5 metres above pre-industrial)	0.68 to 1.75 metres above the 1995 baseline (0.94 to 2 metres above pre-industrial)	The projected sea level rise for 2090 is based on IPCC AR5 plus an estimated additional contribution from Antarctica, based on papers published in *Nature* in 2018. As such, the upper range appears slightly higher than the RCP8.5 H+ from the MFE Coastal Guidance (2017). Note the difference between the 1995 baseline and pre-industrial, as we have already had about 26cm of sea level rise prior to 1995. More regular storm events in the fragile coastal environment may also mean faster and more significant coastal retreat. See the link below for climate change, sea level rise and storm surge maps for the Region: https://mapping1.gw.govt.nz/gw/ClimateChange/
Number of hot days (above 25C) per year	Between 5 and 30 days increase	Between 15 and 60 days increase	

Number of frost nights (below 0C) per year	Up to 5 days reduction	Up to 15 days reduction	
Change in the intensity of wind during windy days (>99th percentile of daily mean)	Up to 3% increase	1% to 4% increase	
Change in annual number of windy days	Up to 6 days increase	Up to 10 days increase	
Change in annual growing degree days base 10	Increase between 0 and 300 GDD units	Increase between 200 and 900 GDD units	Measures potential for crop and pasture growth
Change in annual potential evapotranspiration deficit (mm)	Increase between 40 and 120 mm	Increase between 40 and 160 mm	Measures drought intensity
Change in rivers mean annual low flow discharge (MAL)	Decrease up to 60%	Decrease up to 80%	Measures water shortage in the catchments
Change in rivers mean annual flood discharge (MAF)	Between 20% decrease and 20% increase depending on catchment	Between 20% decrease and 60% increase depending on catchment	Measures flood potential in the catchments
Changes in number of days of very high and extreme forest fire danger	100% to 150% increase	100% to 150% increase	These figures are given by IPCC model averages. Individual models can show much higher increases of up to 700%
Key environmental impacts	Increased flood intensity Increased coastal inundation (some areas to become permanently inundated) Increased erosion Reduced soil fertility Decreased water quality Ground water quality and availability pressures Saltwater intrusion Increase in drought frequency and intensity Increased pressure on water storage Biodiversity losses Increased pests such as wasps and rodents High potential for fruit fly establishment Ocean acidification Decline in fish population Increased wildfire Increased allergies (e.g. pollen)		

Note on uncertainty range:
The six climate models used by NIWA and the regional downscaling approach used to obtain finer detail for this report are widely recognised as the best available in New Zealand.

There is always a source of uncertainty associated with any climate projections. There are uncertainties related to the modelling component (e.g. model physics, resolution), uncertainties related to the actual emissions, climate feedback mechanisms (e.g. methane from permafrost melting, sea ice variations), and unforeseen events such as volcanic eruptions, just to mention a few. There are also uncertainties related to the urban heat island and topographical effects characterising the spatial variability within each area, and the exact definition of the baseline period.

The commentary section on the tables above provides more details on the specific range for each climate variable. The overall range provided for each variable can be interpreted as the spatial variability within each region between a high emissions future and a significant emissions reduction, roughly meeting the Paris agreement goal of limiting global warming within two degrees above pre-industrial (the IPCC RCP 4.5 scenario being an approximate example).

In short, we have the following.

For temperature: lower end of the range increases for the significant emissions reduction, higher increases for higher emissions. Full range also represents the spatial variability across each whaitua region.

For rainfall: A range of decreases and increases is presented, mostly representing the likely spatial variability within the region. In general, for heavy and extreme rainfall there is greater certainty of increases for higher emissions.

For hot days, dry spells and drought indicators: the range mostly represents that we are confident of increased outputs for higher emission scenarios.

The whaitua tables are current as of the date of publication, and will be continuously updated when improved modelling, or additional information, become available.