

Environment & Planning Committee Meeting

24 August 2023

This Report relates to Item 4 in the Agenda

“2023 Rainfall SoE Report”

Rainfall State of the Environment





**MARLBOROUGH
DISTRICT COUNCIL**

2023 Rainfall State of the Environment Report

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Executive Summary

Rainfall data from 35 monitoring stations across Marlborough have been analysed for this report. 14 of those sites have 30 or more years of data available, and seasonal and monthly statistics have been calculated for these sites.

The 2022/23 hydrological year had between 20-60% more rainfall than average across the entire region. In Northern Marlborough, 2022/23 had more rainfall in total than the year prior, however from the Richmond Ranges south 2021/22 was the wetter of the two years.

In the Te Hoiere / Pelorus area 1998/99 is the wettest year on record, with 4,098 mm of rain recorded at Tunakino. This is slightly higher than the total for 2022/23 of 4,055 mm.

In the Wairau and Awatere Valleys either 1994/95 or 2021/22 recorded maximum rainfall, depending on the site. Wairau Valley at Southwold and Blenheim at MDC both recorded maximum rainfall in 1994/95, with 1,487 mm and 1,162 mm respectively.

1972/73 was one of the driest years on record in Marlborough, although few rainfall monitoring stations were established at this time. Rainfall data from Wairau Valley at Southwold confirms that 1972/73 was the driest year in 105 years of data collection (1918-2023), with 596 mm of rain. 2000/01 is another prominent drought year, with 618 mm of rainfall recorded at Southwold and just 305 mm of rain in Blenheim. Although 1972/73 had less rainfall in total than 2000/01, summer 2000/01 has the lowest rainfall of any season at most monitoring sites. For example, Taylor at Tinpot recorded 37 mm of rain in the summer of 2000/01, compared to 54 mm in the 1972/73 summer.

Winter 2022 has the highest rainfall of any season at 12 out of the 14 long-term monitoring sites, including at Linkwater (established 1938) and Wairau Valley at Southwold (established 1917).

February generally records the lowest median rainfall throughout Marlborough. The timing of maximum monthly rainfall is more variable but is generally in winter or spring (June to October).

There were several notable months of rainfall in the 2022/23 hydrological year. In Blenheim, July 2022 became the wettest month in 93 years with 220 mm of rain, which is also the first time monthly rainfall has exceeded 200 mm in Blenheim. August 2022 was the first month where over 1 metre of rainfall was recorded at a monitoring site in Marlborough, with 1,241 mm recorded at Tunakino. October 2022 was particularly dry in the southern Wairau Valley, where new minimum rainfall totals for October were recorded at the Branch, upper Waihopai, and Omaka.

Several rain events affecting the Wairau Valley in May 2023 set a new maximum monthly rainfall at Red Hills and the Branch at Recorder, with 463 mm and 398 mm respectively. Autumn 2023 also recorded a new autumn maximum rainfall at Top Valley, the Branch, and Waihopai at Spray.

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Introduction

The Marlborough District Council (MDC) currently monitors rainfall at 27 sites throughout the region, as shown in *Figure 1* below. There are also a number of rainfall monitoring stations operated by NIWA, the Marlborough Research Centre, and Fire & Emergency New Zealand.

Over the past five years, three new rainfall sites have been installed by MDC. These are Picton at Waitohi Domain (installed August 2018), Branch at Mount Morris (installed May 2021), and Lake Elterwater (installed November 2021). Generally, 10 years of continuous data is required from a site before averages can be calculated.

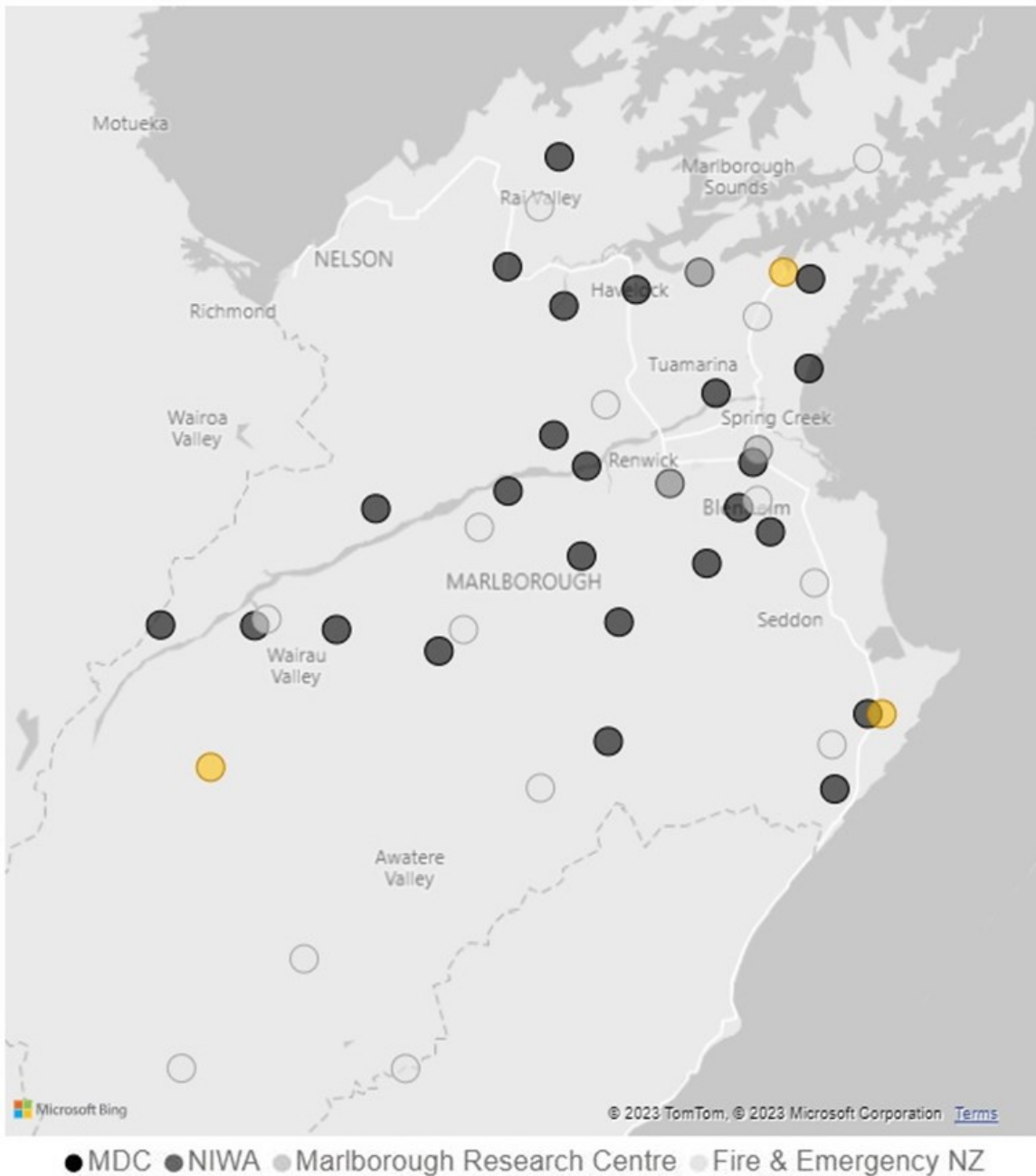


Figure 1: Rainfall monitoring sites in the Marlborough region. Sites marked in yellow have been installed within the past 5 years.

The highest rainfall in Marlborough is in the Richmond Ranges and Rai Valley area, which are exposed to prevailing north-westerlies. Rainfall decreases from the north bank to the south bank of the Wairau Valley, with the driest parts of the region being the lower Wairau Valley and the Awatere Valley, which are well sheltered from most rain events. Rainfall in the Marlborough Sounds is highest in central areas with high elevation, decreasing in the outer sounds. Mean annual rainfall in high elevation areas is shown in *Figure 2* below, while mean annual rainfall in low elevation areas is shown in *Figure 3*.

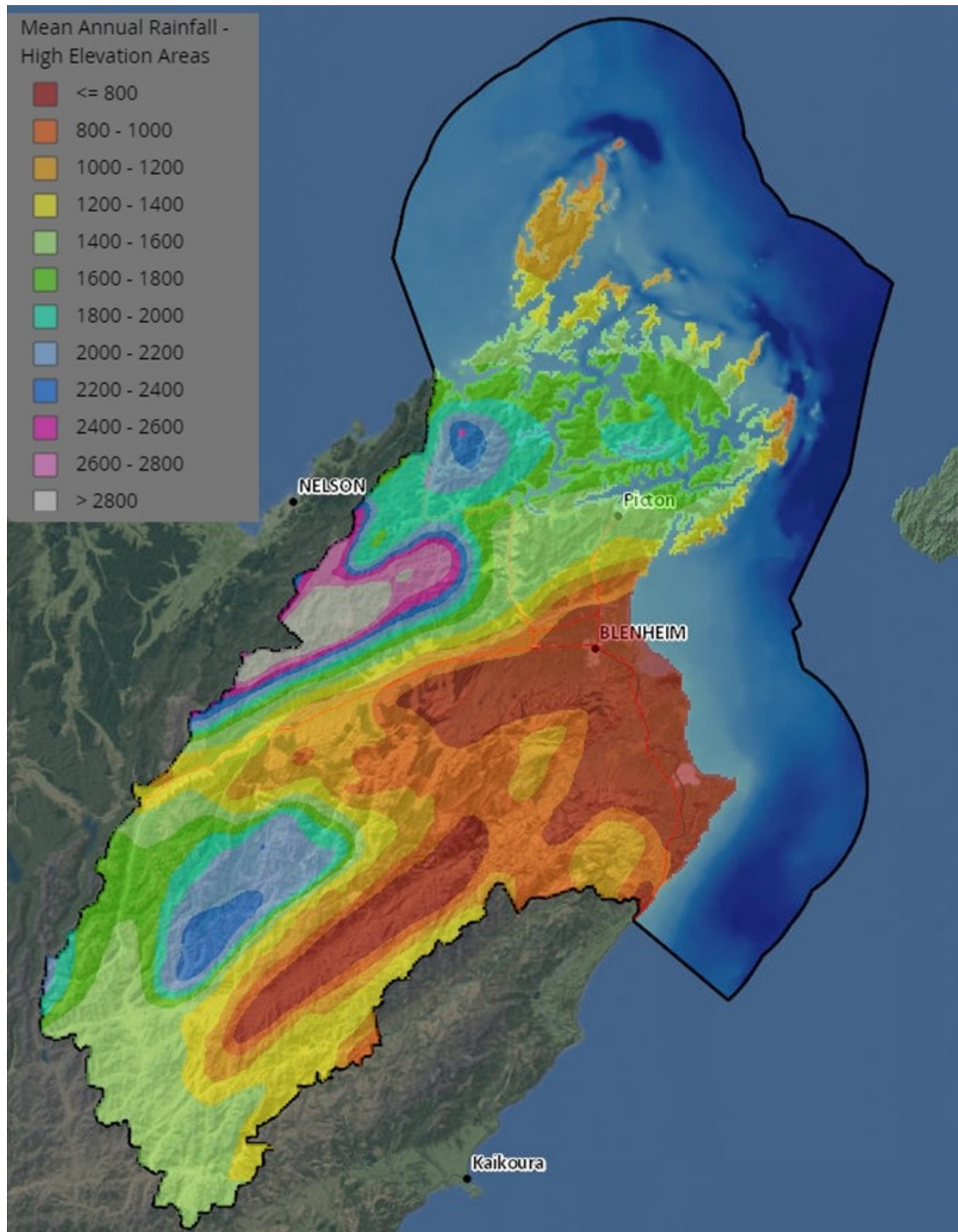


Figure 2: Mean annual rainfall for the Marlborough Region, interpolated by NIWA using data from 1961-2015. The map emphasises the rainfall pattern in high elevation areas.

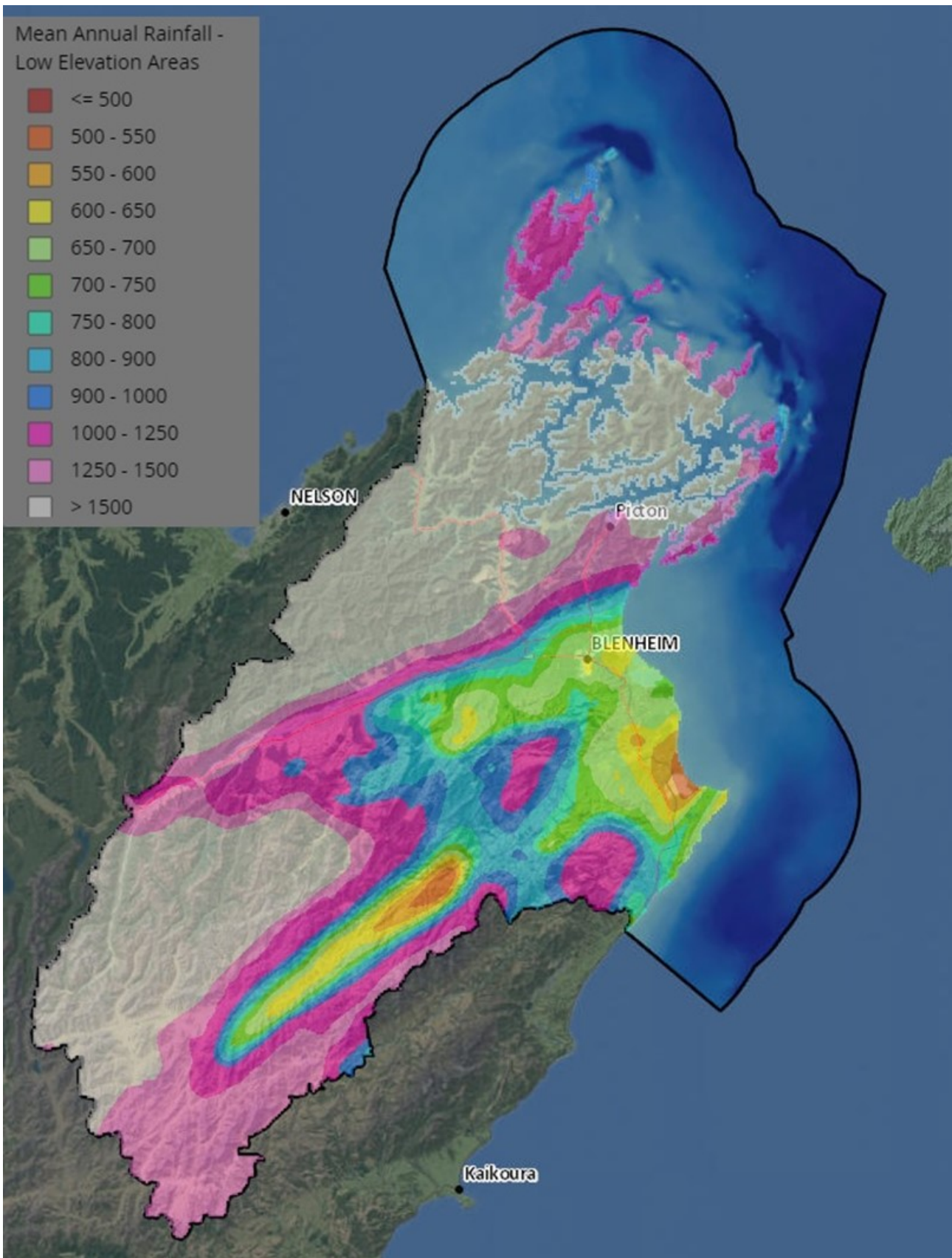


Figure 3: Mean annual rainfall for the Marlborough Region, interpolated by NIWA using data from 1961-2015. The map emphasises the rainfall pattern in low elevation areas.

Rainfall in this report has been analysed based on a hydrological year, which is the 12-month period between 1 of July to the 30 of June the following year. Seasonal and monthly rainfall statistics have also been calculated for sites with 30 or more years of data.

Rainfall was well above average in most parts of Marlborough in the 2022/23 hydrological year, as shown in *Figure 4* below. Monitoring sites are displayed from north to south, grouped into their Freshwater Management Unit (FMU).

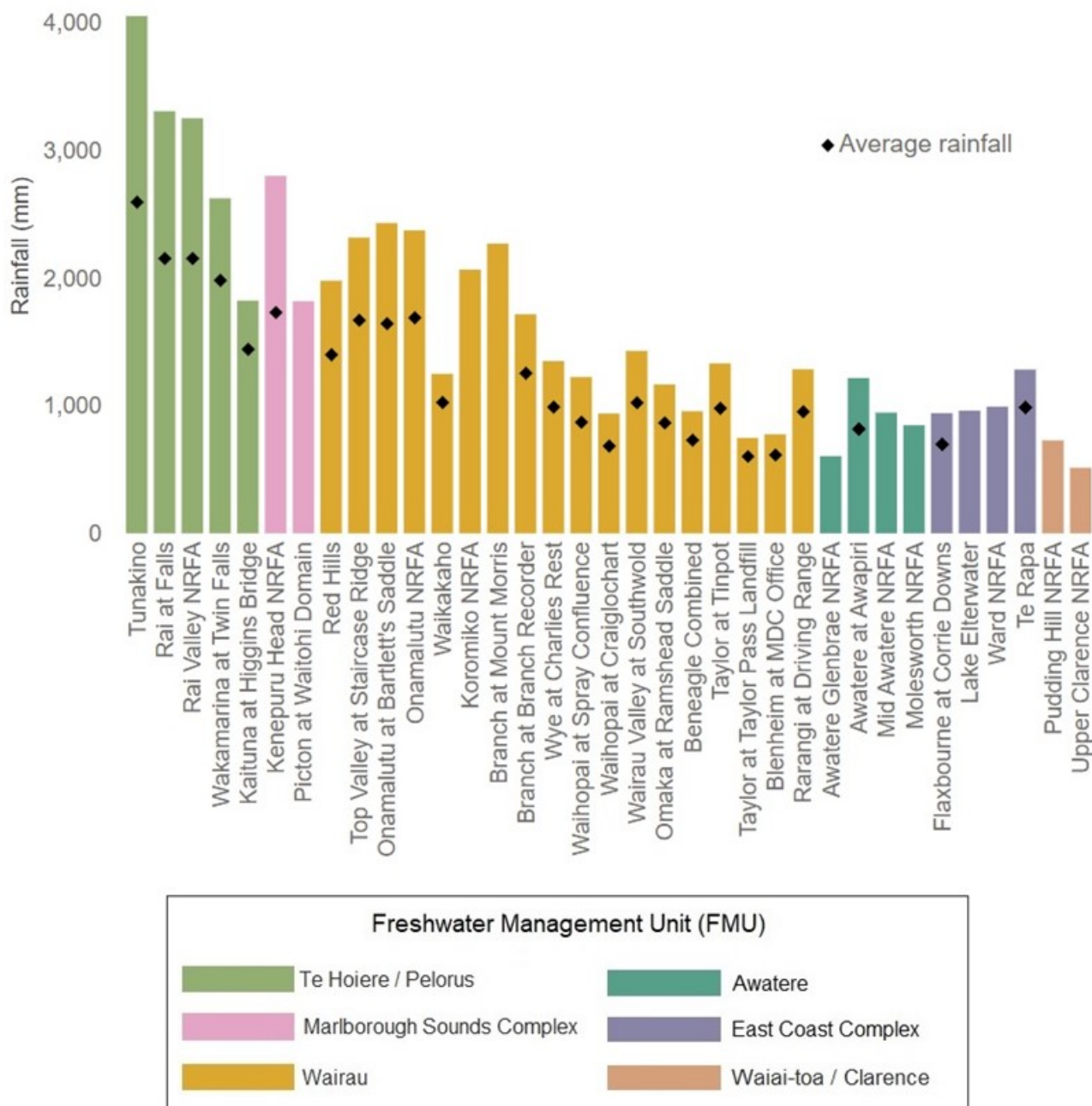


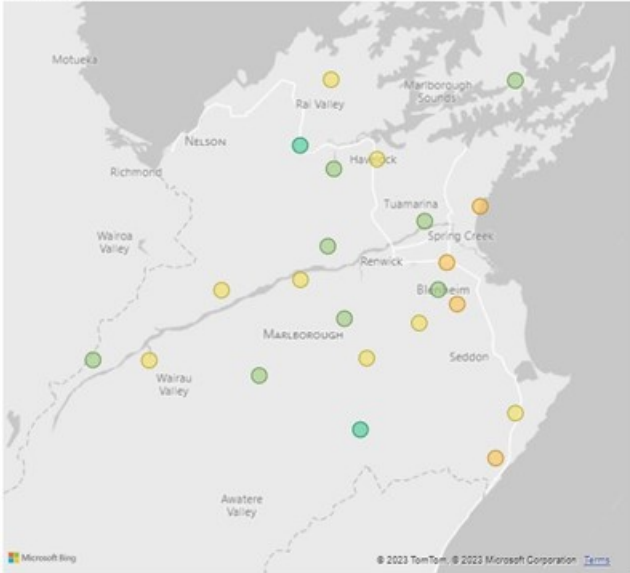
Figure 4: Total rainfall for the 2022/23 hydrological year (1 July-30 June) at monitoring sites across Marlborough. Average rainfall is displayed where sites have 10+ years of data.

The map below (*Figure 5*) shows the locations of rainfall monitoring sites with 10+ years of data, for the last four years. The colours indicate the percentage that annual rainfall deviates from the mean, to give a spatial understanding of rainfall for that year. In 2019/2020 rainfall deviated both above and below average by approximately 20% at monitoring sites, with no clear spatial pattern. Rainfall in 2020/21 was generally below average by 0-30%, with rainfall further below average in the south-east of the region. 2021/22 was a much wetter year. Rainfall in the south-east was near average, but rainfall deviated further above average in the rest of the region, with up to 50%

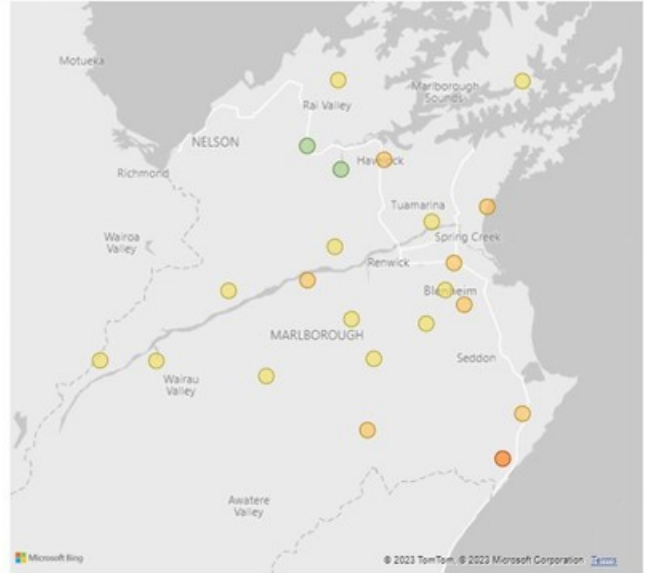
deviation in the mid Awatere, Wairau, and northern Marlborough. Rainfall in the lower Wairau plains was 10-20% above average.

2022/23 saw much higher than average rainfall across the entire region. In northern Marlborough, annual rainfall was more than 50% above average, while at the rest of the monitoring sites rainfall was at least 20% above average. The exception to this may be the upper Clarence, where rainfall seemed to be near or slightly below average. However more data needs to be collected in this area to determine average annual rainfall.

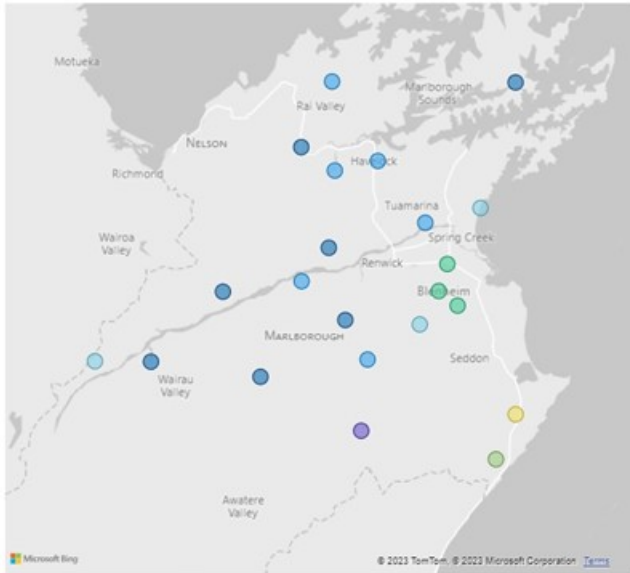
2019/20



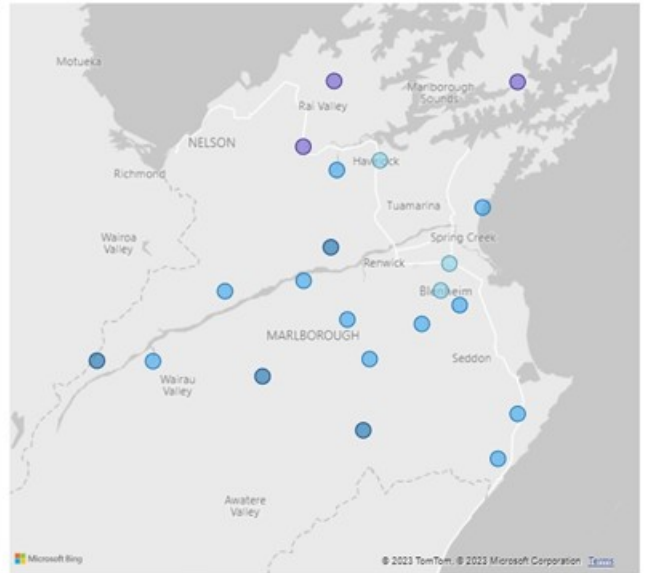
2020/21



2021/22



2022/23



- -50 to -40% (drier) ● -40 to -30% ● -30 to -20% ● -20 to -10% ● -10 to 0%
- 0 to 10% ● 10 to 20% ● 20 to 30%
- 30 to 40% ● 40 to 50% ● over 50% (wetter)

Figure 5: Rainfall deviation from the mean as a percentage is displayed for the last 4 hydrological years at rainfall sites in Marlborough with 10+ years of data.

Te Hoiere / Pelorus

Marlborough District Council operate four rainfall monitoring sites in the Te Hoiere / Pelorus. The locations of these sites can be seen on the map below (*Figure 6*). Both the Tunakino and Whakamarino at Twin Falls sites have collected 30+ years of data and were installed in 1979 and 1991 respectively. The Rai at Rai Falls site was installed in 1999, and Kaituna at Higgins Bridge in 2006.

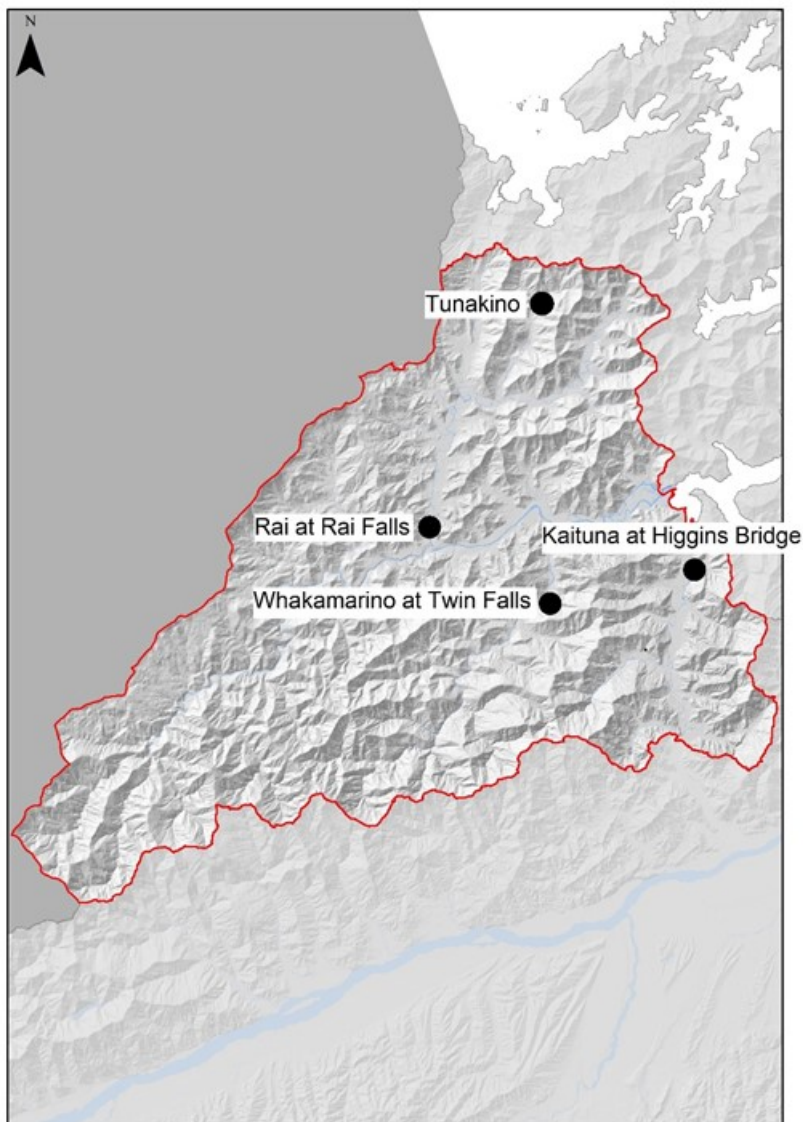


Figure 6: Rainfall monitoring sites within the Te Hoiere / Pelorus FMU.

The Te Hoiere / Pelorus area is exposed to westerly rain-bearing weather systems and is therefore the highest rainfall area in Marlborough. Average rainfall in a hydrological year is highest in the north-west (approximately 2,600 mm in the Tunakino Valley), down to 1,440 mm in the slightly more sheltered Kaituna Valley. Rainfall in the 2022/23 hydrological year was between 25% to 50% higher than average over the Te Hoiere / Pelorus area, with the greatest increase above average to the north-west. The high rainfall totals are due in large part to a prolonged storm event in August 2022.

There is not a strong seasonal rainfall pattern in the Te Hoiere / Pelorus area. On average, summer records a slightly lower proportion of total rainfall (approximately 20%), while winter and spring record slightly higher proportions of just under 30% each. 2022/23 showed a more pronounced seasonal rainfall pattern than average, with over 40% of total rain falling in winter, and just over 10% of rain falling during the summer months.

Tunakino

The Tunakino site was established in 1979, providing 44 years of data for analysis. Seasonal and monthly rainfall statistics have been calculated and full tables can be found in the appendix.

Total rainfall in the 2022/23 hydrological year was more than 50% above average at Tunakino, with 4,080 mm of rain recorded compared to an average of 2,600 mm. This makes 2022/23 the second wettest year on record since the site was established in 1979. The wettest year on record was 1998/99 with 4,098 mm of rain, while the driest year was 2000/01, recording just 1,360 mm.

Seasonal rainfall distribution at Tunakino can be seen below in Figure 7. Rainfall is generally lowest in summer, with median rainfall of 480 mm. Minimum summer rainfall was recorded in 2018/19, with just 164 mm falling in three months. Winter and spring rainfall are fairly equal and generally record more rain than summer and autumn. Winter 2022 is the wettest season since the site was established in 1979, with 2,016 mm of rain. This well surpasses the previous maximum seasonal rainfall of 1,400 mm recorded in the winter of 1998. Autumn rainfall in 2023 was also in the 90th percentile, while spring and summer rainfall were close to normal.

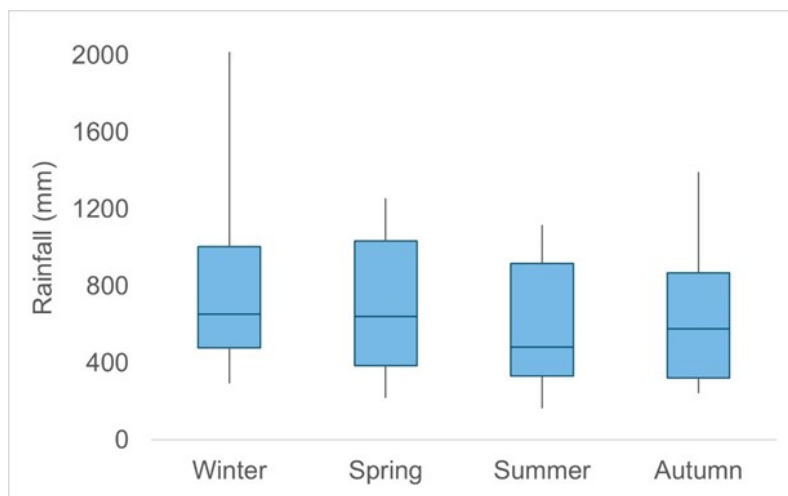


Figure 7: Seasonal rainfall distribution for Tunakino. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Minimum monthly rainfall generally occurs in February, with median rainfall of 114 mm. Dry months are most likely to occur from late summer to early autumn. October has the highest median rainfall of 243 mm, followed by June with 238 mm.

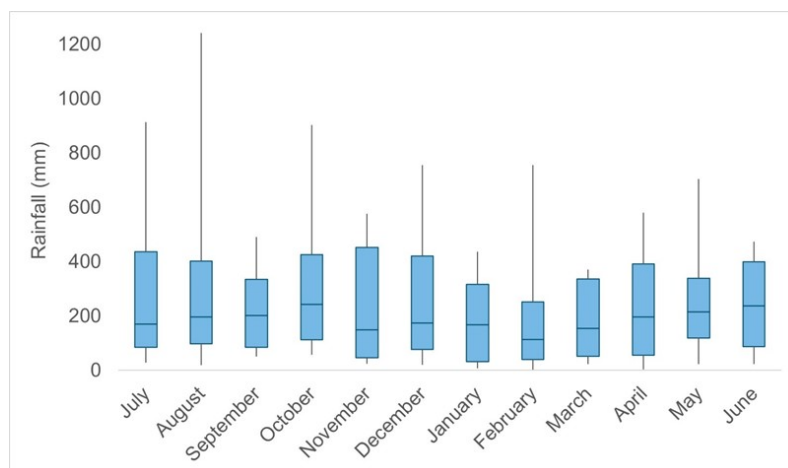


Figure 8: Monthly rainfall distribution for Tunakino. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

In August 2022 a new monthly rainfall maximum of 1,241 mm was recorded, as can be seen in *Figure 10*. The previous monthly maximum was in July 1998, with 914 mm of rain. July 1998 saw several rain events accumulate to produce a high monthly total, whereas in August 2022 the majority of the monthly total rain fell during one prolonged storm event.

The August 2022 storm rainfall accumulation can be seen in *Figure 9* below, compared to the biggest rain event in July 1998. Rainfall totals were similar for the two events up to a 24-hour duration, diverging after this period as the July 1998 storm ceased after 48 hours. The other accumulations shown in greyscale on the graph indicate the HIRDS (high intensity rainfall design system) 250-year average recurrence interval rainfall accumulation, along with the projected 250-year return period accumulations under RCP 4.5, an intermediate climate change scenario. For both the July 1998 and August 2022 events the rainfall accumulation up to a 24-hour duration was below the 250-year recurrence interval, but as heavy rainfall continued in August 2022 the rainfall accumulation quickly exceeded the 250-year recurrence interval.

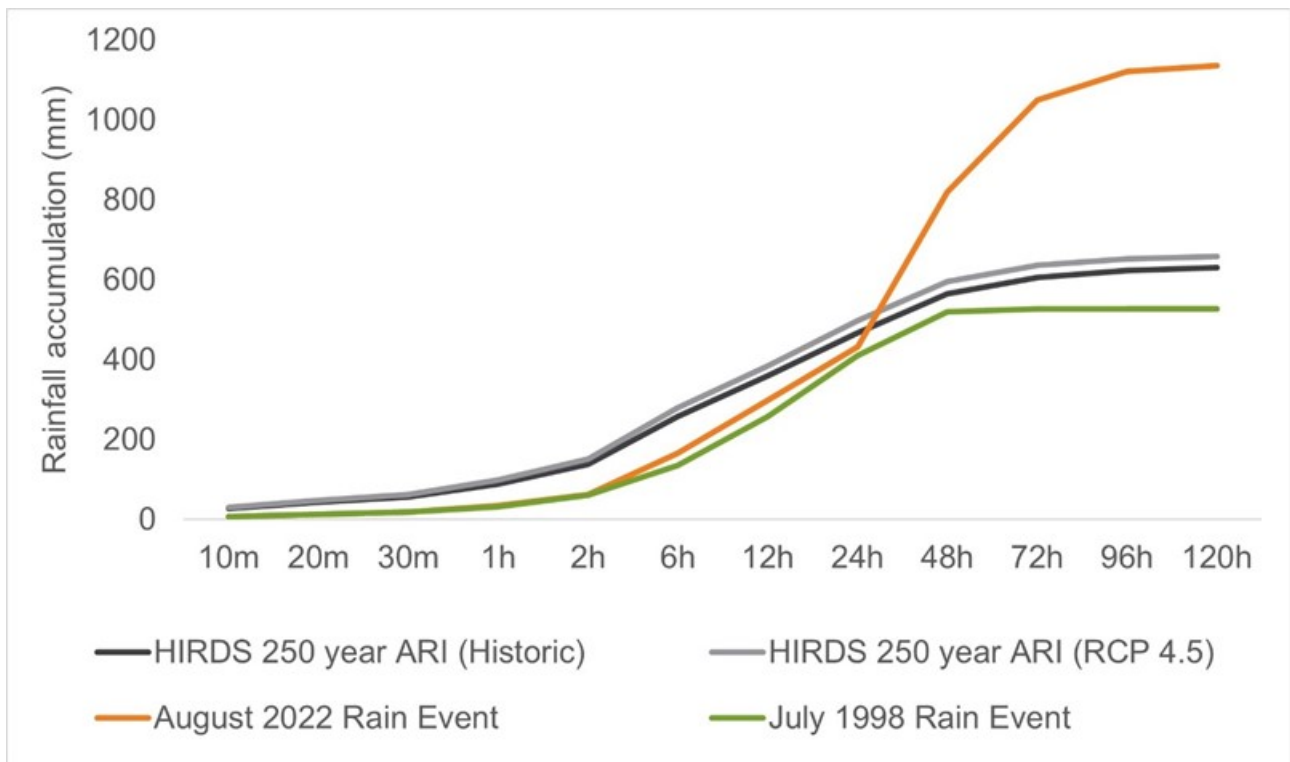


Figure 9: Rainfall accumulations for the July 1998 and August 2022 rain events, compared to the 250 year return period HIRDS accumulation (historic and the RCP 4.5, an intermediate climate change scenario).

Monthly rainfall at Tunakino varied both well above and below average throughout 2022/23 (see *Figure 10* below). Considering that 2022/23 was the second wettest year on record, it is interesting to note that three months (October, December, and June) recorded below average rainfall, with December and June recording less than half of their average monthly rainfall. In contrast, August and May are both in the 90th percentile for monthly rainfall.

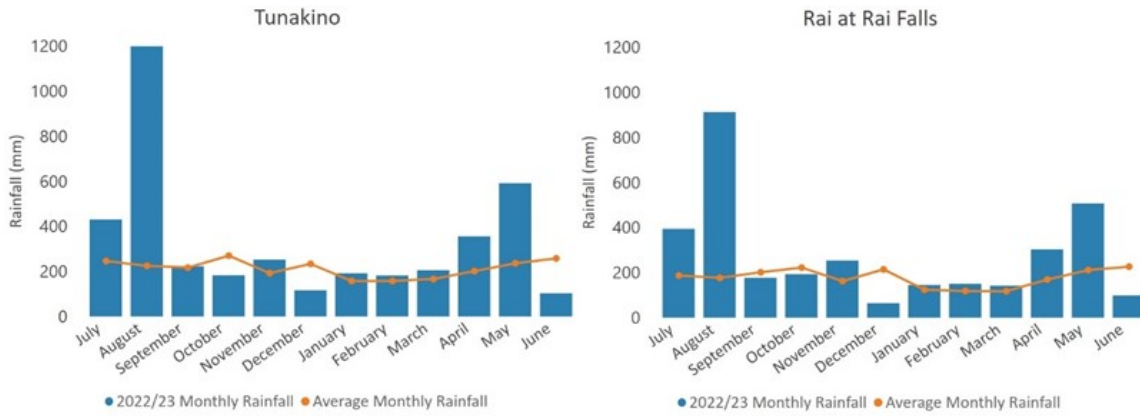


Figure 10: Monthly rainfall in the 2022/23 hydrological year at Tunakino and the Rai at Rai Falls, compared to average monthly rainfall.

Rai at Rai Falls

Average rainfall at the Rai at Rai Falls site is approximately 2,150 mm in a hydrological year. In 2022/23 the site recorded 54% more rainfall than average, with 3,342 mm in total, which is also the wettest year since the site was established in 2000. This exceeds the previous maximum, which was set the year prior (2021/22) with 3,132 mm of rain. The driest year on record is 2000/01 with just 1,337 mm of rain.

In August 2022 a new monthly rainfall maximum of 913 mm was recorded. This greatly surpasses the previous monthly maximum of 598 mm recorded in December 2010.

Whakamarino at Twin Falls

The Whakamarino at Twin Falls site was established in 1991, providing 32 years of data for analysis. Average rainfall at the Whakamarino site is approximately 2,050 mm in a water year, and over 32 years of monitoring has varied from 1,325 mm in the driest year on record (2000/01) to 2,765 mm in the wettest year on record (1998/99). Total rainfall in the 2022/23 hydrological year was 2,636 mm, making it the fourth wettest year on record.

Seasonal rainfall distribution for the Whakamarino can be seen below in *Figure 11*. Rainfall is lowest in the summer months, with a median of 396 mm of rain. As at Tunakino, the minimum monthly rainfall was recorded in 2018/19, with just 128 mm total rainfall at Whakamarino. Spring is generally the wettest season, with median rainfall of 530 mm. Winter 2022 is the wettest season in the site’s history, with 1,267 mm of rainfall. The previous seasonal maximum was recorded in spring of 1998, with 990 mm of rain.

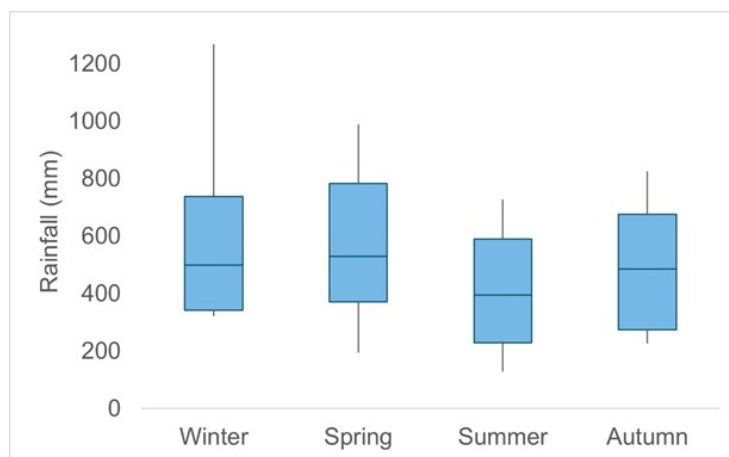


Figure 11: Seasonal rainfall distribution for Whakamarino at Twin Falls. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Minimum monthly rainfall is generally in February, with median rainfall of 88 mm. Dry months can occur year-round but are most likely to occur in late summer/early autumn. October generally records the highest monthly rainfall, with a median of 208 mm. Maximum monthly rainfall of 693 mm was recorded in October of 1998.

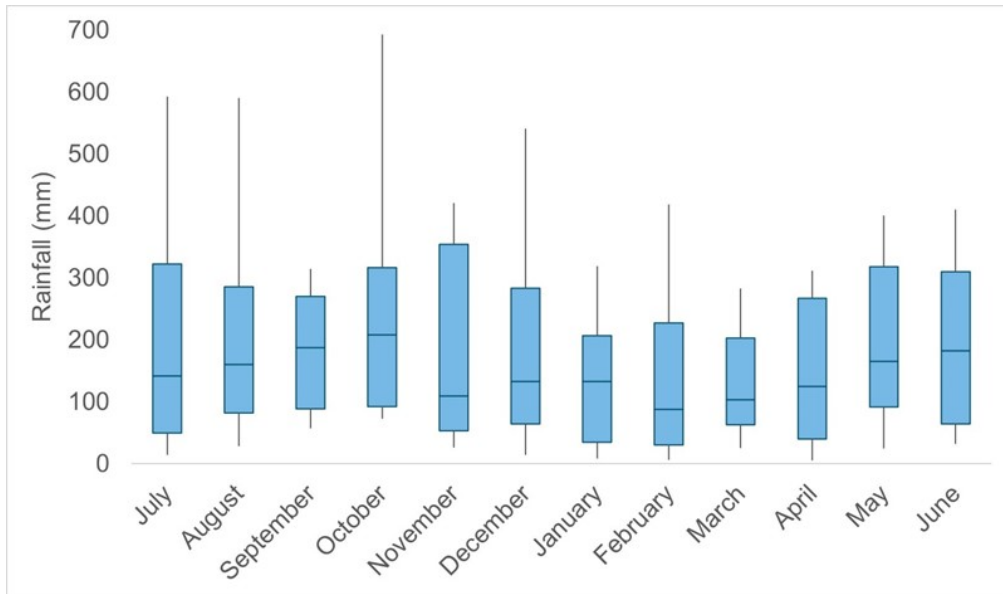


Figure 12: Monthly rainfall distribution for Whakamarino at Twin Falls. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Monthly rainfall for 2022/23 at Whakamarino can be seen below in Figure 13. Total rainfall in August 2022 was 590 mm, the 3rd highest monthly total recorded at the site. The two highest monthly totals were both recorded in 1998, with 693 mm recorded in October 1998, and 592 mm recorded in July 1998. Monthly rainfall totals through the 2022/23 hydrological year were variable. Most significantly, August and May rainfall both scored in the 90th percentile.

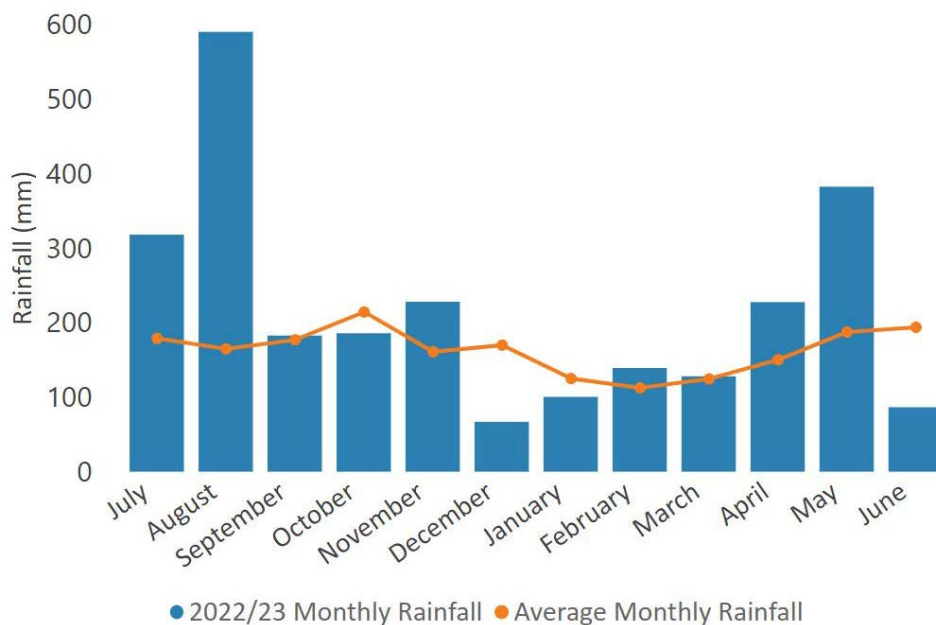


Figure 13: Monthly rainfall in the 2022/23 hydrological year at Whakamarino at Twin Falls, compared to average monthly rainfall.

Kaituna at Higgins Bridge

The 2022/23 hydrological year recorded 26% more rain than average at Kaituna, with 1,824 mm of rain recorded compared to an average of 1,443 mm. This makes 2022/23 the third wettest year on record since the site was established in 2007. The lowest annual rainfall total recorded at Kaituna was 955 mm in 2014/15, while the highest total recorded was 2,036 mm in 2010/11.

2022/23 monthly rainfall at Kaituna can be seen below in *Figure 14*. 363 mm of rain was recorded in August 2022, which is the fourth highest monthly total recorded at the site. The highest monthly total was recorded in July 2021, with 379 mm of rain.

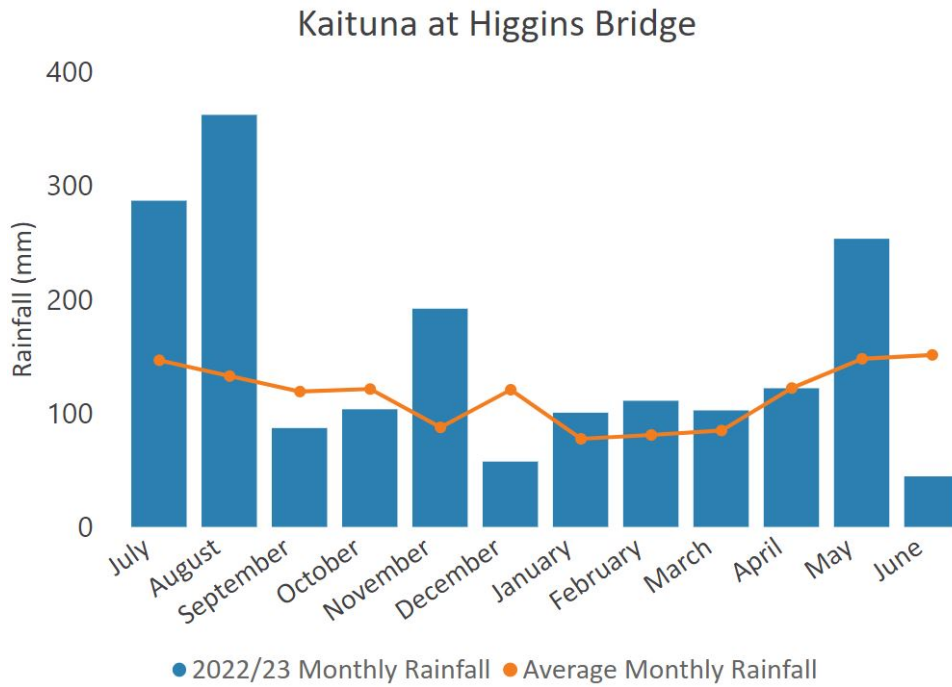


Figure 14: Monthly rainfall in the 2022/23 hydrological year at Kaituna at Higgins Bridge, compared to average monthly rainfall.

Marlborough Sounds Complex

There are four rainfall monitoring sites in the Marlborough Sounds, as shown on the map below (*Figure 15*). MDC operates two rainfall monitoring sites in Picton and Waikawa at Boons Valley. The Picton site was established in 2018, while Waikawa was established in 1994. Fire and Emergency New Zealand also operate a climate site at Kenepuru Head, while NIWA have a long-term rainfall monitoring site in Linkwater, with data from 1938-present.

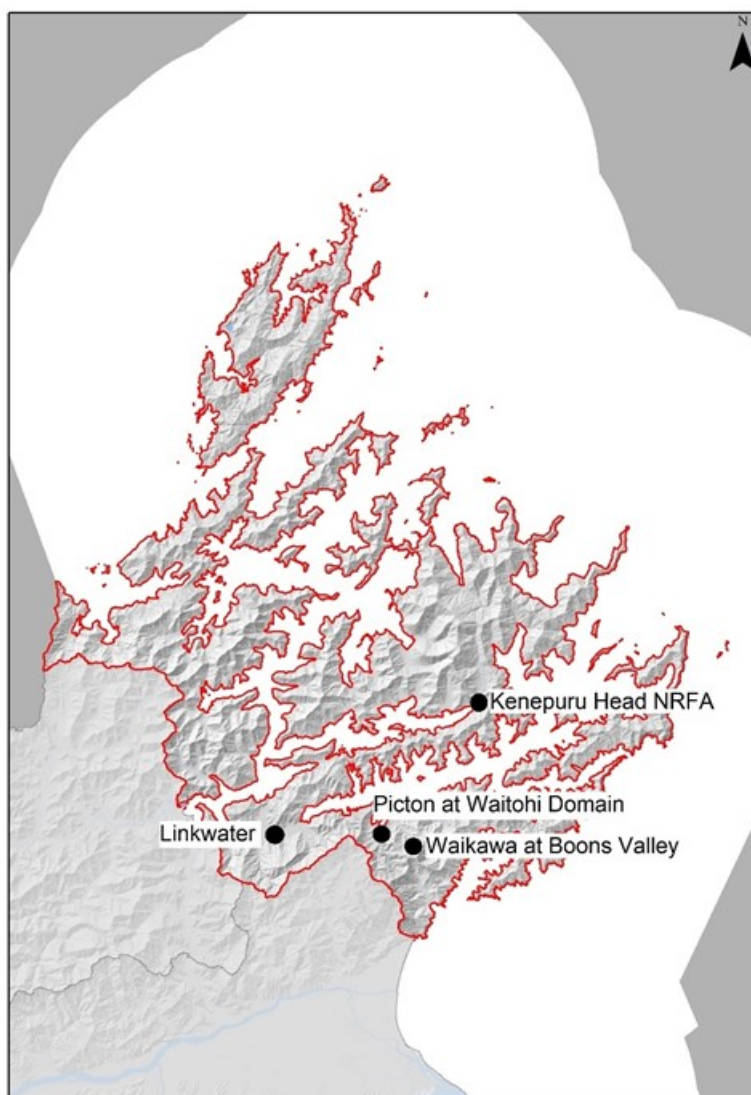


Figure 15: Rainfall monitoring sites within the Marlborough Sounds Complex FMU.

The Marlborough Sounds are exposed to strong west to north-westerly winds. Rainfall is the highest in the south-west, approximately 1,800-2,000 mm annually around Okiwi Bay/Duncan Bay and at higher elevation in the central sounds (around Mt Stokes/Kenepuru Head). Rainfall decreases to approximately 900 mm annually in the outer sounds, including Rangitoto ki te Tonga/D'Urville Island and the Brothers.

Average rainfall at the Kenepuru Head NRFA site is approximately 1,730 mm in a hydrological year. In 2022/23 the site recorded 2,802 mm of rain in total, which is the wettest year since the site was established in 2010. The previous maximum of 2,520 mm was set the year prior (2021/22). The driest year on record is 2016/17 with 905 mm of rain.

The Waitohi/Picton monitoring site was installed in 2018, so limited conclusions can be drawn from the data. In the 2022/23 hydrological year 1,819 mm of rainfall was recorded, which is the wettest year since the site was established four years ago.

Summer generally accounts for just under 20% of annual rainfall in the Marlborough Sounds, while winter records about 30% of annual rainfall. At Kenepuru Head winter 2022 made up over 40% of total annual rainfall, while spring, summer and autumn received just under 20% of total rainfall each.

Monthly rainfall at Kenepuru Head and Waitohi/Picton for 2022/23 can be seen in *Figure 16* below. July and August 2022 both set new monthly maximums at Kenepuru Head of 470 and 516 mm respectively. 516 mm recorded in August 2022 is the second highest monthly total recorded at the site. The monthly maximum of 652 mm was recorded in May 2011.

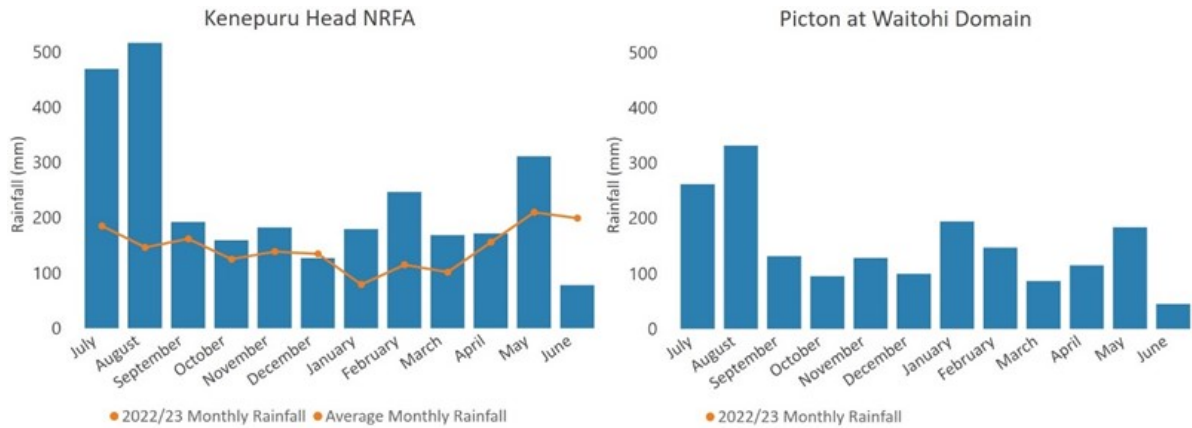


Figure 16: Monthly rainfall in the 2022/23 hydrological year at Kenepuru Head NRFA (left) and Picton at Waitohi Domain (right) climate sites.

Linkwater

The Linkwater site was established in 1938, providing 85 years of daily rainfall data for analysis. Average rainfall at Linkwater is 1,490 mm in a hydrological year, varying between 785 mm in the driest year on record (1958/59) and 2,230 mm in the wettest year (2010/11). Total rainfall for the 2022/23 year is not yet available.

Seasonal rainfall distribution at Linkwater can be seen below in *Figure 17*. Summer generally has the lowest rainfall, with a median of 273 mm. Minimum summer rainfall occurred during the 1971/72 drought, with just 73 mm recorded over the summer months. Winter is generally the wettest season, while spring and autumn have moderate rainfall.

Winter 2022 was the wettest winter on record at Linkwater, with 1,050 mm of rain recorded. Median winter rainfall is 445 mm. The previous winter record of 940 mm was recorded in 1998.

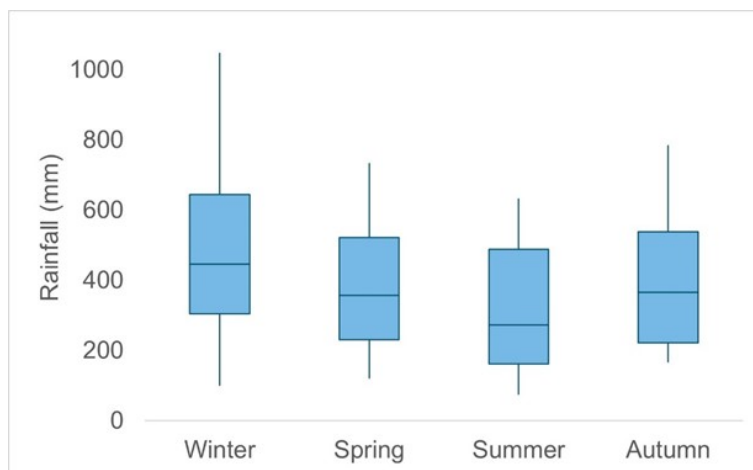


Figure 17: Seasonal rainfall distribution for Linkwater. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per season.

Minimum monthly rainfall is generally in February, with median rainfall of 67 mm. The driest months on record occur throughout summer and into early autumn. July generally records the highest rainfall, with a median of 157 mm. The maximum monthly rainfall of 590 mm was recorded in 1998. The three months June to August 2022 were all in the 90th percentile.

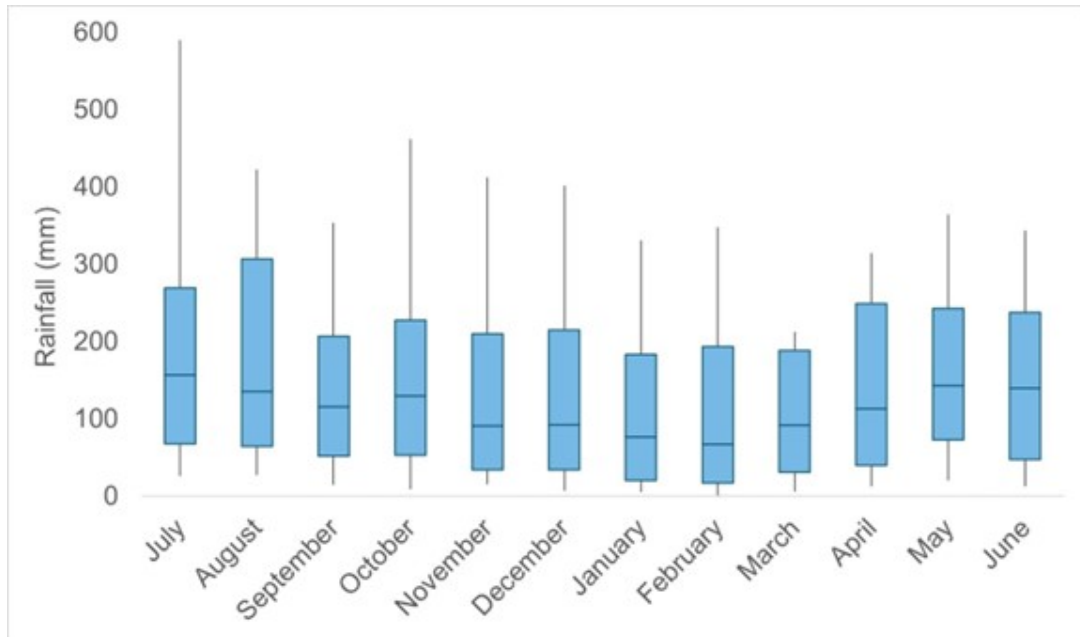


Figure 18: Monthly rainfall distribution for Linkwater. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Wairau

Within the Wairau catchment MDC operates 16 rainfall monitoring stations, and the Koromiko NRFA site is operated by Fire and Emergency New Zealand. These sites can be seen on the map in *Figure 19* below. Of note is the recent addition of the Branch at Mt Morris site, which was installed in May 2021 to provide rainfall data in the upper Branch catchment.

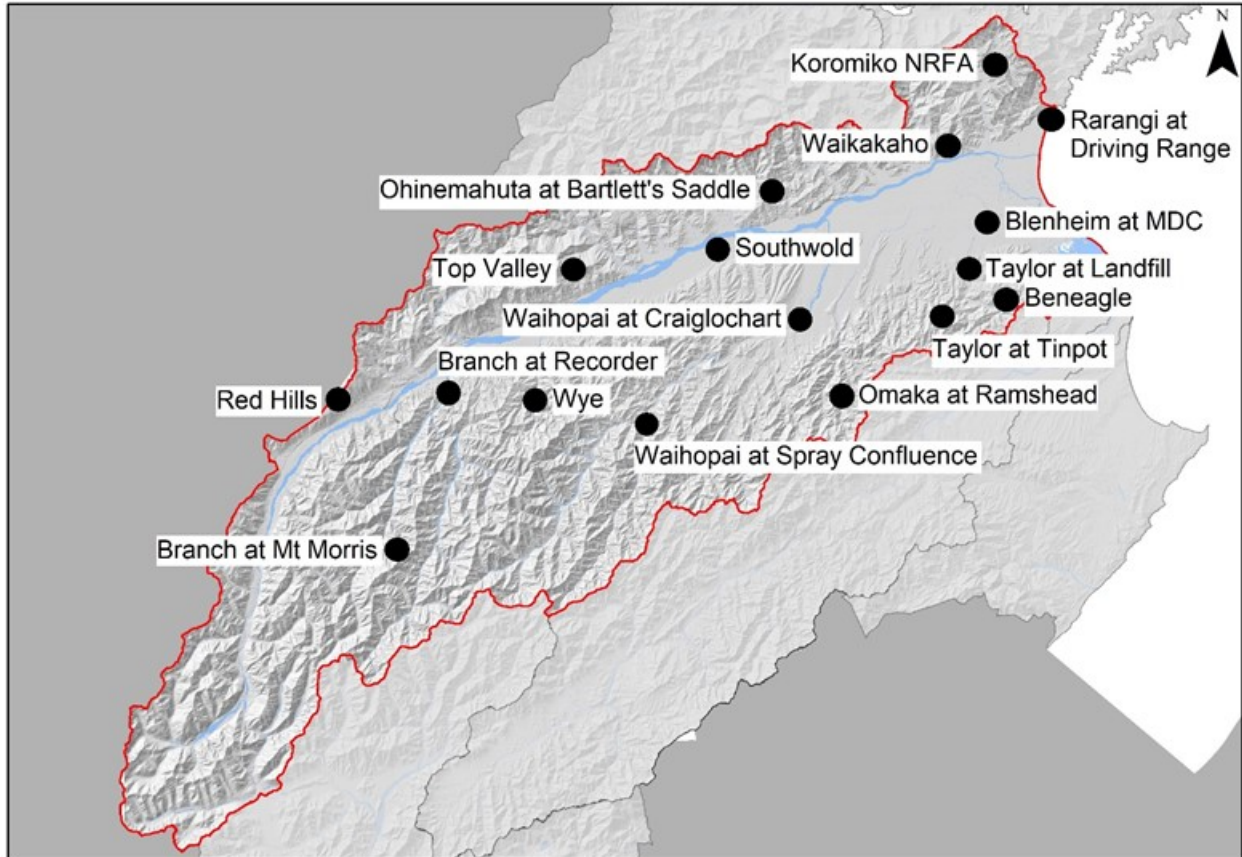


Figure 19: Rainfall monitoring sites within the Wairau FMU.

There is a north to south rainfall gradient in the Wairau catchment. The highest rainfall is in the Richmond Ranges on the north bank of the Wairau River, with average annual rainfall of 1,500 mm or more, declining on the south bank of the river. There is also a rainfall gradient from west to east, with higher rainfall in the mountainous upper catchment declining towards Blenheim and the coast, where average annual rainfall is around 600 mm.

Richmond Ranges West

Red Hills

The Red Hills site is located on the boundary between Tasman and Marlborough and is jointly operated by Tasman and Marlborough District Councils. It is located at the western end of the Richmond Ranges and compared to other parts of the range is more sheltered to the north-west. Average rainfall at Red Hills is approximately 1,400 mm in a water year.

In 2022/23 the site recorded 1,980 mm of rain, the wettest year on record since the site was established in 2005. This exceeds the previous maximum of 1,820 mm which was set the year prior (2021/22). The driest year on record is 2006/07 with 835 mm of rain.

Rainfall generally varies little throughout the seasons at Red Hills. This is likely due to its position, which is sheltered from most storm directions. In the 2022/23 hydrological year, winter and autumn made up a higher proportion of total rainfall (over 30%), while rainfall in spring and summer was lower than average.

2022/23 monthly rainfall at Red Hills can be seen in *Figure 20* below, compared to average monthly rainfall. May 2023 recorded 463 mm of rain, which is the highest monthly total ever recorded at the site, and more than 100 mm above the previous monthly maximum of 335 mm, recorded in December 2019.

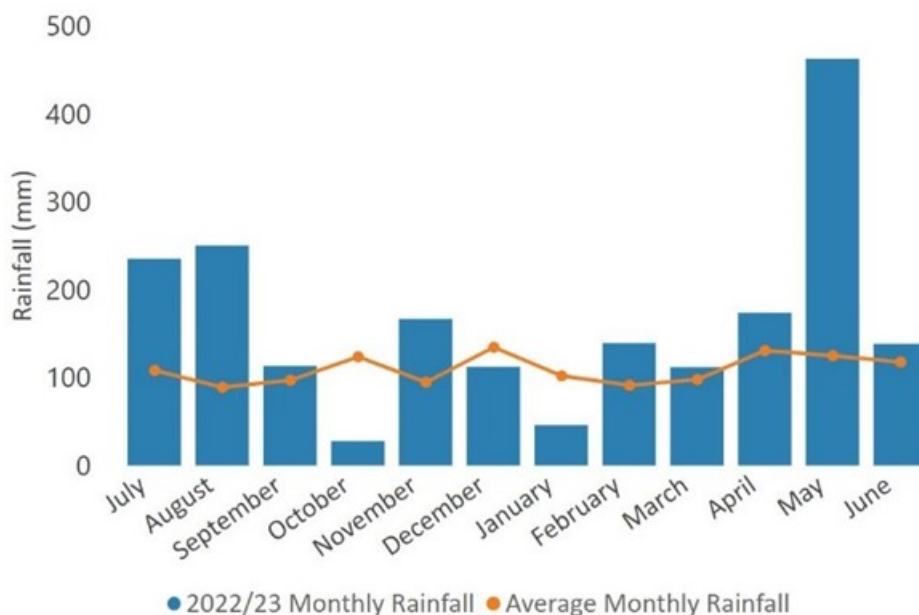


Figure 20: Monthly rainfall in the 2022/23 hydrological year at Red Hills.

Richmond Range East

The Richmond Ranges are exposed to weather systems approaching from the north to north-west, with some of the highest rainfall in the region. Average annual rainfall varies from approximately 1,500 mm to over 3,000 mm in parts of the ranges.

Top Valley at Staircase Ridge

The Top Valley site was established in 1985. Average rainfall at Top Valley is approximately 1,670 mm in a water year. In 2022/23 the site recorded 39% more rainfall than average, with 2,318 mm in total, making it the second wettest year recorded in the 38 years of data collected. The maximum rainfall in a hydrological year was 2,364 mm recorded the year prior (2021/22). 2014/15 was the driest hydrological year on record with 1009 mm of rain.

Rainfall is generally highest in spring, with median rainfall of 445 mm. Summer generally has the least rainfall, with a median of 323 mm. Minimum summer rainfall of 117 mm was recorded during the 2000/01 drought.

In the 2022/23 hydrological year there was a higher proportion of rain over winter and autumn, and less rainfall than usual over spring and summer. Winter 2022 was the wettest winter on record with 1,119 mm of rain recorded, surpassing the previous winter maximum of 810 mm set in 2012. Autumn 2023 also set a new seasonal maximum, with 765 mm of rainfall.

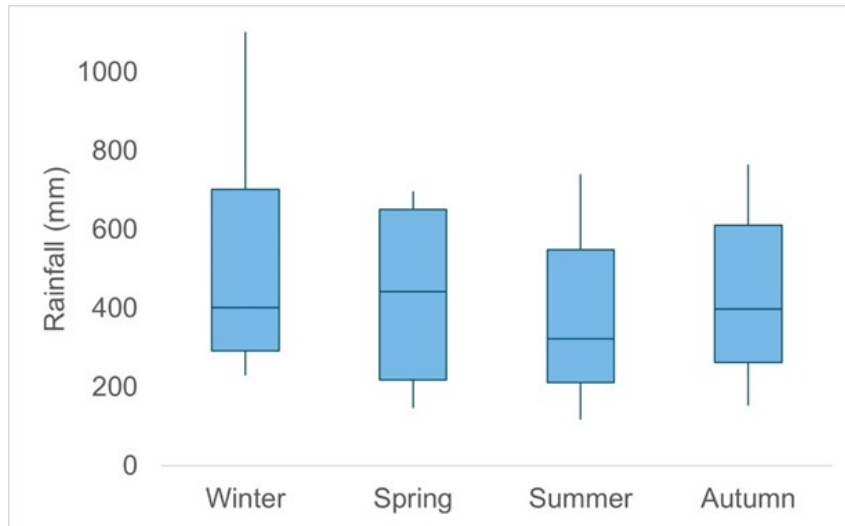


Figure 21: Seasonal rainfall distribution for Top Valley at Staircase Ridge. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Monthly rainfall generally peaks in October with a median of 160 mm, although in 2022/23 October recorded the lowest rainfall total of any month (57 mm), putting it in the 10th percentile. February generally records the lowest monthly rainfall, with a median of 83 mm. Dry months can occur at any time of the year but are the least likely during spring. Monthly rainfall distribution can be seen in *Figure 22*.

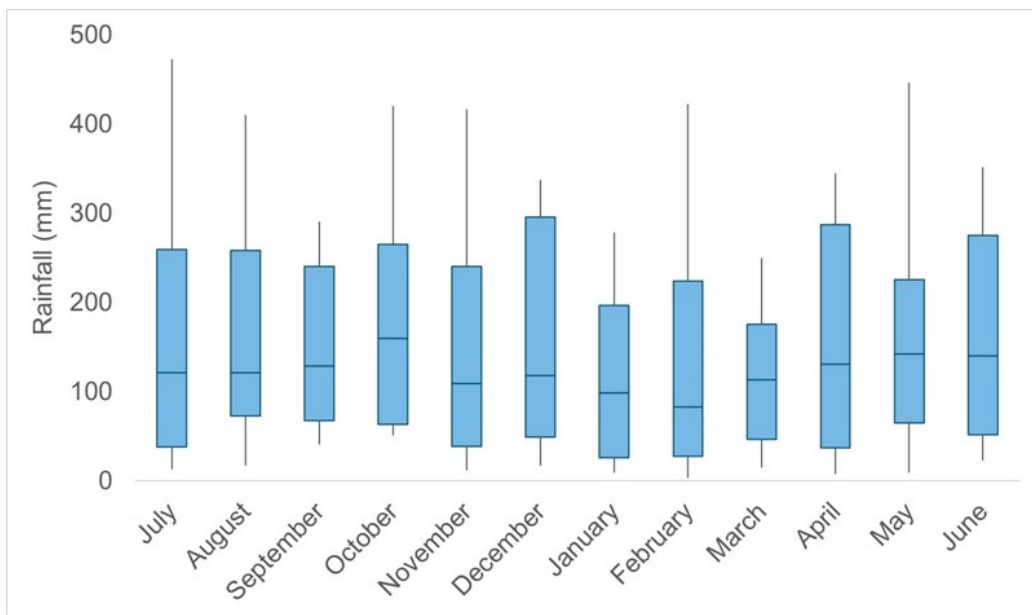


Figure 22: Monthly rainfall distribution for Top Valley at Staircase Ridge. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

In the 2022/23 hydrological year August and May both set new monthly maximums, with 410 and 446 mm respectively (see *Figure 25*). July 2022 rainfall was also in the 90th percentile.

Ohinemahuta at Bartlett’s Creek Saddle

The Ohinemahuta site was established in 1988. Average rainfall at Onamalutu at Bartlett’s Creek Saddle is approximately 1,640 mm in a water year, and over 35 years of monitoring has varied from 847 mm in the driest year on record (2000/01) to 2,564 mm in the wettest year on record (1994/95). Total rainfall in the 2022/23 hydrological year was 2,432 mm, making it the second wettest year on record and 48% more rain than average.

Rainfall at Ohinemahuta is generally highest in winter and spring, while summer generally gets under 20% of total rainfall. The median rainfall in summer is 283 mm, with the minimum summer rainfall of 49mm recorded during the 2000/01 drought. Minimum autumn rainfall of 59 mm was also recorded during the extended 2000/01 drought period. Winter 2022 recorded 1,240 mm of rain, becoming the wettest winter in the site's history. Autumn 2023 was in the 90th percentile with 690 mm. Seasonal rainfall distribution can be seen below in *Figure 23*.

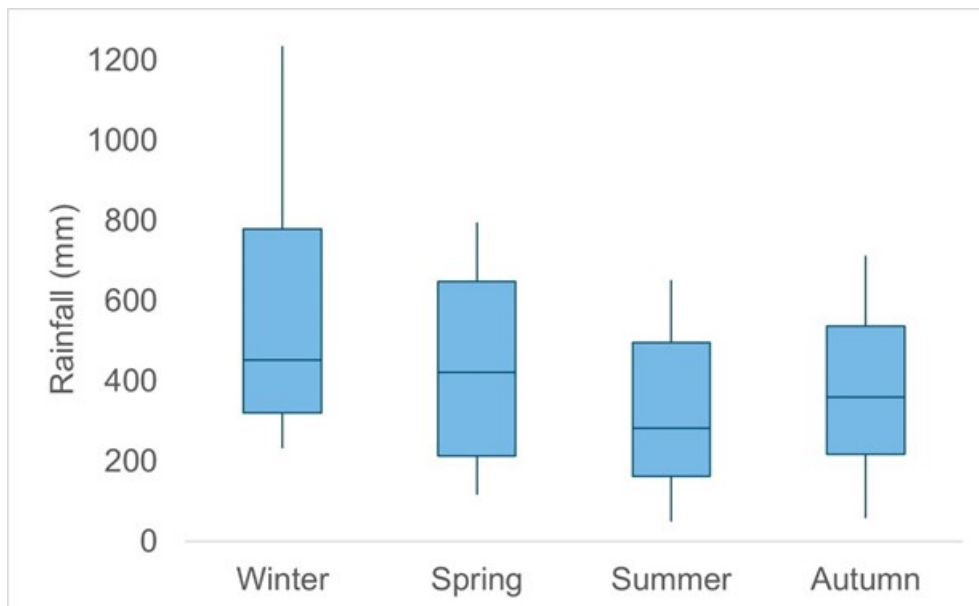


Figure 23: Seasonal rainfall distribution for Ohinemahuta at Bartlett's Creek Saddle. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Monthly rainfall generally peaks in June with a median of 155 mm, although the three highest monthly totals were all recorded in July (536 mm in 1998, 531 mm in 2021, and 459 mm in 2022). February and March usually record the lowest monthly rain totals of around 57 mm each. Monthly rainfall distribution can be seen in *Figure 24*.

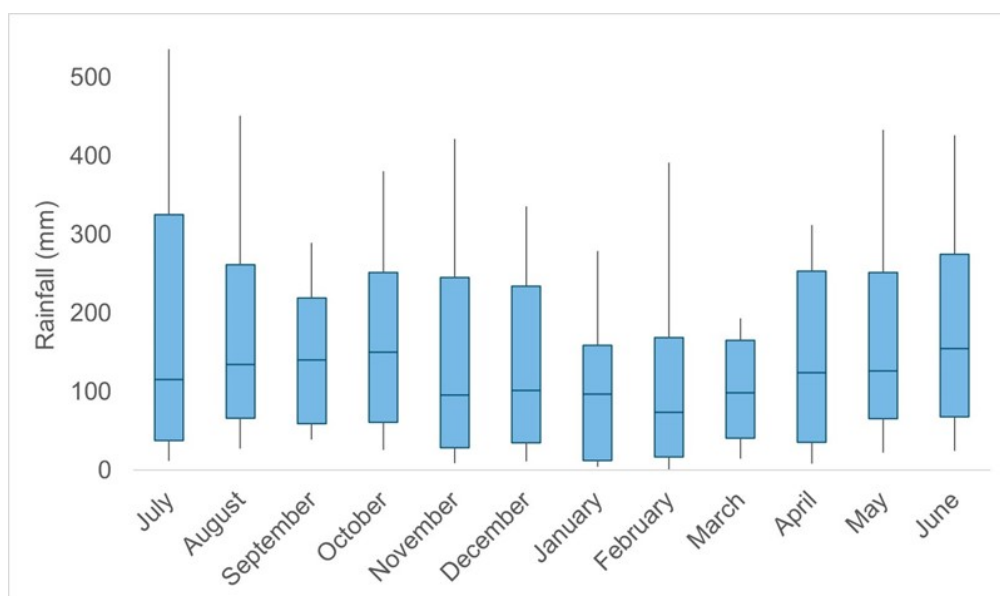


Figure 24: Monthly rainfall distribution for Ohinemahuta at Bartlett's Creek Saddle. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

In the 2022/23 hydrological year several months had high rainfall. August set a new monthly maximum of 451 mm, while July and May were both within the 90th percentile (see *Figure 25* below).

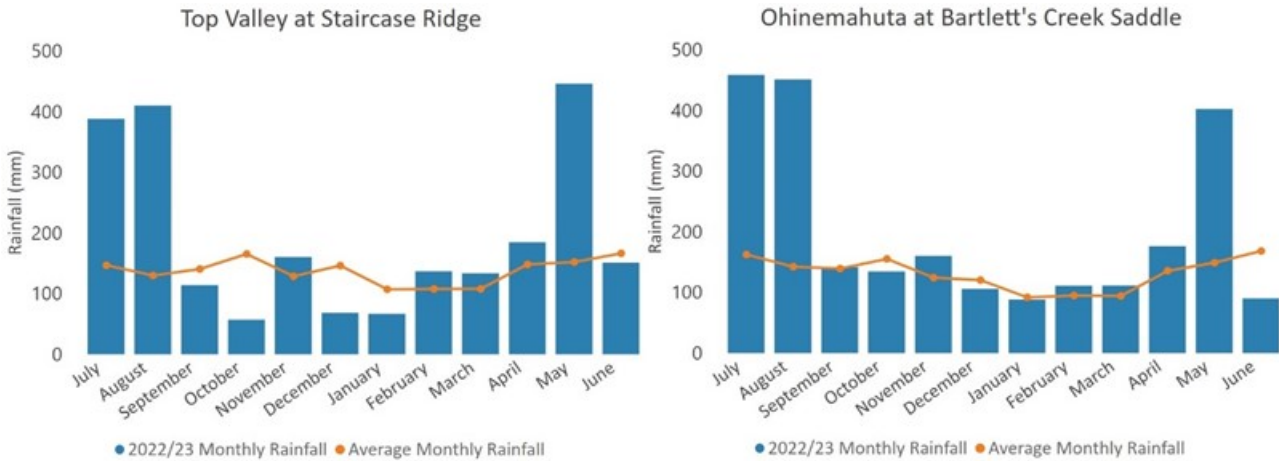


Figure 25: Monthly rainfall in the 2022/23 hydrological year in the eastern Richmond Ranges.

Branch

The Branch catchment is located on the south bank of the Wairau. Annual rainfall is lower than in the Richmond Ranges, although the Branch catchment is mountainous, with higher rainfall at higher elevation in the catchment. The long-term rainfall site in the Branch is located in the lower catchment and receives an average of 1,255 mm of rain in a hydrological year. The new Branch at Mt Morris site is located at an elevation of 1,550 mm in the upper catchment. The two years of data available show rainfall at Mt Morris to be approximately 30% higher than in the lower catchment.

Branch at Branch Recorder

Since the site was established in 1974 rainfall has varied between 893 mm in the driest hydrological year on record (1997/98) to 1,780 mm in the wettest year on record (2021/22). Total rainfall in the 2022/23 hydrological year was 1,717 mm, making it the second wettest year on record and 37% more rain than average.

Summer generally has the lowest rainfall, with median rainfall of 247 mm, however the lowest rainfall on record was in autumn of 1992, with 103 mm of rain. Rainfall is generally highest in spring with a median of 339 mm. Rainfall is the most variable in winter and the least variable in spring. A new winter maximum of 787 mm was set in 2022, surpassing the previous maximum of 597 mm set in winter 2021. Autumn 2023 also set a new seasonal maximum of 635 mm. Seasonal rainfall distribution can be seen in *Figure 26* below.

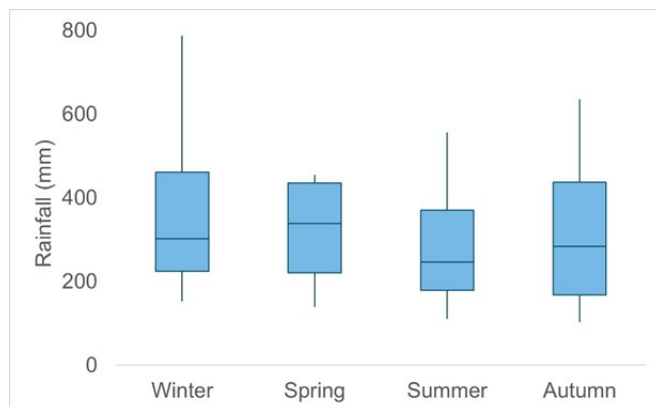


Figure 26: Seasonal rainfall distribution for Branch at Branch Recorder. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

June and October are generally the wettest months at the lower Branch site, both with median rainfall of 108 mm. The driest month is February, with median rainfall of 63 mm. Monthly rainfall distribution can be seen in *Figure 27* below.

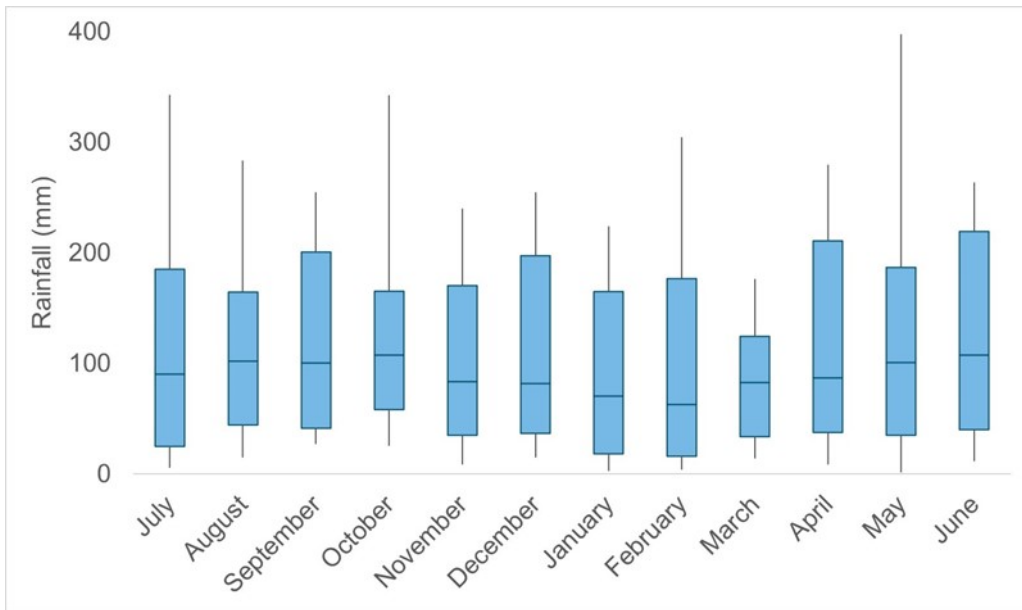


Figure 27: Monthly rainfall distribution for Branch at Branch Recorder. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Monthly rainfall at the Branch at Recorder site varied above and below average throughout the 2022/23 hydrological year. July rainfall was in the 90th percentile, followed by August rainfall of 283 mm which set a new monthly maximum at the site. October recorded just 25 mm of rain, which is the lowest total recorded in October in the sites 49-year history. Storm events in May 2023 led to 398 mm of total rain, the highest monthly total ever recorded at the site.

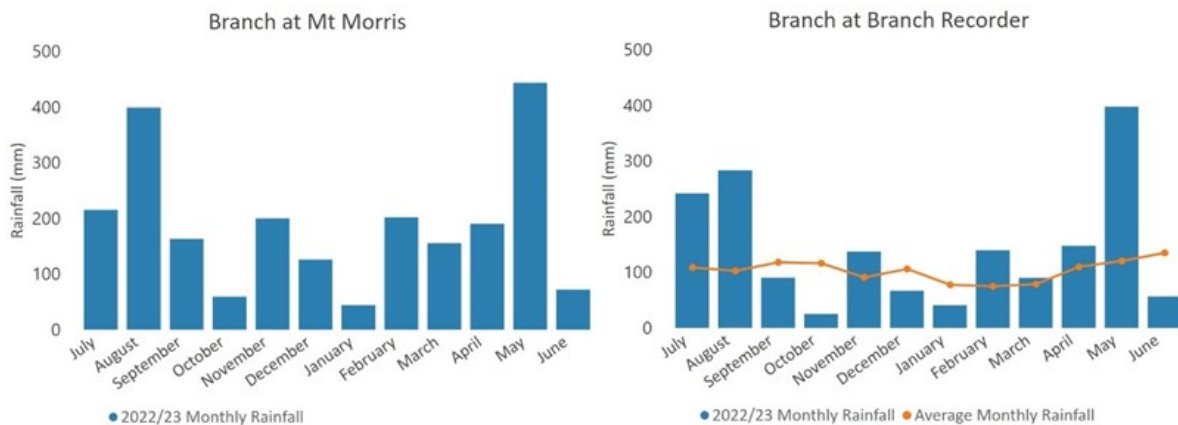


Figure 28: Monthly rainfall in the 2022/23 hydrological year in the Branch Catchment.

Wairau Valley Flats

The flats of the Wairau Valley are sheltered by the Richmond Ranges to the north, and rainfall decreases to the south-east. The Wairau Valley at Southwold site receives an average of 1,023 mm of rain in a hydrological year.

Wairau Valley at Southwold

Wairau Valley at Southwold is one of the rare sites in Marlborough with more than 100 years of rainfall data, having been established in December of 1917. Seasonal and monthly rainfall statistics have been calculated, and full tables can be found in the appendix.

The 2022/23 hydrological year was 40% wetter than average at Southwold, with 1,430 mm of rain recorded compared to an average of 1,023 mm. This makes 2022/23 the second wettest year on record since the site was established. The wettest year on record was 1994/95 with 1,487 mm of rain, while the driest year was during the 1972/73 drought, recording just 596 mm of rain. Other notable drought years include 1930/31 and 2000/01, with 615 and 618 mm of rain respectively.

Summer generally has the least rainfall, with a median of 199 mm. Minimum summer rainfall of 46 mm was recorded during the 2000/01 drought. Rainfall is highest in winter, with a median of 270 mm. Winter 2022 recorded 767 mm of rain, becoming the wettest winter recorded in 106 years. The previous winter maximum was 540 mm recorded in 1998. Seasonal rainfall distribution can be seen below in *Figure 29*.

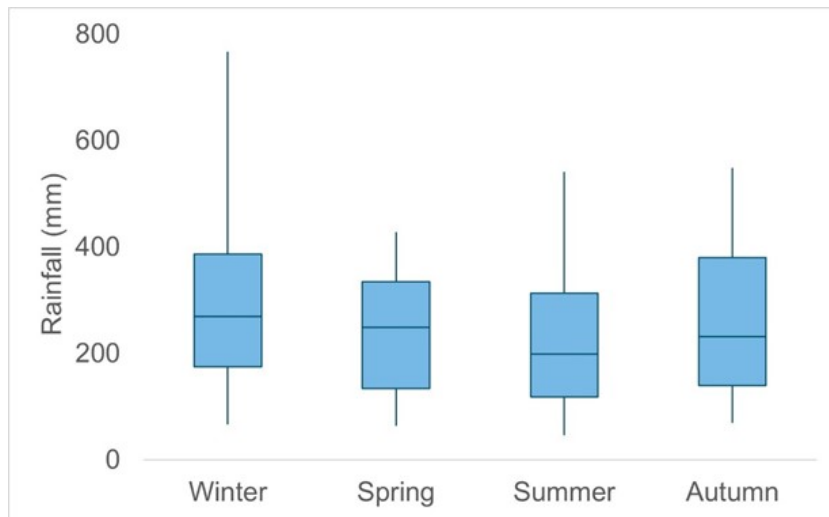


Figure 29: Seasonal rainfall distribution for Wairau Valley at Southwold. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Dry months can occur at any time of the year, although rainfall is generally lowest in February with median rainfall of 54 mm. Higher rainfall is most likely from May to October. February 2017 recorded the highest monthly rainfall of 346 mm. Monthly rainfall distribution can be seen below in *Figure 30*.

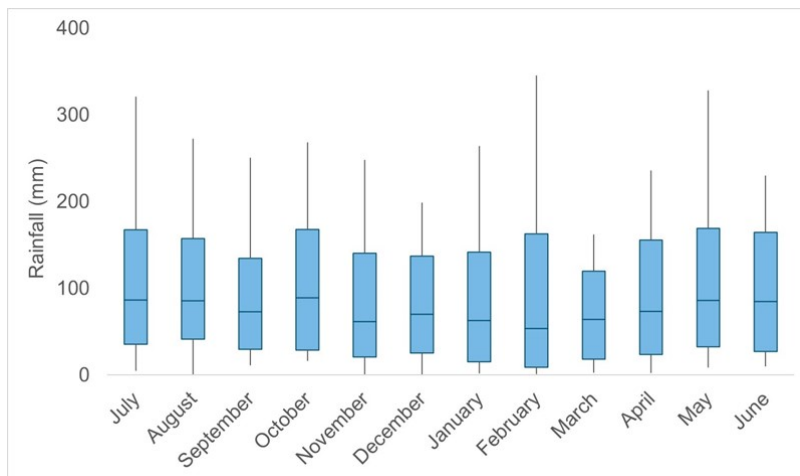


Figure 30: Monthly rainfall distribution for Wairau Valley at Southwold. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

There were several months of high rainfall in the 2022/23 hydrological year. July rainfall of 310 mm was in the 90th percentile, followed by August rainfall of 273 mm which set a new monthly maximum at the site. May 2023 rainfall was also in the 90th percentile.

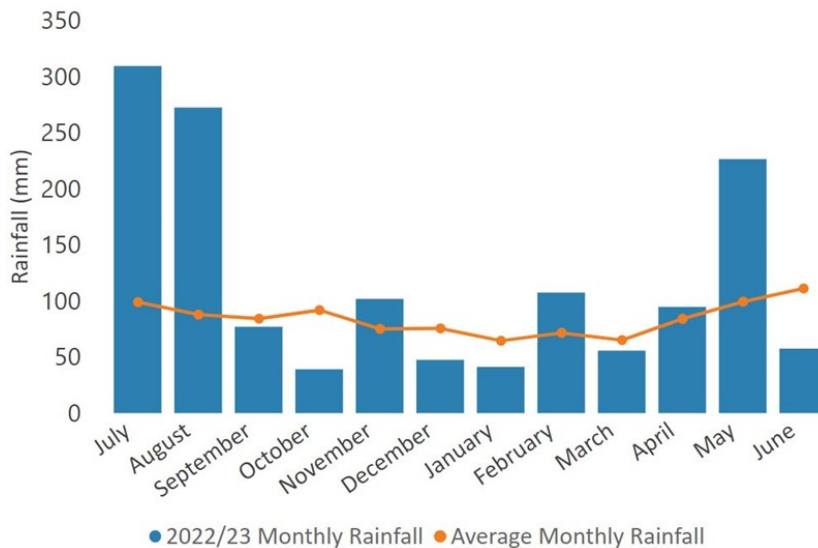


Figure 31: Monthly rainfall in the 2022/23 hydrological year at Wairau Valley at Southwold.

Waihopai

The lower Waihopai Valley is sheltered from rain-bearing systems that predominantly come from the west, so rainfall is low. Waihopai at Craiglochart receives an average of 685 mm of rain in a hydrological year. Rainfall increases with elevation in the upper catchment, with the Waihopai at Spray Confluence site receiving an average of 870 mm of rain in a hydrological year. Both rainfall sites in the catchment were installed in 1988.

Waihopai at Spray

Over 35 years of monitoring, rainfall has varied from 532 mm in the driest hydrological year on record (1997/98) to 1,285 mm in the wettest year on record (2021/22). Total rainfall in the 2022/23 hydrological year was 1,225 mm, the third wettest year on record.

The lowest rainfall is generally in summer and autumn, with median totals of 200 and 194 mm respectively. The lowest rainfall on record is 87 mm both in 2000/01 summer, and spring of 2005. In general, the highest rainfall is in spring, with a median of 232 mm. Winter 2022 set a new maximum of 585 mm, exceeding the previous maximum of 423 mm set the previous winter. Autumn 2023 also set a new seasonal maximum of 394 mm. *Figure 32* below shows the seasonal rainfall distribution.

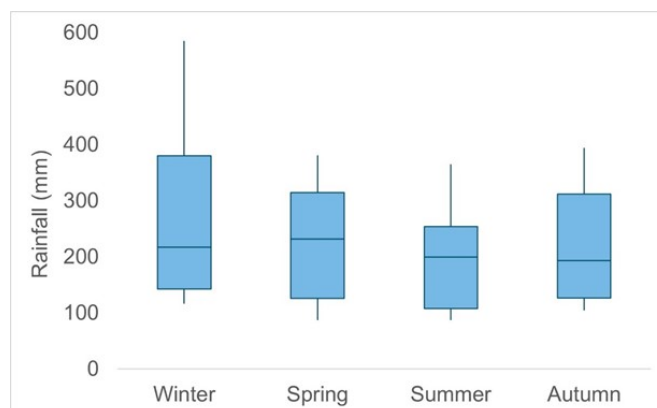


Figure 32: Seasonal rainfall distribution for Waihopai at Spray Confluence. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Rainfall is generally lowest in February, with median rainfall of 45 mm. May and June are the highest rainfall months, with median rainfall of just over 80 mm. July 2021 recorded the highest monthly rainfall of 239 mm. Monthly rainfall distribution for Waihopai at Spray can be seen in *Figure 33* below.

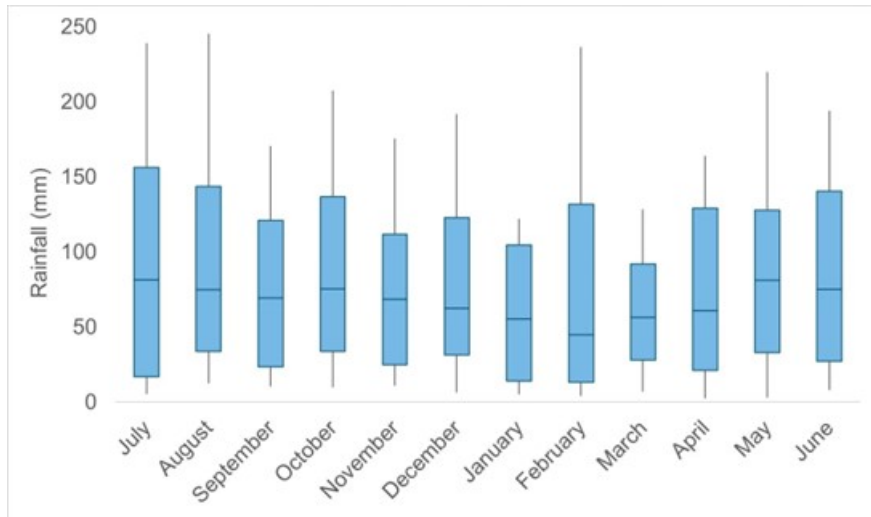


Figure 33: Monthly rainfall distribution for Waihopai at Spray Confluence. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Waihopai at Craiglochchart

Average rainfall at Waihopai at Craiglochchart has varied between 281 mm in the driest hydrological year on record (1997/98) to 995 mm in the wettest year on record (2021/22). Total rainfall in the 2022/23 hydrological year was 940 mm (the fifth wettest year on record).

Summer and autumn generally have the lowest rainfall, with medians of 146 and 149 mm respectively. During the 2000/01 drought summer rainfall was just 30 mm, the lowest on record. Winter generally has the highest rainfall with a median of 177 mm. A new maximum of 451 mm was measured in winter 2022. *Figure 34* below shows the seasonal rainfall distribution.

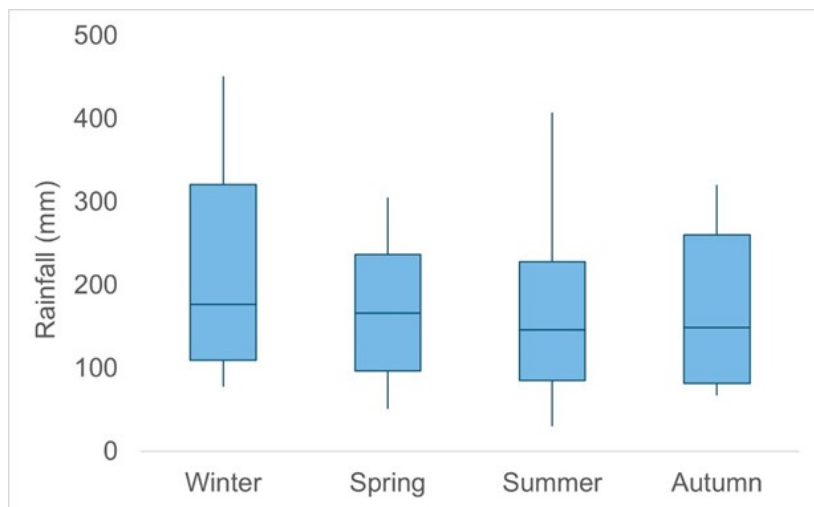


Figure 34: Seasonal rainfall distribution for Waihopai at Craiglochchart. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

February generally has the lowest rainfall, with a median of 33 mm. February also has the most variable rainfall. February 2018 recorded 245 mm of rainfall, the highest total at the site, and the following year recorded 0 mm of rain. June has the highest median rainfall of 64 mm. *Figure 35* below shows monthly rainfall distribution for Waihopai at Craiglochchart.

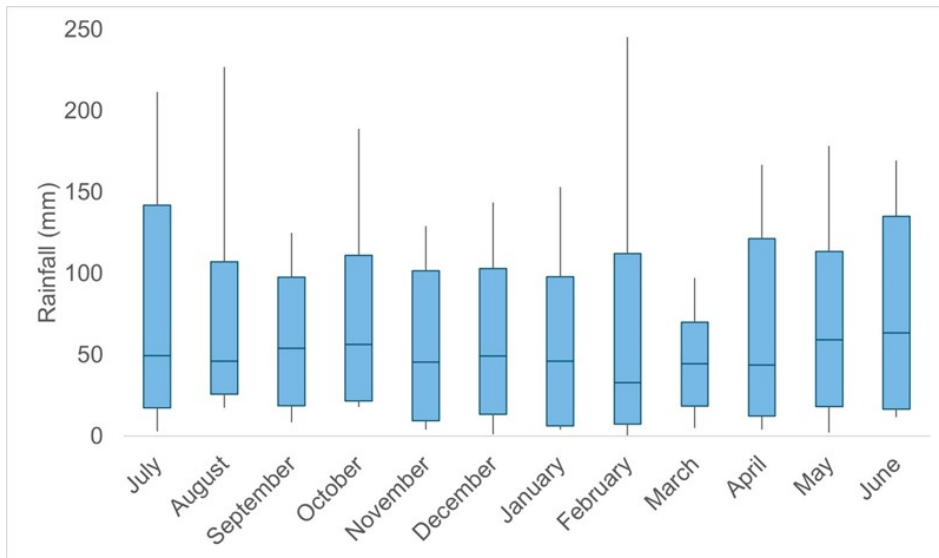


Figure 35: Monthly rainfall distribution for Waihopai at Craiglochchart. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Rainfall in the Waihopai catchment varied in the 2022/23 hydrological year. Monthly totals for both sites can be seen in Figure 36 below, compared to average monthly totals. July and August 2022 were both in the 90th percentile at the Spray and Craiglochchart sites. At Craiglochchart the July total of 212 mm set a new monthly maximum at the site. October was then very dry, setting a new monthly minimum of 10 mm at the Spray. May 2023 also recorded a new monthly maximum of 220 mm at the Spray monitoring site.

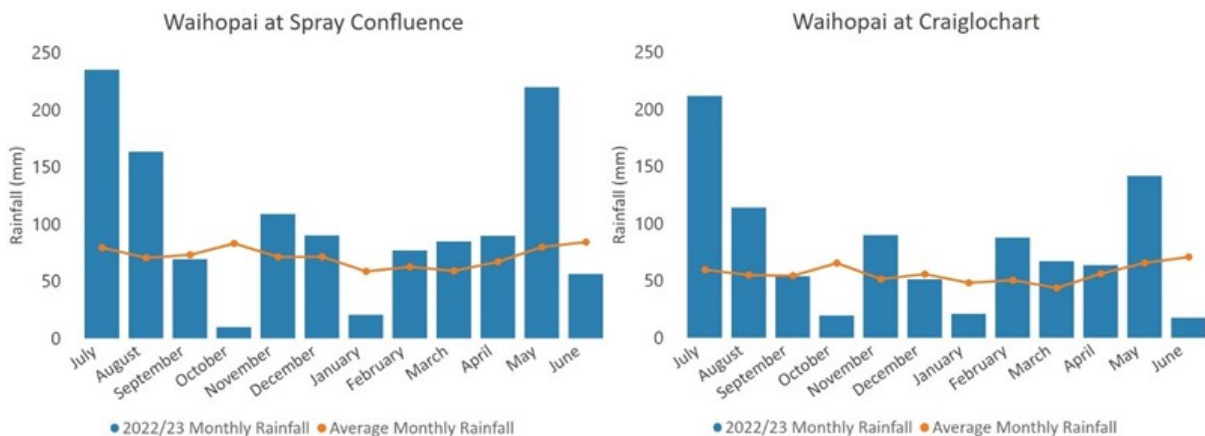


Figure 36: Monthly rainfall in the 2022/23 hydrological year in the Waihopai catchment.

Taylor/Omaka

The Taylor and Omaka catchments have low rainfall due to their sheltered position. Omaka at Ramshead receives an average of 865 mm of rain in a hydrological year. In the Taylor catchment, average rainfall varies between 1,000 mm in the upper catchment, down to 600 mm in the lower lying areas.

Omaka at Ramshead

The 2022/23 hydrological year recorded 35% more rain than average at Ramshead with 1,167 mm of rain recorded. This makes 2022/23 the fourth wettest year on record since the site was established in 1990. The lowest annual rainfall total recorded was 508 mm in 2000/01, while the highest total recorded was 1,304 mm in 2008/09.

Rainfall is lowest in autumn, with a median of 182 mm. The lowest seasonal rainfall total is 47 mm, which occurred in summer during the 2000/01 drought. Rainfall is generally highest in winter, with a median of 218 mm. Maximum rainfall of 573 mm was measured in winter of 2008. *Figure 37* below shows the seasonal rainfall distribution.

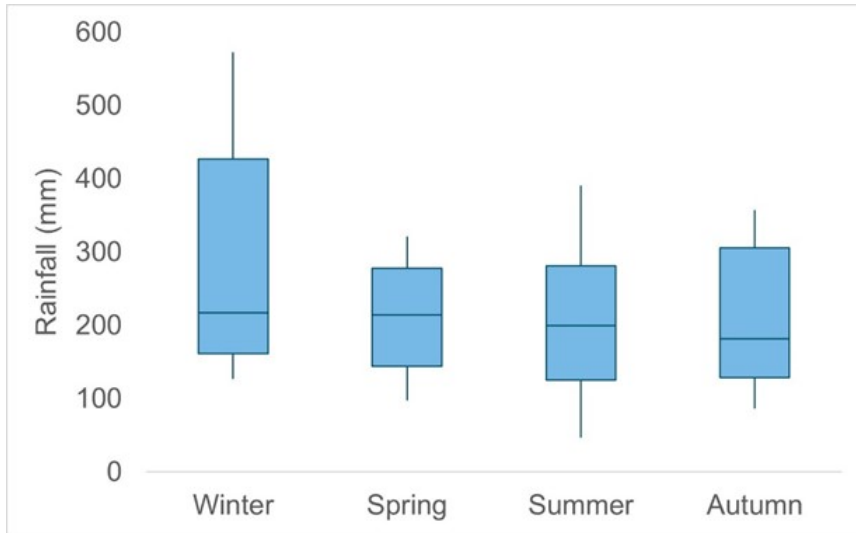


Figure 37: Seasonal rainfall distribution for Omaka at Ramshead Saddle. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

The lowest rainfall is generally in February, with a median of 42 mm. June has the highest rainfall median of 83 mm. July has the most variable rainfall, with the monthly maximum of 312 mm recorded in July 2008. *Figure 38* below shows monthly rainfall distribution for Omaka at Ramshead.

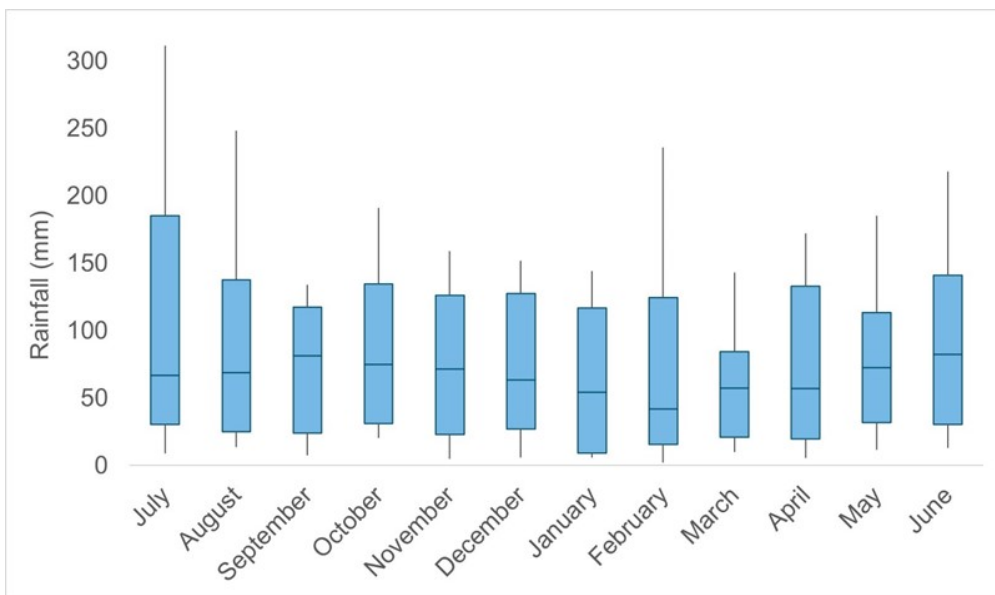


Figure 38: Monthly rainfall distribution for Omaka at Ramshead Saddle. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Monthly rainfall was variable at Omaka at Ramshead in the 2022/23 hydrological year, as can be seen in *Figure 39* below. Rainfall in four months (July, August, March, and May) all scored within their monthly 90th percentiles. October was an unusually dry month, recording a new monthly minimum of 20 mm.

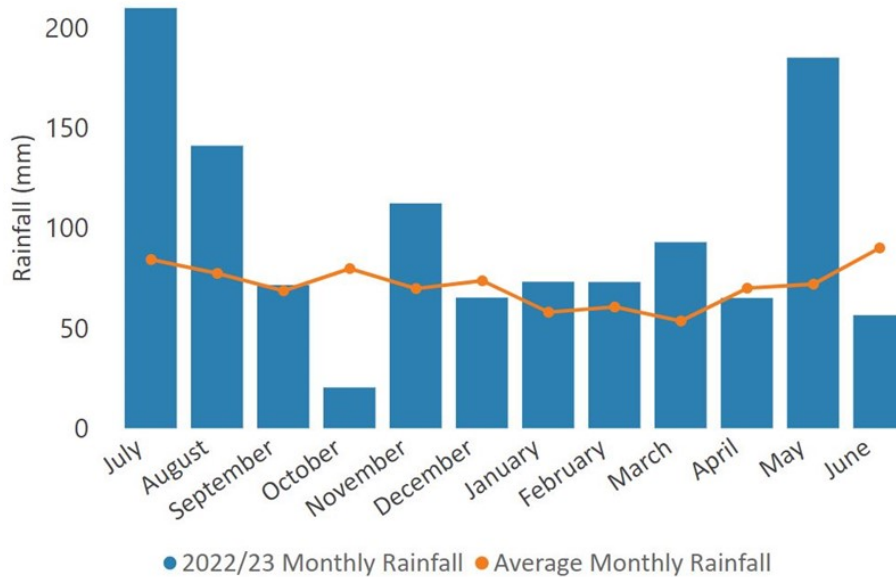


Figure 39: Monthly rainfall in the 2022/23 hydrological year at Omaka at Ramshead Saddle.

Taylor at Tinpot

Average rainfall at Taylor at Tinpot is 980 mm in a hydrological year, and since the site was established in 1963 has varied from 350 mm in the driest year on record (1972/73) to 1,417 mm in the wettest year on record (2013/14). Total rainfall in the 2022/23 hydrological year was 1,332 mm, which is 35% more rainfall than average, and the fifth wettest year on record.

Summer and autumn generally have the lowest rainfall, with median rainfall of 184 and 188 mm respectively. The driest season on record is summer during the 2000/01 drought, recording 37 mm of rain. Rainfall is generally highest in winter, with a median of 265 mm. Winter of 2012 recorded the highest winter total of 679 mm. The seasonal rainfall distribution can be seen in *Figure 40* below.

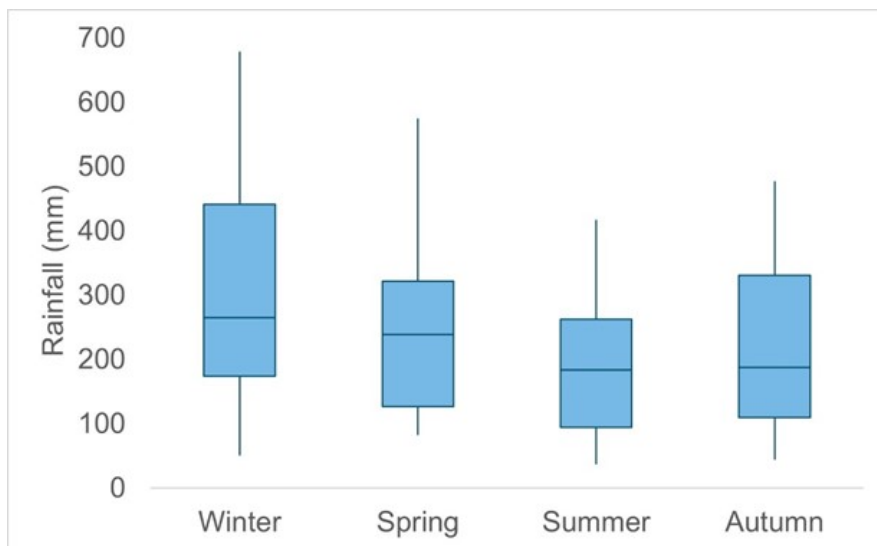


Figure 40: Seasonal rainfall distribution for Taylor at Tinpot. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Maximum monthly rainfall is generally recorded in July, with median rainfall of 81 mm. Maximum monthly rainfall of 349 mm was recorded in September of 1989. The lowest monthly rainfall is generally in February, with a median of 45 mm. *Figure 41* below shows monthly rainfall distribution for Taylor at Tinpot.

Monthly rainfall at Tinpot did not deviate significantly from average in the 2022/23 hydrological year (see *Figure 46*) with the exception of July 2022, which recorded 310 mm of rain, putting it in the 90th percentile.

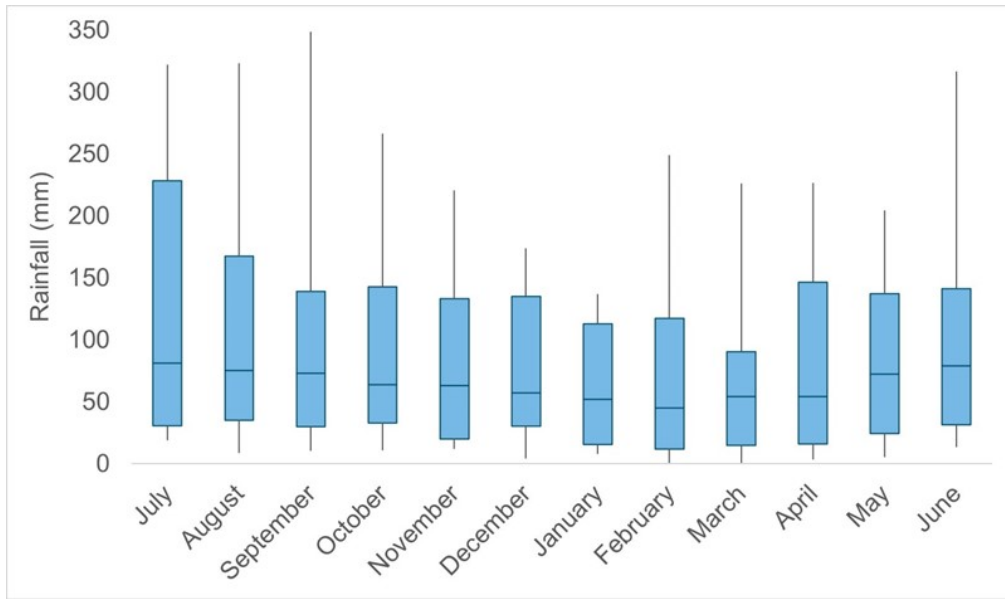


Figure 41: Monthly rainfall distribution for Taylor at Tinpot. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Beneagle

Average rainfall at Beneagle is 730 mm in a hydrological year. In 2022/23 the site recorded 957 mm of rain, making it the eighth wettest year recorded in the 49 years of data collected. The maximum rainfall in a hydrological year was 1,203 mm recorded in 1992/93. 2000/01 was the driest hydrological year on record with 393 mm of rain.

Rainfall is generally lowest in summer, with median rainfall of 140 mm. Just 20 mm of rain was recorded in the driest summer on record, during the 2000/01 drought. Rainfall is highest in winter, with a median of 218 mm. Winter 2022 set a new seasonal maximum of 441 mm. Seasonal rainfall distribution at Beneagle can be seen in *Figure 42* below.

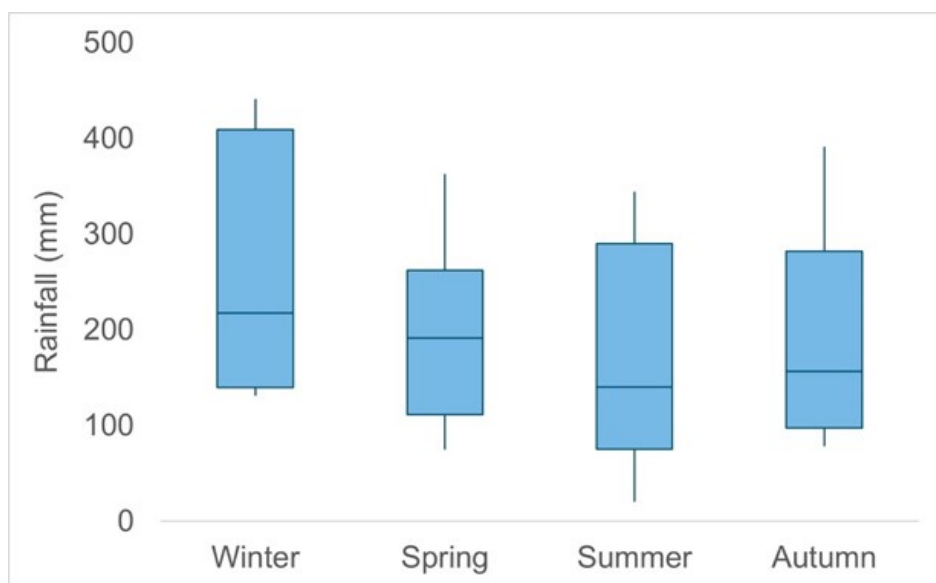


Figure 42: Seasonal rainfall distribution for Beneagle at Farm Stream. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

The lowest rainfall is generally in February, with a median rainfall of 37 mm. June has the highest median rainfall of 67 mm, although maximum monthly rainfall at Beneagle was recorded in August of 1990. Monthly rainfall distribution can be seen in *Figure 43* below.

July 2022 set a new July maximum at Beneagle, with 260 mm of rainfall. Just 21 mm of rain in October 2022 put it in the 10th percentile for that month. Monthly rainfall for the 2022/23 hydrological year can be seen in *Figure 46*, compared to average monthly rainfall.

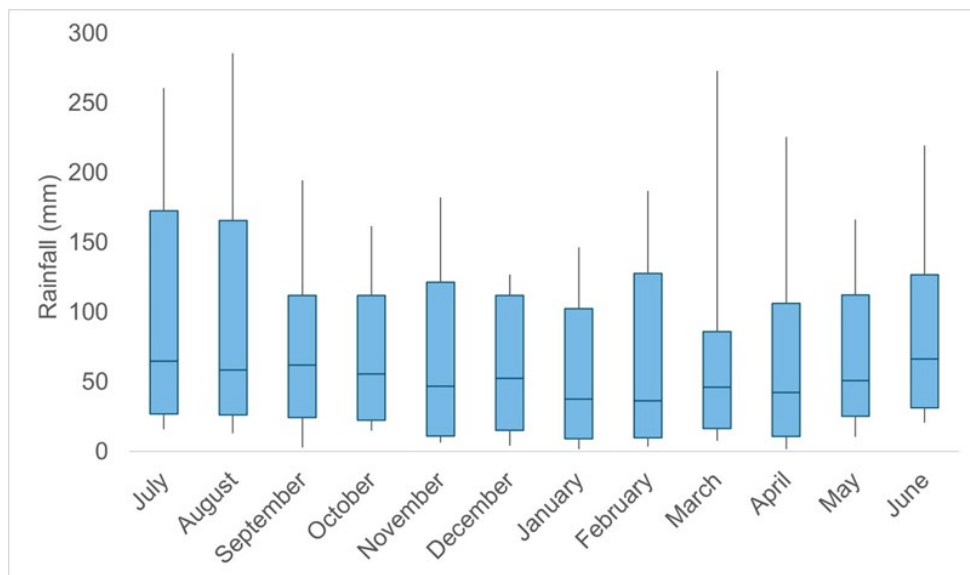


Figure 43: Monthly rainfall distribution for Beneagle at Farm Stream. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

Taylor at Taylor Pass Landfill

Average rainfall at Taylor at Taylor Pass Landfill is 602 mm in a hydrological year. In 2022/23 the site recorded 748 mm of rain in total, making it the third wettest year since the site was established in 2006. The annual maximum was set in 2008/09 with 918 mm of rain. The driest year on record is 2014/15 with 336 mm of rain.

Wairau Floodplain

The lower Wairau is one of the driest areas in Marlborough, being very sheltered from north-westerlies. Blenheim receives an average of 615 mm of rain in a hydrological year.

Blenheim at MDC Office

The 2022/23 hydrological year recorded 26% more rain than average in Blenheim, with 776 mm of rain recorded. This makes 2022/23 the third wettest year on record since the site was established in 1991. The lowest annual rainfall total recorded was 305 mm in 2000/01, while the highest total recorded was 1,162 mm in 1994/95.

The lowest rainfall in Blenheim is generally in summer, with median rainfall of 130 mm. The lowest summer rainfall of 17 mm was recorded during the 2000/01 drought. Winter accounts for the largest proportion of average annual rainfall at around 30%, and the winter median rainfall is 170 mm. Winter 2022 was extremely wet in Blenheim, with a new seasonal maximum rainfall of 403 mm recorded. The previous seasonal maximum of 337 mm was recorded in the winter of 1994. Seasonal rainfall distribution for Blenheim can be seen below in *Figure 44*.

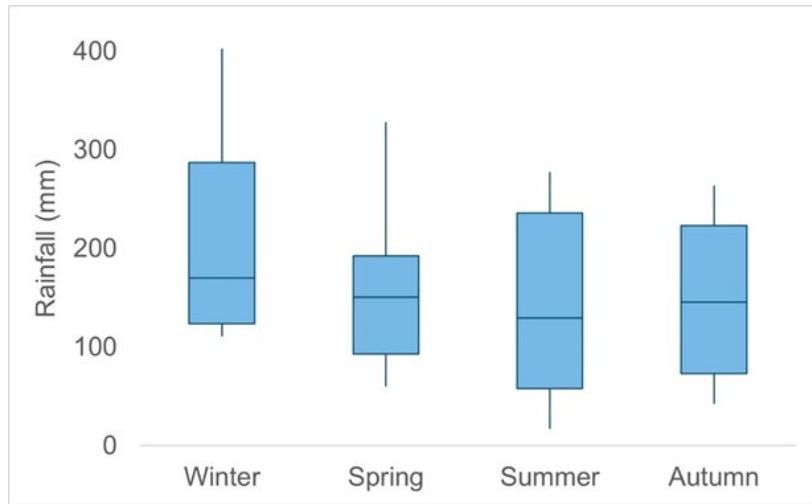


Figure 44: Seasonal rainfall distribution for Blenheim at MDC Office. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

The lowest rainfall in Blenheim is generally in February, with median rainfall of 28 mm. 0 mm of rain in a month has occurred multiple times in Blenheim, including January 2019. Highest monthly rainfall is generally in June, with a median of 63 mm.

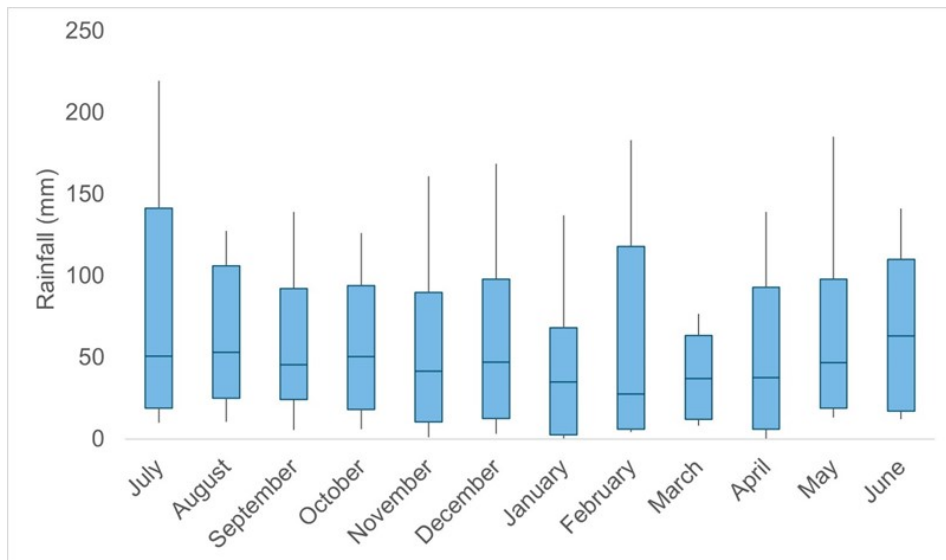


Figure 45: Monthly rainfall distribution for Blenheim at MDC Office. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

July 2022 became the wettest month on record in Blenheim, with 220 mm of rain. This is the first time that monthly rainfall in Blenheim has exceeded 200 mm. The Marlborough Research Centre has been measuring rainfall in Blenheim since 1930, and the rainfall recorded in July 2022 is the highest monthly rainfall recorded over 93 years. Monthly rainfall for the 2022/23 hydrological year can be seen in *Figure 46*, compared to average monthly rainfall.

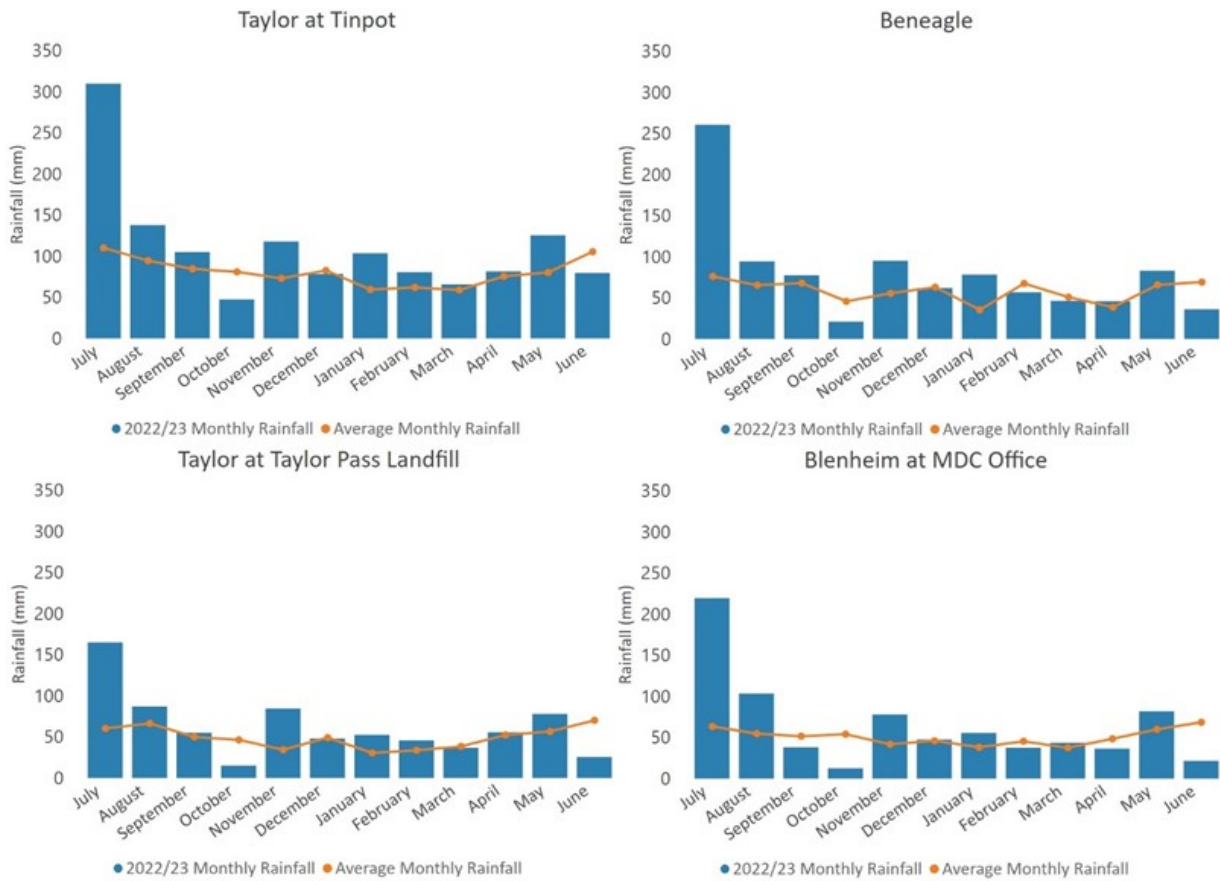


Figure 46: Monthly rainfall in the 2022/23 hydrological year for the Taylor Catchment and lower Wairau Plains.

Rarangi at Driving Range

The 2022/23 hydrological year recorded 1,286 mm of rain at Rarangi compared to an average of 953 mm. This makes 2022/23 the wettest year on record since the site was established in 2010. The driest year on record was 2015/16 with 697 mm of rain.

Awatere

There are four climate monitoring sites in the Awatere as shown on the map in *Figure 47* below. The Awatere at Awapiri site was established in 1982 by MDC. Fire and Emergency New Zealand operate the other three sites in the Awatere, which were installed from 2011 onwards.

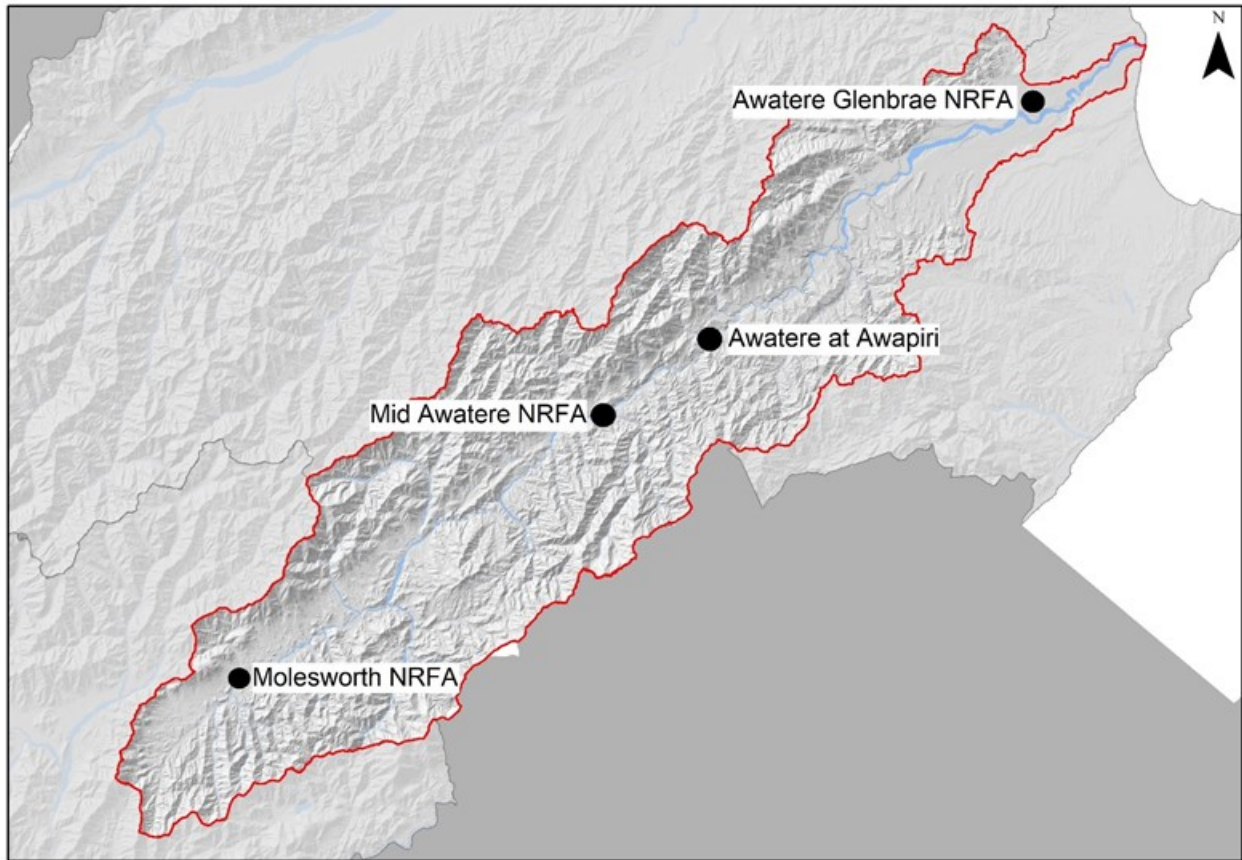


Figure 47: Rainfall monitoring sites within the Awatere FMU.

The Awatere Valley is sheltered from westerly rain-bearing systems and is therefore one of the drier areas in Marlborough. Rainfall is lowest at the coast, with an average hydrological year recording 570 mm at Awatere Glenbrae NRFA. Rainfall increases in the mid catchment, with an average of 817 mm at Awatere at Awapiri, before decreasing in the upper catchment (around Molesworth Station), which is well sheltered by the Kaikoura Ranges to the south-east and by the Raglan Range to the north-west. Average rainfall in a hydrological year at Molesworth NRFA is 745 mm.

Rainfall in 2022/23 varied from slightly to well above average throughout the Awatere catchment, with the greatest deviation from average in the mid catchment. In the lower Awatere, the Glenbrae site recorded 605 mm in the 2022/23 hydrological year, which is just above average.

Awatere at Awapiri recorded 1,217 mm of rain in 2022/23, the second wettest hydrological year on record. The maximum was set the year prior (2021/22) with 1,283 mm of total rain. The driest year on record is 2014/15 with just 464 mm of rain.

At the Mid Awatere site 946 mm of rain was recorded in 2022/23, which is approximately 25% above average. In the upper catchment, the Molesworth site recorded 847 mm of rainfall, which is slightly above average.

Winter generally accounts for about 30% of annual rainfall in the Awatere catchment, with spring and summer being the drier seasons, receiving just over 20% of rainfall each. This seasonal pattern was more pronounced in 2022/23, with winter rainfall accounting for over 40% of total rainfall, while spring and autumn each recorded less than 20% of total rainfall.

Monthly rainfall in the Awatere was variable above and below average throughout the 2022/23 hydrological year, as can be seen in *Figure 48* below. For example, at the Molesworth site July and August 2022 both recorded new monthly maximums (of 152 mm and 99 mm respectively), while 12.4 mm in October became the new minimum rainfall recorded in that month.

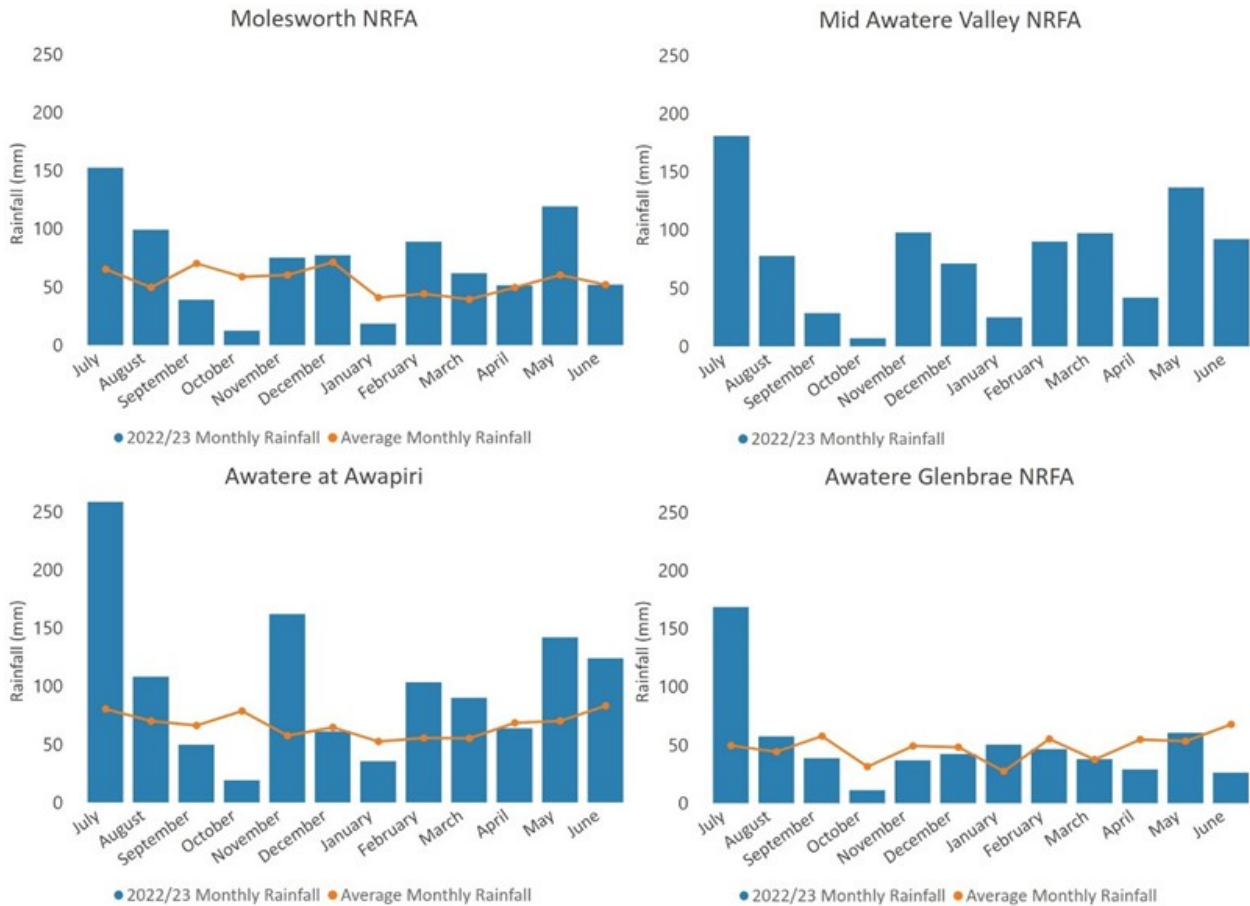


Figure 48: Monthly rainfall 2022/23 in the Awatere, from the upper catchment (top left) to lower catchment (bottom right).

Awatere at Awapiri

The Awatere at Awapiri site was established in 1982, providing 41 years of data for analysis. Seasonal and monthly rainfall statistics have been calculated and full tables can be found in the appendix.

Rainfall is generally lowest in summer with median rainfall of 169 mm. Minimum summer rainfall was recorded in 2000/01, with only 38 mm recorded. Rainfall is least variable in spring and most variable in winter. Seasonal rainfall distribution can be seen below in *Figure 49*. Winter 2022 set a new winter maximum of 555 mm, surpassing the previous winter maximum of 479 mm recorded the year prior (2021/22).

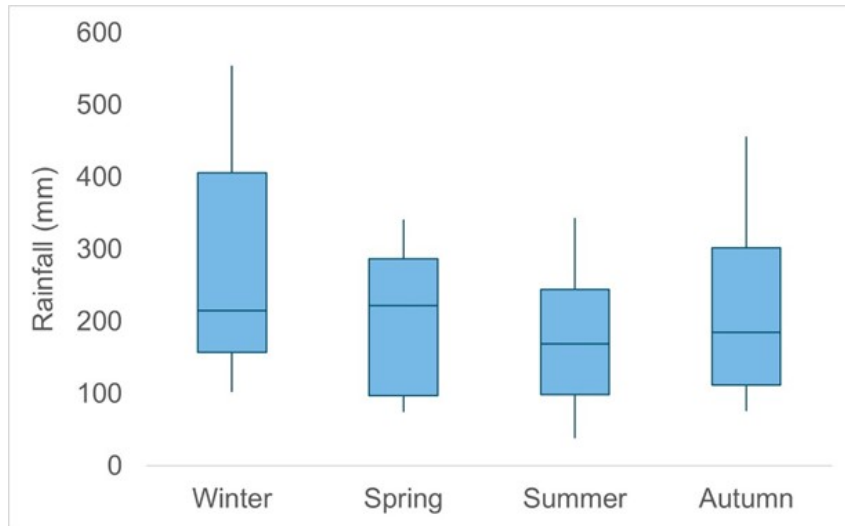


Figure 49: Seasonal rainfall distribution for Awatere at Awapiri. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per season.

Monthly rainfall is generally the lowest in February, with a median of 35 mm for the month. Dry months can occur at any time, although the driest months on record are in summer and early autumn. June is generally the wettest month, with median rainfall of 79 mm. July recorded the highest monthly rainfall total of 260 mm in July 2021. Monthly rainfall distribution can be seen below in *Figure 50*.

Monthly rainfall at the Awatere at Awapiri site was variable in the 2022/23 hydrological year. July 2022 recorded 258 mm of rain, which is very close to the monthly maximum of 260 mm measured the previous July. October 2022 was dry, with 19 mm of rain placing it in the lowest 10% of October totals. November 2022 set a new November maximum of 162 mm, while May 2023 was in the 90th percentile of monthly totals, with 142 mm of rainfall.

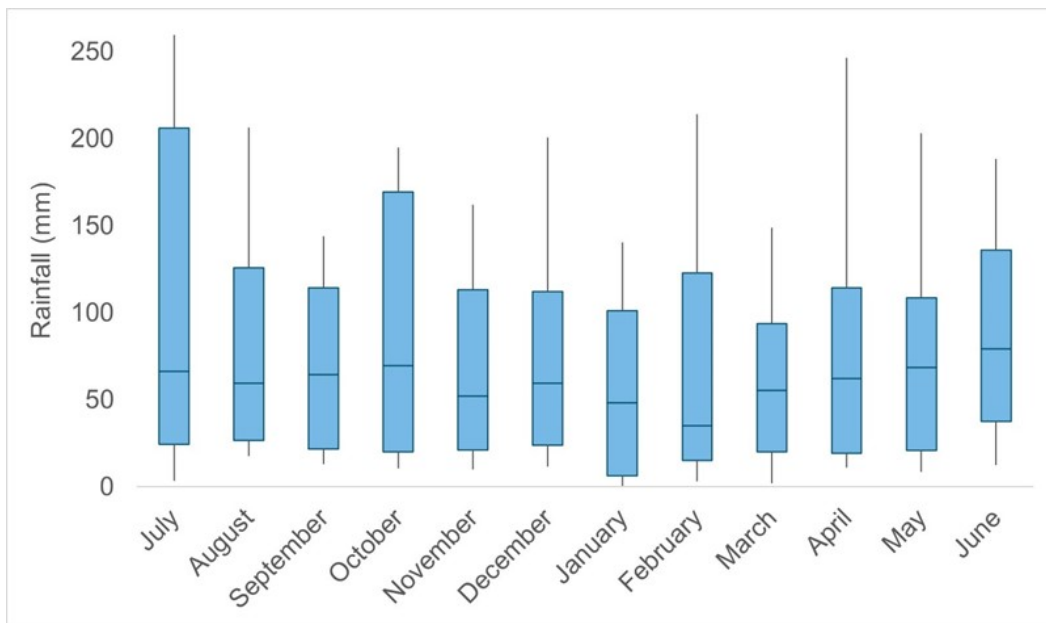


Figure 50: Monthly rainfall distribution for Awatere at Awapiri. The plot shows (from top to bottom): maximum, 90th percentile, median, 10th percentile, and minimum rainfall per month.

East Coast Complex

There are four climate monitoring sites in the East Coast Complex, as shown on the map in *Figure 51* below. The Flaxbourne, Lake Elterwater, and Te Rapa sites are operated by MDC. The Lake Elterwater site was installed recently (November 2021) while the Flaxbourne and Te Rapa sites were installed in 2006 and 2008 respectively. Fire and Emergency New Zealand also operate a climate station near Ward, which was established in 2014.

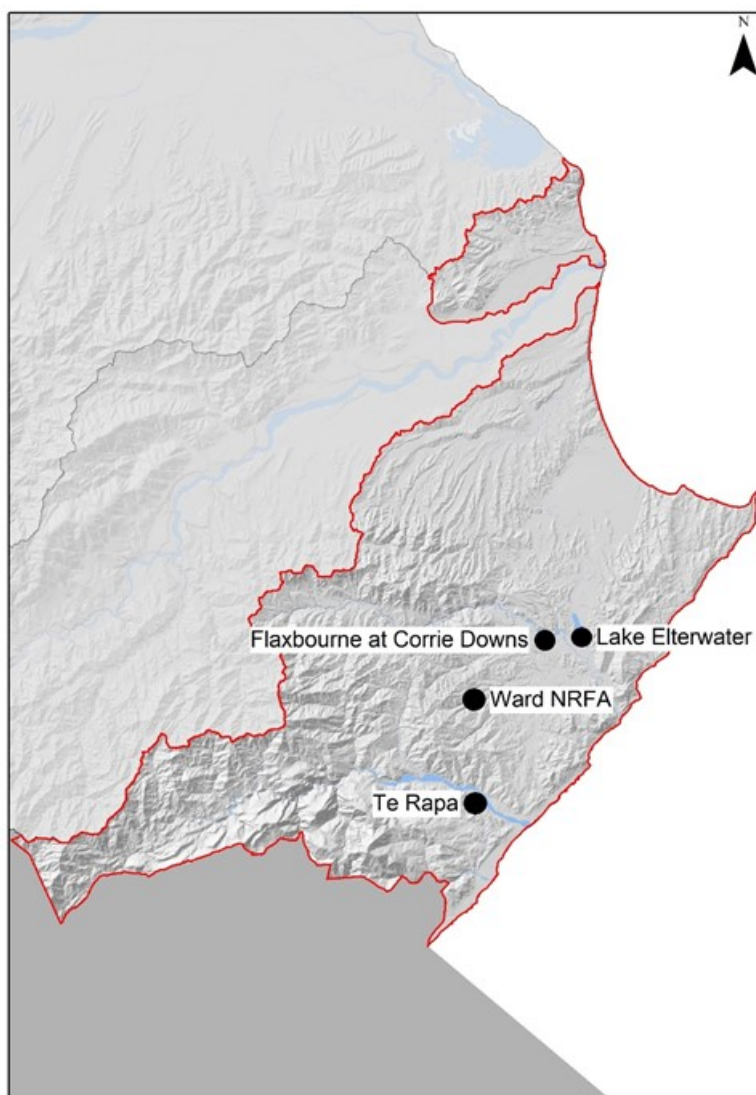


Figure 51: Rainfall monitoring sites within the East Coast Complex FMU.

The East Coast is one of the driest areas in Marlborough, being well sheltered from westerly rain systems. Rainfall is lowest in the north-east, with rainfall at the Flaxbourne site averaging 700 mm in a hydrological year. There is an increase in rainfall to the south-west as the terrain becomes more mountainous, with average rainfall of 770 mm at the Ward NRFA site, increasing to 990 mm at Te Rapa.

Rainfall in the 2022/23 hydrological year was between 30-35% higher than average in the East Coast FMU.

At the Flaxbourne site total rainfall in the 2022/23 hydrological year was 942 mm, making it the second wettest hydrological year on record. Since establishing the site in 2006 rainfall has varied from 346 mm in the driest year (2014/15) to 964 mm in the wettest year (2017/18). The newly established Lake Elterwater monitoring site is located within 2 km of the Flaxbourne rainfall site

with the intent of providing additional rainfall data for the area. Based on the first complete hydrological year of data, the two sites are measuring annual rainfall within $\pm 2\%$ of each other.

Over 15 years of monitoring, rainfall at Te Rapa has varied between 672 mm in the driest year (2015/16) to 1,330 mm in the wettest year (2013/14). 2022/23 was the second wettest hydrological year on record, with 1,284 mm of rain recorded.

There is a slight winter rainfall maximum in the East Coast area. Generally, 30% of annual rain falls over the winter months (June to August), while spring, summer, and autumn receive close to equal proportions of rain. As in the neighbouring Awatere FMU, seasonal rainfall in 2022/23 was more varied on the East Coast, with winter rain accounting for over 40% of total rainfall, while spring and autumn each recorded less than 20% of total rainfall.

Monthly rainfall for the 2022/23 hydrological year for Te Rapa and the Flaxbourne can be seen in *Figure 52* below. July 2022 saw a new monthly maximum recorded at both sites due to a series of south-easterly rain events. At Te Rapa, the July rainfall totalled 378 mm, which is more than 100 mm above the previous monthly maximum at the site. Total rainfall at the Flaxbourne in July was 272 mm.

During the main storm event in July 2022, the 12-hour rainfall totals at Te Rapa and the Flaxbourne were 150 and 100 mm respectively. At Te Rapa the 12-hour rainfall total had an annual probability of 4%.

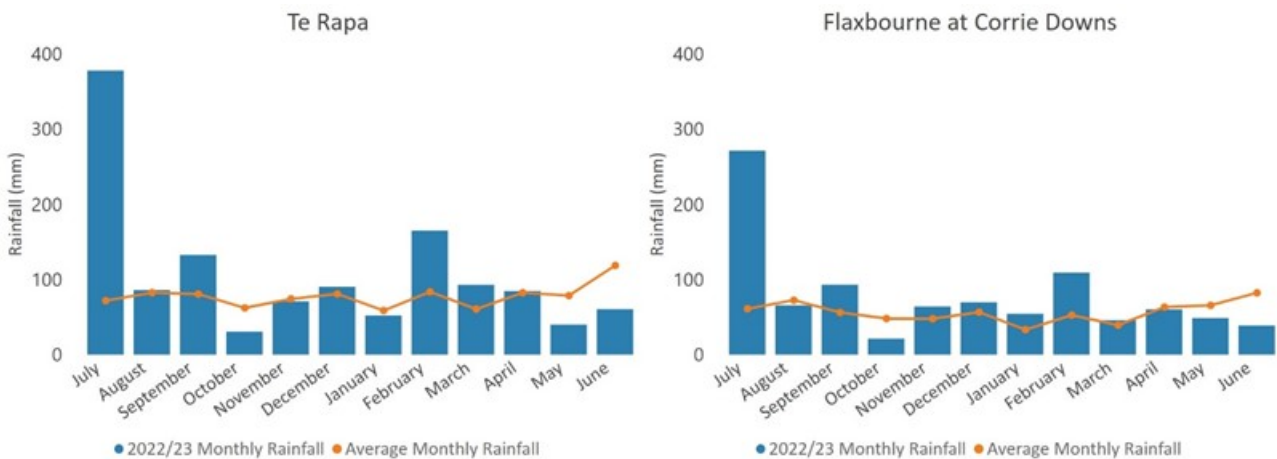


Figure 52: Monthly rainfall 2022/23 at Te Rapa (left) and Flaxbourne at Corrie Downs (right) rainfall monitoring sites.

Waiau-toa / Clarence

Two climate monitoring sites at Pudding Hill and the Upper Clarence are operated by Fire and Emergency New Zealand in the Waiau-toa / Clarence FMU, as shown on the map in Figure 53 below. The sites were established in 2018 and 2014 respectively.

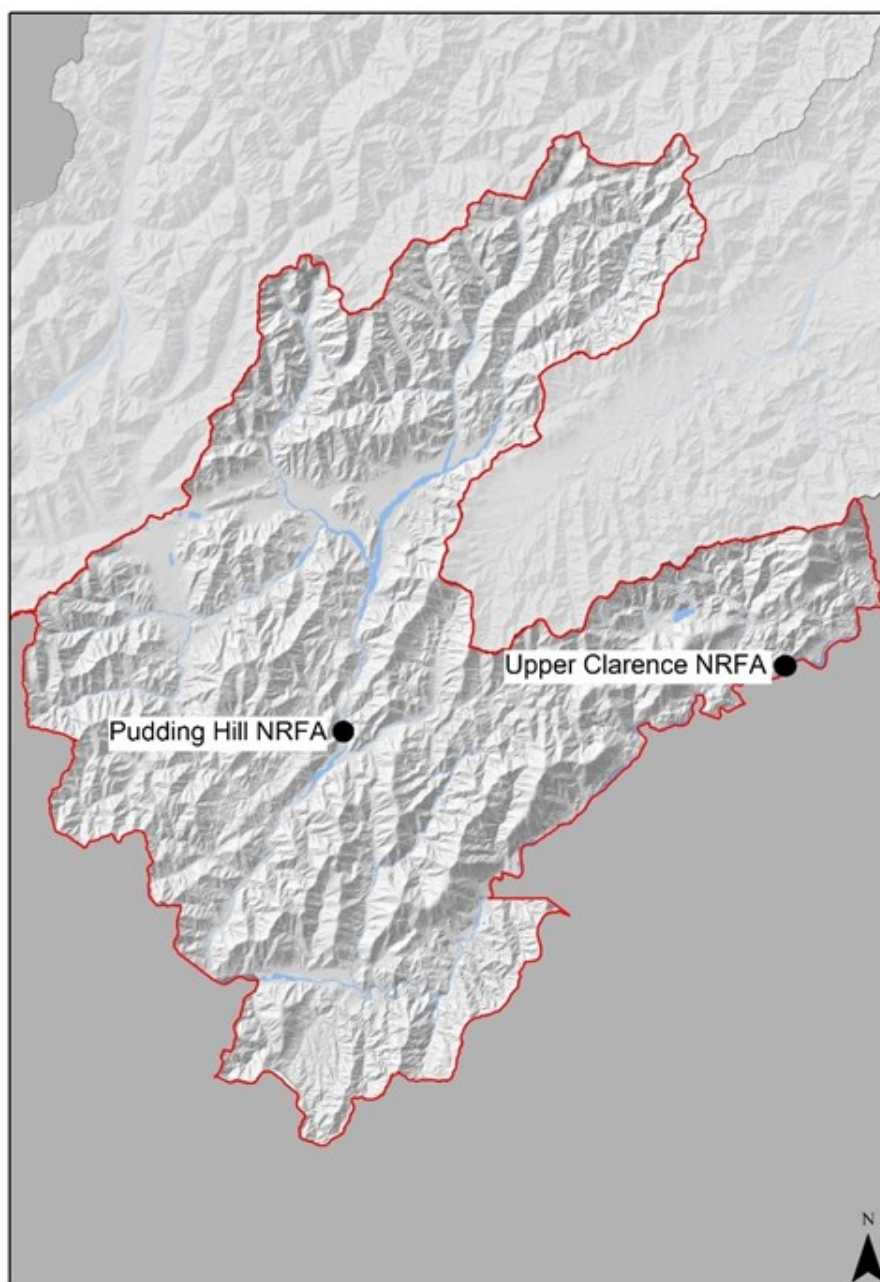


Figure 53: Rainfall monitoring sites within the Waiau-toa / Clarence FMU.

The Waiau-toa / Clarence FMU is a mountainous area characterised by extremes, with generally dry, hot summers and harsh winters. Rainfall is lowest in the east of the FMU where the upper Clarence River flows between the Inland and Seaward Kaikoura Ranges, providing shelter to the north-west and south-east respectively. At the Upper Clarence site average rainfall in a hydrological year is approximately 640 mm. Unlike most of the Marlborough region, rainfall for the 2022/23 year was below average at the site, with 515 mm measured.

Rainfall increases to the west, and Pudding Hill receives on average 760 mm of rain in a hydrological year, with total rainfall in the 2022/23 year slightly below average at 730 mm.

From the available data there does not appear to be pronounced seasonal rainfall variation in the Waiiau-toa / Clarence, although snowfall in winter may increase total precipitation in that season and cannot always be measured. Rainfall in winter 2022 (June-August) accounted for over 40% of total rainfall at both Pudding Hill and the Upper Clarence, which is a much higher proportion than average. Monthly rainfall for the 2022/23 hydrological year for both sites can be seen in *Figure 54* below.

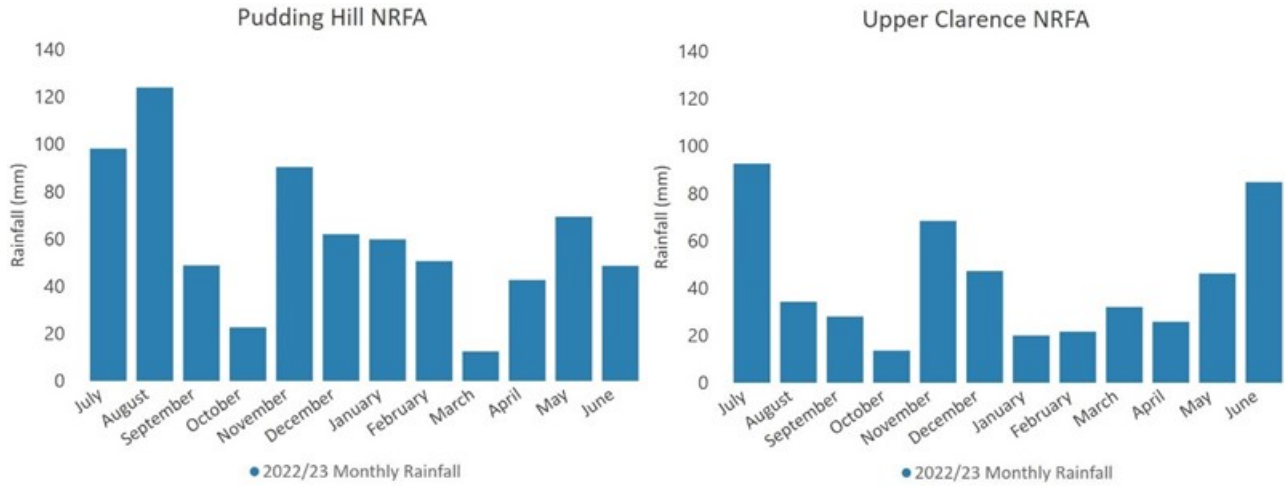


Figure 54: Monthly rainfall 2022/23 at Pudding Hill (left) and Upper Clarence (right) NRFA climate sites.

Appendix

Table 1: Monthly rainfall totals for sites in Marlborough for the 2022/23 hydrological year.

Site	July	August	September	October	November	December	January	February	March	April	May	June	Total
Awatere at Awapiri	258	108	50	19	162	61	36	103	90	64	142	124	1217
Awatere Glenbrae NRFA	169	57	39	11	37	42	50	46	38	29	60	26	605
Beneagle at Farm Stream	261	94	78	21	95	62	78	57	47	46	83	36	957
Blenheim at MDC Office	220	104	38	13	78	48	56	38	44	37	82	22	776
Branch at Branch Recorder	242	283	90	25	137	67	41	140	90	148	398	57	1717
Branch at Mt Morris	216	399	163	59	200	126	44	202	155	190	444	72	2271
Flaxbourne at Corrie Downs	272	66	93	21	64	70	54	109	46	60	49	39	942
Kaituna Rainfall at Higgins Bridge	287	363	87	104	192	58	101	111	103	122	254	45	1824
Kenepuru Head NRFA	469	516	192	159	182	127	179	247	168	172	311	78	2802
Koromiko NRFA	337	287	186	130	126	148	233	111	139	122	171	76	2067
Lake Elterwater Climate	289	67	106	23	56	76	72	122	52	56	42	37	997
Lansdowne NRFA	298	239	88	25	130	50	42	87	74	113	234	40	1419
Linkwater	333	423	110	103	157	85							
Malings	201	276	91	95	151	54	14	90	186	99	206	58	1518
Mid Awatere Valley NRFA	181	78	29	7	98	71	25	90	97	42	137	92	946
Molesworth NRFA	152	99	39	12	75	77	18	89	62	51	119	52	847
Omaka at Ramshead Saddle	210	141	72	20	112	65	73	73	93	65	185	57	1167
Onamalutu at Bartletts Creek Saddle	459	451	142	135	160	106	88	111	111	176	402	90	2431
Onamalutu at Hilltop Road NRFA	462	448	135	169	167	88	110	98	107	199	287	106	2375
Picton Climate at Waitohi Domain	262	332	132	95	128	100	194	147	86	115	184	45	1819
Pudding Hill NRFA	98	124	49	23	90	62	60	51	12	43	69	49	729
Rai at Rai Falls	394	913	177	193	254	65	145	151	142	304	507	99	3342
Rai Valley NRFA	419	735	209	158	263	110	188	173	181	250	453	115	3253
Rarangi at Driving Range	324	186	68	58	121	79	76	77	90	53	122	34	1286
Red Hills	236	251	114	28	167	113	46	140	112	174	463	139	1980
Sevenoaks	277	172	71	30	98	59							
St Arnaud NRFA	208	199	138	67	177	84	42	84	129	112	240	44	1525
Taylor at Taylor Pass Landfill	165	87	55	15	85	48	53	46	37	56	78	26	748

Table 1. (continued).

Site ▲	July	August	September	October	November	December	January	February	March	April	May	June	Total
Taylor at Tinpot	310	138	105	47	118	78	104	81	66	82	125	80	1332
Te Rapa	378	86	133	31	71	90	52	165	96	94	41	66	1303
Top Valley at Staircase Ridge	388	410	114	57	161	68	67	137	134	185	446	151	2318
Tor Darroch NRFA	248	164	79	20	139	91	36	91	131	106	219	71	1394
Tunakino	431	1241	224	184	253	117	192	183	206	356	592	103	4079
Upper Clarence NRFA	93	34	28	14	68	47	20	22	32	26	46	85	514
Waihopai at Craiglochart	212	114	54	20	90	51	21	88	67	64	142	18	939
Waihopai at Spray Confluence	235	163	69	10	109	90	21	77	85	90	220	56	1225
Waikakaho	358			54	117	87	95	57	69	74	194	46	
Waikawa at Boons Valley	357	231	133	83	111		243		122	202	174	49	
Wairau Valley at Southwold	310	273	77	39	102	48	41	108	56	95	227	58	1431
Wakamarina at Twin Falls	318	590	183	186	228	67	100	139	128	228	383	87	2636
Ward NRFA	294	65	87	24	80	67	36	115	54	57	59	55	993
Wye at Charlies Rest	215	208	95	22	114	75	43	119	89	94	225	52	1350

Table 2: Seasonal rainfall statistics for sites in Marlborough with 30+ years of data: minimum (a; mm), 10th percentile (b; mm), median (c; mm), 90th percentile (d; mm), maximum (e; mm).

Site		Winter	Spring	Summer	Autumn
Tunakino	a	293	217	164	242
	b	478	385	331	322
	c	655	643	483	578
	d	1005	1035	918	868
	e	2016	1256	1118	1392
Whakamarino at Twin Falls	a	321	194	128	227
	b	343	371	228	274
	c	500	530	396	485
	d	739	784	591	676
	e	1267	989	728	825
Linkwater	a	99	119	74	165
	b	305	231	162	222
	c	447	356	273	366
	d	644	521	488	538
	e	1049	734	633	785
Top Valley at Staircase Ridge	a	230	147	117	153
	b	292	218	211	263
	c	402	443	323	399
	d	702	651	548	611
	e	1119	698	741	765
Ohinemahuta at Bartlett's Creek Saddle	a	233	116	49	59
	b	320	213	163	218
	c	454	423	283	360
	d	779	649	497	537
	e	1236	795	652	713
Branch at Branch Recorder	a	152	140	110	103
	b	224	221	179	168
	c	303	339	247	284
	d	462	435	370	437
	e	787	455	557	635
Wairau Valley at Southwold	a	66	64	46	69
	b	175	134	119	139
	c	270	249	199	232
	d	386	335	313	381
	e	767	428	541	549
Waihopai at Spray Confluence	a	116	87	87	105
	b	143	126	108	127
	c	217	232	200	194
	d	380	315	254	312
	e	585	381	365	394

Table 2. (continued).

Site		Winter	Spring	Summer	Autumn
Waihopai at Craiglochart	a	78	51	30	67
	b	109	97	85	82
	c	177	167	146	149
	d	321	237	228	261
	e	451	305	408	321
Omaka at Ramshead Saddle	a	127	98	47	87
	b	162	144	125	129
	c	218	215	200	182
	d	427	278	282	305
	e	573	321	391	358
Taylor at Tinpot	a	51	83	37	44
	b	174	127	95	110
	c	265	239	184	188
	d	441	322	263	331
	e	679	575	417	477
Beneagle at Farm Stream	a	131	75	20	79
	b	140	111	76	97
	c	218	191	140	157
	d	409	263	290	282
	e	441	363	345	391
Blenheim at MDC Office	a	111	60	17	43
	b	124	93	58	73
	c	170	151	130	146
	d	287	192	236	223
	e	403	328	278	264
Awatere at Awapiri	a	103	75	38	76
	b	157	97	99	112
	c	215	222	169	185
	d	406	287	245	302
	e	555	342	343	456

Table 3: Monthly rainfall statistics for sites in Marlborough with 30+ years of data: minimum (a; mm), 10th percentile (b; mm), median (c; mm), 90th percentile (d; mm), maximum (e; mm).

Site		Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Tunakino	a	28	18	50	57	24	20	7	1	23	3	23	23
	b	85	97	85	113	47	77	32	40	51	56	119	87
	c	171	197	202	243	149	174	168	114	154	197	216	238
	d	436	402	334	426	452	420	316	252	336	391	339	399
	e	914	1241	491	903	577	756	437	755	371	581	704	473
Whakamarino at Twin Falls	a	15	29	57	73	26	14	9	6	25	5	24	32
	b	50	82	89	92	53	64	35	31	63	40	92	64
	c	142	160	188	208	110	133	133	88	103	125	165	183
	d	323	285	270	316	354	284	207	227	203	267	318	310
	e	592	590	315	693	421	541	319	418	283	312	401	410
Linkwater	a	26	27	14	9	15	7	5	0	6	13	20	13
	b	67	65	52	53	34	34	20	17	31	40	72	47
	c	157	135	115	129	91	92	76	67	92	113	143	139
	d	269	306	207	228	210	215	184	193	188	249	243	238
	e	590	423	353	462	412	401	331	348	212	314	364	343
Top Valley at Staircase Ridge	a	13	17	41	51	12	17	9	3	15	8	9	23
	b	38	73	67	63	39	49	26	28	46	37	65	52
	c	122	122	128	160	109	118	99	83	113	131	143	140
	d	259	259	241	265	241	296	197	224	175	287	226	275
	e	473	410	291	420	417	338	279	422	250	345	446	352
Ohinemahuta at Bartlett's Creek Saddle	a	12	28	39	26	9	12	4	0	15	9	23	25
	b	38	67	59	61	29	35	12	17	41	36	66	68
	c	116	135	141	151	96	102	97	74	99	124	127	155
	d	325	262	219	252	246	234	159	169	166	254	252	275
	e	536	451	290	381	422	336	279	392	194	312	434	426

Table 3. (continued).

Site		Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Branch at Branch Recorder	a	6	15	27	25	9	15	3	4	14	9	2	11
	b	25	45	41	58	35	37	18	16	34	38	35	40
	c	90	102	101	108	84	82	70	63	83	87	101	108
	d	185	165	201	165	170	198	165	177	124	211	187	219
	e	343	283	255	343	240	255	224	304	177	280	398	264
Wairau Valley at Southwold	a	5	0	11	16	0	0	2	1	3	2	8	10
	b	36	42	29	29	21	25	15	9	18	24	32	27
	c	87	86	73	89	61	70	63	54	64	74	86	85
	d	167	157	134	168	141	137	142	163	120	156	169	164
	e	321	273	250	268	248	199	264	346	162	236	328	230
Waihopai at Spray Confluence	a	6	13	11	10	11	7	5	4	7	3	3	8
	b	17	34	24	34	25	32	14	13	28	21	33	27
	c	82	75	69	76	69	63	56	45	57	61	81	75
	d	156	144	121	137	112	123	105	132	92	129	128	141
	e	239	246	171	208	176	192	122	237	129	164	220	194
Waihopai at Craiglochart	a	3	18	9	18	4	1	4	0	5	4	2	12
	b	18	26	19	22	10	14	6	8	19	13	18	17
	c	50	46	54	57	46	49	46	33	45	44	59	64
	d	142	107	98	111	102	103	98	112	70	122	114	135
	e	212	227	125	189	129	144	153	245	97	167	179	170
Omaka at Ramshead Saddle	a	9	14	8	20	5	6	6	2	10	6	12	13
	b	31	25	24	31	23	27	9	16	21	20	32	31
	c	67	69	81	75	72	63	54	42	58	57	73	83
	d	185	138	117	135	126	128	117	125	84	133	113	141
	e	312	248	134	191	159	152	144	236	143	172	185	218

Table 3. (continued).

Site		Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Taylor at Tinpot	a	19	8	11	11	12	4	8	0	1	4	5	13
	b	31	35	30	33	20	30	16	12	15	16	25	31
	c	81	76	73	64	63	57	52	45	54	54	72	79
	d	229	168	139	143	133	135	113	118	90	146	137	142
	e	322	323	349	266	221	174	137	249	226	227	205	317
Beneagle at Farm Stream	a	16	13	3	15	7	4	2	4	8	2	10	21
	b	27	26	24	23	11	15	9	10	16	11	25	31
	c	65	59	62	56	47	53	38	37	46	43	51	67
	d	173	166	112	112	121	112	102	128	86	106	112	127
	e	260	286	195	162	182	127	147	187	273	226	167	220
Blenheim at MDC Office	a	10	11	6	6	1	3	0	4	8	0	13	12
	b	19	25	24	18	10	13	3	6	12	6	19	17
	c	51	53	46	51	42	47	35	28	37	38	47	63
	d	141	106	92	94	90	98	68	118	64	93	98	110
	e	220	128	139	126	161	169	137	183	77	139	185	141
Awatere at Awapiri	a	4	18	13	11	10	12	0	3	2	11	9	13
	b	24	27	22	20	21	24	6	15	20	19	21	38
	c	67	60	65	70	52	60	48	35	56	62	69	79
	d	206	126	114	169	113	112	101	123	94	114	109	136
	e	260	207	144	195	162	201	141	214	149	247	203	188