Eastern Mount Lofty Ranges Prescribed Water Resources Area 2020–21 water resources assessment

Department for Environment and Water
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DEW Technical Note 2022/12

Government of South Australia
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1 Summary

			Status
Angas Bremer PWA	Murray Group Limestone		Very much above average
EMLR PWRA	Fractured rock aquifers		Average
	Murray Group Limestone	Currency	Above average
	Permian sand	Finniss	Average
		Tookayerta	Below average
	Surface water (Angas & Bremer)		Average
	Surface water (Finniss & Currency)		Average

LEGEND

- Highest on record
- Very much above average
- Above average
- Average
- Below average
- Very much below average
- Lowest on record

Rainfall

- Rainfall across the region in 2020–21 (July to June) is similar to the long-term average (1976 to 2021). Total annual rainfall is 723 mm at Mount Barker and 387 mm at Langhorne Creek, which is commensurate with their respective long-term averages of 722 and 381 mm/y (1976 to 2021).
- Rainfall totals are typically higher in highland areas and decrease eastwards over the plains towards the River Murray due to the ‘rain shadow’ effect.

Surface water

- In 2020–21 (July to June), streamflow is classified ‘Average’ in the Bremer River, Angas River, and Finniss River. Currency Creek streamflow is classified ‘Below average’. Long-term data at the Bremer and Finniss gauges (1976 to 2021) indicate a declining trend in annual streamflow.
- The highest salinity in 2020–21 (July to June) was 1,811 mg/L in the Bremer River which is within the historical ranges recorded at this site with most median monthly values being below the median salinity values for the 1994 to 2021 period of record.

Groundwater

- In 2021, all water levels in the Murray Group Limestone aquifer in the Currency Limestone underground water management zone and Angas Bremer Prescribed Wells Area (PWA) are classified ‘Average’ or higher.
- In 2021, the majority of water levels in the fractured rock aquifers are classified ‘Average’ or higher.
- In 2021, the majority of water levels for the Permian Sands aquifer are classified ‘Average’ or higher.
- The majority of wells in the Murray Group Limestone aquifer of the Currency Limestone area show salinity increases of greater than 10% over the past 15 years.
- Groundwater salinity in the Murray Group Limestone aquifer in the Angas-Bremer PWA is highly variable as it is influenced by rates of injection of low-salinity surface water via managed aquifer recharge.

Water use

- Consumptive water use is for a variety of licensed purposes (irrigation, industrial, intensive animal production, environmental and recreational uses) and non-licensed uses such as stock and domestic, and plantation forestry. Water is sourced through pumping and diversions from watercourses and aquifers, and interception and storage by farm dams.
- Water consumption in 2020–21 (July to June) is 30,701 ML. This includes metered groundwater extraction (8,919 ML), allocation to licensed surface water dams (4,136 ML), allocation to licensed watercourse extractions (5,724 ML), estimated surface water demand from non-licensed dams (3,483 ML), estimated forestry demand (3,191 ML) and Lower Angas-Bremer flood allocation (5,247 ML).

1.1 Purpose

The Department for Environment and Water (DEW) has a key responsibility to monitor and report annually on the status of prescribed and other groundwater and surface water resources. To fulfil this, data on water resources are collected regularly, analysed, and reported in a series of annual reports. Three reports are provided to suit a range of audiences and their needs for differing levels of information:

- **Technical Notes:** (this document) provides detailed information and assessment for each resource area, helping to identify resource condition in further detail.
- **Fact sheets**: provide summary information for each resource area with an Annual Resource Status Overview.
- **State-wide summary**: provides summary information for the main water resources across most regions in a quick-reference format.

This document is the Technical Note for the Eastern Mount Lofty Ranges (EMLR) Prescribed Water Resources Area (PWRA) which includes the Angas-Bremer Prescribed Wells Area (PWA) and collates rainfall, surface water, groundwater, and water-use data for 2020–21.

1.2 Regional context

The EMLR PWRA is located approximately 50 km east of Adelaide and occupies an area of 2,845 km^2 (Figure 1.1). The area incorporates the eastern slopes of the Mount Lofty Ranges, which lies within the Hills and Fleurieu Landscape region, and the Murray Plains, which lie within the Murraylands and Riverland Landscape region. It is a regional-scale resource for which groundwater and surface water are prescribed under the *Landscape South Australia Act 2019*. The Water Allocation Plan for the Eastern Mount Lofty Ranges, which was adopted in 2013 (SAMDB NRM Board 2013), provides rules for management of the water resources.

The PWRA is located within the Murray–Darling Basin and can be divided into two topographically distinct regions. The west of the PWRA is characterised by steep hills and valleys, while the eastern side comprises flat plains and localised rises stretching out towards the River Murray.

The PWRA extends from the Milendella Creek catchment in the north to Currency Creek catchment in the south and contains sixteen surface water catchments. Eleven catchments have watercourses that drain from the eastern slopes of the Mount Lofty Ranges to the River Murray and Lake Alexandrina, with the Bremer, Angas and Finniss Rivers being the larger watercourses. There are also a number of catchments with streams that rise in the ranges but fail to persist and contribute little water into the River Murray.

A number of different aquifers containing underground water occur within the PWRA. These include both fractured rock aquifers in the Mount Lofty Ranges (Adelaidean and Kanmantoo Group rocks) where water is stored and moves through joints and fractures in rock, as well as sedimentary aquifers in Permian Sand deposits located in some valleys around Mount Compass and Ashbourne (Figure 1.1).

The Murray Group Limestone aquifer, from which groundwater is also used, occurs in the eastern part of the PWRA within the Currency Creek Limestone underground water management zone, and also within the Angas-Bremer PWA located around Langhorne Creek and Milang (Figure 1.1).

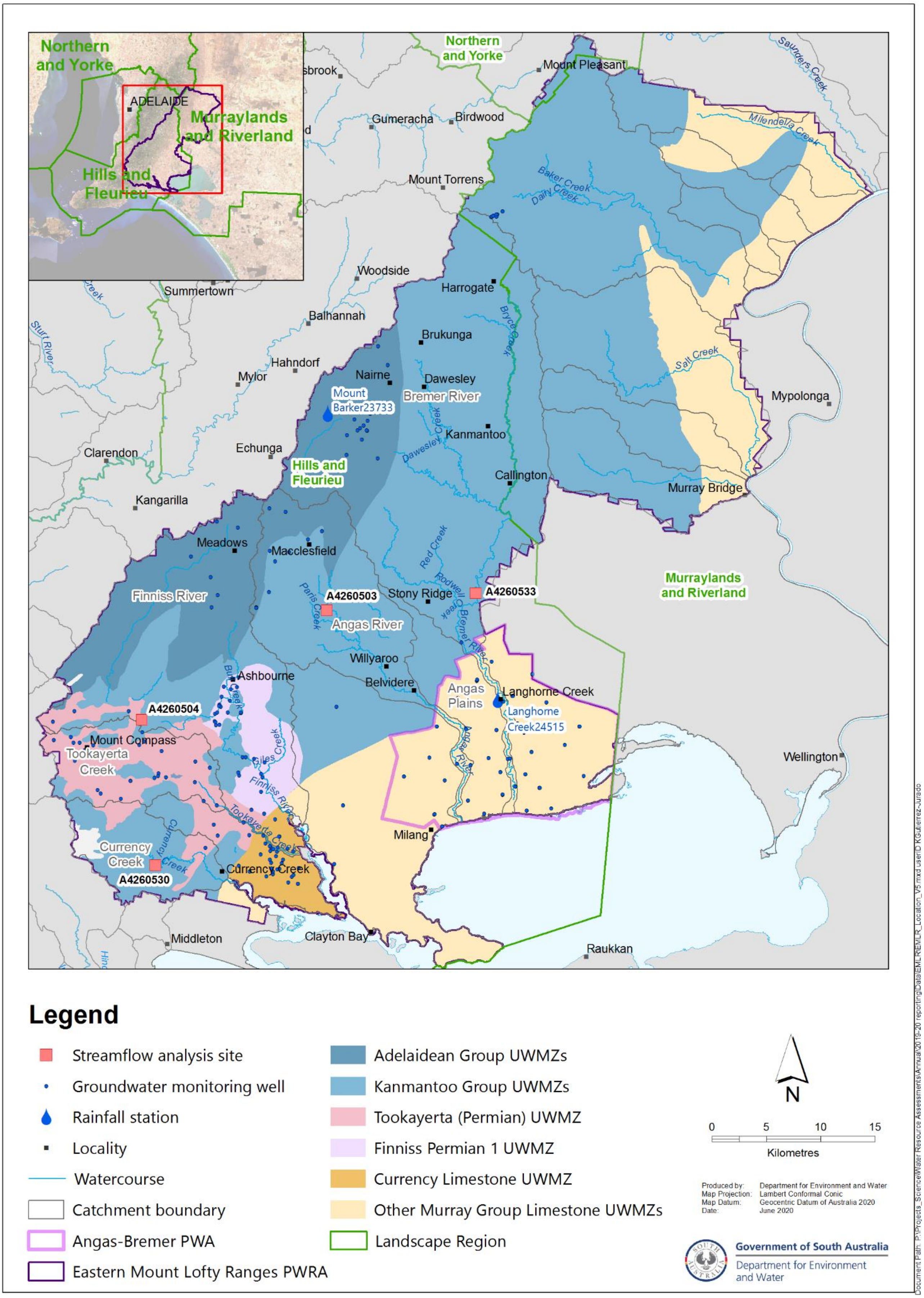

Figure 1.1 Location of EMLR PWRA and relevant underground water management zones (UWMZs)

2 Methods and data

This section describes the source of rainfall, surface water, groundwater and water use data presented in this assessment and the methods used to analyse and present these data. The period of data adopted for each parameter is shown in Table 2.1.

Table 2.1 Reporting period description

Parameter	Reporting period	Comment
Rainfall	1 July 2020 to 30 June 2021	Monthly data for July to September 2021 are also presented to provide additional context
Surface water	1 July 2020 to 30 June 2021	Monthly data for July to September 2021 are also presented to provide additional context
Groundwater	1 January to 31 December 2021	Groundwater levels typically show a delayed response to incident rainfall and aggregate groundwater extraction; hence the lag in reporting period (See Section 2.3.1)
Water use	1 July 2020 to 30 June 2021	In South Australia, water accounting is reported between 1 July through to 30 June of the following year

For rainfall, surface water and water-use data, the financial year or 'water year' was adopted, as defined in the BOM Australian Water Information Dictionary.

2.1 Rainfall

Daily rainfall observations were used from selected Bureau of Meteorology (BoM) stations to calculate monthly and annual totals. Data were obtained from the SILO Patched Point Dataset[1] service provided by the Queensland Government, which provides interpolated values to fill gaps in observations (Figure 3.2 to Figure 3.5).

Rainfall maps were compiled using gridded datasets obtained from the BoM (Figure 3.1). The latest available longer-term annual rainfall map (1986 to 2015 average) was obtained from Climate Data Online[2]. The map of total rainfall in 2020–21 was compiled from monthly rainfall grids obtained for the months between July 2020 and June 2021 from the Australian Landscape Water Balance[3] website.

[1]https://www.data.qld.gov.au/dataset/silo-patched-point-data

[2]http://www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp

[3]http://www.bom.gov.au/water/landscape/#/rr/Actual/year/-28.4/130.4/3/Point////2020/12/31/

2.2 Surface water

2.2.1 Annual streamflow

The status of each gauging station is determined by expressing annual streamflow for the reporting year as a percentile[4] of the total period of data availability (Figure 4.1). The period of data availability for the streamflow gauging stations is 1976 to 2021. Streamflow data were then given a description based on their percentile and decile[4] (Table 2.2).

Table 2.2 Percentile/decile descriptions*

Decile	Percentile	Description	Colour
N/A	100	Highest on record	
10	90 to 100	Very much above average	
8 and 9	70 to 90	Above average	
4, 5, 6, and 7	30 to 70	Average	
2 and 3	10 to 30	Below average	
1	0 to 10	Very much below average	
N/A	0	Lowest on record	

* Deciles and descriptions as defined by the BoM[5]

Annual streamflow data (Figure 4.2 and Figure 4.4) is presented as the deviation of each year's streamflow from the 1976 to 2021 period of record average with the bars shaded using the BoM classification shown in Table 2.2.

2.2.2 Monthly streamflow

Monthly streamflow for the reporting year is assessed alongside the 1976 to 2021 average monthly streamflow and monthly statistics including (a) high flows (75th percentile), (b) median flows (50th percentile) and (c) low flows (25th percentile, Figure 4.3A and Figure 4.5A). Monthly data is presented for an extended period (July 2020 to September 2021) to capture the full flow season.

2.2.3 Daily streamflow

Daily streamflow is presented to highlight the detailed variability throughout the extended period (July 2020 to September 2021, Figure 4.3B and Figure 4.5B).

2.2.4 Flow regime

The term 'flow regime' in this document is used to describe the timing and quantity streamflow characteristics that are important in supporting water-dependent ecosystems. For instance, the temporal variability of streamflow significantly influences aquatic biodiversity, with longer flowing periods linked to ecosystems with higher diversity and supporting more sensitive species. Physical and chemical processes such as nutrient transport and groundwater–surface water interactions are also heavily influenced by the flow regime.

[4] The nth percentile of a set of data is the value at which n% of the data is below it. For example, if the 75th percentile annual flow is 100 ML, 75% of the years on record had annual flow of less than 100 ML. Median streamflow: 50% of the records were above this value and 50% below. Decile: a division of a ranked set of data into ten groups with an equal number of values. In this case e.g., the first decile contains those values below the 10th percentile.

[5] Bureau of Meteorology Rainfall Map information http://www.bom.gov.au/climate/austmaps/about-rain-maps.shtml

A range of hydrological metrics have been selected to characterise and describe ecologically important parts of the flow regime. The annual number of flowing days and the annual number of flowing days above the threshold flow rate (TFR) are the two flow regime metrics assessed and reported in this document. Evaluation of these two metrics provides a simple yet effective assessment of the waterways flow regime. Further details for each metric are provided below:

- The annual number of flow days for the reporting year (July to June) is measured as the number of days with total flow greater than 0.05 ML (50,000 litres).
- The annual number of flow days above the threshold flow rate (TFR) for the reporting year (July to June) is defined as a 24hr period with flow equal to or greater than the TFR (expressed as ML/d). The recommended ecologically significant TFR is the 20th percentile exceedance non-zero daily flow. TFR is defined in the Water Allocation Plan for the EMLR and is based on a unit threshold flow rate multiplied by upstream catchment area.

Annual number of flow days and days above the TFR are presented for the 1976 to 2021 period of record (Figure 4.6 and Figure 4.7). The 1976 to 2021 trend and the number of years in the last decade above the period of record average are provided. For the assessment of both flow days and days above the TFR, years with more than 5% missing data were removed from the assessment.

2.2.5 Salinity

Monthly median salinity (as total dissolved solids (TDS) in mg/L) for the 2020–21 reporting period is presented along with daily streamflow (ML/d) as a reference and assessed alongside the period of record monthly salinity statistics including (a) high salinities (75th percentile), (b) median salinities (50th percentile), and (c) low salinities (25th percentile, Figure 4.8). The period of data availability for salinity is 1994 to 2021 for the Bremer River station and 2004 to 2021 for the Finniss River station. The monthly data is shown for an extended period (July 2020 to September 2021) to capture the full flow season. Salinity values for periods where no flow was reported were removed for this analysis due to uncertainty about those records.

2.3 Groundwater

2.3.1 Water level

Water level[6] data were obtained from wells in the monitoring network by both manual and continuous logger measurements. All available water level data are verified and reduced to an annual maximum water level for each well for further analysis. The annual maximum level is used as this represents the unstressed or recovered water level following pumping each year for irrigation and other uses. The amount of pumping can vary from year to year and the proximity of pumping wells to monitoring wells may affect the reliability of trends and historical comparisons. Therefore, the recovered level is used as it is a more reliable indicator of the status of the groundwater resource. The period of recovery each year was reviewed for each well; in general the aquifers in the EMLR PWRA return to a recovered maximum level between June and December.

For those wells with suitable long-term records, the annual recovered water levels were then ranked from lowest to highest and given a description in the same way as annual streamflow, according to their decile range (Table 2.2). The definition of a suitable long-term record varies depending on the history of monitoring activities in different areas; for the EMLR PWRA, any well with 10 years or more of recovered water level data is included. The number of wells in each description class for the most recent year is then summarised for each aquifer (for example see

[6] 'Water level' in this report refers to both the watertable elevation, as measured in wells completed in unconfined aquifers, and the potentiometric water level elevation, as measured in wells completed in confined aquifers where the water level or pressure in the monitoring well rises above the top of the aquifer. These are collectively referred to as the 'reduced standing water level' (RSWL).

Figure 5.1). Hydrographs are shown for a selection of wells to illustrate common or important trends (for example see Figure 5.3).

Five-year trends are calculated using annual recovered water levels for those wells which have at least 5 measurements (i.e., at least one measurement a year). The trend line is calculated by linear regression and the well is given a status of 'declining', 'rising', or 'stable', depending on whether the slope of this trend line is below, above, or within a given tolerance threshold. This threshold allows for the demarcation of wells where water levels are changing at very low rates and the water level can therefore be considered stable. The threshold also accommodates for very small measurement errors. The number of rising, declining and stable wells are then summarised for each aquifer.

Sedimentary confined and unconfined aquifers such as the Murray Group Limestone and Permian Sand aquifers in this report are given tolerance thresholds of 2 cm/y, while fractured rock aquifers with lower storages are given a tolerance threshold of 1 cm/y.

Twenty-year changes in water level are calculated as the difference between the average water level in a three-year period 20 years ago (i.e., 2000 to 2002) and the average water level in 2021.

2.3.2 Salinity

Water samples from pumping irrigation wells are provided to DEW by licence holders in the EMLR PWRA and Angas-Bremer PWA. These samples are tested for electrical conductivity (EC) and the salinity (total dissolved solids measured in mg/L, abbreviated as TDS) is calculated. Measurement of electrical conductivity of a water sample is often subject to small instrument errors.

Where more than one water sample has been collected in the course of a year, the annual mean salinity is used for analysis. An example of the results is shown in Figure 5.4.

Ten-year salinity trends are calculated where there are at least 7 years of salinity data (i.e., at least one measurement per year). The trend line is calculated by linear regression and the percentage change in salinity is calculated through the following formula:

$$\text{Percentage change in salinity (\%)} = \frac{\text{Slope of linear trend line (mg/L/y)} * 10}{\text{Value of trend line at start of period (mg/L)}} * 100$$

The percentage of change over the trend period is then summarised in categories depending on the range of change for each resource (e.g., Figure 5.5). In resources with gaps in the 10-year data, different periods were used for the calculation of salinity trends (i.e., 7-year trends in Permian Sand and fractured rock aquifers, and 15-year trends in the Currency Limestone management zone).

2.4 Water use

Meter readings are used to report licensed extraction volumes for both surface water and groundwater sources for the reporting year (1 July to 30 June). Where meter readings are not available, licensed allocated volumes are used for surface water sources (Figure 6.1 to Figure 6.3).

Non-licensed water use (stock and domestic) from farm dams is not metered and is estimated at 30% of dam capacity (SAMDB NRM Board, 2013). Further information on the number, type and distribution of farm dams in the PWRA is provided in Section 6.2.1, Dam capacity estimates are undertaken using different methods with data derived from aerial surveys being one of the primary sources.

2.5 Further information

Both surface water and groundwater data can be viewed and downloaded using the *Surface Water Data* and *Groundwater Data* pages under the Data Systems tab on WaterConnect[7]. For additional information related to groundwater monitoring well nomenclature, please refer to the Well Details page on WaterConnect[8].

Other important sources of information on water resources on the EMLR PWRA are:

- Summary reports on the surface water and groundwater resources of the EMLR PWRA (DEWNR 2014) and groundwater resources of the Angas-Bremer PWA (DEWNR 2012) are available, as well as annual surface water status reports such as DEW (2019 a) and groundwater level and salinity status reports such as DEW (2019 b, c and d).
- The Water Allocation Plan for the Eastern Mount Lofty Prescribed Water Resources Area is available (SAMDB NRM Board, 2013).
- Penney, Savadamuthu and van der Wielen (2019) detail the surface water modelling to support South Australia's requirements under the Basin Plan in the Eastern Mount Lofty Ranges Water Resources Plan area.
- Alcorn (2006, 2008) and Savadamuthu (2003, 2004, 2006) provide surface water assessments of the Currency Creek, Bremer, Finniss, Tookayerta and Angas catchments, respectively.
- Zulfic and Barnett (2004) provide a detailed background of hydrogeological data and sustainable yield estimates for the groundwater resources of the EMLR PWRA.
- The *Water Security Statement 2022 – Water for Sustainable Growth* is also available (DEW 2022)

[7] https://www.waterconnect.sa.gov.au/Systems/SitePages/Home.aspx

[8] https://www.waterconnect.sa.gov.au/Systems/GD/Pages/Well-Details.aspx

3 Rainfall

The eastern slopes of the Mount Lofty Ranges descend to the broad plains and eventually to the River Murray and lower lakes of Lake Alexandrina and Lake Albert. The variation in topography from the Western Mount Lofty Ranges PWRA to the EMLR PWRA produces a ‘rain shadow’ effect, which explains the contrast in rainfall across the area. The Mount Lofty Ranges cause westerly winds to rise and cool resulting in precipitation occurring along the mountain ranges, predominantly on the western side, and ensuing comparatively less rainfall on the plains.

Following the hills from south-west to north-west in the EMLR PWRA, the 1986 to 2015 average annual rainfall ranges from approximately 900 to 500 mm/y (Figure 3.1)[9]. In contrast, average annual rainfall on the plains from the north-east to the south-east of the PWRA ranges from less than 300 mm/y to 500 mm/y. Rainfall in 2020–21 (July to June) is similar to the latest available longer-term (1986 to 2015) average annual rainfall in the plains on the east of the PWRA but lower in the high rainfall areas towards the west. The 2020–21 rainfall map (Figure 3.1) is missing the higher rainfall band (800 to 950 mm/y) in the area to the west of Meadows and Ashbourne. In general, the extent of the higher rainfall bands (+600 mm/y) for 2020–21 are less prevalent towards the west of the PWRA than in the 1986 to 2015 average annual rainfall map.

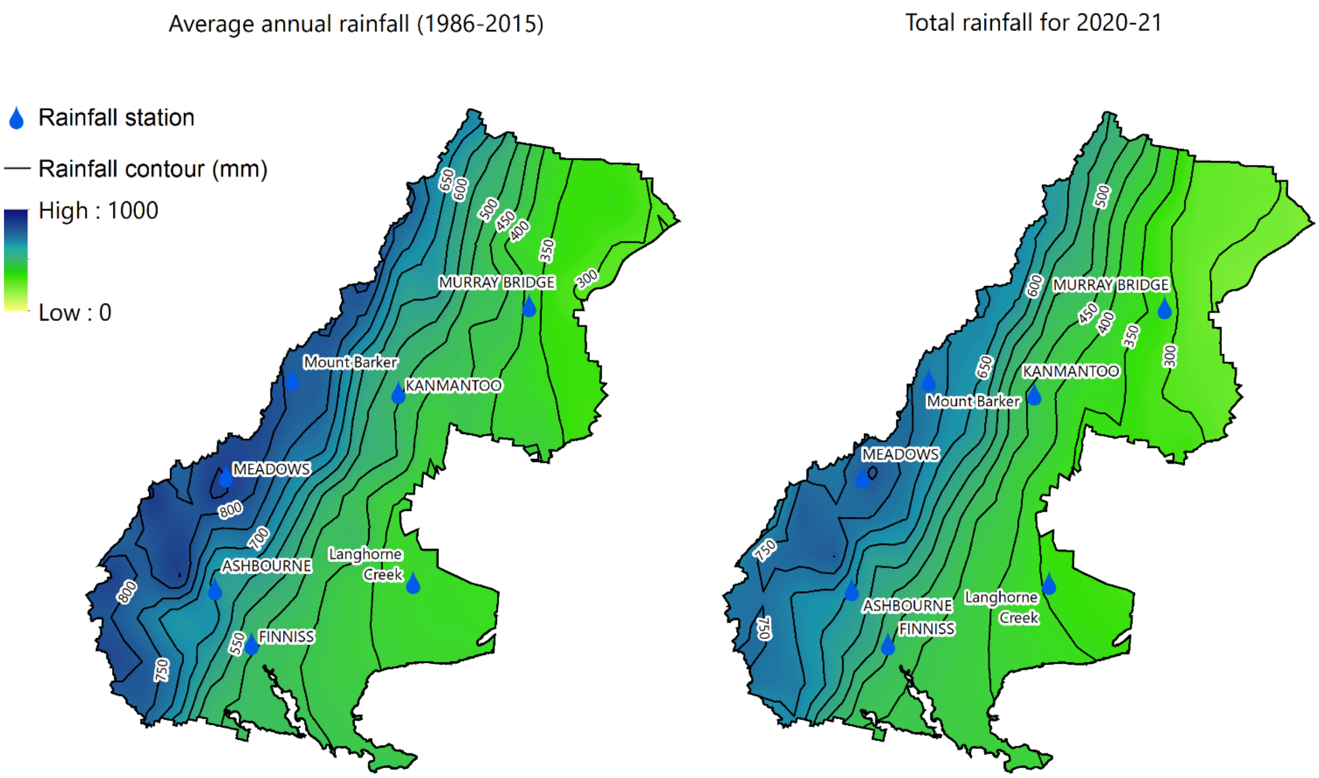

Figure 3.1 Rainfall in the EMLR PWRA for 2020–21 compared to the latest available standard 30-year climatological average (1986 to 2015)

[9] Some differences may be noticeable between the spatial rainfall maps and the annual rainfall from individual stations. This is due to the use of different data sources and time periods (Section 2.1).

Two stations were selected to represent the spatial variation of precipitation across the EMLR PWRA. The common period of record used for these stations is 1976 to 2021. The Mount Barker rainfall station (BoM station 23733) represents the higher rainfall areas of the Mount Lofty Ranges and Langhorne Creek rainfall station (BoM station 24515) represents the lower rainfall areas of the plains (Figure 3.1).

Total annual rainfall recorded in 2020–21 is 723 mm at Mount Barker and 387 mm at Langhorne Creek, both close to the 1976 to 2021 average annual rainfall (Figure 3.2 and Figure 3.4). The trend in annual rainfall (1976 to 2021) for the Mount Barker station indicates a slightly increasing trend, primarily due to above average and average annual values for 4 out of the last 5 last years, while for Langhorne Creek the trend is stable.

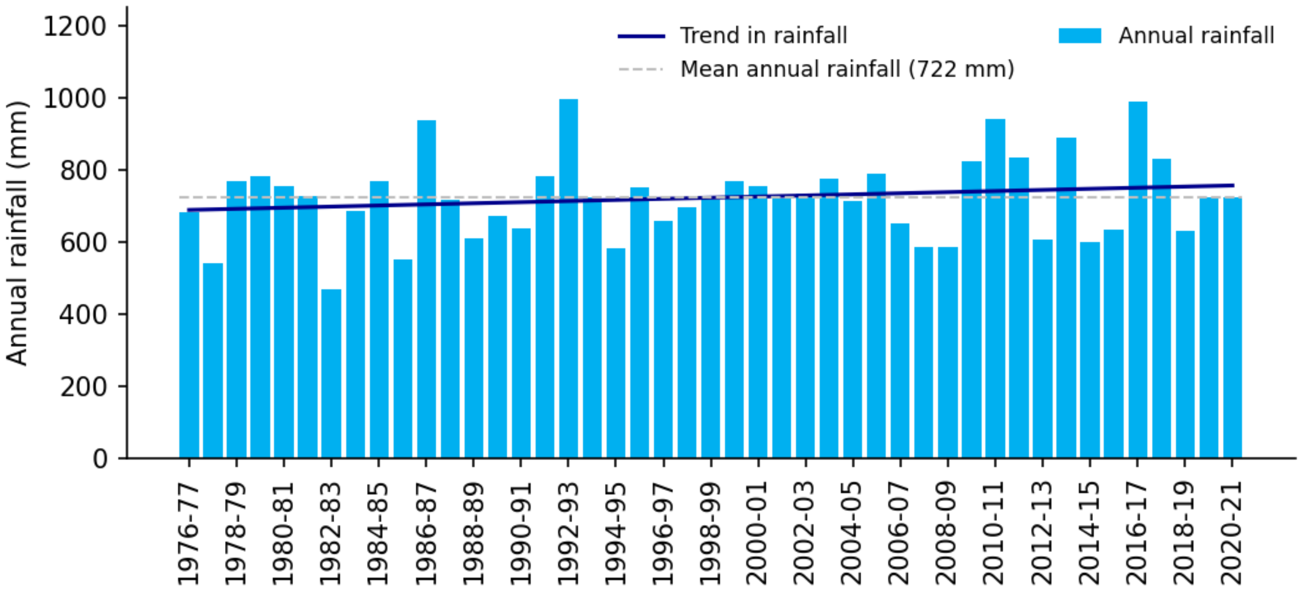

Figure 3.2 Annual rainfall for 1976–77 to 2020–21 at the Mount Barker rainfall station (BoM station 23733)

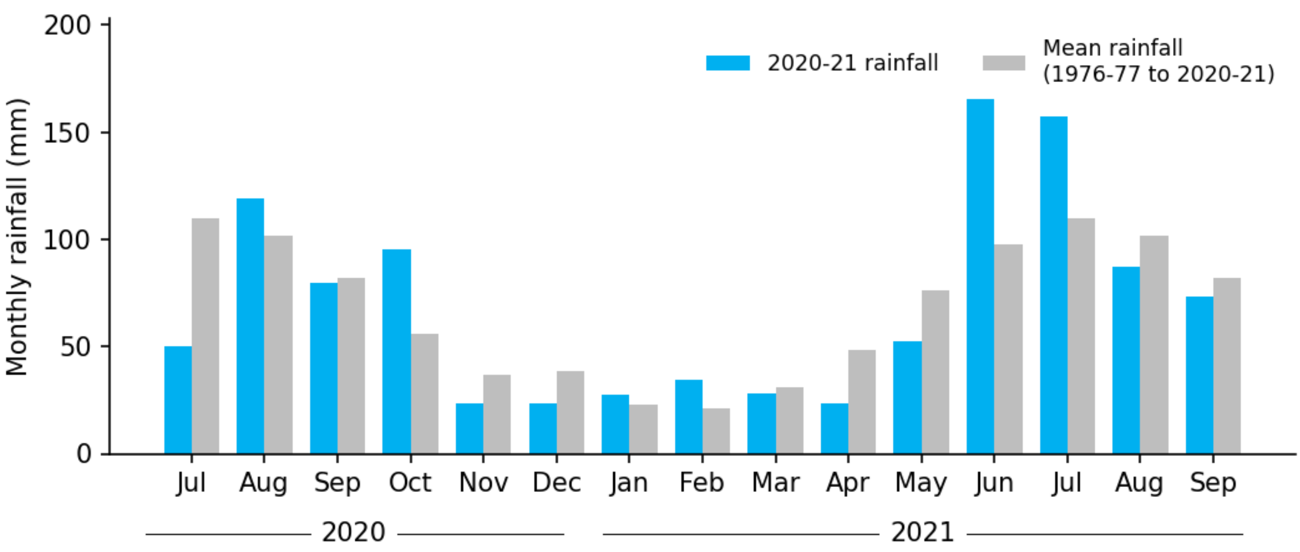

Figure 3.3 Monthly rainfall between July 2020 and September 2021, compared to the 1976–77 to 2020–21 monthly average at Mount Barker rainfall station (BoM station 23733)

Considerably drier than historical conditions were recorded at both stations in July, November and December 2020 and during autumn 2021. Conversely, wetter than historical conditions were recorded during early spring 2020 and early winter 2021 (Figure 3.3 and Figure 3.5).

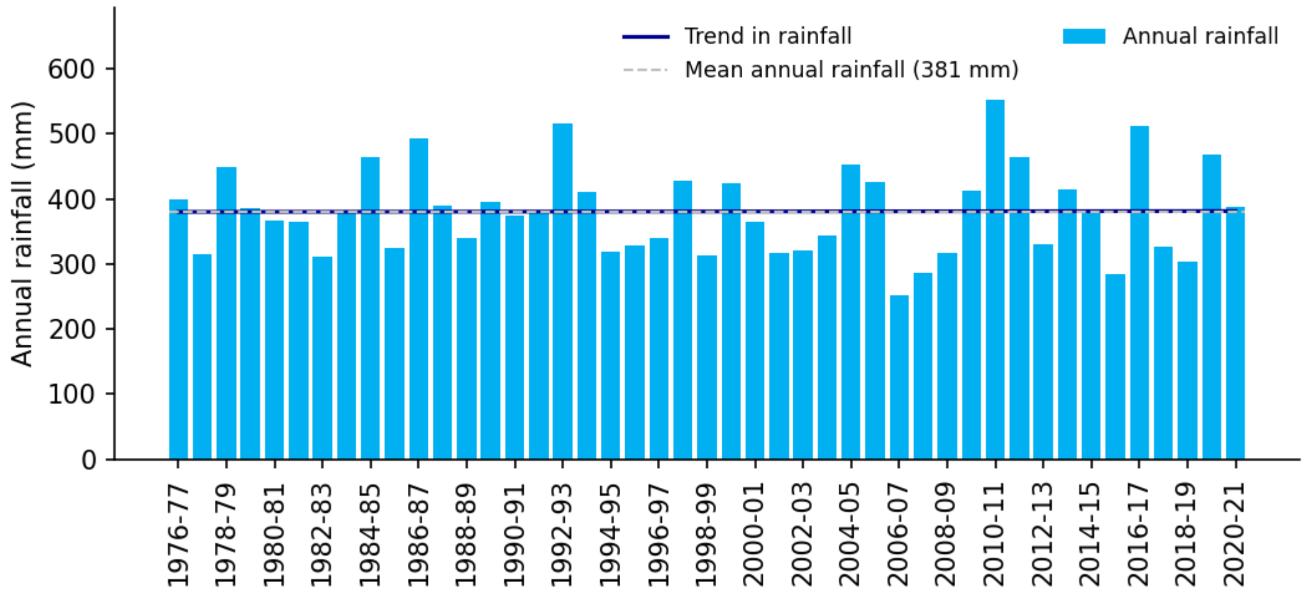

Figure 3.4. Annual rainfall for 1976–77 to 2020–21 at the Langhorne Creek rainfall station (BoM station 24515)

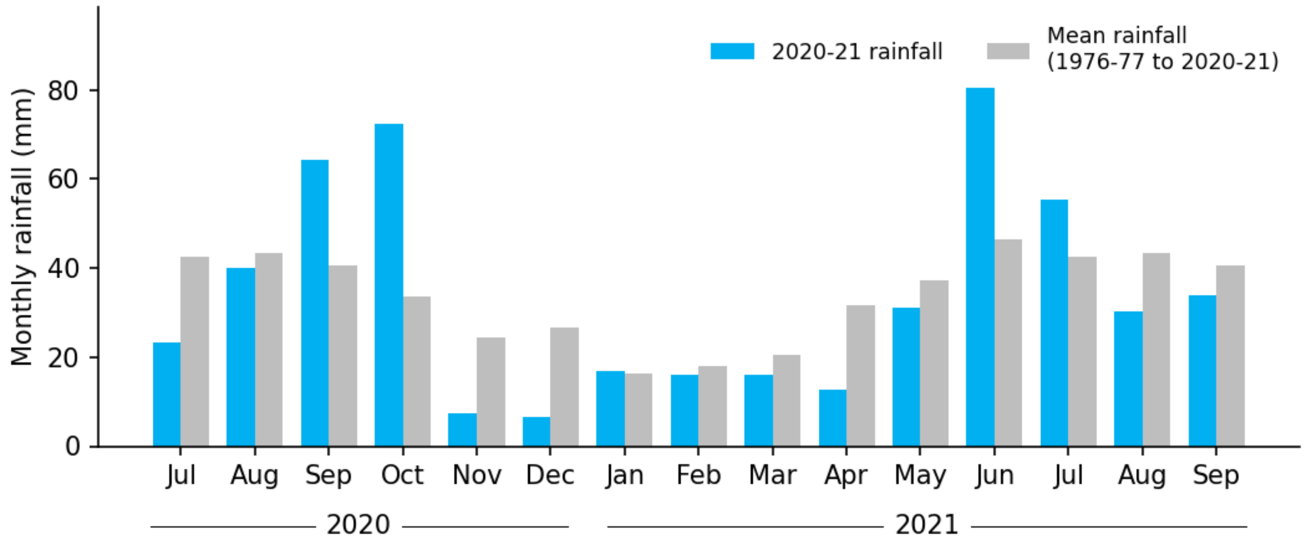

Figure 3.5. Monthly rainfall between July 2020 and September 2021, compared to the 1976–77 to 2020–21 monthly average at Langhorne Creek rainfall station (BoM station 24515)

4 Surface water

4.1 Streamflow

The main watercourses in the EMLR PWRA include the lower-yielding Bremer River and Angas River and the higher-yielding Finniss River and Currency Creek. These main watercourses, along with numerous streams from other smaller catchments within the PWRA, drain from the eastern side of the Mount Lofty Ranges and discharge into the River Murray and Lake Alexandrina. Trends in streamflow are primarily rainfall driven, i.e., below average rainfall will generally result in reduced annual streamflow. Conversely, higher rainfall will generally result in increased surface water availability. Differences in precipitation and topography across the EMLR result in spatial variability of hydrological response of surface water across different catchments. To better represent the spatially variable surface water hydrology, multiple streamflow gauging stations were used for the streamflow analysis (Figure 1.1).

The following stations were chosen to be representative of higher rainfall and streamflow areas of the EMLR PWRA:

- Finniss River (A4260504)
- Currency Creek (A4260530).

The following stations were chosen for the lower rainfall and streamflow areas of the EMLR PWRA:

- Angas River (A4260503)
- Bremer River (A4260533).

The common period of streamflow data availability across the stations is 1976 to 2021. Further detail on the methods and data used in this analysis can be found in Section 2.

In 2020–21, Angas, Bremer and Finniss stations recorded 'Average' streamflow conditions and Currency Creek recorded 'Below average' conditions (Figure 4.1). Streamflow data are displayed in the chart with a dashed outline when the records are incomplete and total annual flow for each station is displayed at the top of the respective column. Periods when data are missing for the 2020–21 reporting period for the Bremer River are during the dry low-flow season and over months with 'Average' and 'Below-average' rainfall. Therefore, the impact of the missing data on the annual streamflow for the Bremer River is considered minimal.

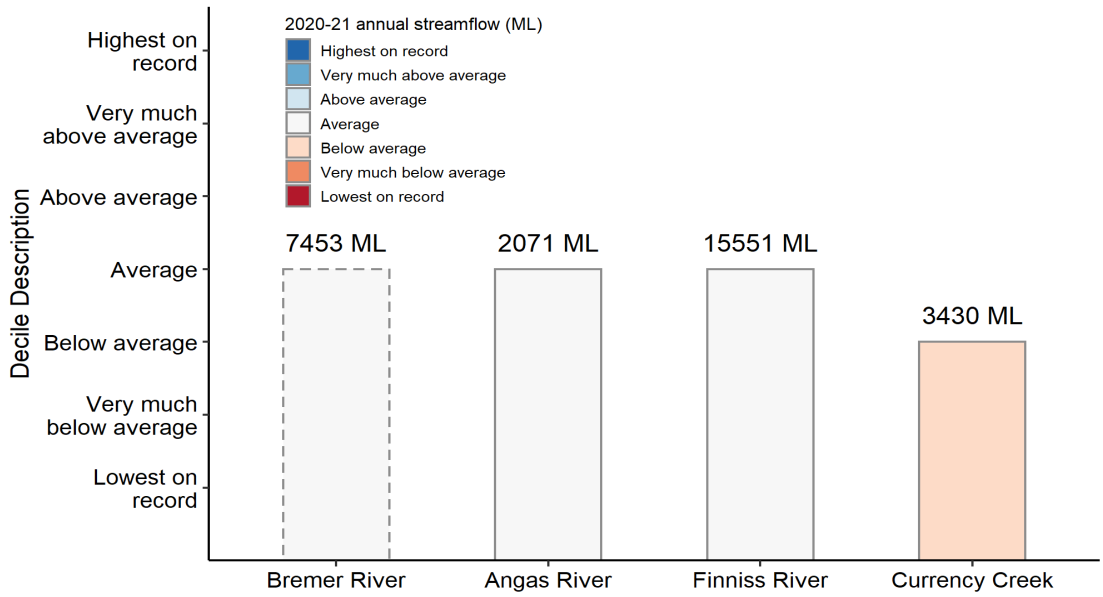

Figure 4.1 EMLR PWRA annual streamflow summary 2020–21

4.1.1 Bremer River (A4260533)

The Bremer River is the largest catchment in the PWRA and covers an area of 583 km^2. The principal long-term streamflow monitoring station in this catchment is located on the foothills near Hartley with a catchment area of 473 km^2. Downstream of the gauging station, the river flows through plains past the township of Langhorne Creek and into Lake Alexandrina.

Total annual streamflow recorded at the station for 2020–21 (July to June) is 7,453 ML, 54% less than the 1976 to 2021 annual average of 16,283 ML. The deviation of each year's streamflow from the 1976 to 2021 average for the Bremer River is shown in Figure 4.2.

The 2020–21 annual streamflow decile for Bremer is ranked as 'Average' (between 30th and 70th percentile – refer to Table 2.2) calculated from the 1976 to 2021 period of record. Annual streamflow data (1976 to 2021) shows a declining trend, with annual streamflow values lower than the average for 3 out of the last 5 years and decile rankings of 'Below average' for 2 out of the last 5 years (Figure 4.2). Since 1994, there have only been 6 years where 'Above average' flow has occurred.

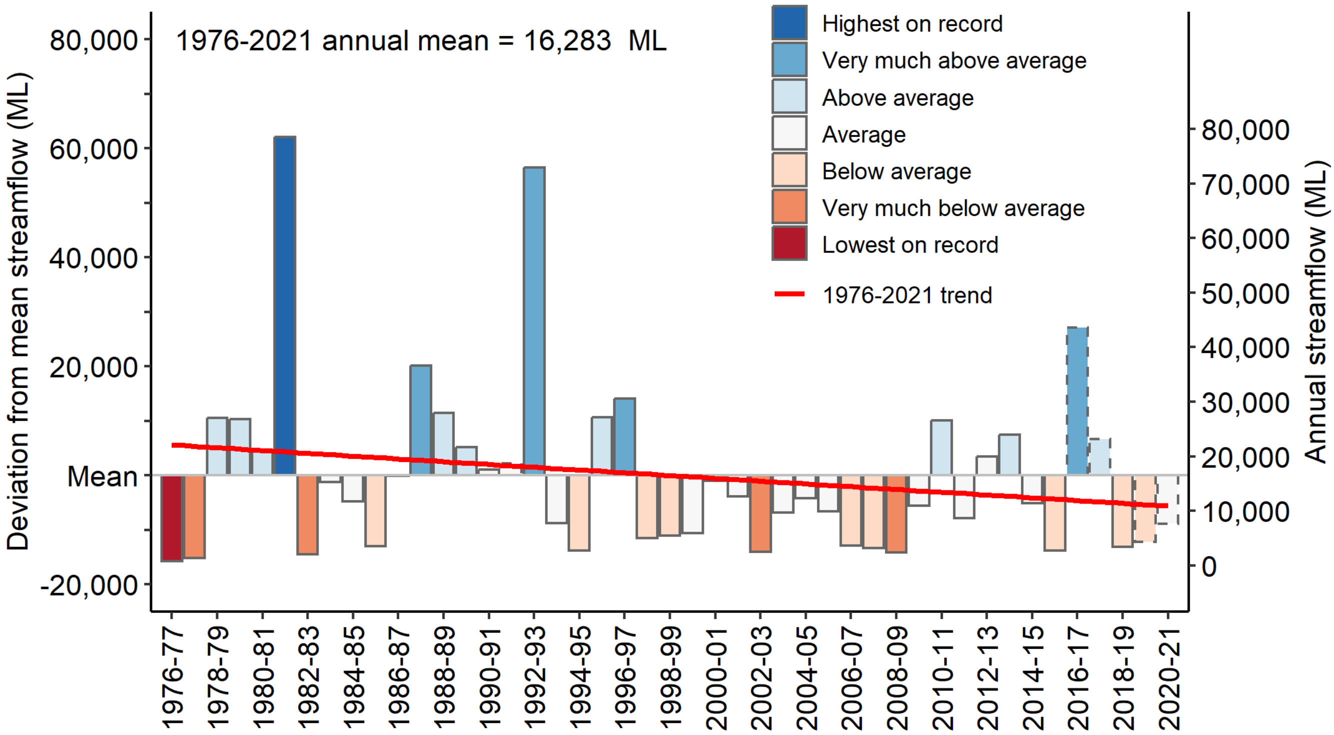

Figure 4.2 Annual deviation from mean streamflow on the Bremer River (1976–77 to 2020–21) (Incomplete streamflow records are displayed with a dashed outline)

Figure 4.3A shows the Bremer River monthly streamflow for the extended 2020–21 reporting period (July to September, grey bars) relative to the 1976 to 2021 monthly streamflow for (a) high flows (75th percentile), (b) median flows (50th percentile) and (c) low flows (25th percentile). The majority of months in 2020–21 were drier than the 1976 to 2021 average monthly streamflow . Periods of unavailable data were present for most of December 2020 and throughout April 2021. The majority of streamflow typically occurs between June and October, accounting for roughly 90% of total annual flow in any given year.

Figure 4.3B presents the average monthly streamflow (1976 to 2021) and daily flows for the extended 2020-21 reporting period for the Bremer River. Maximum daily flows were recorded in August 2020 and in July 2021.

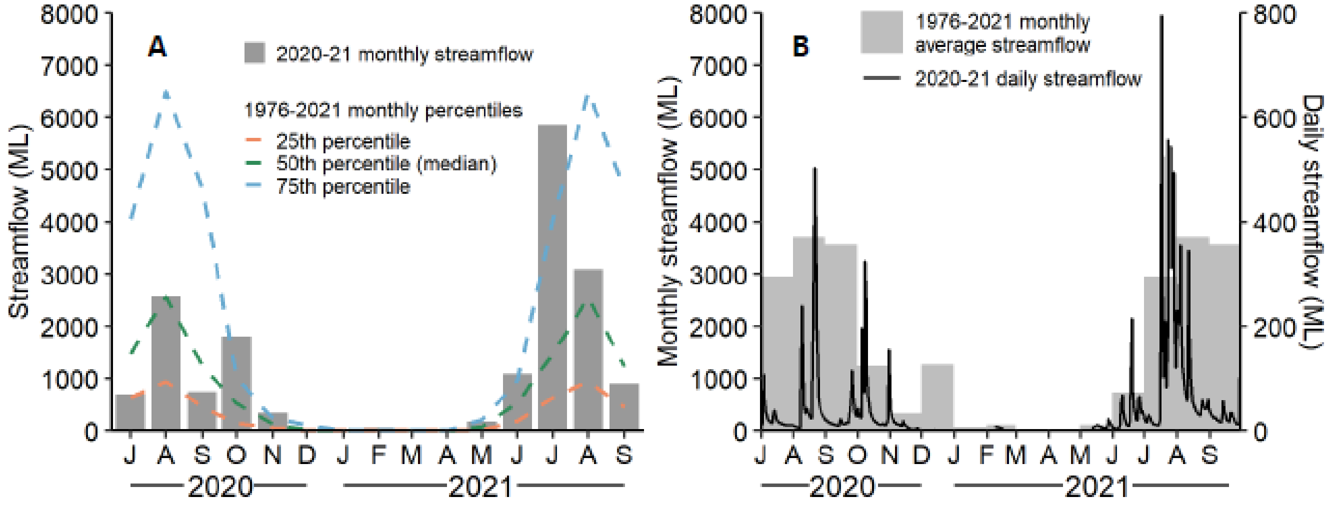

Figure 4.3 **(A) 1976 to 2021 monthly statistics and 2020–21 monthly streamflow on the Bremer River; (B) 1976 to 2021 average monthly streamflow and 2020–21 daily streamflow on the Bremer River**

4.1.2 Finniss River (A4260504)

The Finniss River is the highest surface water yielding catchment in the PWRA and flows from the Eastern Mount Lofty Ranges into Lake Alexandrina. The principal long-term streamflow gauging station within the catchment is located at the outlet of the largest and wettest Meadows Creek sub-catchment that covers a catchment area of 193 km^2.

Total annual streamflow recorded at the station for 2020–21 (July to June) is 15,551 ML, 30% less than the 1976 to 2021 annual average of 22,204 ML . The deviation of each year's streamflow from the 1976 to 2021 average for the Finniss River is shown in Figure 4.4.

The 2020–21 annual streamflow decile for Finniss is ranked as 'Average' (between 30th and 70th percentile – refer to Table 2.2) calculated from the 1976 to 2021 period of record. Annual streamflow data (1976 to 2021) show a declining trend, with only 2 out of the last 10 years experiencing 'Above average' annual streamflow (Figure 4.4). Since 1994, there have only been 6 years where 'Above average' flow has occurred.

Figure 4.5A shows the Finniss River monthly streamflow for the extended 2020–21 reporting period (July to September, grey bars) relative to the 1976 to 2021 monthly streamflow for (a) high flows (75th percentile), (b) median flows (50th percentile), and (c) low flows (25th percentile). Most months in 2020–21 are drier than the 1976 to 2021 average monthly streamflow and are between the 25th and 50th percentiles. The exception is July 2021, when flows are above the 75th percentile.

Figure 4.5B presents the average monthly streamflow (1976 to 2021) and the daily flows for the extended 2020–21 reporting period for the Finniss River. Maximum daily flows are recorded in August 2021 and no zero-flow days are recorded in 2020–21 (note that flows from January through to April were small and cannot be seen in the graphs below).

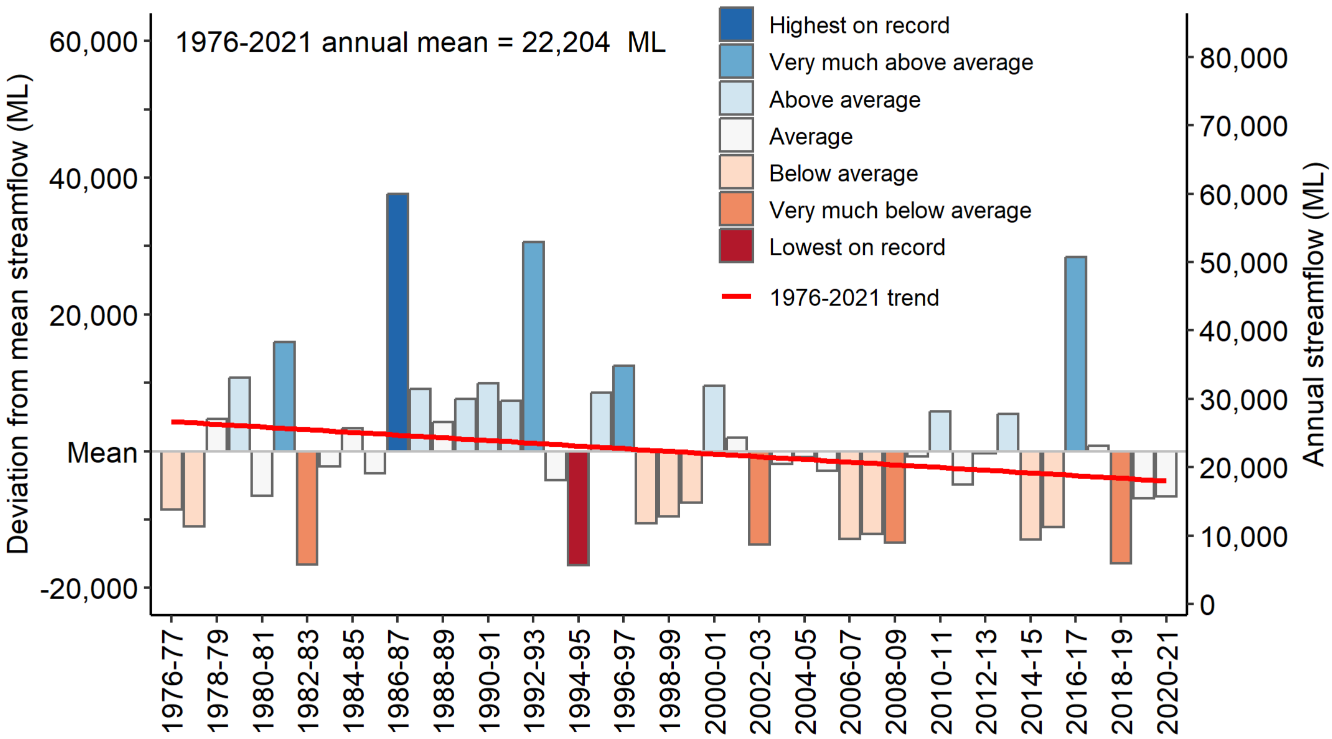

Figure 4.4 Annual deviation from mean streamflow on the Finniss River (1976-77 to 2020–21)

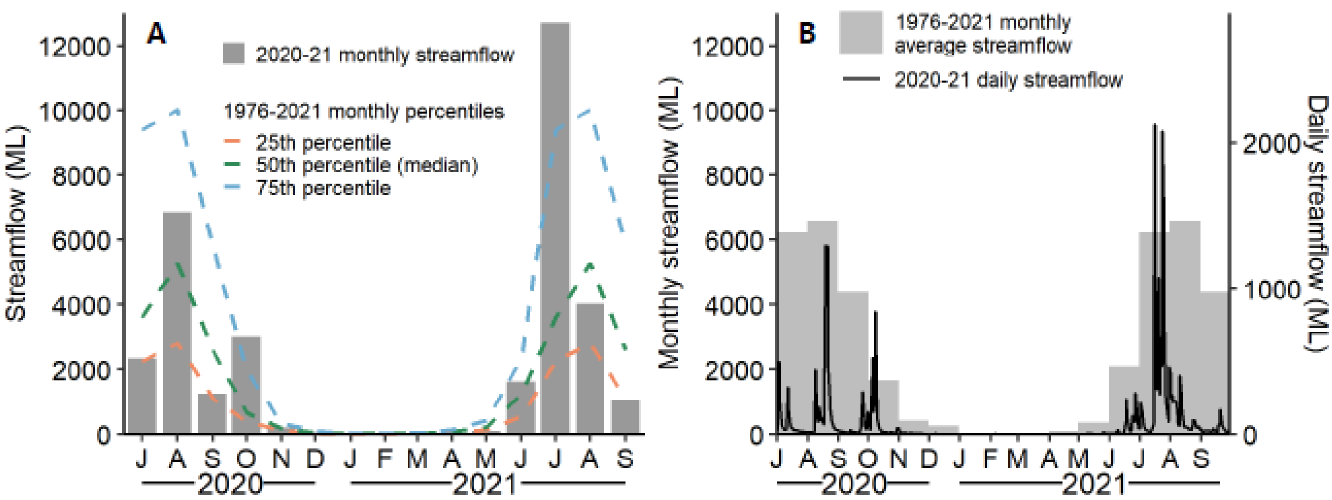

Figure 4.5 (A) 1976 to 2021 monthly statistics and 2020–21 monthly streamflow on the Finniss River; (B) 1976 to 2021 average monthly streamflow and 2020–21 daily streamflow on the Finniss River

4.3 Flow regime

Analysis of the flow regime was undertaken for the main EMLR PWRA watercourses mentioned in section 4.1. Flow data collected at streamflow gauging stations are used in this assessment to complement the streamflow analysis (Section 4.1). Further detail on the methods and data used in this analysis can be found in Section 2.2.4.

Angas River (A4260503)

The assessment of the flow regime information from the Angas station for 2020–21 (July to June) shows 330 total flowing days. This is 17 days higher than the 1976 to 2021 reporting period average of 313 flowing days (Figure 4.6). The number of days with flows above the threshold flow rate (TFR) is 70 days, 25 fewer days than the reporting period average of 95 days (Figure 4.7).

Over the last decade (2011–12 to 2020–21), 4 out of 10 years (with sufficient data) had above average number of flowing days. In the past decade there have been 2 years when the number of days above the TFR have been above the reporting period average.

Currency Creek (A4260530)

The assessment of the flow regime information from the Currency station for 2020–21 (July to June) shows perennial flow with 365 flow days. This is 6 days higher than the 1976 to 2021 reporting period average of 359 flowing days (Figure 4.6). In this case, the reporting period average is close to the maximum given the site is perennial most years. The number of days with flows above the TFR is 71 days, 12 days lower than the reporting period average of 83 days (Figure 4.7).

Over the last decade, 5 out of 10 years (with sufficient data) had above average number of flowing days. In the past decade there have been 3 years when the number of days above the TFR has been above the reporting period average.

Finniss River (A4260504)

The assessment of the flow regime information from the Finniss station for 2020–21 (July to June) shows perennial flow with 365 flow days. This is 10 days higher than the 1976 to 2021 reporting period average of 355 flowing days (Figure 4.6). In this case, the reporting period average is close to the maximum given the site is perennial most years. The number of days with flow above TFR is 53 days, 15 days lower than the reporting period average of 68 days (Figure 4.7).

Over the last decade, all years have been perennial and there have been 3 years where the numbers of days above the TFR have been above the reporting period average.

Bremer River (A4260533)

Due to gaps in the data from the Bremer gauging station, the number of flowing days and the number of days above the TFR are not available post-2010, including the 2020–21 reporting period (Figure 4.6 and Figure 4.7).

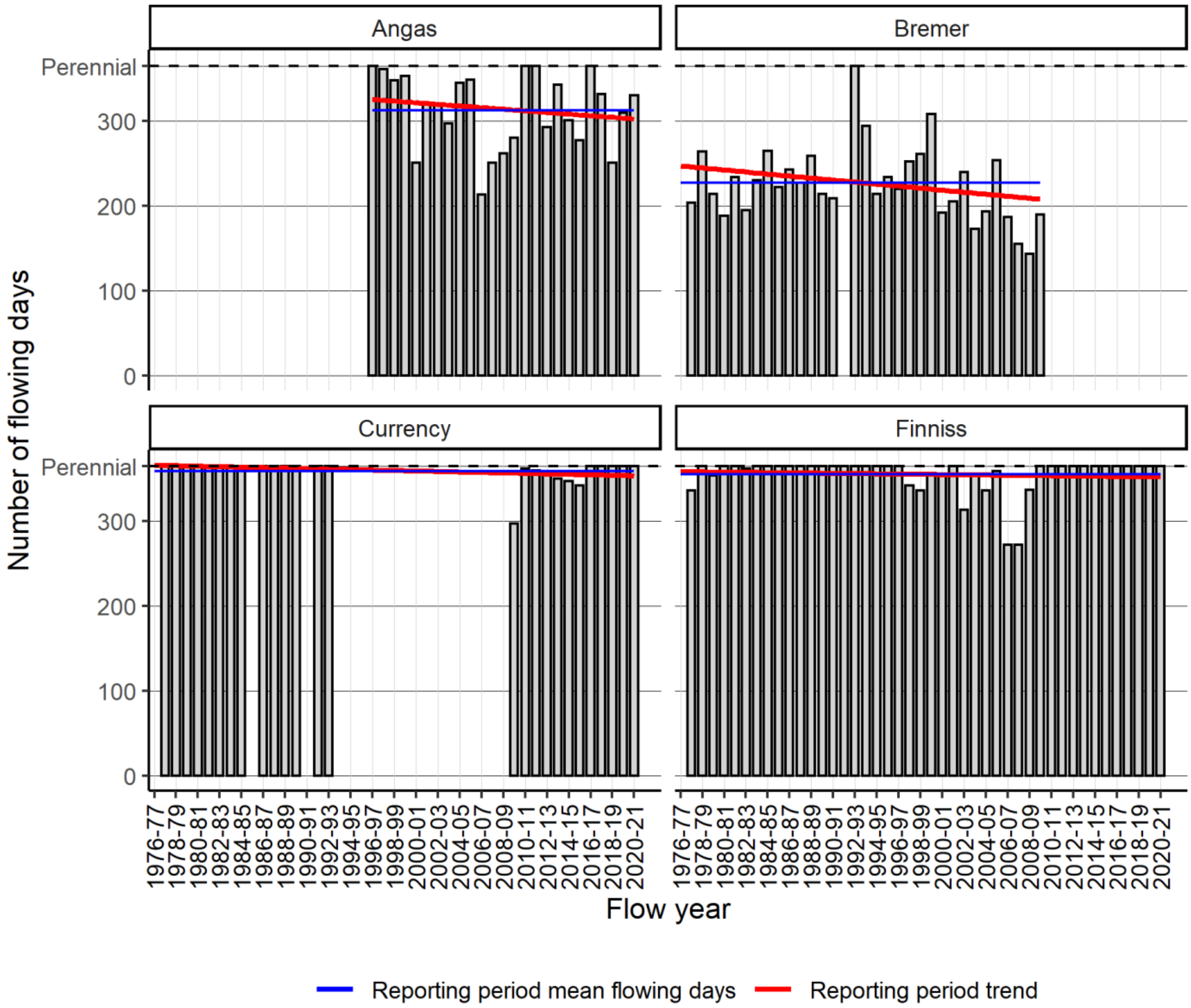

Figure 4.6 **The number of flowing days (flow >0.05ML/day) for the stations assessed in the EMLR PWRA including the average and trend over the 1976 to 2021 reporting period (years with more than 5% missing data were removed from the assessment)**

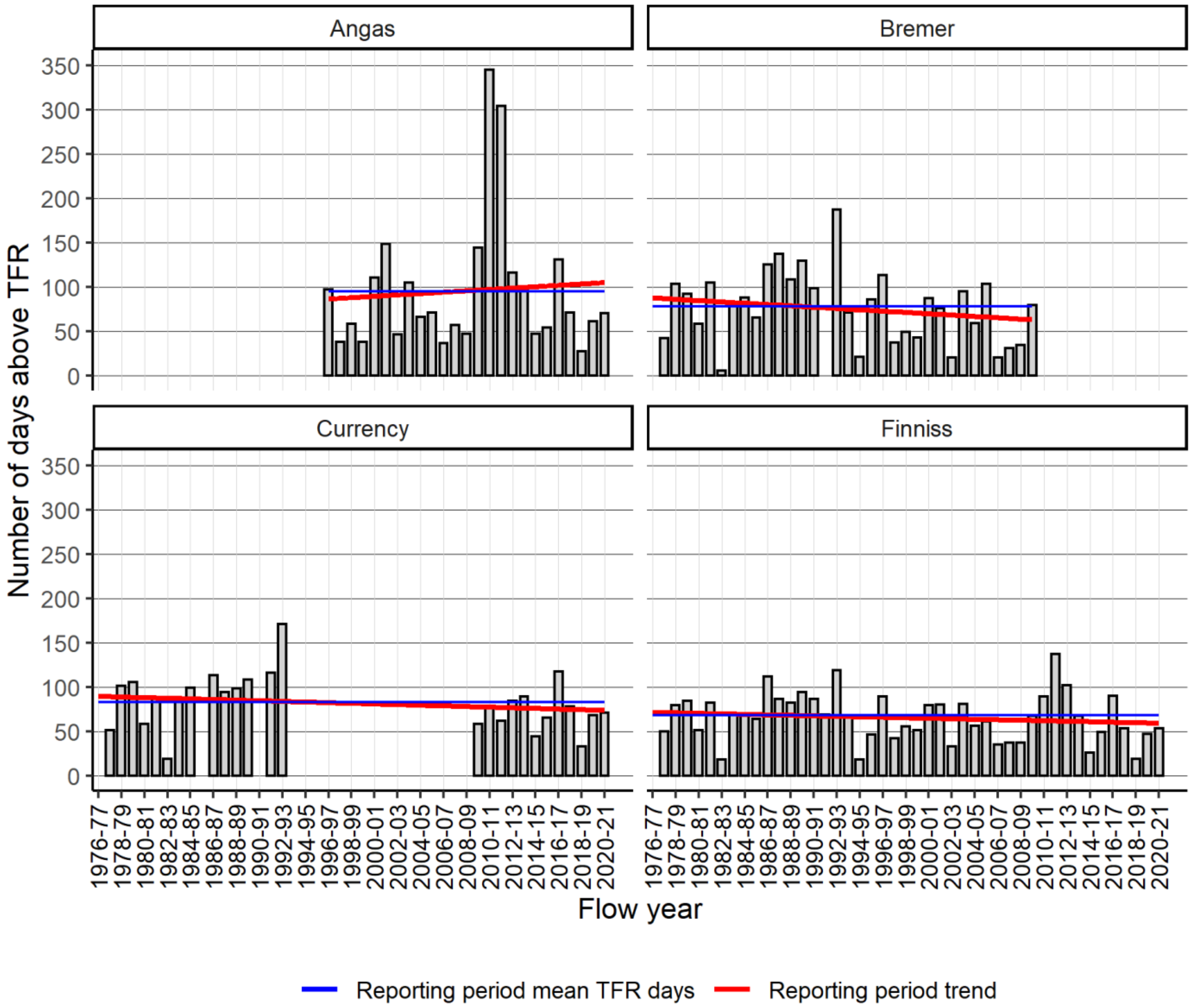

Figure 4.7 **The number of days with flow above the TFR for the stations assessed in the EMLR PWRA including the average and trend over the reporting period (years with more than 5% missing data were removed from the assessment)**

Implications of flow regime for aquatic ecosystems in 2020–21

The flow regime across the EMLR PWRA shows better conditions for aquatic ecosystems than has been observed in the previous few years. The two wetter catchments (Finniss and Currency) show perennial flow providing year round habitat for still water and flowing water species of fish and macroinvertebrates. The Angas Catchment, while not perennial, maintains flow for longer than average, providing increased opportunity for species to move into and out of the area and complete their breeding and lifecycles. The flow regime observed in 2020–21 is likely to have helped maintain current aquatic species distribution and diversity.

4.4 Salinity

Below average summer rainfall can result in increased irrigation extractions. These two elements can increase surface water salinities by reducing the amount of streamflow available to dilute mobilised salts. Conversely, higher rainfall increases surface water availability and decreases irrigation extractions, resulting in a reduction or stabilisation of salinity. General trends across the PWRA show lower salinities for the wetter (i.e., higher rainfall and streamflow) catchments in the south (Finniss River and Currency Creek) and higher salinities for the drier (i.e., lower rainfall and streamflow) catchments in the north (Angas River and Bremer River).

Salinity is recorded routinely at gauging stations within the PWRA. Two sites were selected to represent salinity trends for the high and low salinity areas of the PWRA. The station at the Bremer River catchment near Hartley (A4260533) with salinity data available from 1995 represents the higher salinity areas. The station at the Finniss River catchment at Ford Road (A4261075) with salinity data available from 2004 represents the lower salinity areas. However, data for the Finniss River station were not available for the 2020-21 reporting period and only data for the Bremer River is presented herein.

Figure 4.8 shows the Bremer River monthly median salinities for 2020–21 (bars) with the 1995 to 2021 period of data for (a) low salinities (25th percentile), (b) median salinities (50th percentile), and (c) high salinities (75th percentile). Streamflow data is provided for context.

In 2020–21 the annual median salinity for the Bremer River is 1,067 mg/L, which is lower than the 1995 to 2021 median salinity of 1,522 mg/L. Monthly data for the period of record at the Bremer station shows high variability of salinities throughout the year, with higher median salinities generally observed during the drier months from November through to April and lower median salinities during wetter months from June through to September. Most of the median monthly salinity values for the Bremer River for 2020–21 are below the 1995 to 2021 median values.

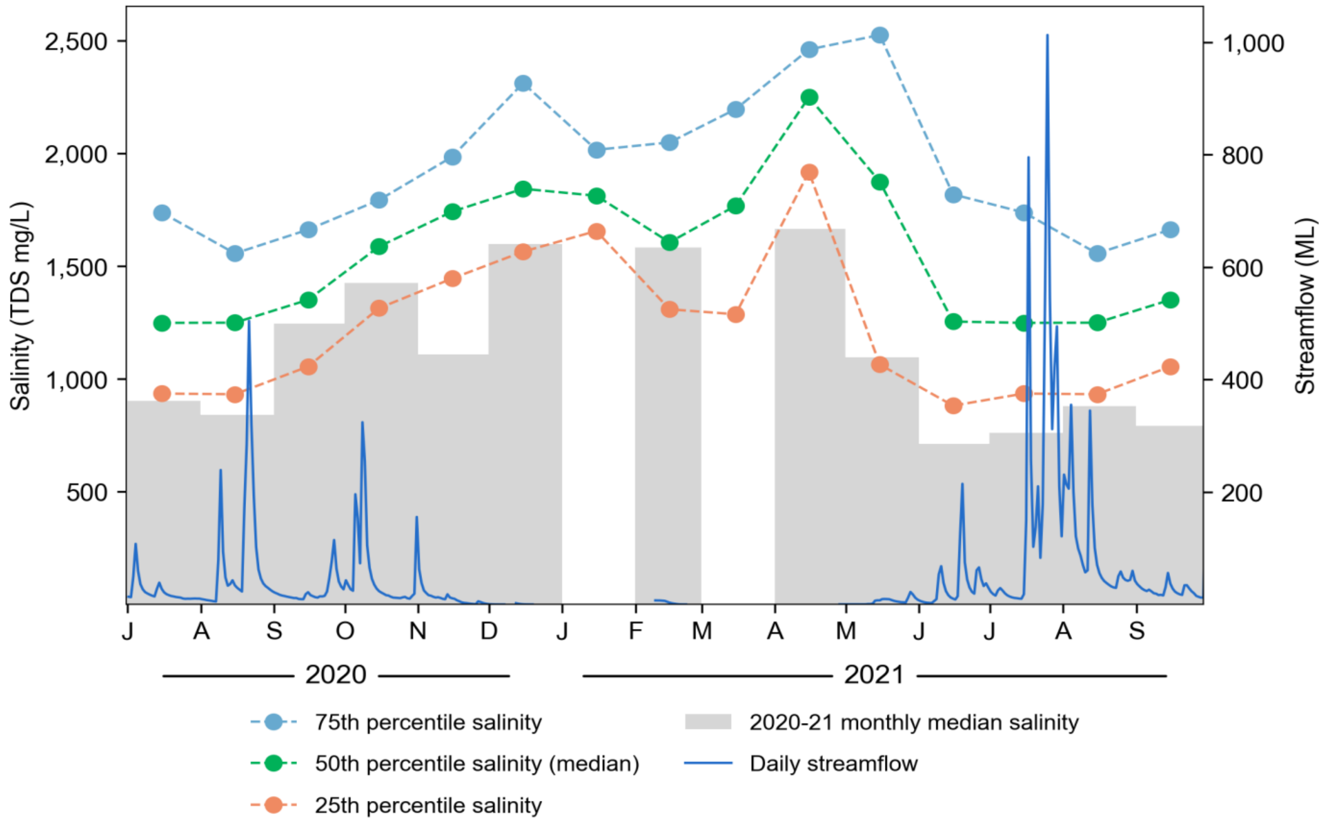

Figure 4.8 1995 to 2021 and 2020–21 monthly salinity at the Bremer River streamflow gauging station (A4260533)

5 Groundwater

5.1 Hydrogeology

The EMLR PWRA is topographically separated into highlands of the EMLRs and the plains leading down to the River Murray. The highlands region is underlain by Neoproterozoic and Palaeozoic rocks of the Adelaide Geosyncline, and the plains region is underlain by younger sedimentary rocks of the Murray Basin. Thinner Quaternary deposits occur in valleys in the highlands and widely across the eastern part of the PWRA. Basement rocks in the highlands areas form fractured rock aquifers, where groundwater is stored in, and moves and mixes through, joints and fractures, while sedimentary rocks and sediments in both the highlands and plains areas form sedimentary aquifers such as the Permian Sand aquifer and the Murray Group Limestone aquifer. In sedimentary aquifers, groundwater is stored in, and flows and mixes through, the pore spaces within the sediments. Recharge to all aquifers of the EMLR PWRA generally occurs directly from rainfall percolating to the water table through the soil profile or indirectly through lateral flow from adjacent aquifers. Shallow Quaternary aquifers are generally low yielding and contain poorer quality water with limited use and as such, they are omitted from this assessment.

5.1.1 Fractured rock aquifers

The fractured rock aquifers of the EMLR PWRA occur in four geological units; the Barossa Complex, Adelaidean rocks, the Normanville Group, and the Kanmantoo Group. Generally, Adelaidean rocks along the higher elevation, western part of the PWRA, are more favourable in terms of recharge, salinity and yields, while the Barossa Complex and Kanmantoo Group provide groundwater of poorer quality and lower yields. Groundwater flow within fractured rock aquifers generally follows the topography and moves from higher elevations toward lower elevations, where it eventually flows through sedimentary aquifers in the valleys and discharges to rivers and streams. The regional flow direction in the fractured rock aquifers is generally from north–west to south–east.

5.1.2 Permian Sand aquifer

The Permian Sand aquifer (also known as the Cape Jervis Formation) occurs in several large U-shaped valleys that were carved by large continental ice sheets about 280 million years ago. This aquifer comprises glacial deposits of unconsolidated sands, silts, and clays with occasional gravel beds. The Permian Sand aquifer forms part of the eastern slopes of the highlands region and underlies the Murray Basin sediments of the plains region. It can be highly permeable which results in high yields and low salinities; however, productivity of this aquifer varies due to a high clay content in some areas, and at these locations, the aquifer is instead low yielding and high in salinity. The Permian Sand aquifer is widely developed for irrigation and town water supply. This report focuses on the Permian Sand aquifer in the Finniss Permian 1 and Tookayerta Permian underground water management zones (UWMZs) (Figure 1.1), which are formally defined in the Water Allocation Plan for the EMLR PWRA (SAMDB NRM Board, 2013).

5.1.3 Murray Group Limestone aquifer

The Murray Group Limestone occurs in the Murray Basin and predominantly consists of shallow marine fossiliferous limestone that was deposited about 50 million years ago. The aquifer is up to 100 m in thickness and overlies the Kanmantoo Group and the Permian Sand aquifer in some areas. It is confined by the overlying Quaternary clay sediments to the south-west of Murray Bridge; however, it is unconfined to the north. Low-salinity groundwater occurs in the southern area of the plains region where it is the main source of groundwater for irrigation. This is the result of freshwater recharge to the aquifer thought to have occurred several thousand years ago during a period of much higher rainfall. However, today there is little evidence of natural freshwater recharge to this aquifer. Increased extraction from this aquifer during the Millennium drought (2002 to 2009) led to increased groundwater salinities. Since 2010, salinities have decreased due to decreased pumping, and managed aquifer recharge (MAR) injections in the Langhorne Creek area have also increased confined aquifer pressure levels and helped freshened the aquifer.

This assessment focuses on the Murray Group Limestone aquifer in the Currency Limestone underground water management zone and the Angas-Bremer Prescribed Wells Area, which are defined in the Water Allocation Plan for the EMLR PWRA (SAMDB NRM Board, 2013) (Figure 1.1).

5.2 Fractured rock aquifers water level

In 2021, winter recovered water levels in 17 out of 25 monitoring wells (68%) in the fractured rock aquifers of the EMLR PWRA are classified 'Average' or higher (see Section 2.3.1 for details of the classification; Figure 5.1). The majority of monitoring wells are located toward the western extent of the PWRA where most groundwater extraction occurs.

Over the past 20 years, variations in water level in 19 wells range from a decline of 5.58 m to a rise of 1.19 m (median is a decline of 0.4 m).

Five-year trends show declining water levels for the majority of wells (82%), at rates which range from 0.03 m/y to 2.93 m/y, with a median decline of 0.25 m/y (Figure 5.2).

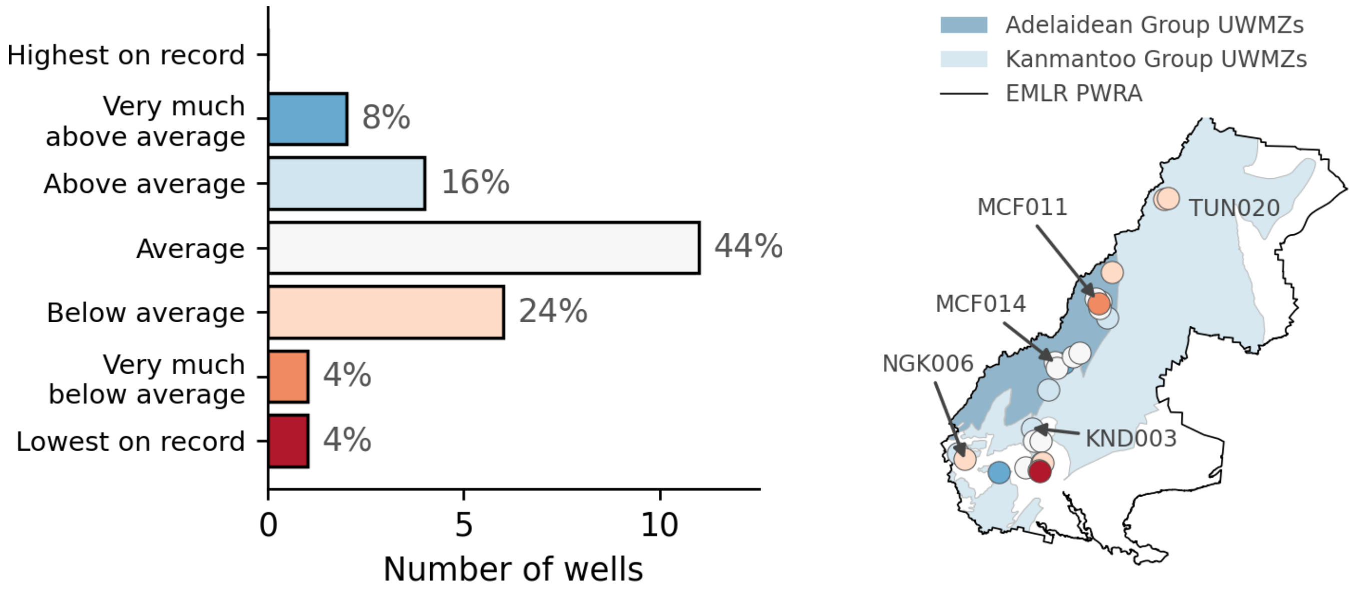

Figure 5.1 2021 recovered water levels for wells in the fractured rock aquifers

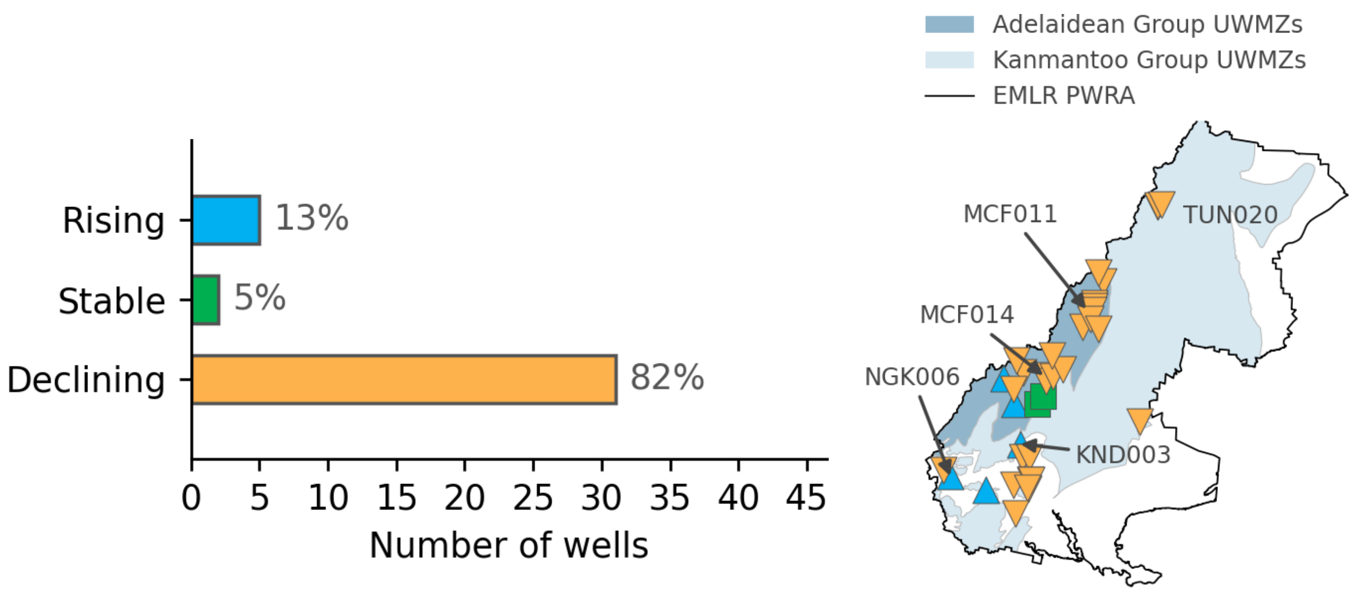

Figure 5.2 2017 to 2021 trend in recovered water levels for wells in the fractured rock aquifers

Water levels in most fractured rock aquifer wells show seasonal fluctuations (e.g. KND003, MCF011, NGK006). Monitoring well MCF011 at Mount Barker shows a reduction in the range of seasonal fluctuations since around 2002, which is likely due to a decrease in irrigation caused by the urban expansion of Mount Barker (DEWNR 2014). Recovered water levels at MCF011 have remained generally stable over the past 30 years; the 2021 water level is classified 'Average'.

Groundwater levels at the dryland salinity monitoring site TUN020, which is located south of Tungkillo on superficial Quaternary sediments overlying the fractured rock aquifer in Kanmantoo Group rocks, have generally shown a steady decline since 1990.

Further south, the monitoring well KND003 is completed in Kanmantoo Group siltstones and shows relatively stable recovered levels since monitoring began in the late-1990s.

MCF014 is located between Meadows and Macclesfield. The groundwater level was declining prior to 2010 but has since recovered and was classified 'Highest on record' following above-average rainfall in 2016. The groundwater level has since stabilised and in 2021 is classified 'Average' (Section 2.3.1).

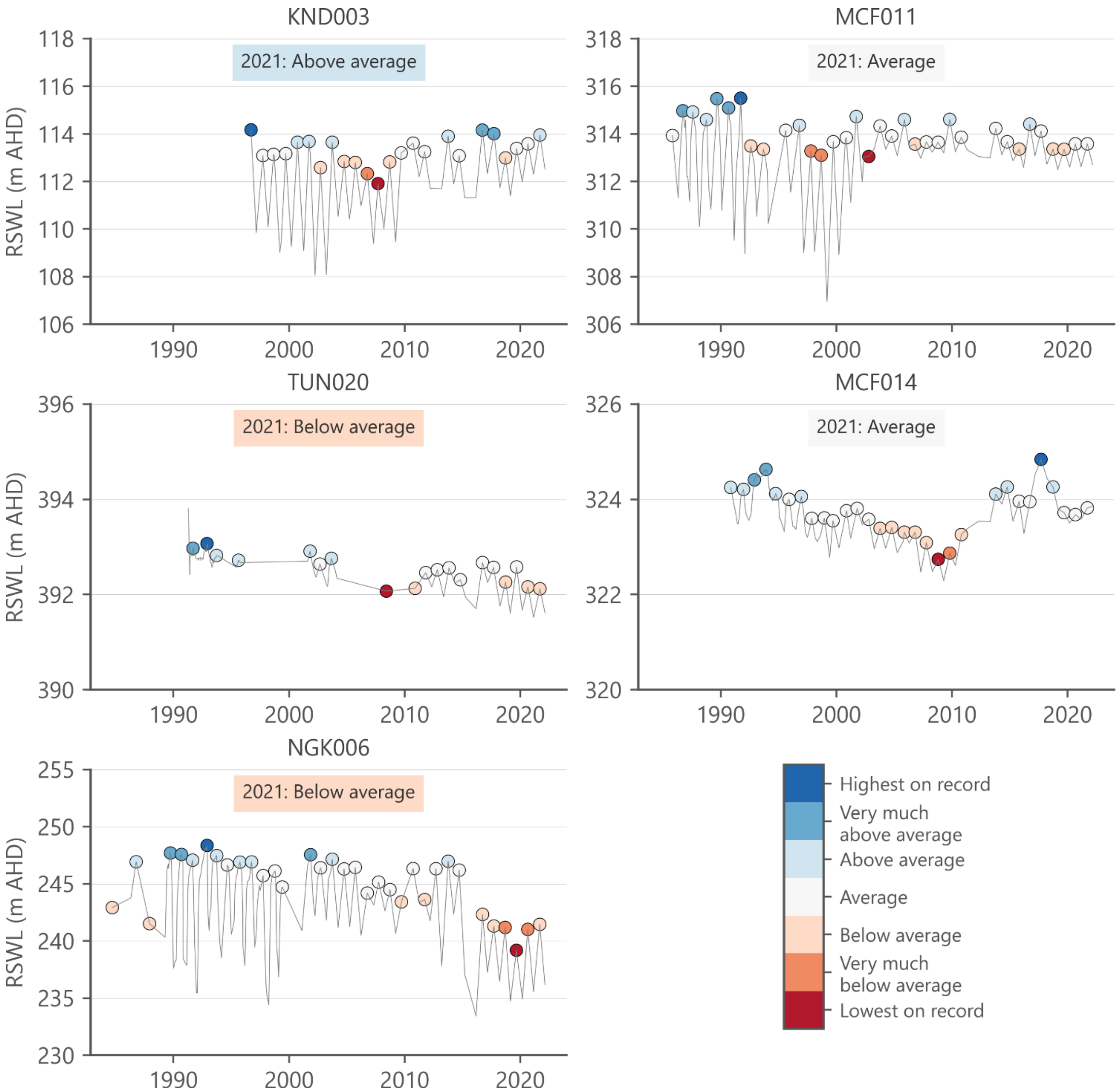

Figure 5.3 Selected fractured rock aquifer hydrographs

5.3 Fractured rock aquifers salinity

Groundwater salinity in fractured rock aquifers is often highly variable and can be influenced by the type of rock in which fractures occur. Since 2015, irrigators in the EMLR PWRA have submitted groundwater samples to augment DEW's state-wide monitoring network. In 2021, salinity results from 317 wells in the fractured rock aquifers of the EMLR PWRA range between 150 mg/L and 14,862 mg/L, with a median of 1,396 mg/L (Figure 5.4).

In the 7 years to 2021, 67 of 125 wells (54%) show a declining trend in salinity (see Section 2.3.2 for details of the calculation); Figure 5.5). Trends in salinity over this period vary from a decrease of 19.0% per year to an increase of 12.7% per year, with a median rate of change of 0.2% decrease per year.

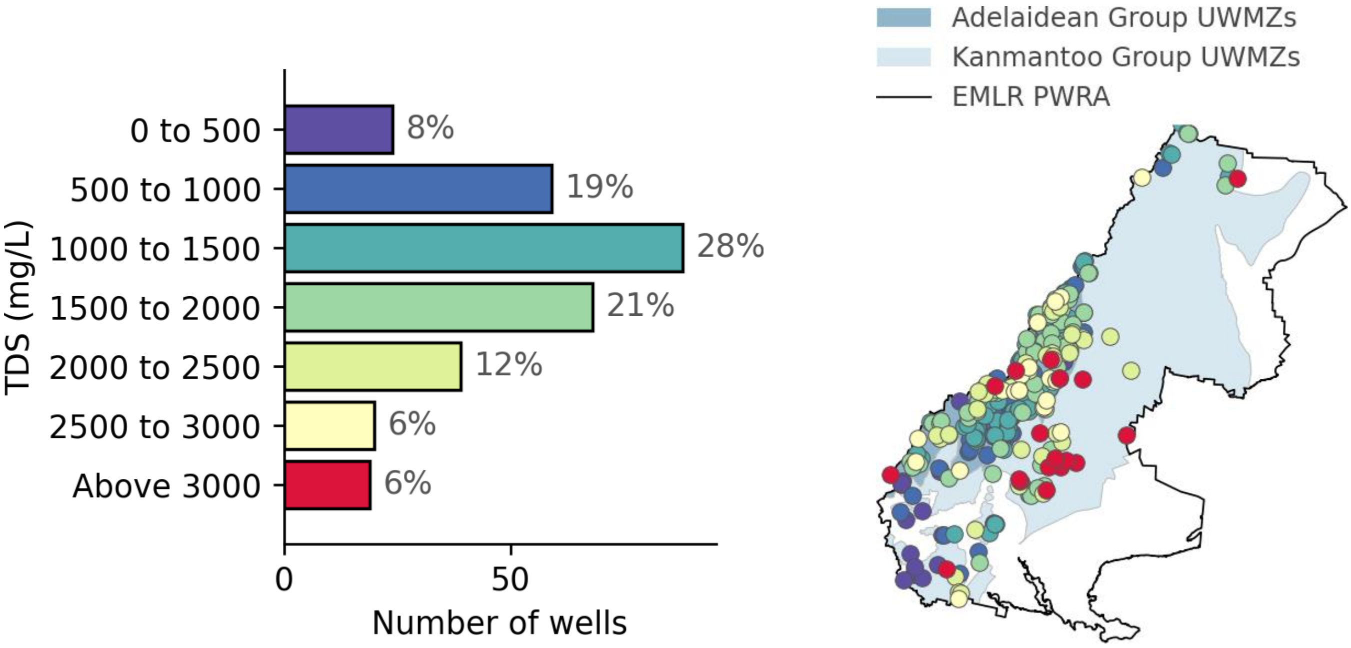

Figure 5.4 2021 salinity observations from wells in the fractured rock aquifers

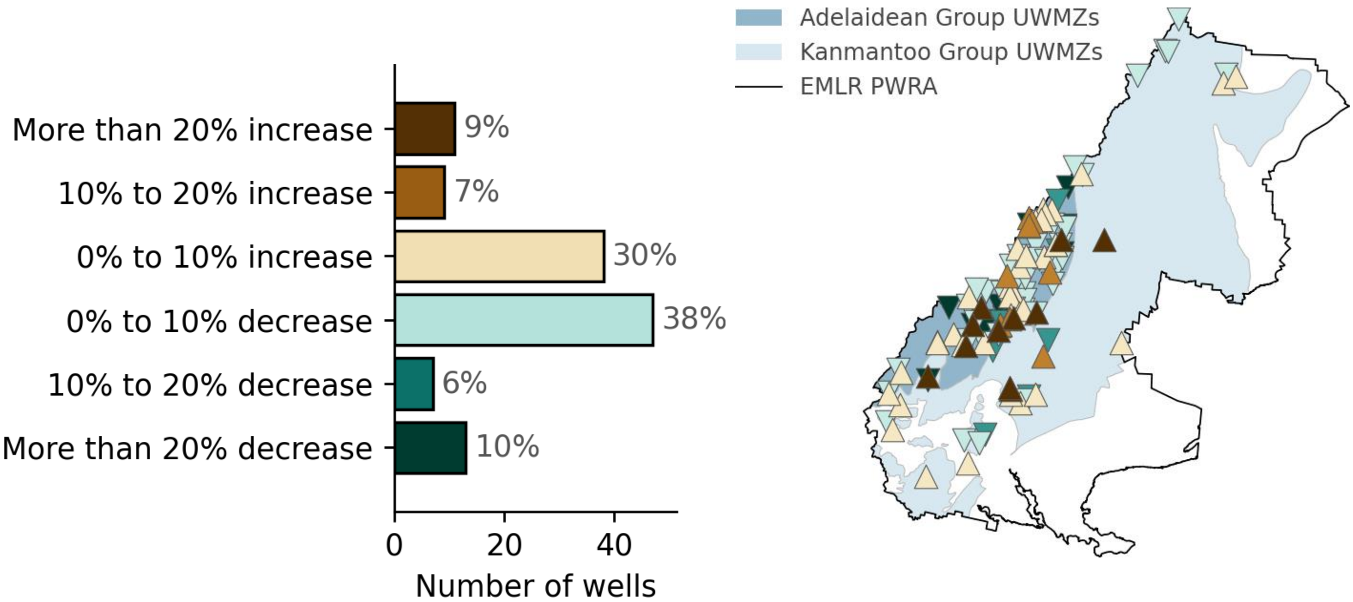

Figure 5.5 Salinity trend in the 7 years to 2021 for wells in the fractured rock aquifers

5.4 Permian Sand aquifer

5.4.1 Finniss Permian 1 UWMZ water level

In 2021, winter recovered water levels in 15 out of 20 (75%) of monitoring wells in the Finniss Permian aquifer of the EMLR PWRA are classified 'Average' (Section 2.3.1; Figure 5.6).

Over the past 20 years, variations in water level in 14 wells range from a decline of 1.35 m to a rise of 1.59 m (median is a decline of 0.3 m).

Five-year trends show declining water levels in the majority of wells (55%), with rates of decline ranging between 0.28 to 0.05 m/y (median is a decline of 0.08 m/y; Figure 5.7). Most wells that show a declining 5-year trend are located towards the north of the Finniss UWMZ.

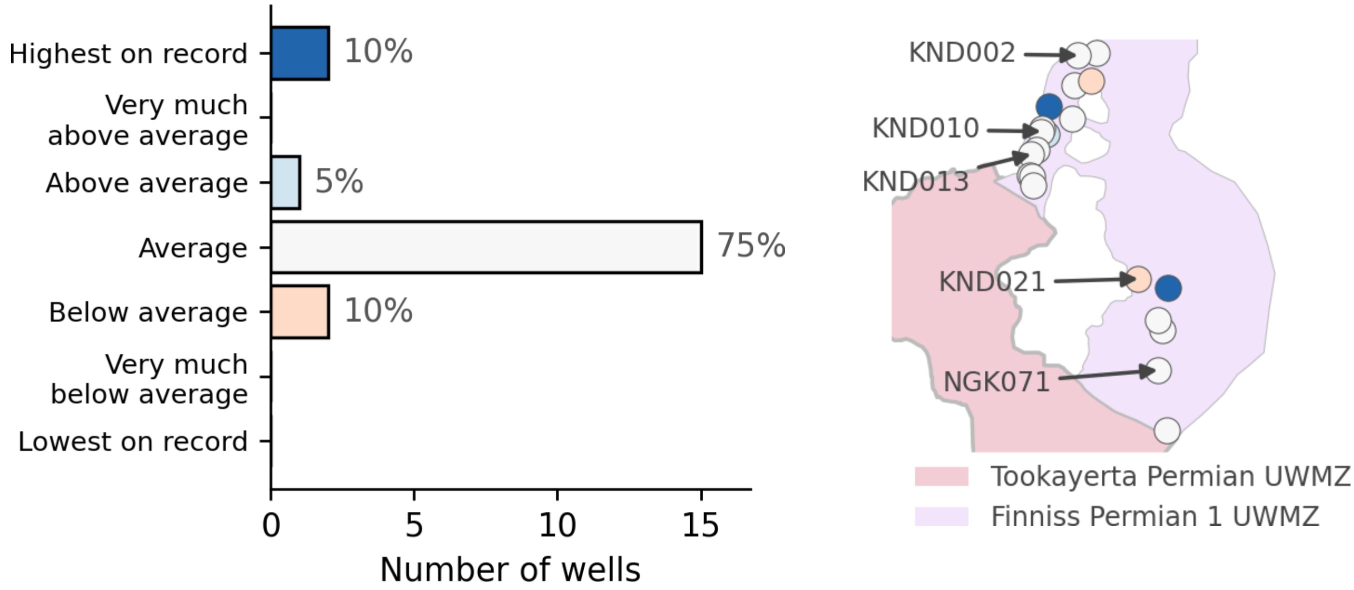

Figure 5.6 2021 recovered water levels for wells in the Finniss Permian 1 UWMZ

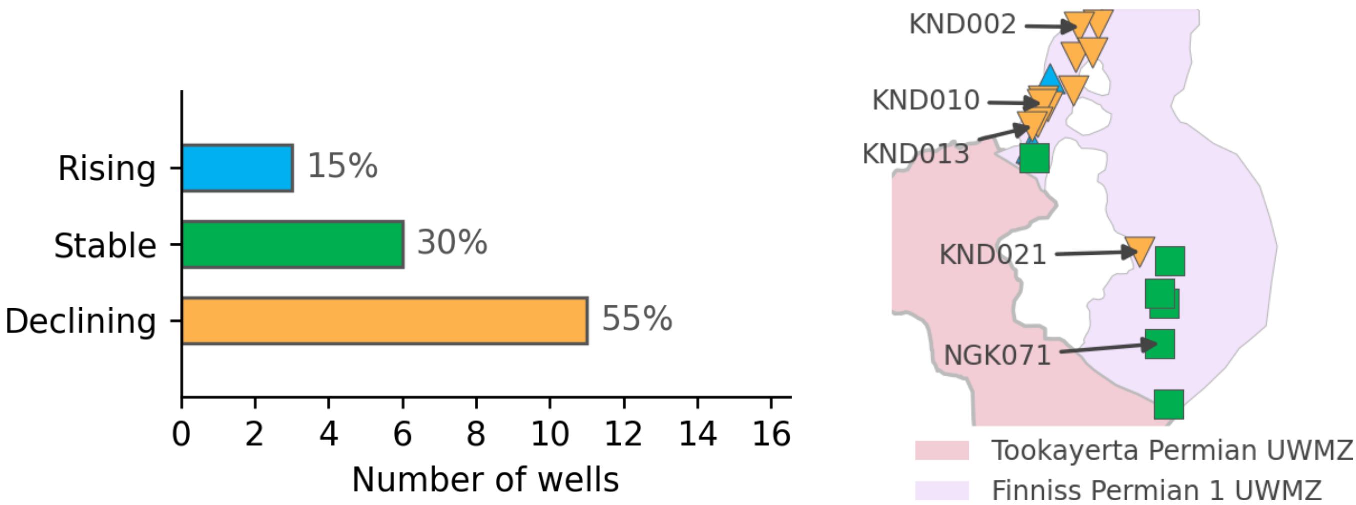

Figure 5.7 2017-21 trend in recovered water levels for wells in the Finniss Permian 1 UWMZ

Monitoring wells KND002, KND010 and KND013 are located towards the north of the Finniss Permian 1 UWMZ, near or south of Ashbourne (Figure 5.6), where the majority of groundwater extraction occurs. Groundwater levels in these wells were classified 'Lowest on record' during the Millennium drought (2004 to 2009) (Figure 5.8). Despite seasonal fluctuations due to pumping and winter-dominant rainfall, winter-recovered groundwater levels in this area are relatively stable over the past 25 years and are currently classified 'Average' (Section 2.3.1) when compared to their respective historical record.

Monitoring wells KND021 and NGK071 are located in the lower parts of the Finniss River catchment where groundwater monitoring started in 2005. NGK071 shows a relatively stable water level and is classified 'Average', while KND021 is classified 'Below average'.

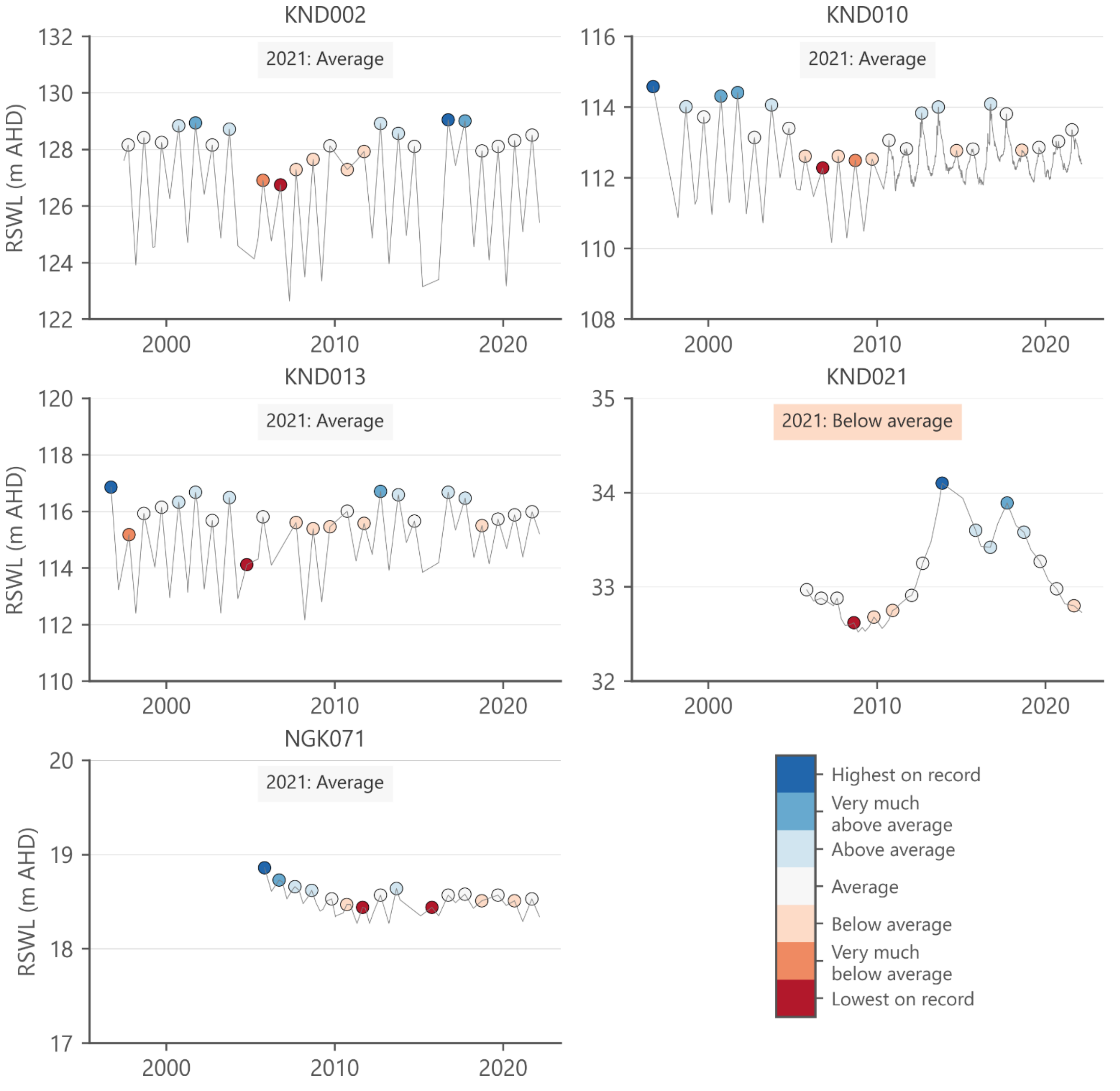

Figure 5.8 Selected hydrographs for the Permian Sand aquifer in the Finniss Permian 1 UWMZ

5.4.2 Tookayerta Permian UWMZ water level

In 2021, winter recovered water levels in 12 out of 21 monitoring wells (57%) in the Tookayerta Permian aquifer of the EMLR PWRA are classified 'Below average' or lower (Section 2.3.1; Figure 5.9). These wells are mainly located toward the western extent of the UWMZ, high in the Tookayerta Creek catchment near Mount Compass (Figure 1.1), where groundwater is used extensively for irrigation, town water supply and industrial purposes. In contrast, water levels in the remaining 43% of wells are classified 'Average' to 'Very much above average'; these wells are mostly located towards the centre and eastern extent of the UWMZ.

Over the past 20 years, variations in water level in 17 wells range from a decline of 3.38 m to a rise of 2.38 m (median is a decline of 0.8 m).

Five-year trends show declining water levels in the majority of wells (84%), with rates of decline ranging between 0.45 to 0.03 m/y (median is a decline of 0.14 m/y) (Figure 5.10).

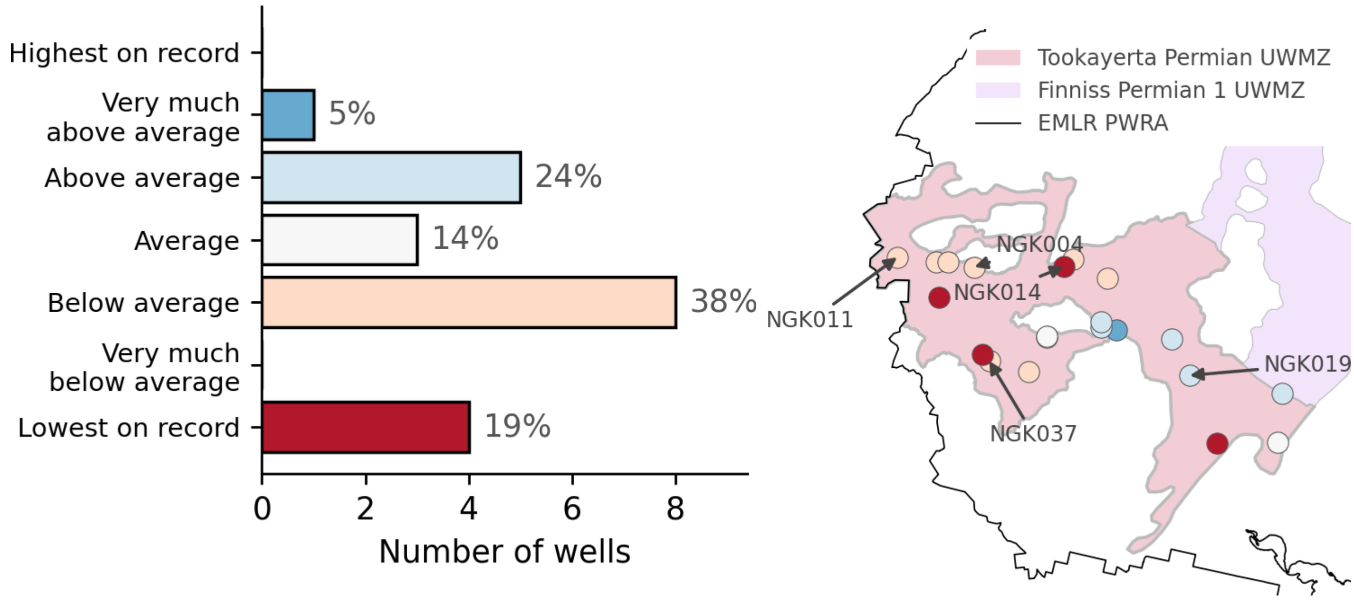

Figure 5.9 2021 recovered water levels for wells in the Permian Sand aquifer, within the Tookayerta Permian UWMZ

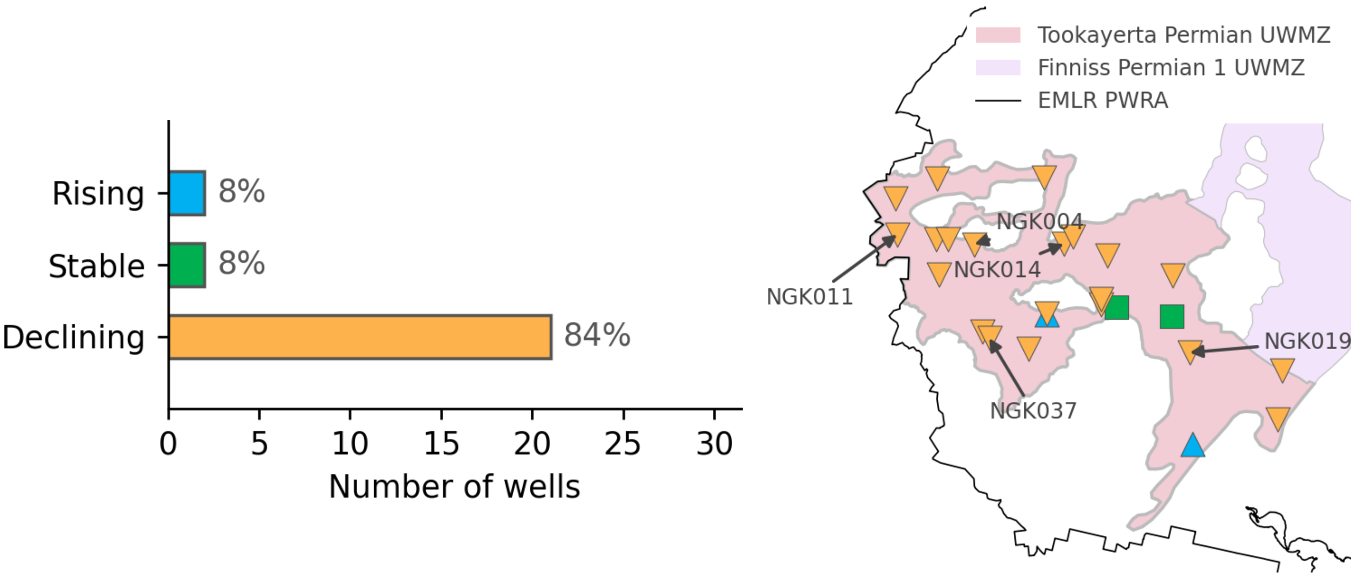

Figure 5.10 2017 to 2021 trend in recovered water levels for wells in the Permian Sand aquifer, within the Tookayerta Permian UWMZ

Monitoring wells NGK011, NGK004, NKG014 and NGK037 are located in the vicinity of Mount Compass in the west of the UWMZ (Figure 1.1 and Figure 5.9). All wells show a gradual declining trend since monitoring started (Figure 5.11). Monitoring wells NGK011, NGK004 and NGK037 show seasonal fluctuation and are classified 'Below average'. While NGK014 shows the a similar declining trend, there are no seasonal water level fluctuations and the well is classified 'Lowest on record'.

Monitoring well NGK019 is located toward the south-east of the UWMZ, where rates of licensed groundwater extraction are low. NGK019 shows a declining trend since monitoring started in the late-1990s until the end of the Millennium drought in 2009; the groundwater level has since recovered and in recent years, the level has stabilised. In 2021, the groundwater level is classified 'Above average'.

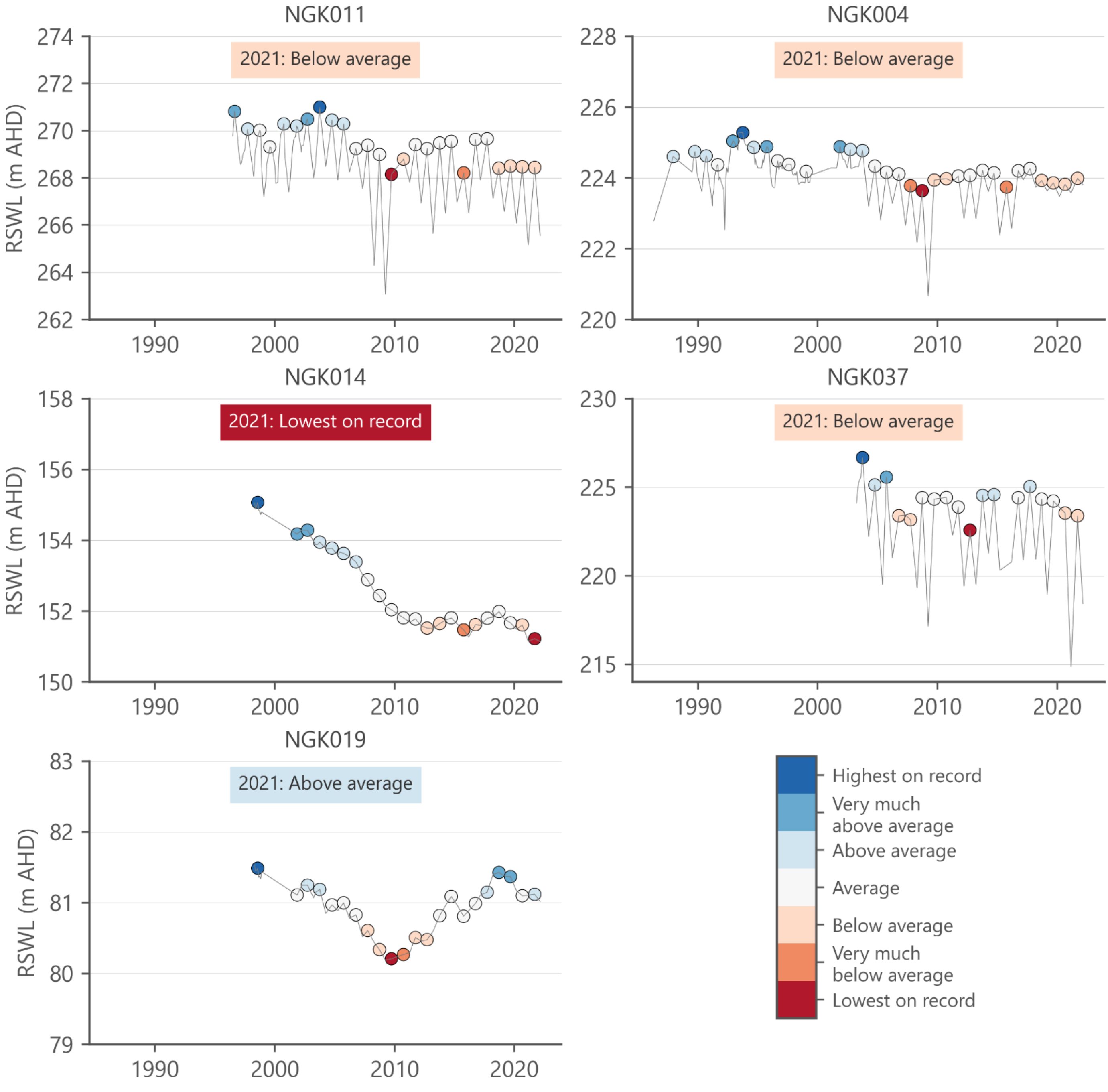

Figure 5.11 Selected hydrographs for the Permian Sand aquifer, Tookayerta Permian UWMZ

5.4.3 Finniss Permian 1 and Tookayerta UWMZs salinity

The salinity of the Permian Sand aquifer within the Finniss Permian 1 and Tookayerta Permian UWMZs is generally very low, with the majority of irrigation wells showing salinity less than 500 mg/L. Since 2015, irrigators in the EMLR PWRA have submitted groundwater samples that DEW has analysed for salinity concentration. In 2021, salinity results from 101 wells in the Finniss and Tookayerta UWMZs range between 66 mg/L and 2,955 mg/L, with a median of 305 mg/L (Figure 5.12).

In the 7 years to 2021, 31 of 52 wells (59%) show a declining trend in salinity (Section 2.3.2; Figure 5.13). Trends in salinity over this period vary from a decrease of 16.4% per year to an increase of 6.2% per year, with a median rate of 0.3% decrease per year.

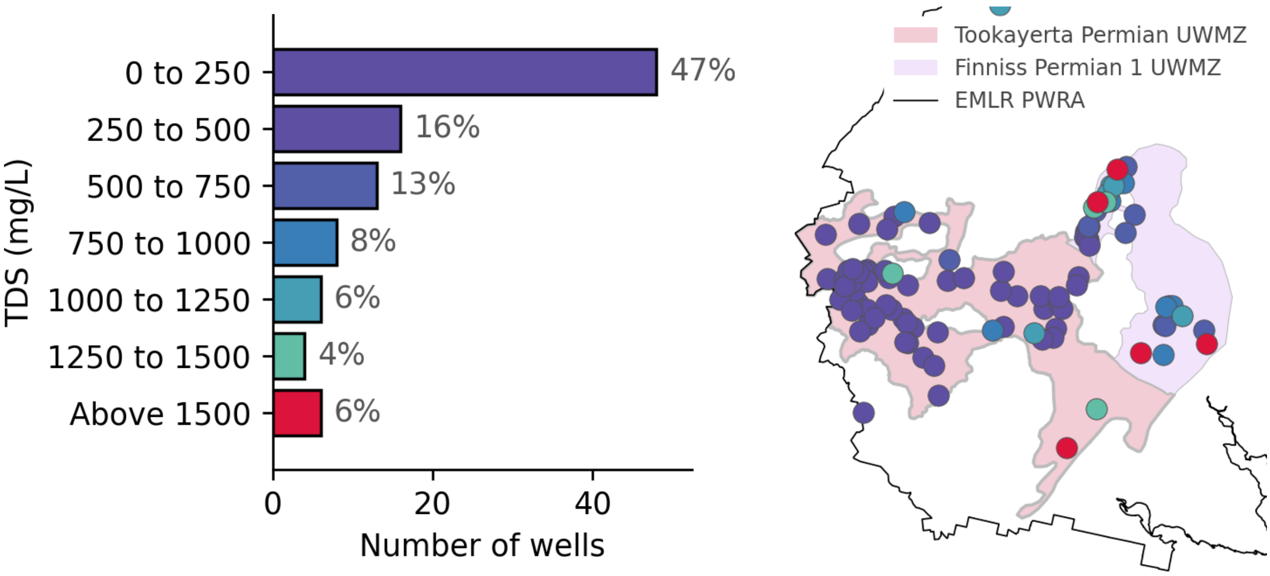

Figure 5.12 2021 salinity observations in the Permian Sand aquifer

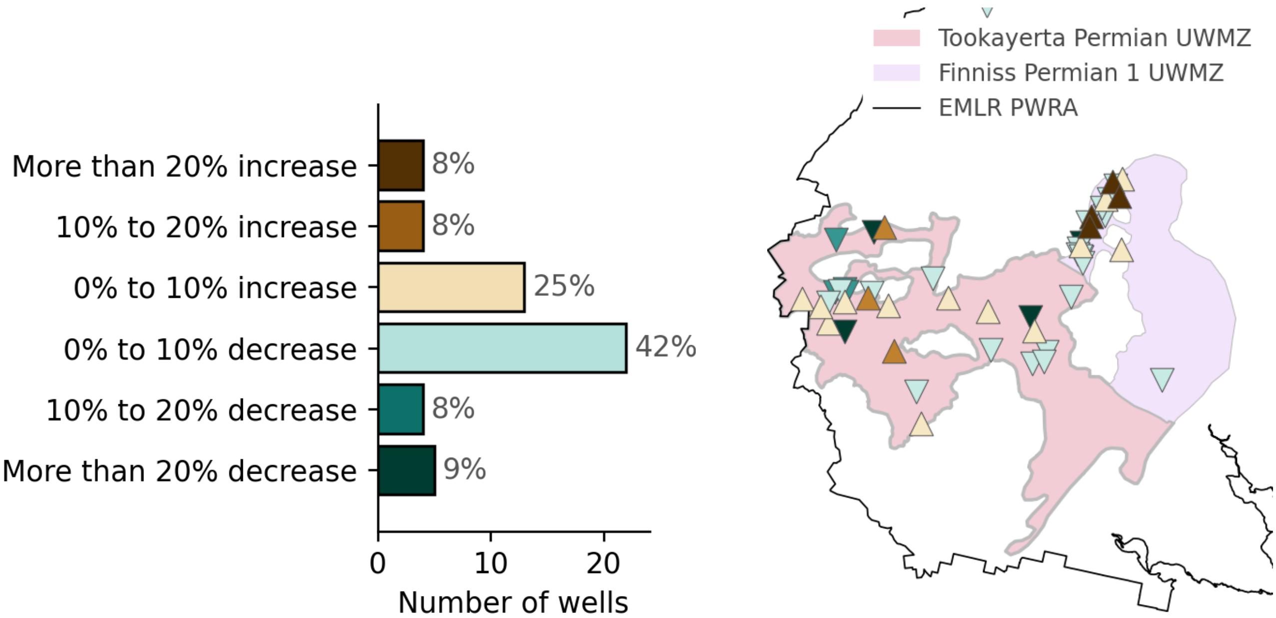

Figure 5.13 Salinity trend in the 7 years to 2021 for wells in the Permian Sand aquifer

5.5 Murray Group Limestone aquifer

5.5.1 Currency Limestone UWMZ water level

In 2021, winter recovered water levels in all monitoring wells in the Currency Limestone aquifer of the EMLR PWA are classified 'Average' or higher (Section 2.3.1; Figure 5.14). Importantly, these statistics are influenced by the relatively short period of historical monitoring which includes the Millennium drought.

Over the past 20 years, variations in water level in 6 wells range from a decline of 1.96 m to a rise of 0.14 m (median is a decline of 0.2 m).

Five-year trends show declining water levels in the majority of wells (69%), with rates of decline ranging between 0.26 to 0.03 m/y (median is a decline of 0.05 m/y) (Figure 5.15).

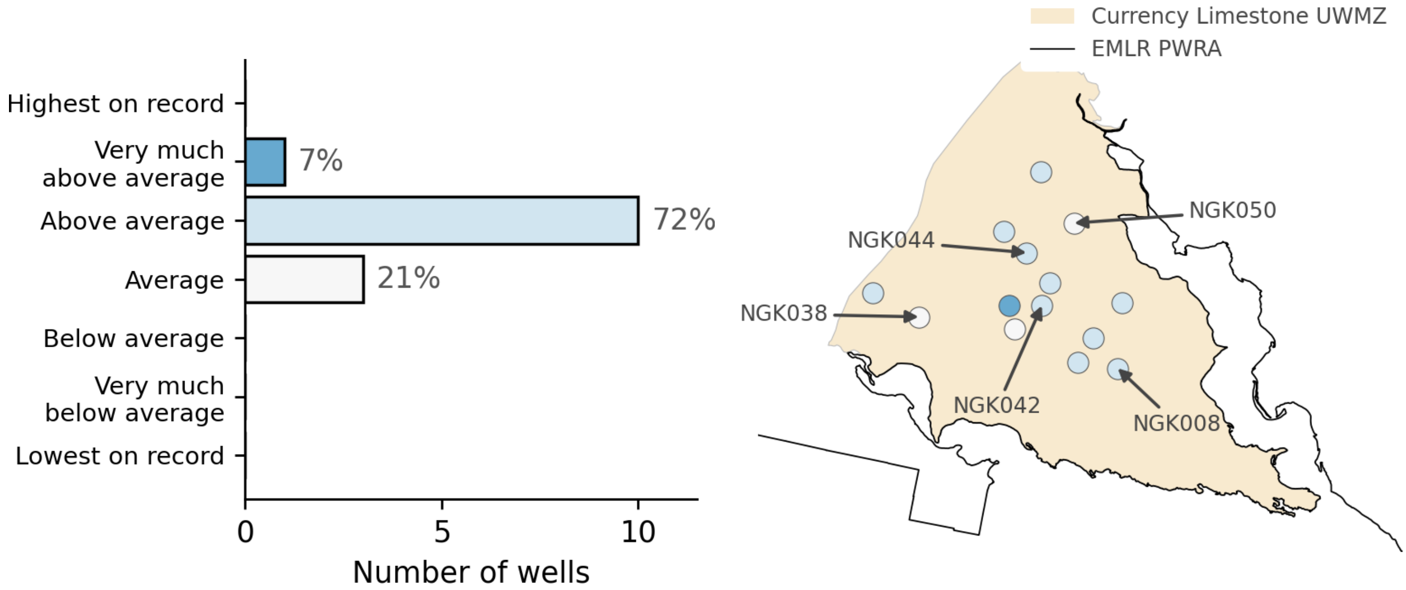

Figure 5.14 2021 recovered water levels for wells in the Murray Group Limestone aquifer

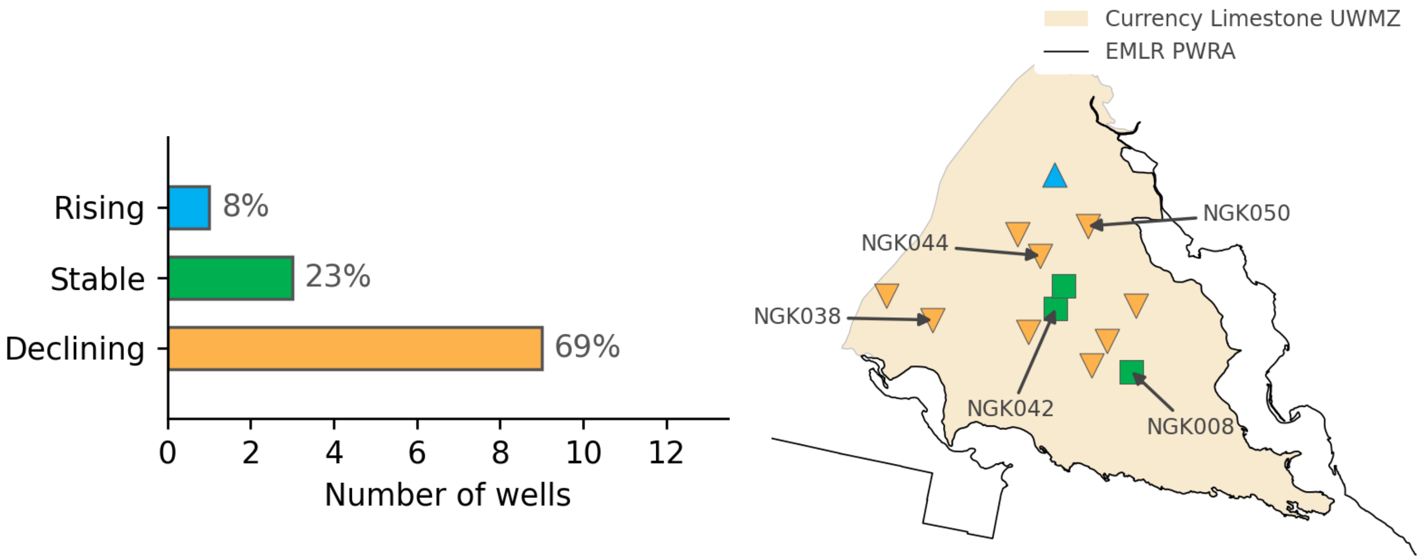

Figure 5.15 2017 to 2021 trend in recovered water levels for wells in the Murray Group Limestone aquifer

Monitoring wells in the Currency Limestone UWMZ generally show a consistent trend of declining water levels from the mid-2000s to 2010 (the peak of the Millennium drought) followed by recovery (Figure 5.16); most wells are currently classified 'Above average'. However, the length of monitoring record is short, beginning mainly around 2004, at a time when groundwater levels were declining. Some wells with longer records suggest that groundwater levels have been higher in the past (e.g., NGK008).

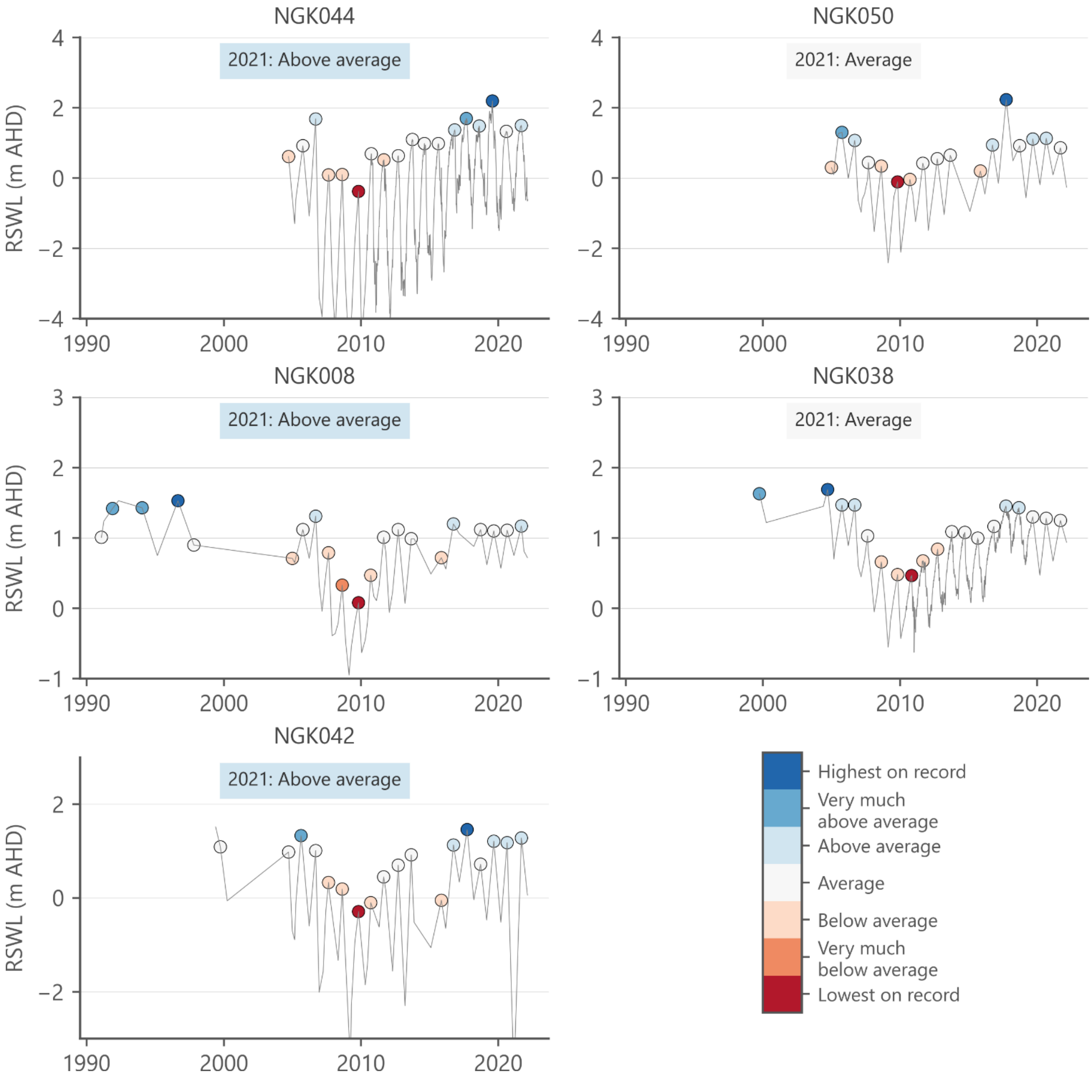

Figure 5.16 Selected hydrographs for wells in the Murray Group Limestone aquifer

5.5.2 Currency Limestone management zone salinity

Within the Currency Limestone UWMZ, the salinity of the Murray Group Limestone aquifer can increase due to downward leakage from the overlying brackish Quaternary aquifer. This leakage can occur when the groundwater elevation of the Quaternary (water table) aquifer is greater than that of the deeper Murray Group Limestone aquifer, which may occur if rates of extraction from the latter are high. Salinity in the Currency Limestone UWMZ has been monitored since 2015, using water samples which have been submitted by irrigators.

In 2021, sampling results from 24 wells range between 711 mg/L and 5,658 mg/L, with a median of 1395 mg/L (Figure 5.17). Salinities are generally below 2000 mg/L - wells with higher salinity tend to be located towards the eastern extent of the UWMZ.

In the fifteen years to 2021, 16 of 19 wells (85%) show a rising trend in salinity (Section 2.3.2; Figure 5.18). Trends in salinity over this period vary from a decrease of 2.3% per year to an increase of 4.5% per year, with a median rate of 1.2% increase per year.

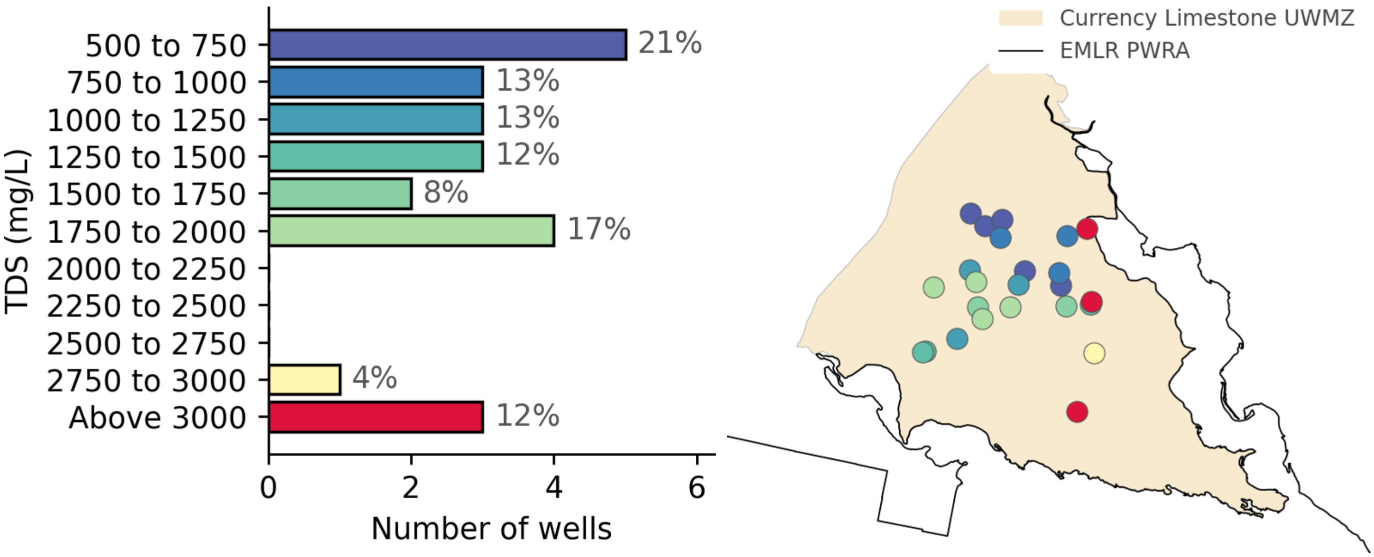

Figure 5.17 2021 salinity observations from Murray Group Limestone aquifer wells in the Currency Limestone UWMZ

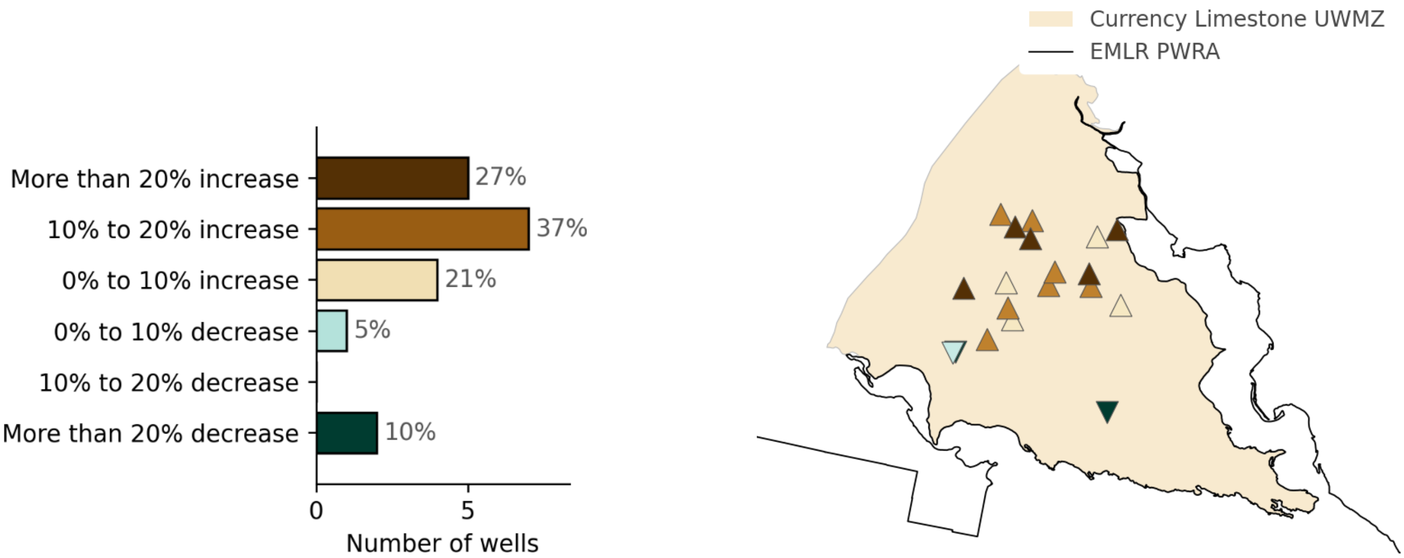

Figure 5.18 Salinity trend in the 15 years to 2021 for wells in the Murray Group Limestone wells in the Currency Limestone UWMZ

5.5.3 Angas-Bremer PWA water level

In 2021, winter recovered water levels in all monitoring wells in the Murray Group Limestone aquifer of the Angas Bremer PWA are classified 'Average' or higher; 94% are classified 'Above average' or higher (Section 2.3.1; Figure 5.19).

Over the past 20 years, variations in water level in 31 wells range from a decline of 0.41 m to a rise of 1.95 m (median is a rise of 0.7 m).

Five-year trends show declining water levels in the majority of wells (77%), with rates of decline ranging between 0.88 to 0.03 m/y (median is a decline of 0.18 m/y) (Figure 5.20). Wells showing stable water levels or a rising 5-year trend tend to be located around the periphery of the PWA, where extraction tends to be less intensive.

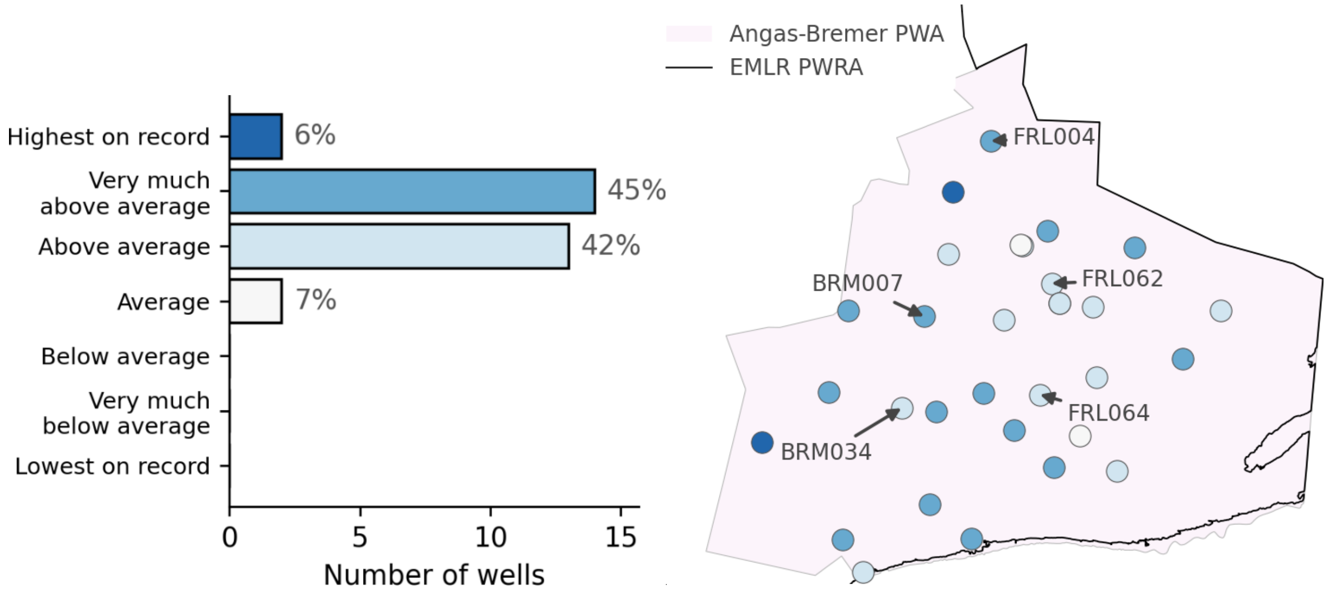

Figure 5.19 2021 recovered water levels for the Murray Group Limestone aquifer of the Angas Bremer PWA

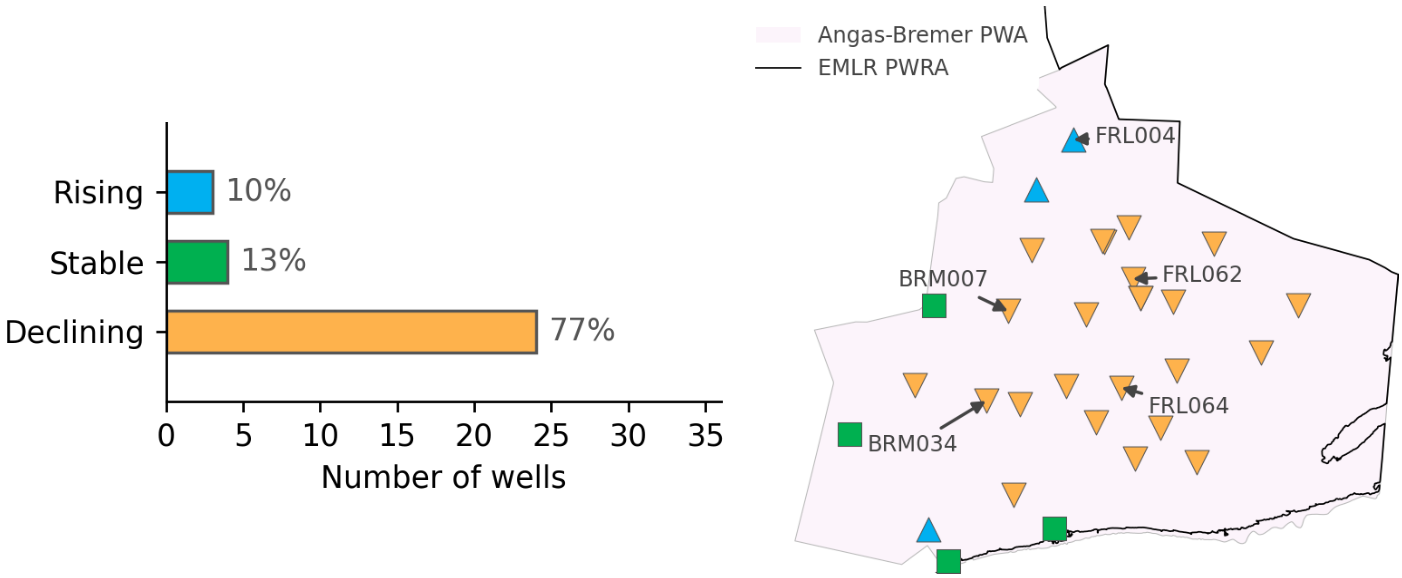

Figure 5.20 2017 to 2021 trend in recovered water levels for wells in the Murray Group Limestone aquifer of the Angas-Bremer PWA

The groundwater levels observed in the Murray Group Limestone aquifer are strongly influenced by groundwater extractions. Hydrographs for selected monitoring wells (Figure 5.21) are located adjacent to the Angas River (BRM007, BRM034) and the Bremer River (FRL004, FRL062, FRL064) (Figures 5.19 and 5.20) where the majority of groundwater extraction occurs. The aquifer shows stable or declining trends in water levels throughout the PWA, prior to considerable reductions in rates of groundwater extraction in the early 1990s.

Reductions in rates of groundwater extraction were in response to the increased availability of River Murray allocations sourced via Lake Alexandrina, and this led to a substantial recovery in groundwater levels, which continued until the Millennium drought. Rates of groundwater extraction subsequently increased due to increasing salinity and decreasing storage in Lake Alexandrina and a receding shoreline. Drawdowns in the confined Murray Group limestone aquifer reached a peak toward the end of the Millennium drought (circa 2009–10), by which time new pipelines from the River Murray had been constructed. Managed aquifer recharge schemes that inject River Murray and ephemeral surface water flows have also added to diversification of the region's water mix and aided in the recent recovery in water levels.

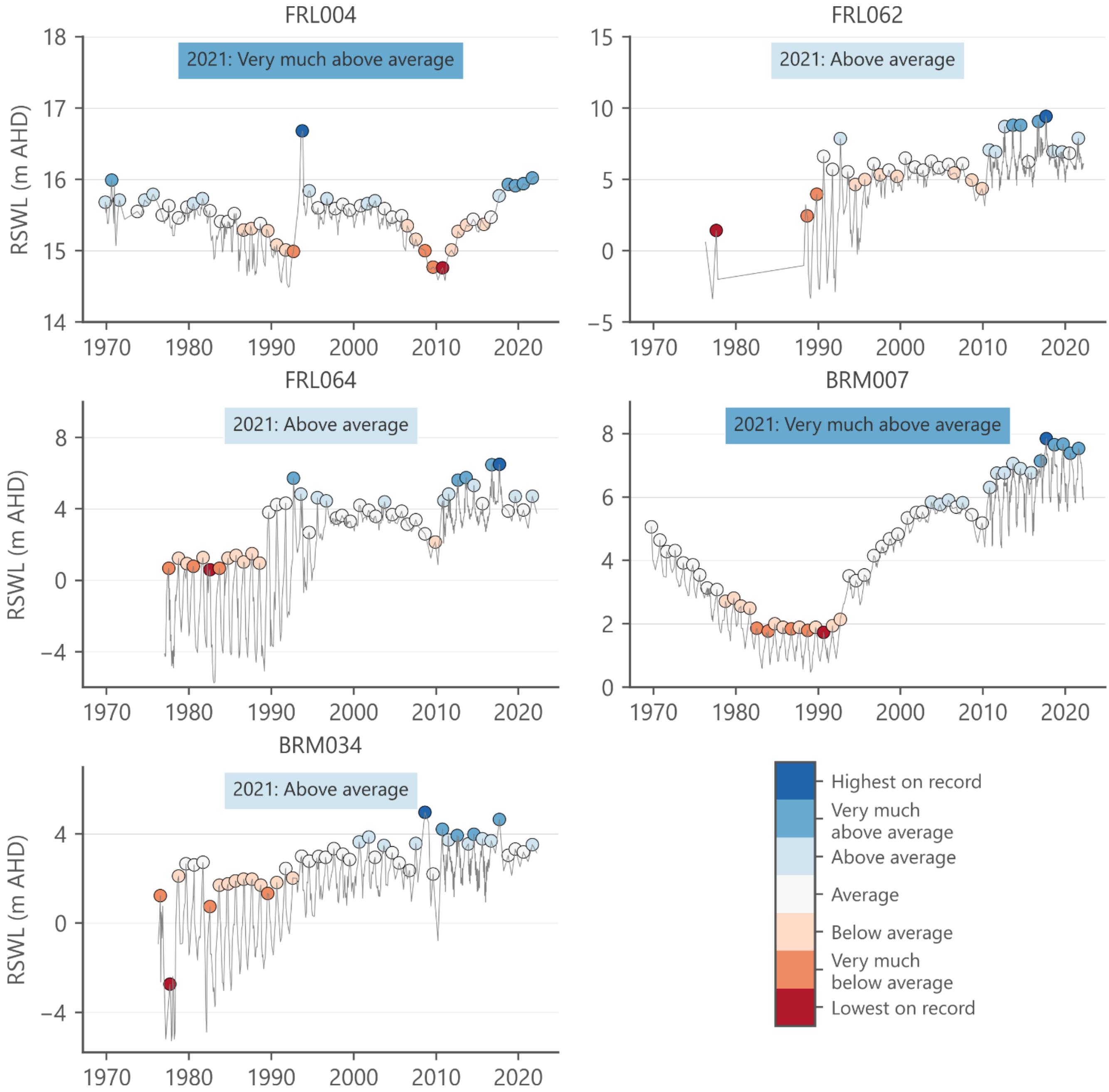

Figure 5.21 Selected hydrographs for Murray Group Limestone aquifer wells in the Angas-Bremer PWA

5.5.4 Angas-Bremer PWA salinity

Since 2015, irrigators in the Angas-Bremer PWA have submitted groundwater samples that DEW has analysed for salinity concentration. In 2021, salinity results from 41 wells in the Murray Group Limestone aquifer range between 150 mg/L and 5,687 mg/L with a median of 1,917 mg/L (Section 2.3.2; Figure 5.22). Groundwater salinity in many irrigation wells may vary considerably from year to year depending on the volume of fresher surface water which is being injected into the aquifer as part of MAR operations, and the timing of injection.

In the 10 years to 2021, 19 of 28 wells (68%) show a rising trend in salinity (Section 2.3.2; Figure 5.23). Over this period, rates of change in salinity vary from a decrease of 20.6% per year to an increase of 9.9% per year, with a median rate of 0.6% increase per year. The wide variety of salinity trends are likely influenced by the volume and timing of MAR operations (e.g., an increasing 10-year salinity trend may be indicative of a well that experienced significant freshening during the early part of the 10-year period, followed by a cessation of MAR in that area, and a return towards pre-injection salinity).

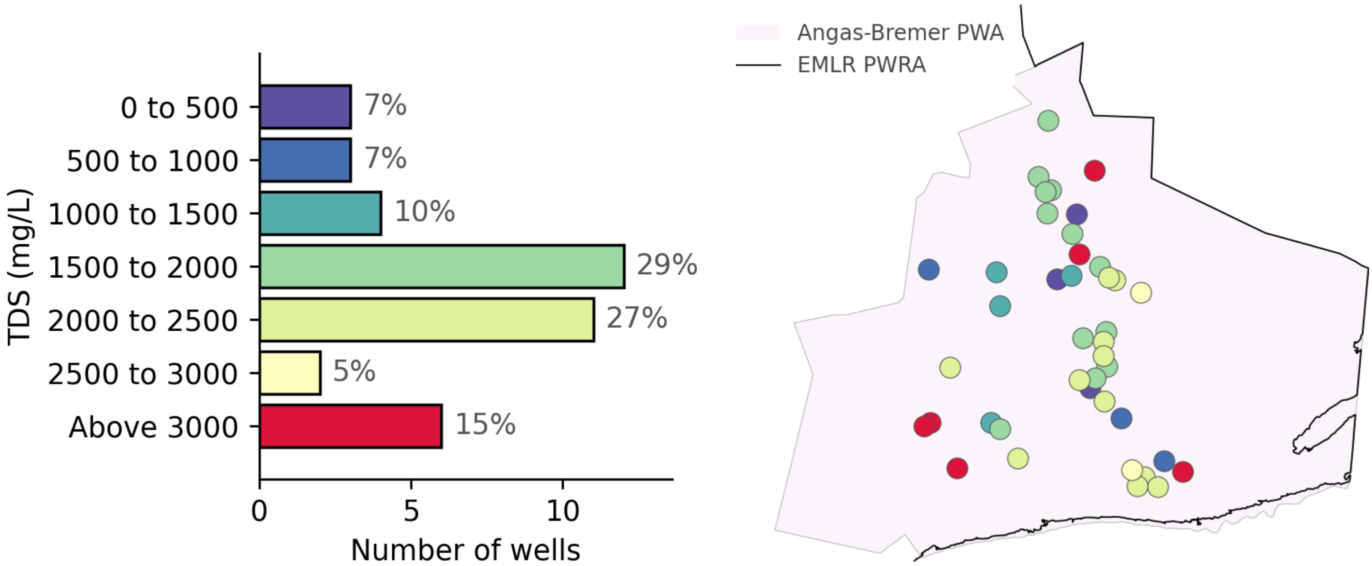

Figure 5.22 2021 salinity observations in Murray Group Limestone aquifer wells in the Angas-Bremer PWA

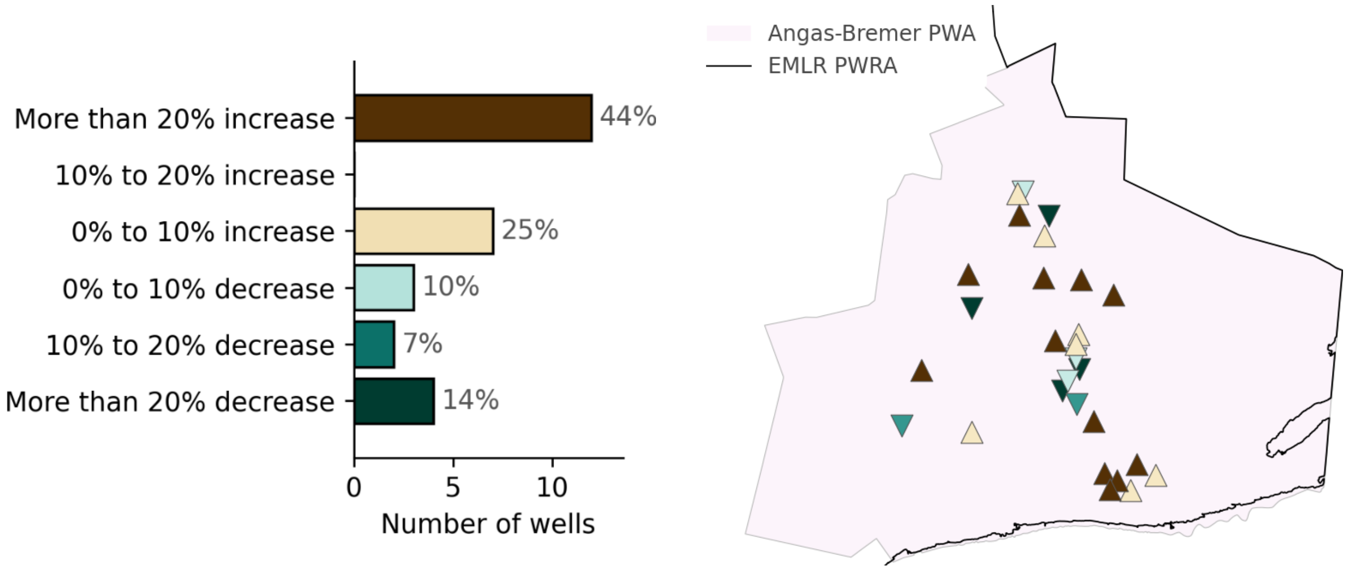

Figure 5.23 Salinity trend in the 10 years to 2021 for wells in the Murray Group Limestone aquifer of the Angas-Bremer PWA

6 Water use

The main consumptive uses of water in the EMLR PWRA are non-licensed (stock and domestic uses), forestry and licensed purposes (e.g., irrigation, industrial use, and intensive animal production). Other uses consist of social uses (including, but not limited to, indigenous and cultural values, recreation, fisheries, tourism, and amenity) and environmental water provisions. Metering of groundwater extractions across the EMLR PWRA began in 2015–16 (Figure 6.1). Surface water use in the EMLR PWRA is not comprehensively metered and therefore licensed allocation volumes are used as surrogates for usage volumes in this assessment.

The total volume of water used in 2020–21 (1 July to 30 June) is 30,701 ML (Figure 6.1). This includes estimated surface water volumes (Section 6.2) and metered groundwater extraction (Section 6.1) across both the EMLR PWRA and Angas-Bremer PWA.

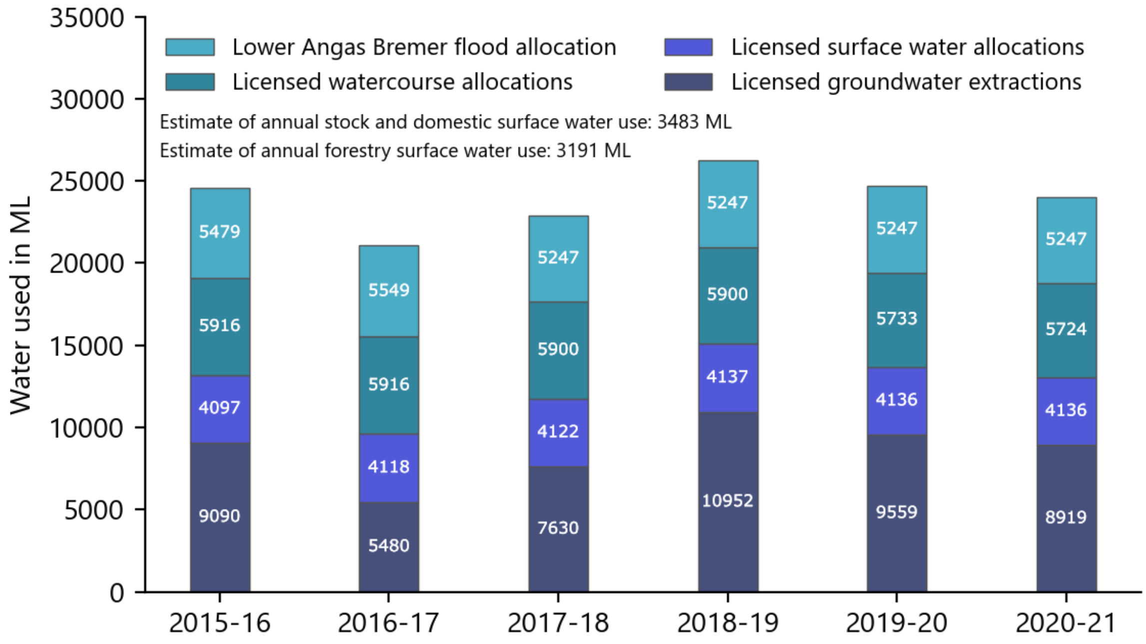

Figure 6.1 Water use from 2015–16 to 2020–21 for the EMLR PWRA, including the Angas-Bremer PWA

6.1 Groundwater use

Groundwater is extracted from the aquifers of the EMLR PWRA for a range of purposes, such as irrigation of crops, town water supply and stock and domestic use. Water taken for irrigation and town water supply is metered and is managed by principles in the Water Allocation Plan for the Eastern Mount Lofty Prescribed Water Resources Area. Water taken for stock and domestic purposes is exempt from this requirement (SAMDB NRM Board, 2013).

In 2020–21, a total volume of 8919 ML is extracted from all groundwater resources across the PWRA (Figure 6.2), proportionally:

- 45% from fractured rock aquifer UWMZs,
- 33% from the Permian Sand aquifer in the Tookayerta and Finniss Permian 1 UWMZs,
- 21% from the Murray Group Limestone (10% from Angas-Bremer PWA, and 11% from the Currency Limestone UWMZ in the EMLR PWRA).

Metered extraction data indicate that the spatial distribution of extraction across each management zone is similar to that of previous years.

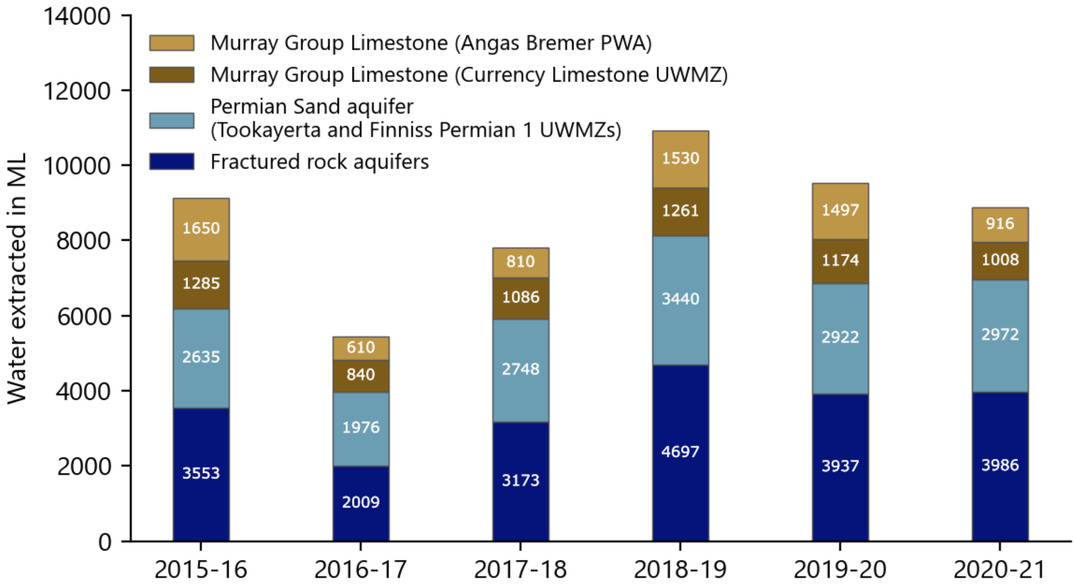

Figure 6.2 Metered groundwater extraction in aquifers of the EMLR PWRA

6.1.1 Groundwater use in the Angas-Bremer PWA

Metered groundwater extractions for licensed purposes (excluding stock and domestic use) in the Angas-Bremer PWA total 916 ML in the 2020–21 water-use year (Figure 6.3), which represents a 39% decrease from the previous water-use year.

Increases in extraction during 2005 to 2010 were due to Lake Alexandrina being an unsuitable source due to high salinity and difficulties accessing water due to the receding shoreline. As a consequence, demand for groundwater increased considerably. The recent decrease in rates of groundwater extractions reflects the recovery in the condition of the lake and increased access to River Murray water allocations via pipelines.

MAR occurs along the Angas River, Bremer River, and Mosquito Creek. The volume of surface water injected into the confined limestone aquifer from these sources varies markedly, depending on the availability of stream flow with salinities less than 1,500 mg/L. The construction of two pipelines from the River Murray during the millennium drought has increased the reliability and the volumes of water available for MAR injections.

In 2020–21, the total volume of injected water was slightly higher than in the previous 2 years, but considerably lower than historical injection volumes due to less surplus river water being available for injection. During 2020–21, injection is commensurate with extraction.

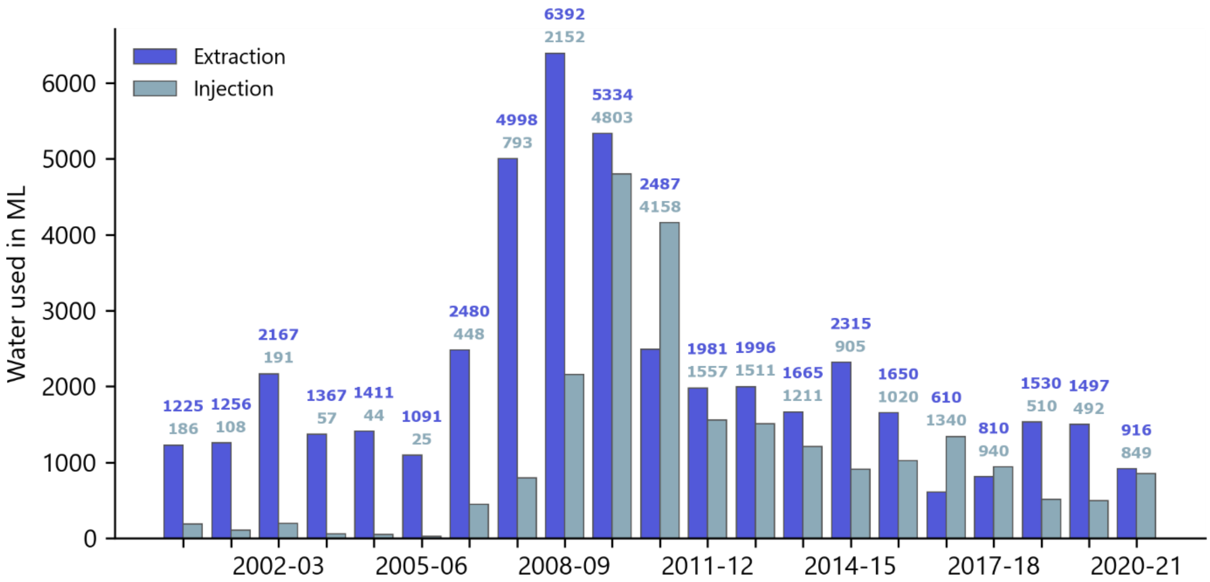

Figure 6.3 Metered groundwater extraction and injection in the Murray Group Limestone aquifer in the Angas-Bremer PWA

6.2 Surface water use

Total surface water allocation for the EMLR PWRA in 2020–21 is 21,781 ML (compared to 21,790 ML in 2019–20). This consists of (Figure 6.1):

- 5,247 ML for the Lower Angas-Bremer flood allocation (excluding the volume allocated for delivery of flood diversions)
- 4,136 ML from licensed surface water sources (dams)
- 5,724 ML from licensed watercourse sources (excluding flood diversions)
- 3,191 ML from plantation forestry (based on analysis in the EMLR water allocation plan (EMLR WAP, SAMDB NRM Board, 2013))
- 3,483 ML water demand for stock and domestic, which is not required to be licensed (approximated at 30% of dam capacity and based on analysis in the water allocation plan (SAMDB NRM Board, 2013)[10].

[10] Stock and domestic and forestry demand is included in the total consumptive total but is not presented in the bar chart (Figure 6.1), given it is an estimated value.

6.2.1 Farm dams

Based on information contained in the EMLR WAP, there are approximately 7,000 farm dams in the PWRA with an estimated total storage capacity of about 18,285 ML. The Angas River catchment contains 15% of the farm dams (which equates to 18% of the storage capacity). The Bremer River has 27% of the farm dams and 27% of storage capacity. The Currency Creek catchment contains 8% of the farm dams and 8% of storage capacity, while the Finniss River catchment has 30% of the total farm dams and 30% of storage capacity.

Non-licensed dams make up most dam numbers in the PWRA, with 86% of them being non-licensed dams less than 5 ML in capacity. However, they only make up about 32% of the total dam capacity. Non-licensed dams of 5 ML or more account for 31% of the total dam capacity, and licensed dams represent 37% of this total capacity.

Detailed analysis of farm dams in the Bremer River catchment (Figure 6.4 inset) shows there are 2,294 farm dams (139 are licensed) with a total storage capacity of 5,473 ML. Across the Bremer catchment, smaller dams (less than 5 ML) account for the majority of dams (91%), but represent only 42% of the total storage capacity of dams. Larger dams (5 ML or greater capacity) make up only 9% of the total dam count but contribute to 58% of the total storage capacity. The average farm dam density (i.e., ML of dam storage per km^2) of the EMLR PWRA as a whole and the Bremer catchment is 9 ML/km^2. Higher concentrations of dams are typically found in headwater catchments and high rainfall areas (Figure 6.4).

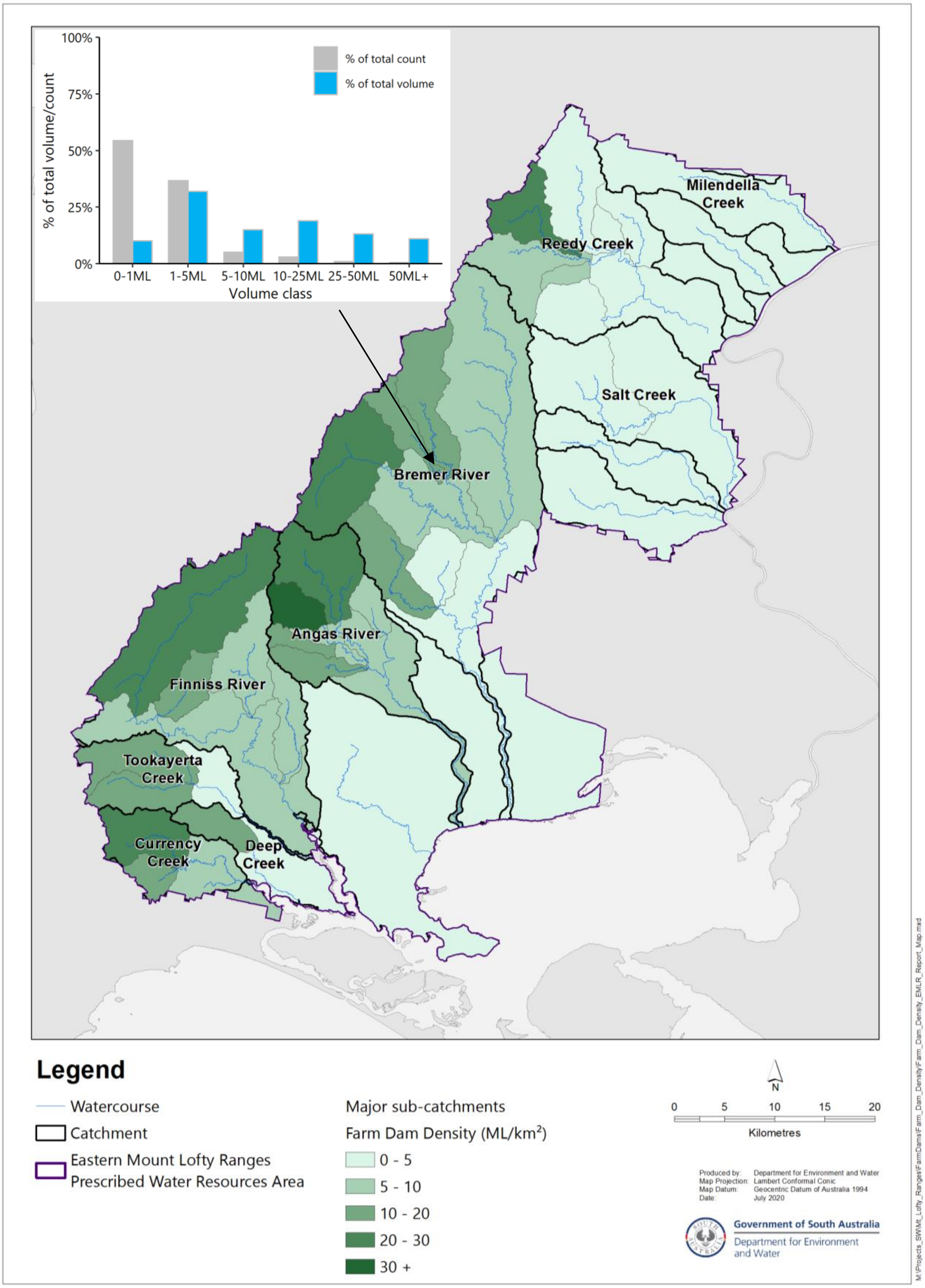

Figure 6.4 Farm dam density in the EMLR PWRA (Inset: farm dam volume and count in the Bremer River catchment)

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