Prescribed areas of the Eastern Mount Lofty Ranges
2019–20 water resources assessment

Department for Environment and Water
October, 2021

DEW Technical Note 2021/09

Government of South Australia
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Government of South Australia

October 2021

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ISBN 978-1-922027-06-1

Preferred way to cite this publication

DEW (2021). *Prescribed areas of the Eastern Mount Lofty Ranges 2019–20 water resource assessment*, DEW Technical Note 2021/09, Government of South Australia, Department for Environment and Water, Adelaide.

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Contents

1 Summary

			Status
Angas Bremer PWA	Murray Group Limestone		Above average
EMLR PWRA	Fractured rock aquifers		Average
	Murray Group Limestone	Currency	Average
	Permian sand	Finniss	Average
		Tookayerta	Below average
	Surface water (Angas & Bremer)		Below 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 2019–20 was similar to the long-term average. Rainfall at Mount Barker in 2019–20 was 722 mm/y, commensurate with the long-term average of 722 mm/y, while rainfall at Langhorne Creek was 468 mm, 23% above average.
- Rainfall totals are typically higher in highland areas and decreases eastwards over the Murray Plains due to the 'rain shadow' effect.

Surface water

- In 2019–20, 'average' streamflow was recorded in the Angas River and Finniss River (Section 2.2). The Bremer River and Currency Creek recorded 'below average' streamflow. Long-term data trends (1976–20) at the representative gauges show a decline in streamflow.
- The highest salinities in 2019–20 were 1923 mg/L in the Bremer River and 1199 mg/L in the Finniss River. These values remain within the historical ranges experienced at each site.

Groundwater

- Water levels in the three groundwater systems (fractured rock, Permian Sand, and Murray Group Limestone) were generally classified as 'average' (Section 2.3), with wells in the Murray Group Limestone within the Angas Bremer PWA generally at above-average levels and wells in Permian Sand aquifer of the Tookayerta management zone at below-average levels.
- Of the 113 monitoring wells, 49 (43%) had average recovered water levels in 2019–20 when compared to historical levels. Five wells were lowest on record (in fractured rock aquifers and the Permian Sand aquifer) and four were highest on record.
- 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 of Angas Bremer PWA is highly variable as it is influenced by rates of fresh surface water that is injected into the aquifer via managed aquifer recharge.

Water use

- Consumptive water use includes 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.
- Estimated water consumption in 2019–20 is 31 249 ML. This includes metered groundwater extraction (9559 ML), licensed surface water dams (4136 ML), licensed watercourse extractions (5733 ML), non-licensed surface water demand (3483 ML), forestry (3191 ML) and Lower Angas Bremer flood allocation (5247 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) provide a detailed information and assessment for each resource area, helping to identify the resource condition in further detail;
- **Fact sheets**: provide summary information for each resource area with an Annual Resource Status Overview;
- **State-wide summary**: this summarises 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)) for 2019–20 and collates rainfall, surface water and water use (i.e. surface water and groundwater) data collected between July 2019 and September 2020, and groundwater level and salinity data collected between July 2019 and December 2020.

1.2 Regional context

The EMLR PWRA is located approximately 50 km east of Adelaide and occupies an area of 2845 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 of the catchments have watercourses that drain from the eastern slopes of the Mount Lofty Ranges to the River Murray and Lake Alexandrina, with the Bremer River, Angas River and Finniss Rivers being the larger watercourses. There are also a number of catchments that have streams that rise in the ranges but do not 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 utilised, 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).

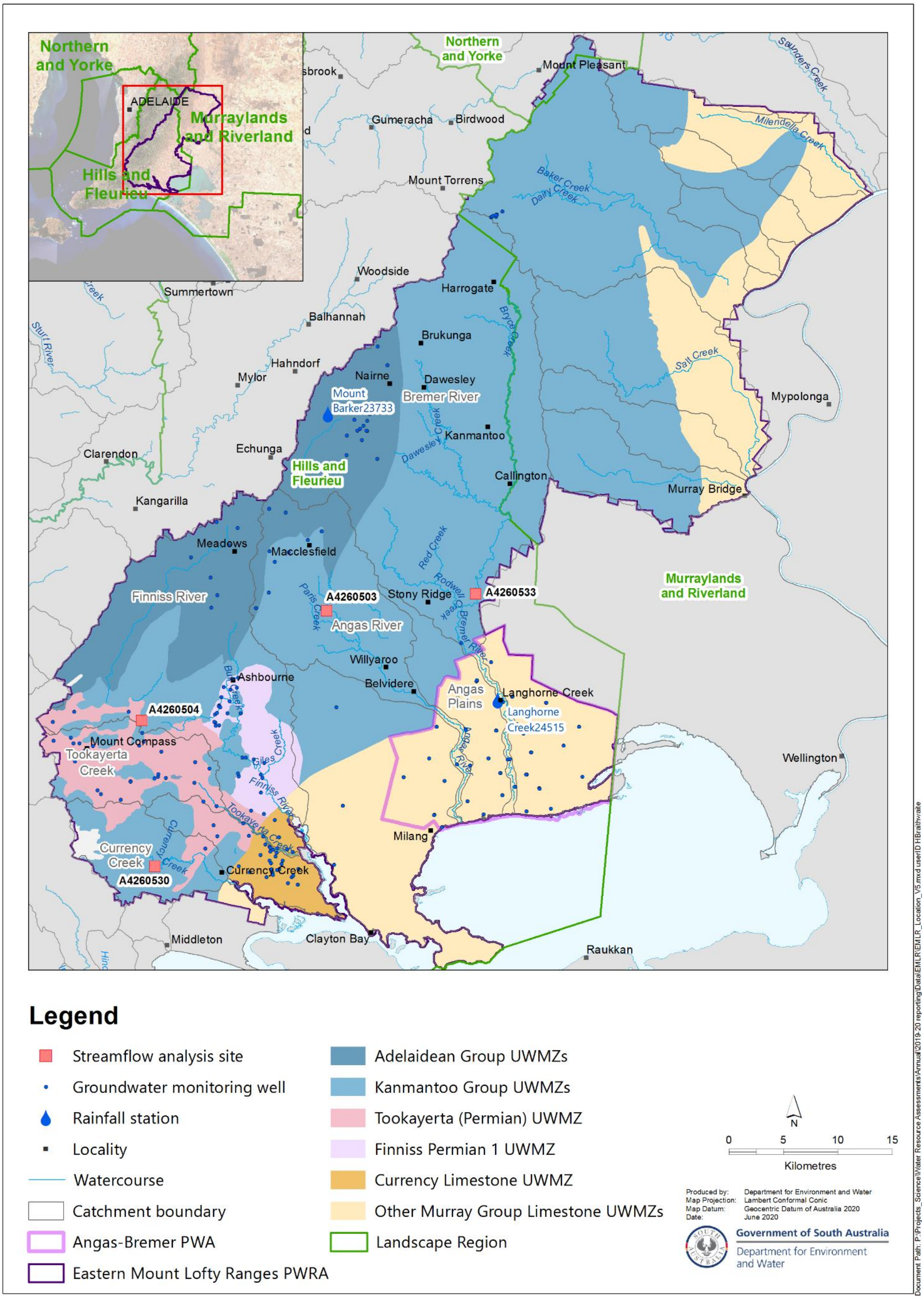

Figure 1.1. Location of EMLR PWRA and relevant underground water management zones (UWMZs)

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.

2.1 Rainfall

Daily rainfall observations were used from selected Bureau of Meteorology (BoM) stations in order to calculate monthly and annual totals. The 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 3.1 to Figure 3.4).

Rainfall maps were compiled using gridded datasets obtained from the BoM (Figure 3.5). The long-term annual rainfall map (1986-2015 average) was obtained from Climate Data Online[2]. The map of total rainfall in 2019–20 was compiled from monthly rainfall grids obtained for the months between July 2019 and June 2020 from the Australian Landscape Water Balance[3] website.

2.2 Surface water

2.2.1 Annual streamflow

The status of each of the gauging stations is determined by expressing the annual streamflow for the applicable year as a percentile[4] of the total period of data availability. The period of data availability for the Bremer and Finniss River streamflow gauging stations is 1976–20. Streamflow data were then given a description based on their percentile and decile[1] (Table 2.1 and Figure 4.1).

Table 2.1. 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]

[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/

[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 Annual climate statement at http://www.bom.gov.au/climate/current/annual/aus/

Annual streamflow data (Figure 4.2) is presented as the deviation of each year's streamflow from the long-term average with the bars shaded using the BoM classification shown in Table 2.1.

2.2.2 Monthly streamflow

Monthly streamflow for the applicable year is assessed alongside the long-term average monthly streamflow (Figure 4.3A and Figure 4.5A) for the period 1976–20 and long-term monthly statistics including (a) high flows (25th percentile), (b) median flows (50th percentile) and low flows (75th percentile).

2.2.3 Daily streamflow

Daily streamflow is presented to show the detailed variability throughout the applicable year (Figure 4.3B and Figure 4.5B).

2.2.4 Salinity

Box plots on a monthly basis are used to assess surface water salinity (Figure 2.1, Figure 4.6 and Figure 4.7). This enables the salinity (TDS; total dissolved solids in mg/L) for the applicable year to be presented against long-term salinity statistics (maximum, 75th percentile, median or 50th percentile, 25th percentile and minimum).

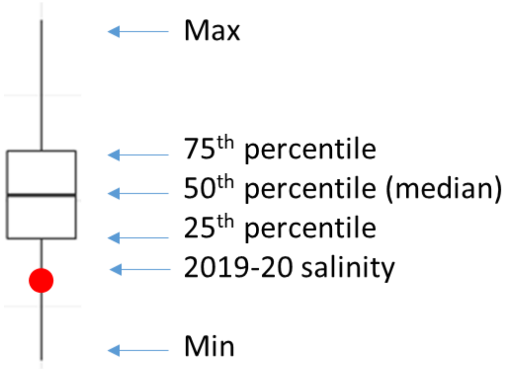

Figure 2.1. Box and whisker plot

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.

[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).

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 2.1). 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 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 five measurements (i.e. at least one measurement a year). The trend line was 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 twenty years ago (i.e. 2000–2002) and the average water level in 2020.

2.3.2 Salinity

Water samples from pumping irrigation wells are provided to DEW by licence holders in the EMLR PWRA and Angas Bremer PWAs. These samples are tested for electrical conductivity (EC) and the salinity (total dissolved solids measured in mg/L, abbreviated as TDS) is calculated. 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 seven 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. In resources with gaps in the ten-year data, different periods were used for the calculation of salinity trends (i.e. five-year trends in Permian Sand and fractured rock aquifers, and 15-year trends at Currency Limestone management zone). The salinity measurements are based on the measurement of the electrical conductivity of a water sample and are often subject to small instrument errors (e.g. Figure 5.5).

Where data available, salinity graphs are shown for a selection of wells to illustrate common or important trends (for example see Figure 5.6).

2.4 Water use

Meter readings are used to estimate licensed extraction volumes for both surface water and groundwater sources. Where meter readings are not available, licensed or 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 (AMLR NRM Board, 2019). Futher information on the number, type and distribution of farm dams in the PWRA is provided in Section 6.3. Dam capacity estimates are undertaken using different methods with data derived from aerial surveys 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), annual surface water status reports such as DEW (2019 a) and groundwater level and salinity status reports such as DEW (2019 b,c,d).
- The Water Allocation Plan for the Eastern Mount Lofty Prescribed Water Resources Area (SAMDB NRM Board, 2013).
- Penney et al. (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.

[7] https://www.waterconnect.sa.gov.au/Systems/GD/Pages/default.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 Murray Plains and eventually to the River Murray and the 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' that is the main reason for the contrast in rainfall across the area. The Mount Lofty Ranges cause westerly winds to rise and cool where precipitation along the mountain ranges occurs predominantly on the western side, resulting in comparatively less rainfall on the Murray Plains.

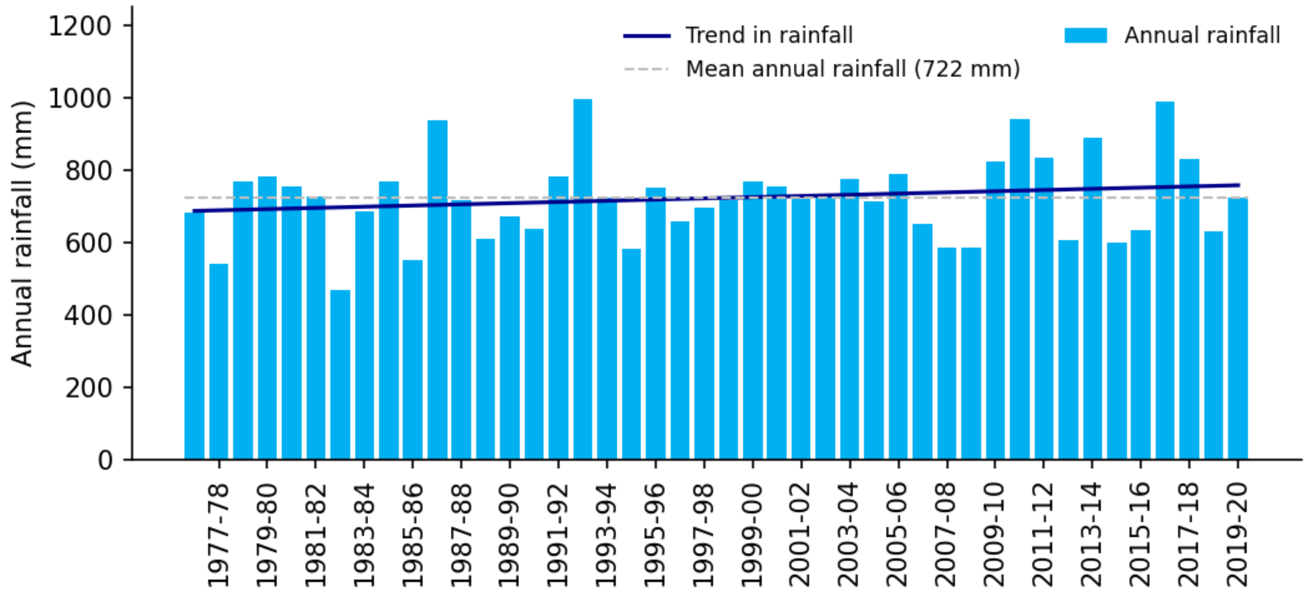

Figure 3.1. Annual rainfall for 1976–77 to 2019–20 at the Mount Barker rainfall station (23733)

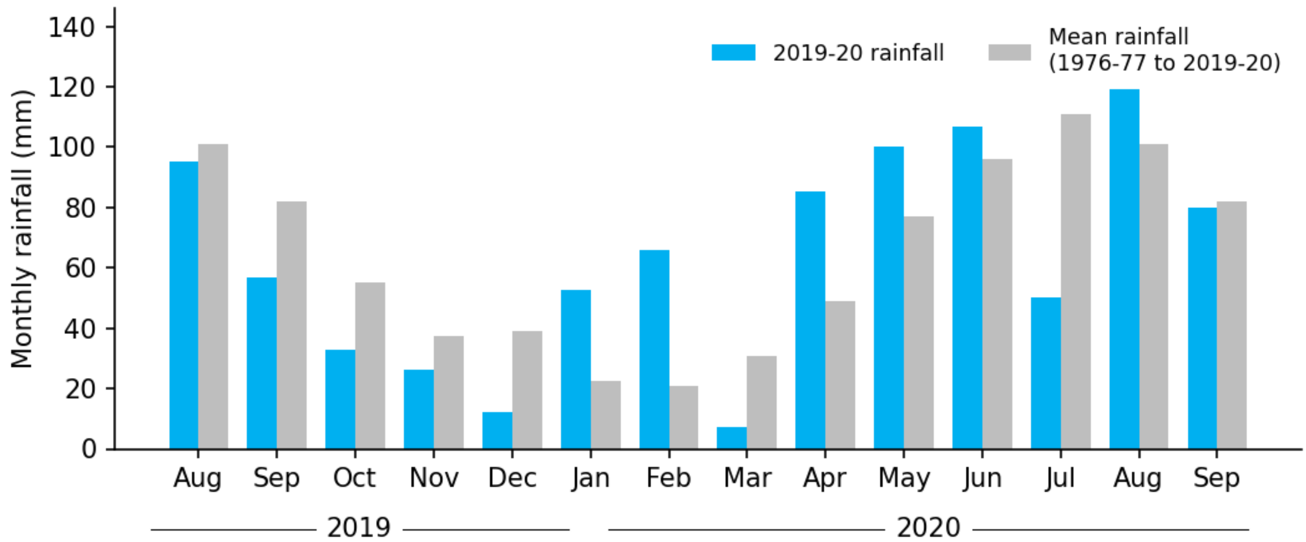

Figure 3.2. Monthly rainfall between July 2019 and September 2020, Mount Barker rainfall station (23733)

Following the hills from south-west to north-west in the EMLR PWRA, rainfall ranges from approximately 500 to 1000 mm/y (Figure 3.5). In contrast, the Murray Plains rainfall ranges from less than 300 mm/y to 500 mm/y from the north-east to the south-east of the PWRA.

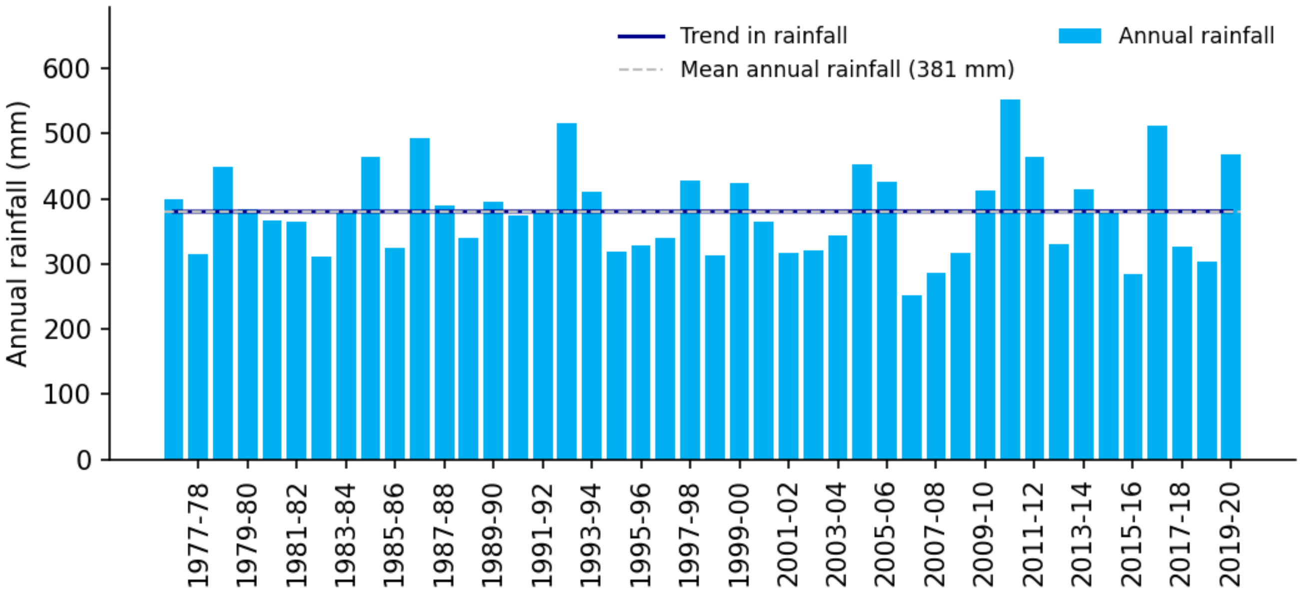

Figure 3.3. Annual rainfall for 1976–77 to 2019–20 at the Langhorne Creek rainfall station (24515)

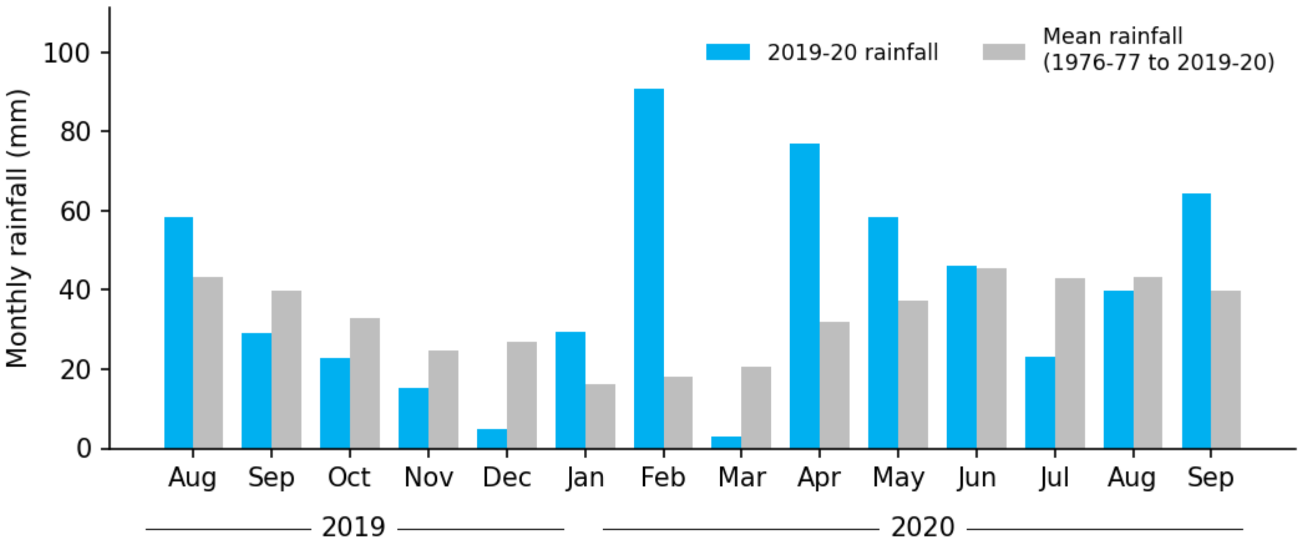

Figure 3.4. Monthly rainfall between July 2019 and September 2020, Langhorne Creek rainfall station (24515)

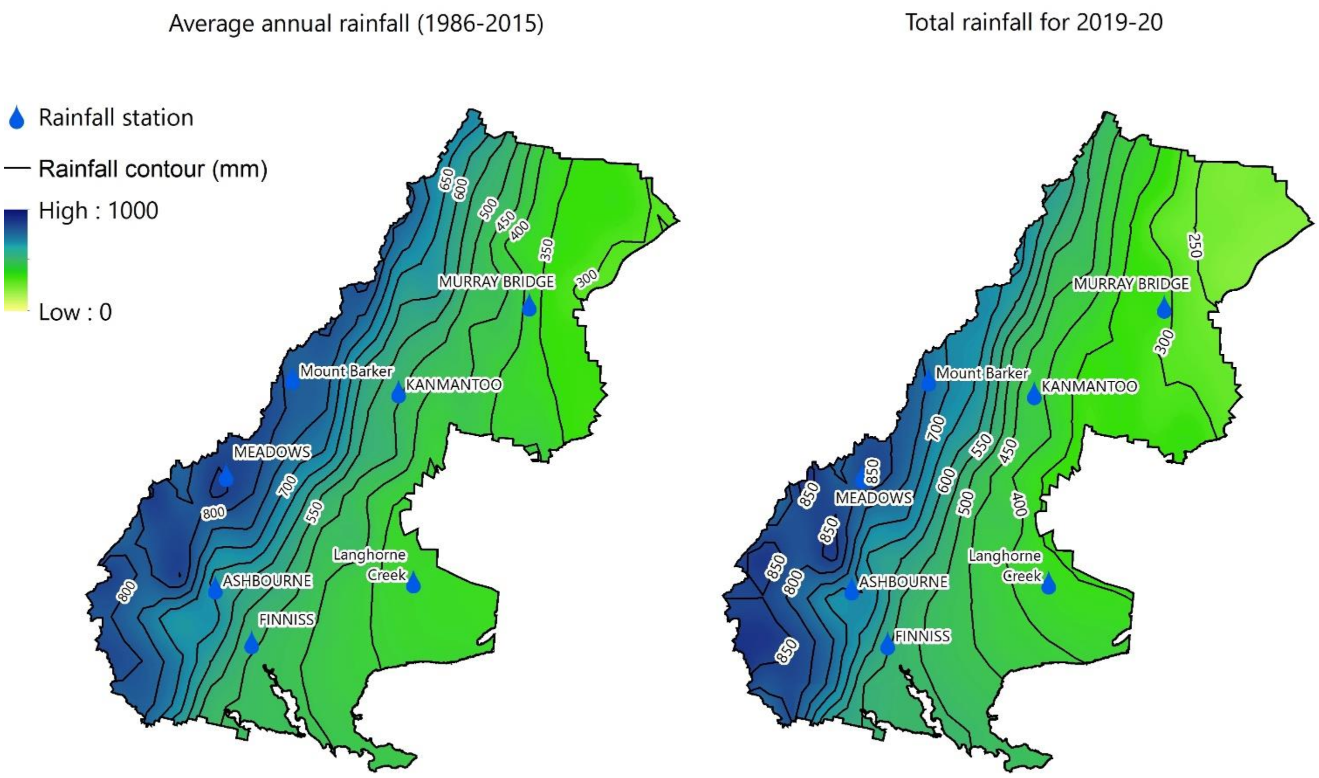

Figure 3.5. Rainfall in the EMLR PWRA for 2019–20 compared to the standard 30-year climatological average (1986–2015)

- Mount Barker rainfall station (BoM station 23318) represents the higher rainfall areas of the Mount Lofty Ranges. The annual total recorded for 2019–20 was 722 mm, the same as the average annual rainfall for the period 1976–20.
- Langhorne Creek rainfall station (BoM station 23318) represents the lower rainfall areas of the plains. The annual total recorded for 2019–20 was 468 mm, 88 mm higher than the average annual rainfall of 380 mm/y (1976–20).
- Dry conditions were recorded in spring 2019 and early summer 2019 at both Mount Barker and Langhorne Creek rainfall stations. Generally wetter conditions were recorded between January and September 2020 at both stations apart from March and July 2020.
- Rainfall in 2019–20 was similar to, or slightly higher than, long-term average annual rainfall in all parts of the PWRA. The 2019–20 rainfall map (Figure 3.5) shows the higher rainfall band (850–900 mm/y) being present in the area to the west of Meadows and Ashbourne. This rainfall band is less prevalent in the west of the PWRA in the long-term average annual rainfall map[9].

[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 and further detail is provided in Section 2.1.

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 watercourses, along with numerous streams from a number of 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 and salinity are primarily rainfall driven, i.e. below-average winter rainfall will result in reduced annual streamflow volumes. Conversely, higher rainfall will result in increased surface water availability. The spatial variability in hydrological behaviour of the surface water catchments within the EMLR makes it challenging when assigning a single representative streamflow gauging station for the PWRA. Therefore multiple streamflow gauging stations were used for the analysis (Figure 1.1). The following stations were chosen to be representative of higher rainfall and streamflow areas of the EMLR PWRA:

- Finniss River (A4260533).
- 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).

In 2019–20, two sites recorded 'Average' streamflow conditions and two sites recorded 'Below average' streamflow conditions (Figure 4.1). The common period of streamflow data availability is 1976–20. Further detail on analysis methodologies used can be found in Section 2.

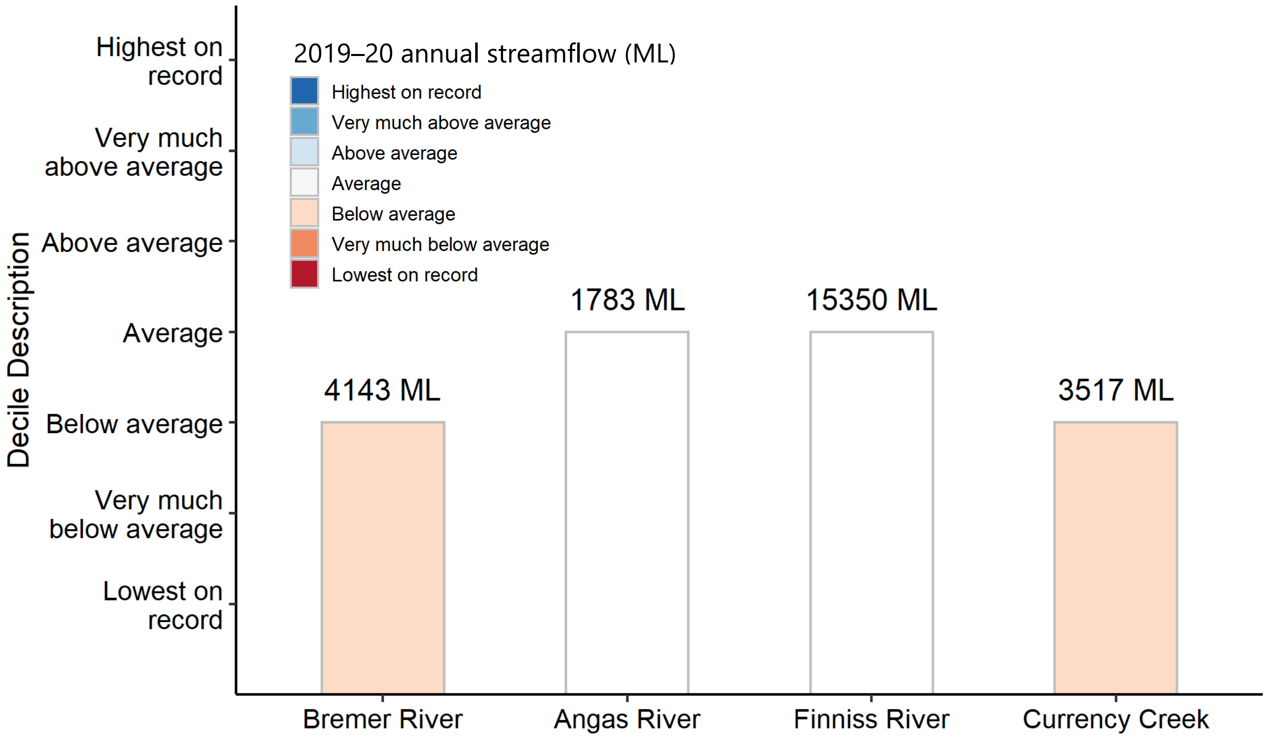

Figure 4.1. EMLR PWRA annual streamflow summary 2019–20

4.1.1 Bremer River (A4260533)

One of the principal long-term streamflow gauging stations for the drier parts of the PWRA is on the Bremer River and covers a catchment area of 492 km². This site is located where the Bremer River flows from the Eastern Mount Lofty Ranges onto the Bremer Plains. The Bremer River then flows past the township of Langhorne Creek and into Lake Alexandrina.

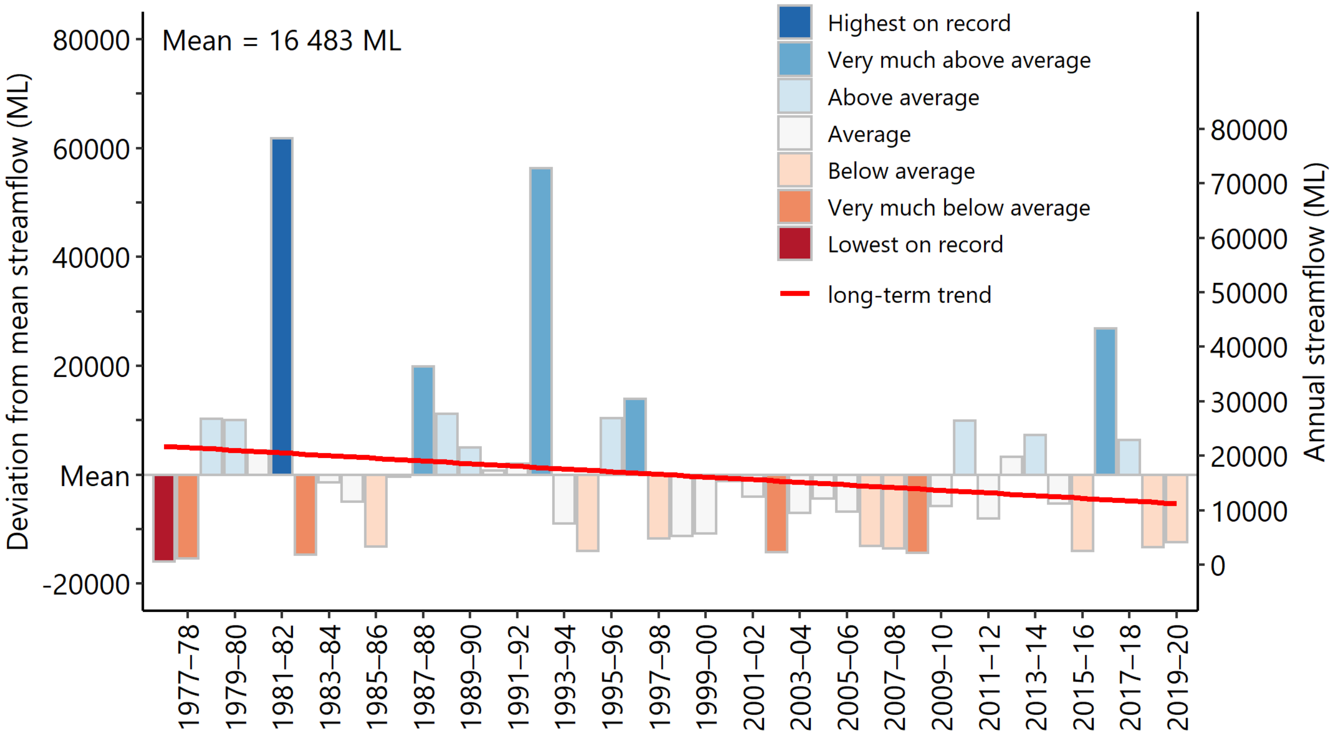

Figure 4.2. Annual deviation from mean streamflow on the Bremer River (1976-77 to 2019–20)

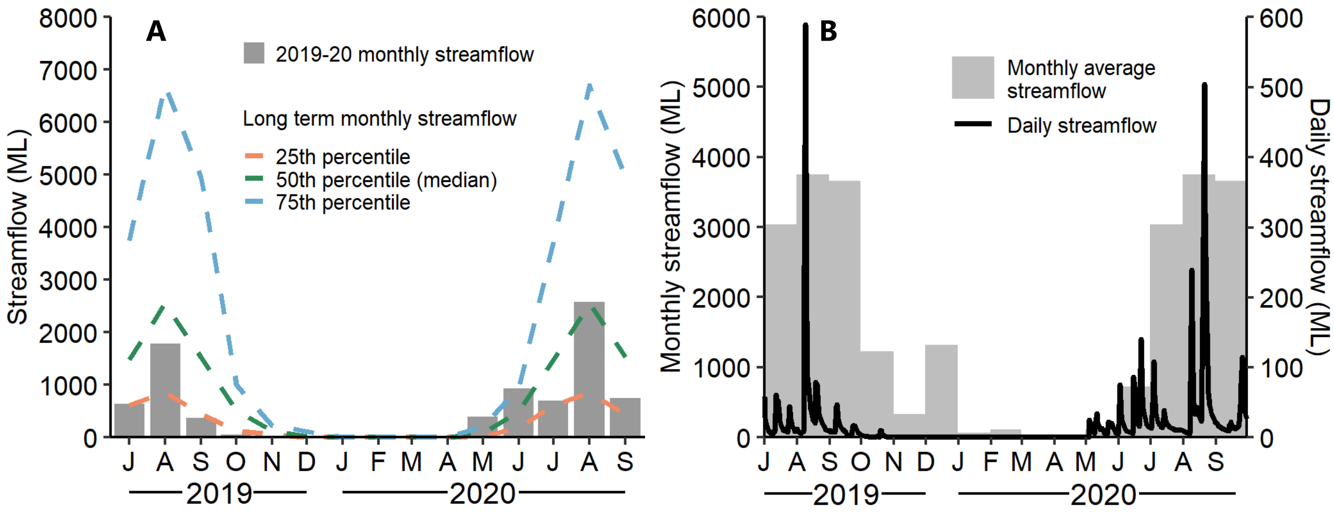

Figure 4.3. (A) Long-term monthly statistics and 2019–20 monthly streamflow on the Bremer River; (B) Long-term average monthly streamflow and 2019–20 daily streamflow on the Bremer River

The deviation of each individual year's streamflow from the long-term average is shown in Figure 4.2. The annual streamflow in the Bremer River was 4143 ML for 2019–20, 12 341 ML (75%) below the average annual streamflow of 16 483 ML (1976–20).

The annual total is ranked as 'below average' assessed for the period 1976–20. Annual streamflow in the Bremer River indicates a long-term declining trend, with 3 of the last 5 years below the average annual streamflow (Figure 4.2). Rainfall data at Mount Barker and Langhorne Creek are showing long-term stable or increasing trends in rainfall but the decreasing trend in streamflow on the Bremer River is likely to be the result of high levels of watercourse extraction.

Figure 4.3A shows the monthly streamflow for 2019–20 (grey bars) relative to the long-term monthly streamflow (1976–20) for (a) low flows (25th percentile), (b) median flows (50th percentile) and high flows (75th percentile). The majority of the months were drier-than-average in 2019–20 and were below the 50th percentile (or median) monthly streamflow. The exceptions were May, June and August 2020 with monthly totals between the 50th and 75th percentiles. No streamflow was recorded between December 2019 and April 2020. Typically, the majority of the streamflow occurs between July and December on the Bremer River and accounts for over 80% of the total annual flow in any given year.

Figure 4.3B presents the long-term average monthly streamflow (1976–20) and the daily flows for 2019–20. Maximum daily flows were recorded in August 2019.

4.1.2 Finniss River (A4260504)

One of the principal long-term streamflow gauging stations for the wetter parts of the PWRA is on the Finniss River and the station has an upstream catchment area of 193 km^2. The Finniss is the highest yielding catchment in the PWRA, and flows from the Eastern Mount Lofty Ranges and eventually into Lake Alexandrina. The station measures flow only from one of the main sub-catchments (Meadows Creek) and not the flow from the entire Finniss catchment.

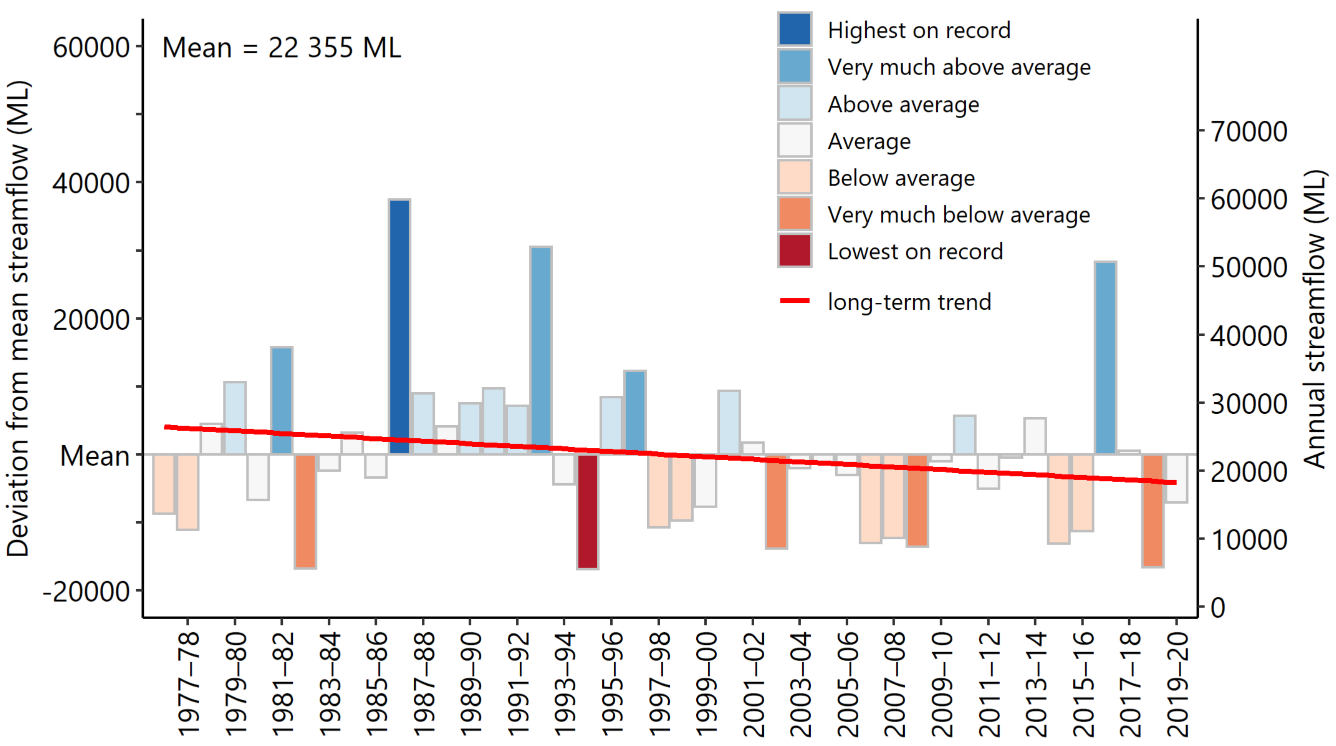

Figure 4.4. Annual deviation from mean streamflow on the Finniss River (1976-77 to 2019–20)

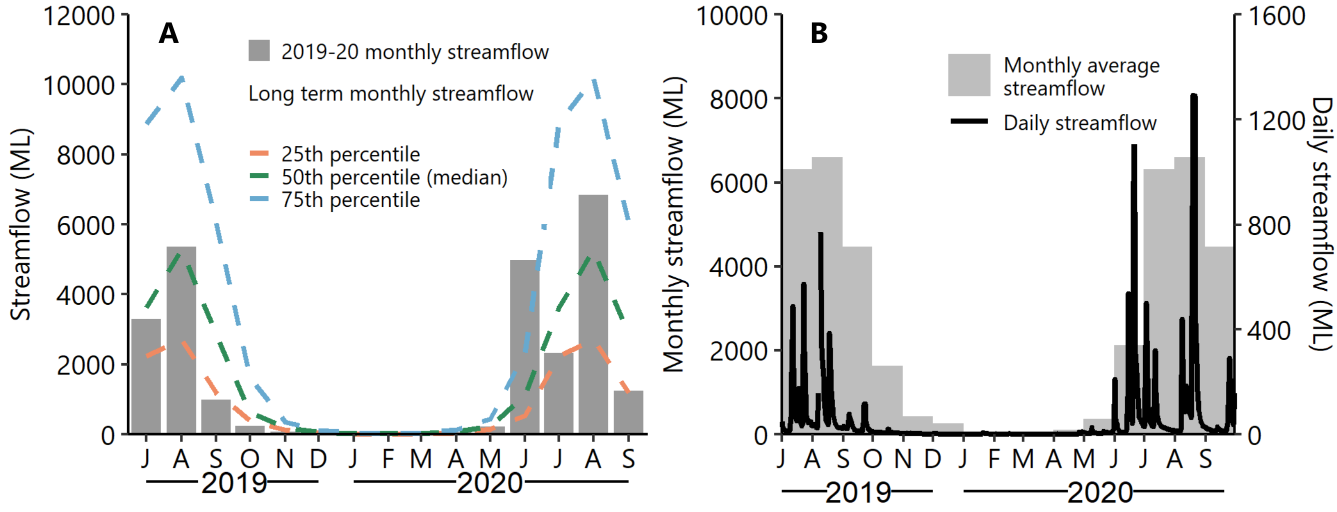

Figure 4.5. (A) Long term monthly statistics and 2019–20 monthly streamflow on the Finniss River; (B) Long term average monthly streamflow and 2019–20 daily streamflow on the Finniss River

The deviation of each individual year's streamflow from the long-term average is shown in Figure 4.4. The annual streamflow in the Finniss River was 15 350 ML in 2019–20, which was 7004 ML below the average annual streamflow of 22 355 ML (1976–20).

The annual total is ranked as 'average' (between 30th and 70th percentile – refer to Table 2.1) assessed for the period 1976–20. Annual streamflow in the Finniss River indicates a long-term declining trend with 4 of the last 6 years below the average annual streamflow (Figure 4.4).

Figure 4.5A shows the monthly streamflow for 2019–20 (grey bars) relative to the long-term monthly streamflow (1976–20) for (a) low flows (25th percentile), (b) median flows (50th percentile) and high flows (75th percentile). Above-average monthly flows were recorded in August 2019, June and August 2020. The remainder of the months were similar to the average monthly flows or were drier-than-average in 2019–20.

Streamflow occurred throughout the year but most was concentrated between July and October 2019 and 2020. Typically, the majority of the flows occur between July and October on the Bremer River and account for almost 85% of the total annual flow in any given year. Flows were below the long-term average monthly streamflow for July and September 2020 but August 2020 was above-average.

Figure 4.5B presents the long-term monthly average streamflow (1976–20) and the daily flows for 2019–20. Maximum daily flows were recorded in August 2020 and there were no zero-flow days experienced in 2019–20.

4.2 Salinity

Below-average summer rainfall can result in increased irrigation extractions. These two elements can cause salinities to increase by reducing the amount of streamflow available to dilute mobilised salts. Conversely, higher rainfall will result in increased surface water availability and decreased irrigation extractions, resulting in a reduction or stabilisation of salinity. In general, the higher rainfall and streamflow catchments in the south (Finniss River and Currency Creek) show lower salinities than the lower rainfall and streamflow catchments in the north (Angas River and Bremer River).

Salinity is recorded routinely in many locations across the PWRA. Two sites are used as representative stations, one in the Bremer River catchment (A4260533) with data available from 1995. The second station is located on the Finniss River (A4261075) with data available from 2004. Figure 4.6 and Figure 4.7 show the long-term monthly salinity statistics for the period of data availability and median monthly values for 2019–20 (red dots) at the two streamflow gauging stations.

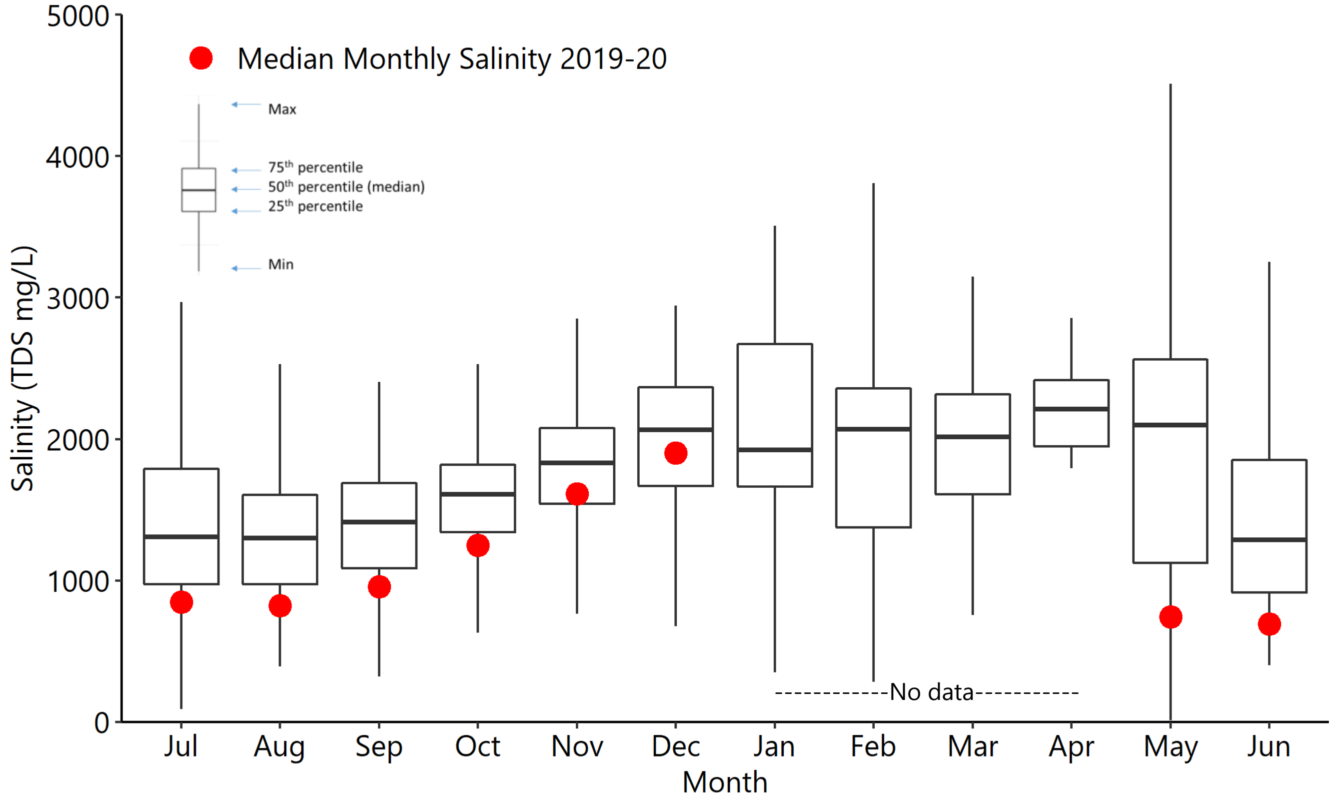

Figure 4.6. Long-term and 2019–20 monthly salinity at the Bremer River streamflow gauging station (A4260533)

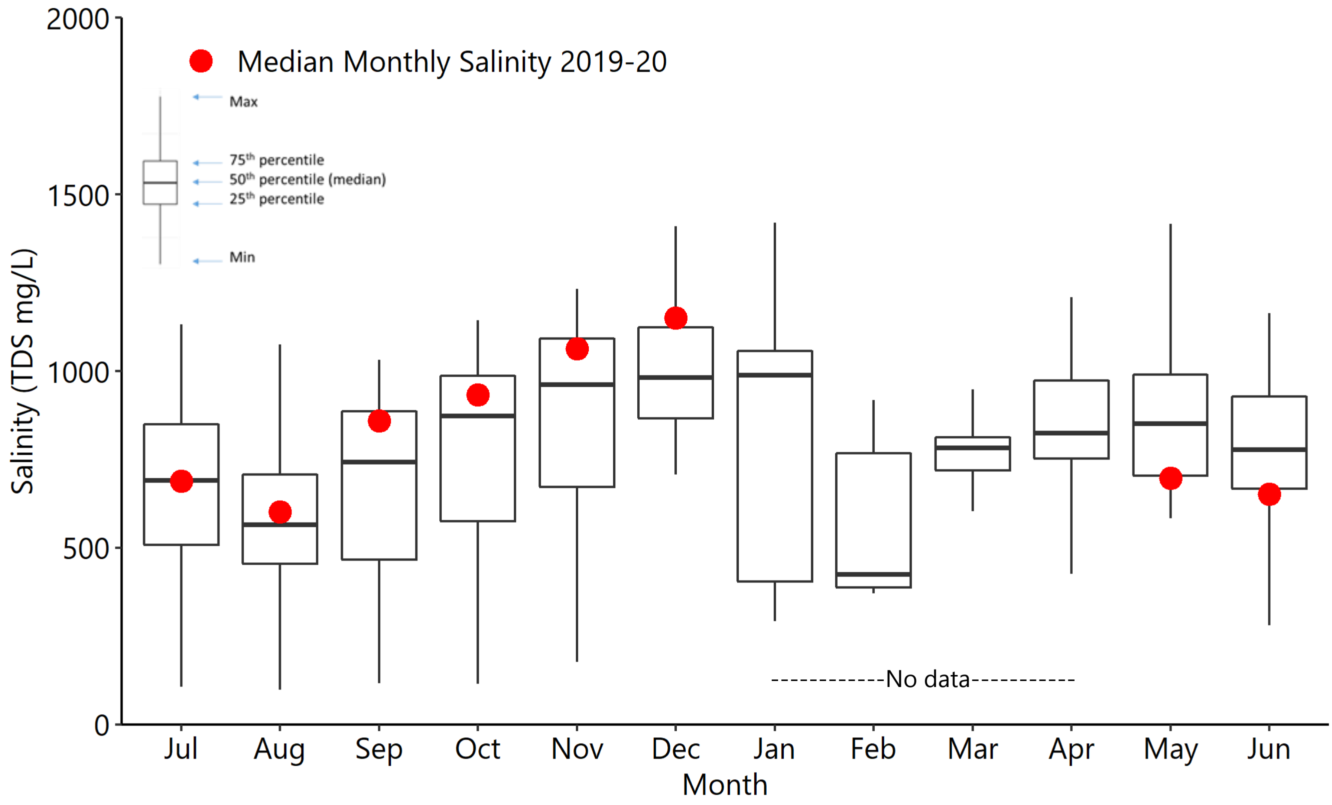

Figure 4.7. Long-term and 2019–20 monthly salinity at the Finniss River streamflow gauging station (A4261075)

The median long-term salinity observed is 1618 mg/L for the Bremer River and 790 mg/L for the Finniss River. The long-term monthly data for both the Bremer River and Finniss River indicate a high variability in salinity than other catchments, which is indicated by the greater range between the minimum and maximum values. The median monthly salinity values for 2019–20 can also be seen in Figure 4.6 and Figure 4.7 (red dots).

The highest salinity recorded in the Bremer River and Finniss River in 2019–20 was 1923 mg/L and 1199 mg/L respectively. No salinity data was recorded between January and April 2019 due to insufficient streamflow recorded at both sites. The remainder of the months experienced salinity levels within the historical ranges recorded each month.

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 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 (2002-09) 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 Water Allocation Plan for the EMLR PWRA (SAMDB NRM Board, 2013) (Figure 1.1).

5.2 Fractured rock aquifers - water level

During 2019–20, the majority (58%) of fractured rock aquifer monitoring wells showed recovered water levels that are classified as 'Average' (Section 2.3.1) (Figure 5.1). The majority of these wells are located toward the western extent of PWRA where most groundwater extraction occurs. Water levels for two monitoring wells were 'Lowest on record'. Over the past 20 years, the change in water level in 23 wells ranged from a decline of 9.30 m to a rise of 1.11 m (median change is a decline of 0.29 m).

Five-year trends in water levels show declining trends for the majority of wells (92%) ranging from 0.01 m/y to 2.32 m/y with a median decline of 0.24 m/y (Figure 5.2).

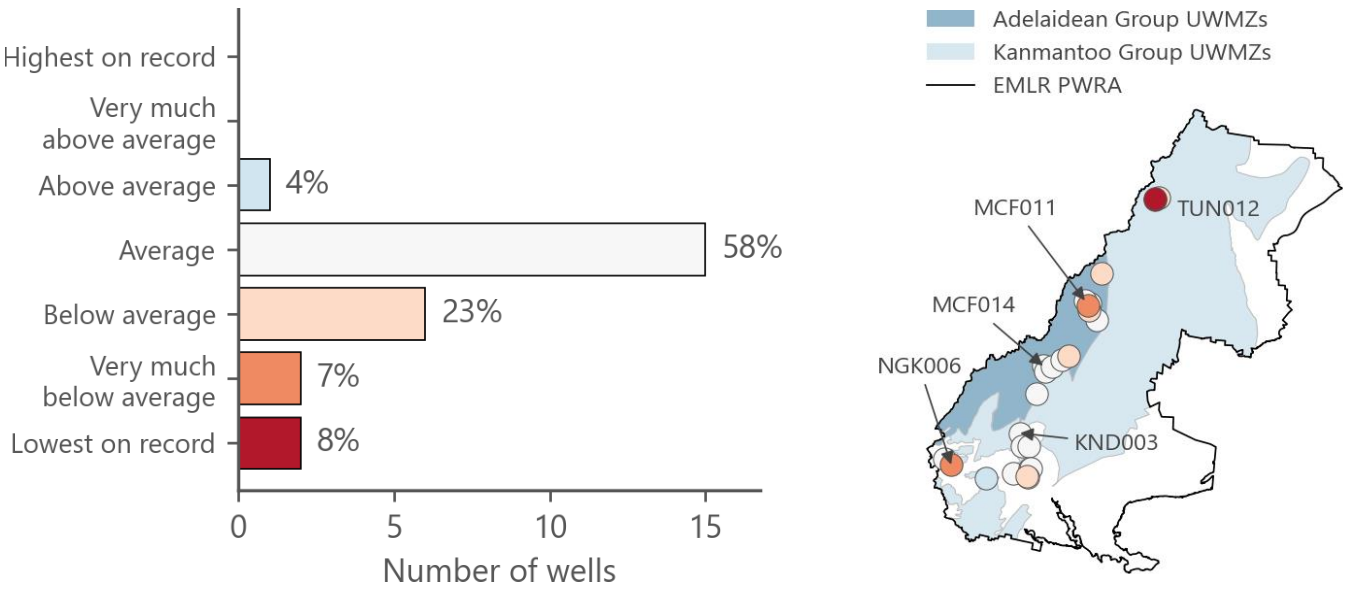

Figure 5.1. 2020 recovered water levels for wells in the fractured rock aquifers

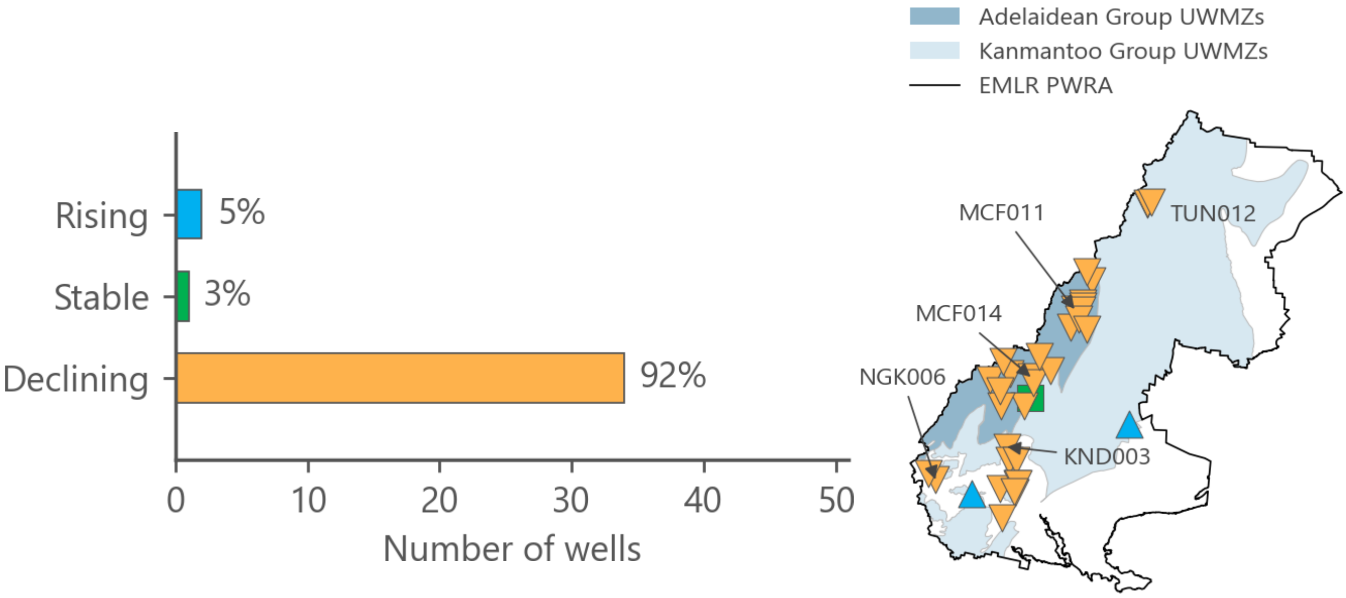

Figure 5.2. 2020 recovered water levels for wells in the fractured rock aquifers

FRA levels across the PWRA show seasonal fluctuations, although from 1990 to 2014, levels after winter recovery are generally stable (Figure 5.3).

Monitoring well MCF011 is located in Mount Barker. The range of fluctuations in groundwater levels here have reduced since 2002, which is likely due to a decrease in irrigation caused by the urban expansion of Mount Barker (DEWNR, 2014). Recovered water levels have remained generally stable over the past 30 years; the 2020 water level is classified as 'Average'.

Groundwater levels at the dryland salinity monitoring site TUN012, which is located on superficial Quaternary sediments overlying the fractured rock aquifer in Kanmantoo Group rocks, south of Tungkillo, have been declining for the past three years, continuing a slow decline of 1.9 m since 1990. Further south, the monitoring well KND003 is completed in Kanmantoo Group siltstones and shows relatively stable levels since the late 1990s.

MCF014 is located between Meadows and Macclesfield. The groundwater level was declining prior to 2010 but has since recovered and reached 'Highest on record' following above-average rainfall in 2016. The groundwater level has since declined and in 2020 is classified 'Average' (Section 2.3.1).

Figure 5.3. Selected fractured rock aquifer hydrographs

5.3 Fractured rock aquifers - salinity

Groundwater salinity is often highly variable in fractured rock aquifers and is influenced by the type of rock in which fractures occur. Since 2015, irrigators in the EMLR PWRA have submitted groundwater samples to DEW. In 2020, results from 204 irrigation wells in the fractured rock aquifers ranged between 169 mg/L and 14271 mg/L with a median of 1471 mg/L (Figure 5.4).

In the five years to 2020, the majority of wells (75%) recorded a decrease in salinity levels (Section 2.3.2). Trends in salinity over the five year period varies from a decrease of 10.93% per year to an increase of 4.69% per year, with a median rate of 0.77% decrease per year (Figure 5.5).

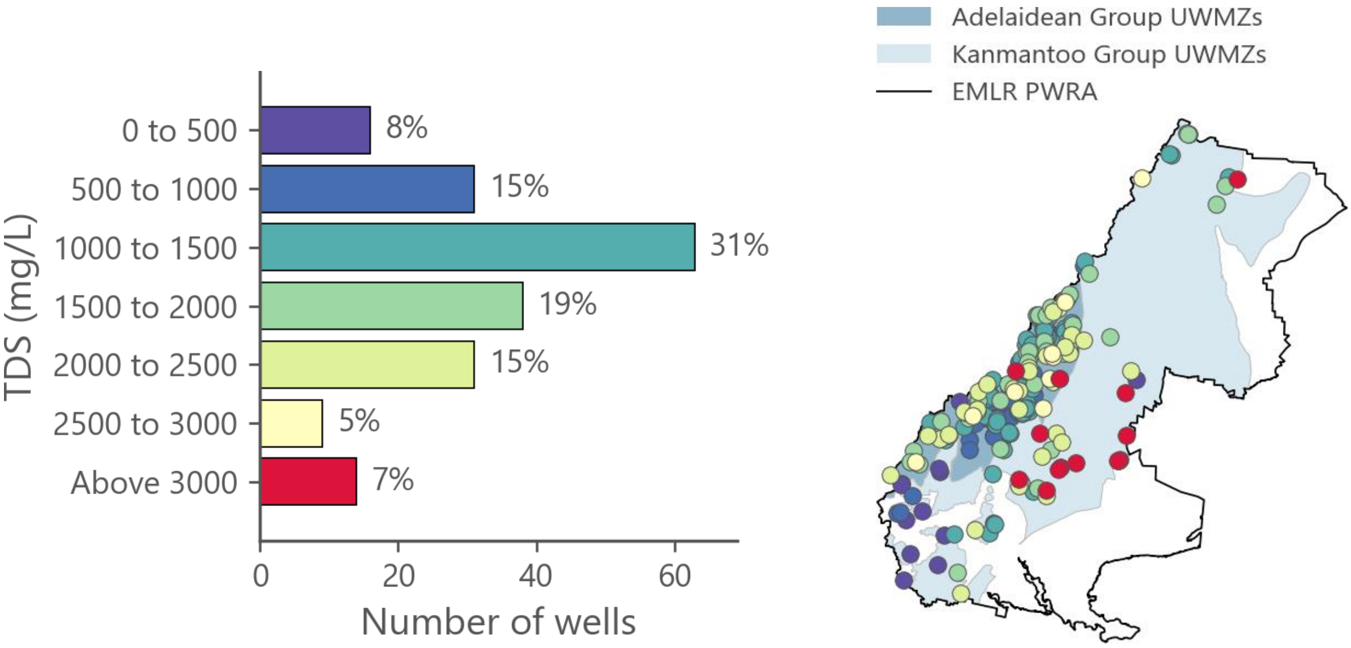

Figure 5.4. 2020 salinity observations from wells in the fractured rock aquifers

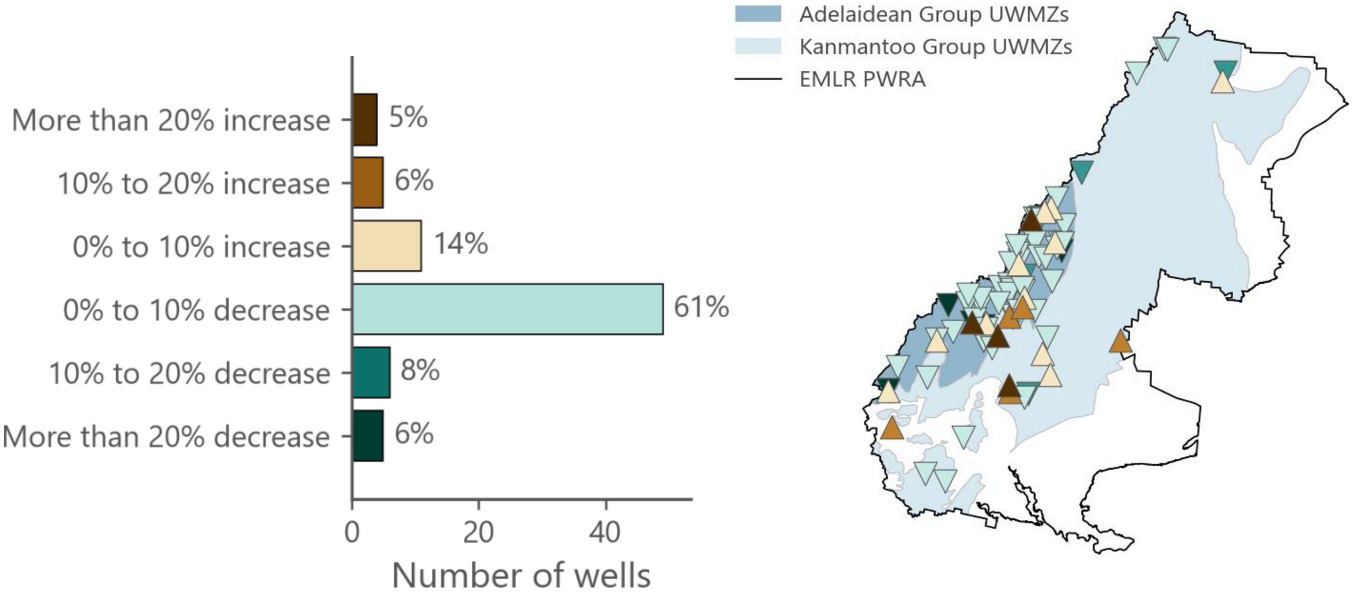

Figure 5.5. Salinity trend in the five years to 2020 for wells in the fractured rock aquifers

5.4 Permian Sand aquifer

5.4.1 Finniss Permian 1 UWMZ - water level

During 2019–20, recovered water levels observed in the majority (85%) of Permian Sand monitoring wells in the Finniss Permian 1 UWMZ were classified 'Average' when compared to their historical records (Section 2.3.1) (Figure 5.6). The change in water level over the past 20 years in 15 wells ranged from a decline of 1.09 m to a rise of 0.32 m (median change is a decline of 0.48 m). The majority of wells (80%) show declining water levels over this period.

Five-year trends in water levels show declining water levels for 60% of wells, ranging between 0.03–0.33 m/y, with a median of 0.24 m/y (Figure 5.7).

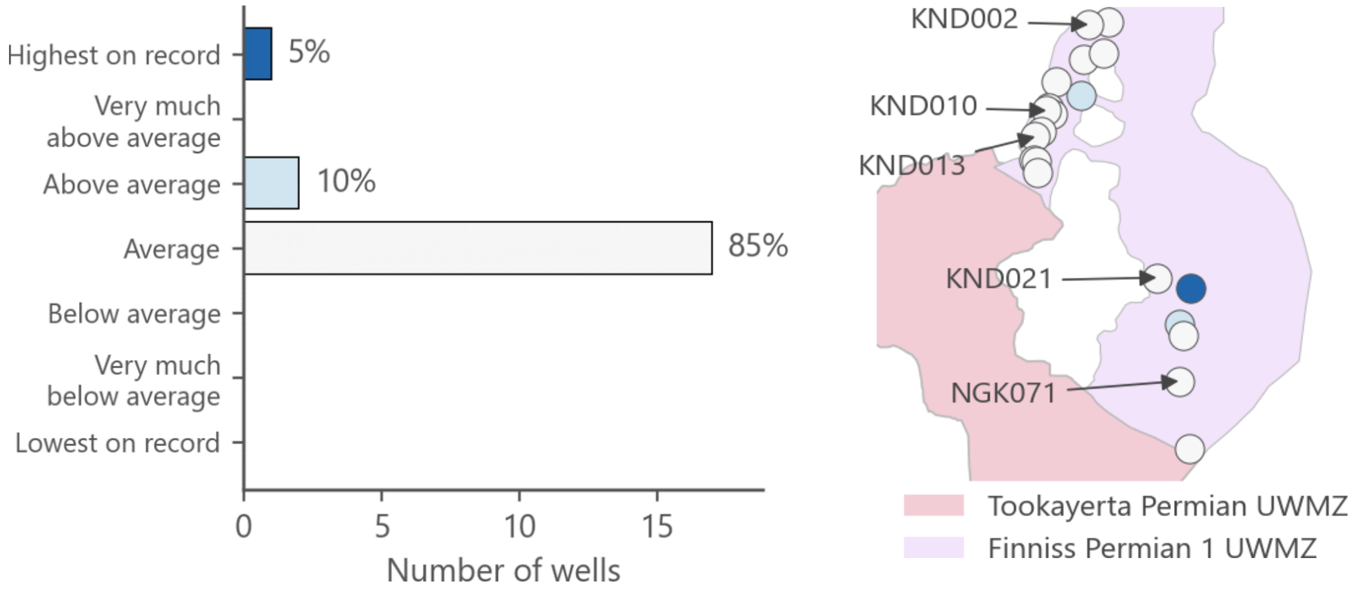

Figure 5.6. 2020 recovered water levels for wells in the Finniss Permian 1 UWMZ

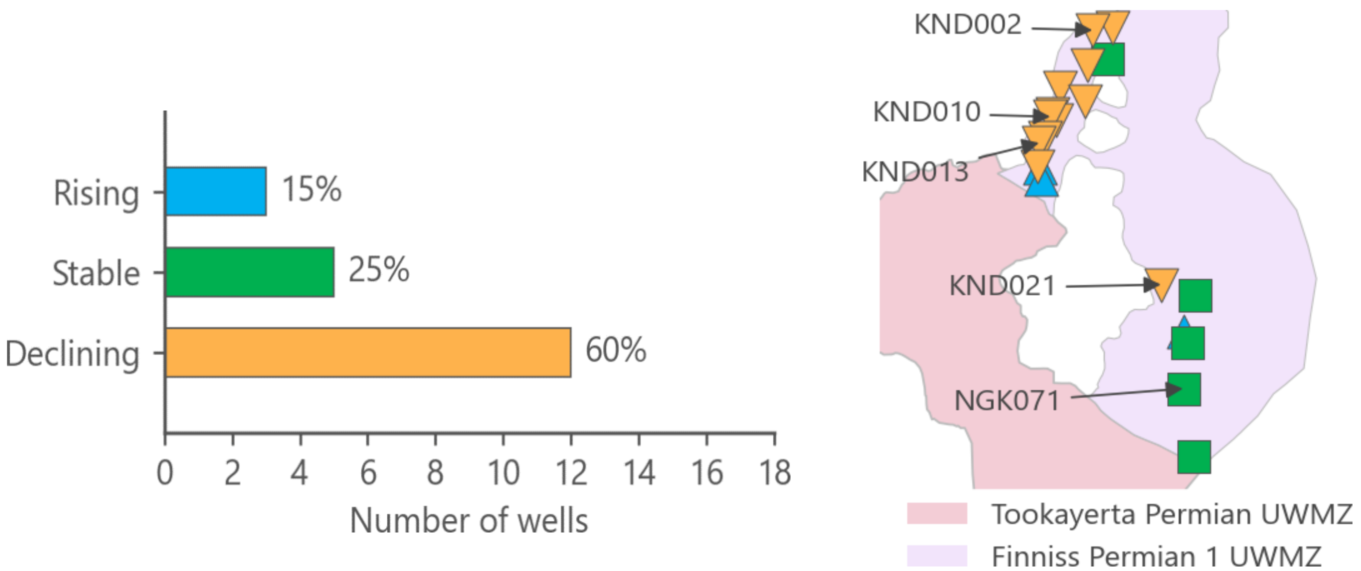

Figure 5.7. 2016–20 trend in recovered water levels for wells in the Finniss Permian 1 UWMZ

Monitoring wells KND002, KND010 and KND013 are located in the northern parts 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 showed their lowest levels on record during the Millennium drought (2004–09) (Figure 5.8). Despite seasonal fluctuations due to pumping and winter-dominant rainfall, recovered groundwater levels in this area are relatively stable over the past 25 years; current levels are ranked 'Average' (Section 2.3.1) when compared to their respective historical record.

Monitoring wells KND021 and NGK071 are located on the lower parts of the Finniss River catchment where groundwater monitoring started in 2005. Groundwater levels for both these wells are stable with minor seasonal fluctuations. In 2020, groundwater levels for both these wells are ranked 'Average' when compared to their respective historical record.

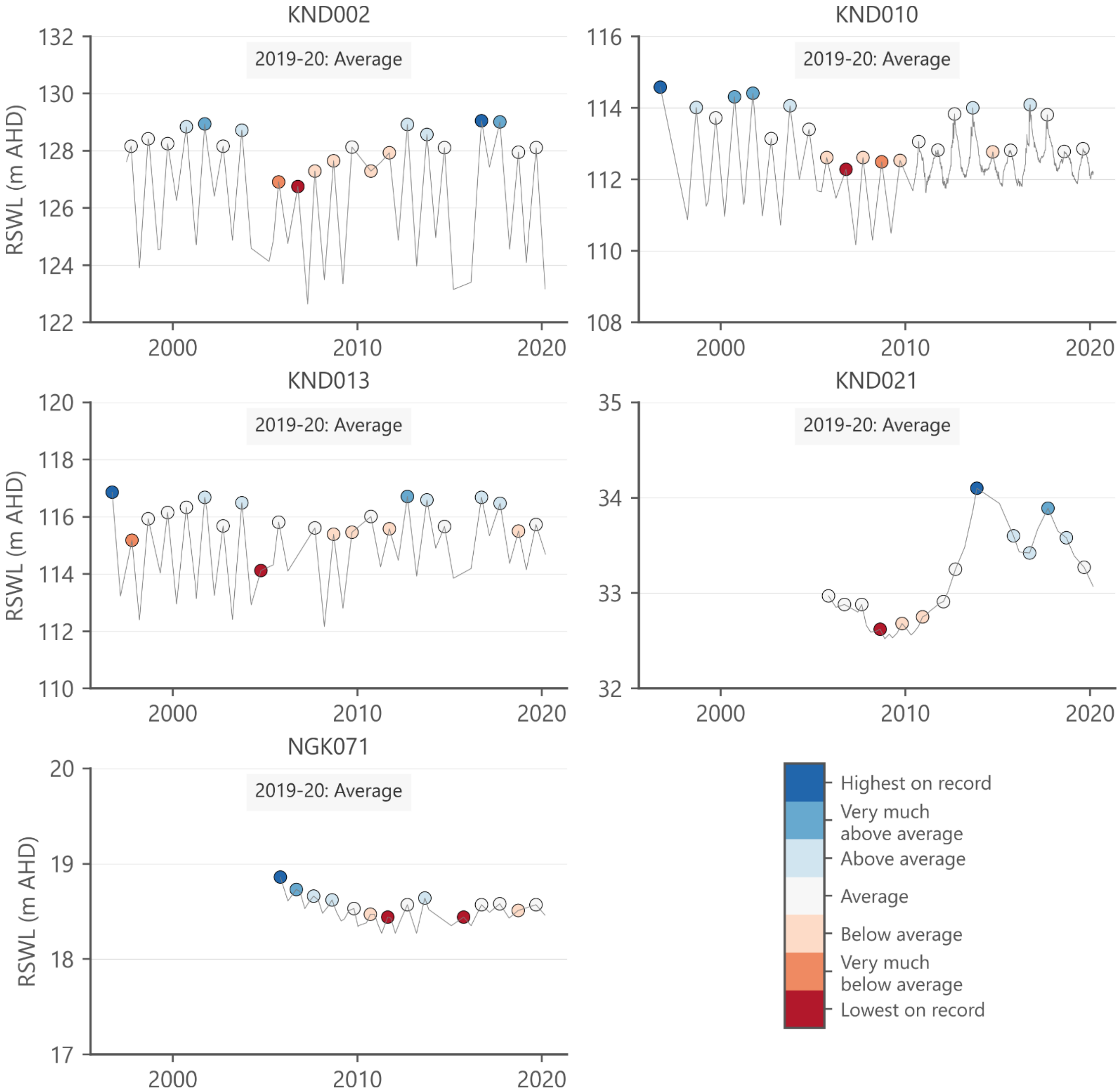

Figure 5.8. Selected hydrographs for the Permian Sand aquifer in the Finniss Permian 1 UWMZ

5.4.2 Tookayerta Permian UWMZ - water level

During 2019–20, recovered water levels in 60% of Permian Sand monitoring wells in the Tookayerta Permian UWMZ are classified 'Below average' to 'Lowest on record' when compared to their respective historical record (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 two wells, recovered water levels are classified 'Lowest on record'. In contrast, 40% of wells showed recovered water levels that are 'Average' to 'Very much above average'. Changes in water levels in fourteen wells illustrate this variability, where changes over the past 20 years range from a decline of 3.40 m to a rise of 2.45 m (median change is a decline of 0.89 m).

Five-year trends in water levels show declining levels for the majority of wells (78%), ranging from 0.03 m/y to 0.48 m/y with a median of 0.15 m/y (Figure 5.10).

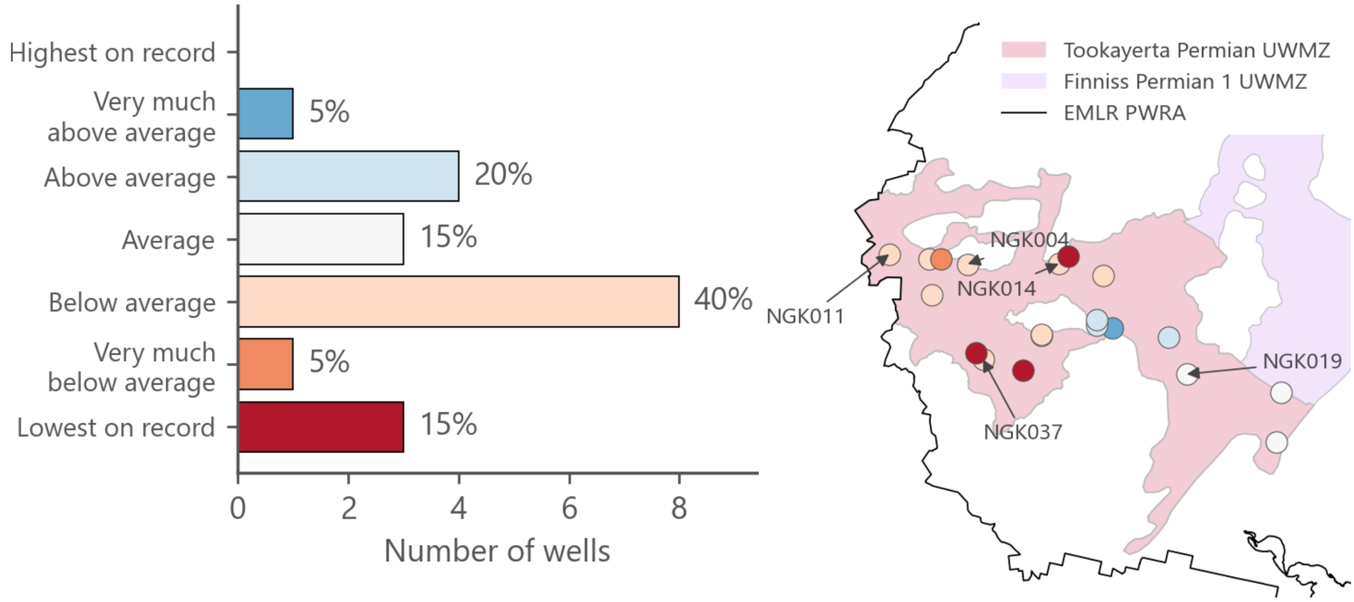

Figure 5.9. 2020 recovered water levels for wells in the Permian Sand aquifer, within the Tookayerta Permian UWMZ

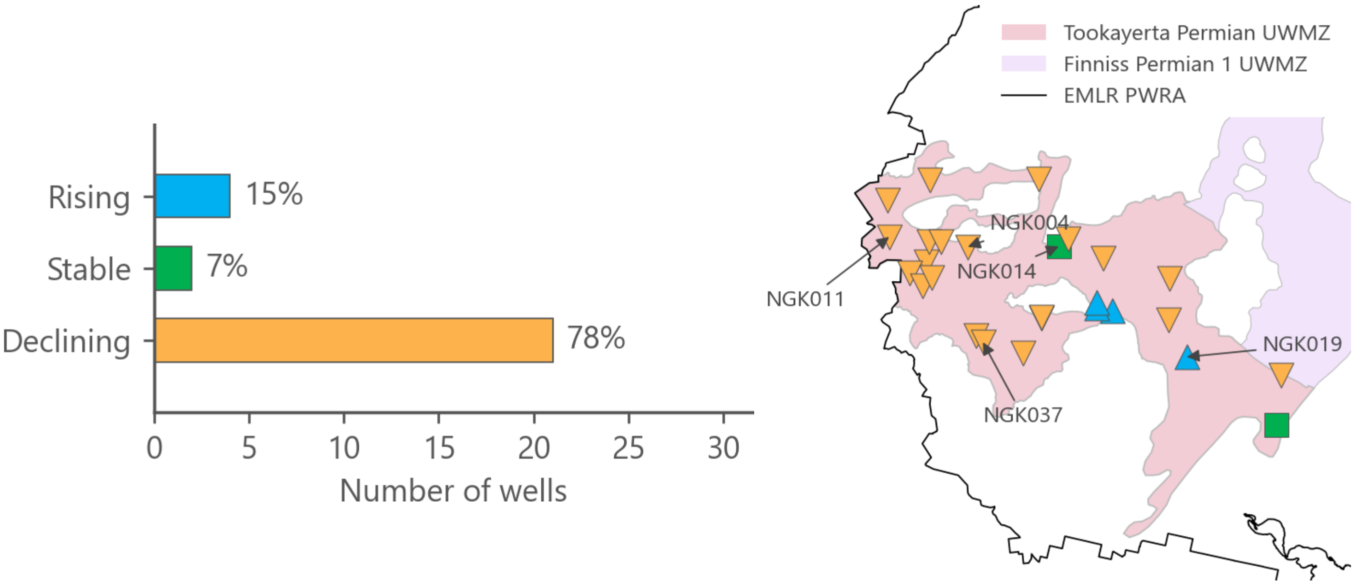

Figure 5.10. 2016–20 trend in recovered water levels for wells in the Permian Sand aquifer, within the Tookayerta Permian UWMZ

Monitoring wells NGK011, NGK004 and NKG014 are located in the vicinity of Mount Compass (Figures 1.1 and 5.9). All three wells show a gradual declining trend since monitoring started (Figure 5.11). Monitoring wells NGK011 and NGK004 show seasonal fluctuation, but this signal is absent from NGK014, which is located around 5 km east of Mount Compass. Current levels in these wells are ranked 'Below average' compared to their respective historical record.

Monitoring well NGK037 is located 4 km southeast of Mount Compass and shows relatively stable groundwater levels since monitoring started in 2003. Monitoring well NGK019 is located in the south-eastern part of the UWMZ, where metered groundwater extraction is low. NGK019 shows a declining trend since monitoring started in the late-1990s until the end of the Millennium drought in 2009 but, in the past 10 years, groundwater levels have recovered. In 2020, the groundwater level was classified as 'Average'.

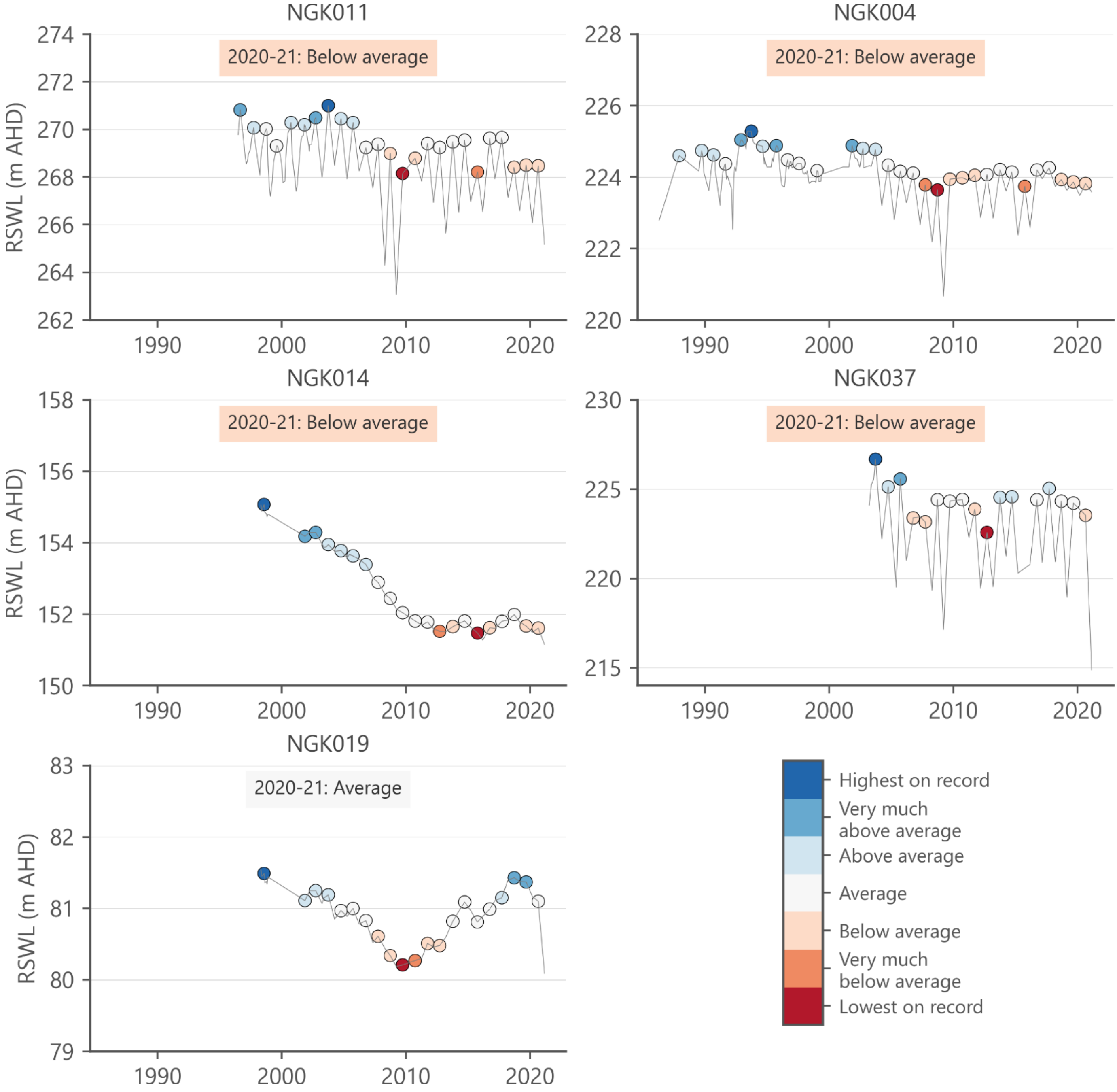

Figure 5.11. Selected hydrographs for the Permian Sand aquifer, Tookayerta Permian UWMZ

5.4.3 Finniss Permian 1 and Tookayerta UWMZs – salinity

The salinity of wells completed in the Permian Sand aquifer within the Finniss Permian 1 and Tookayerta Permian UWMZs is very low, with most irrigation showing salinity less than 750 mg/L. Since 2015, irrigators in the EMLR PWRA have submitted groundwater samples that DEW has analysed for salinity concentration. In 2020, salinity results from 112 irrigation wells in the Permian Sand aquifer ranged between 69 mg/L and 8858 mg/L with a median of 216 mg/L (Figure 5.12).

In the five years to 2020, the majority of wells (66%) show a decrease in salinity (Section 2.3.2). Trends in salinity over this period vary from a decrease of 20.92% per year to an increase of 16.98% per year, with the median rate of 0.60% decrease per year (Figure 5.13).

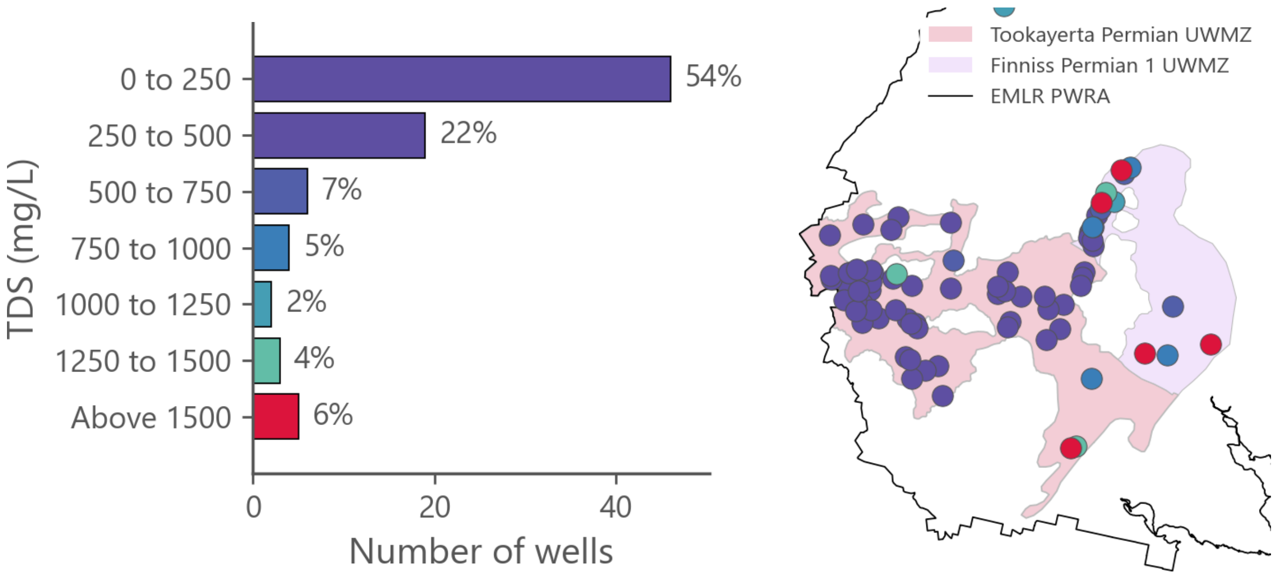

Figure 5.12. 2020 salinity observations in the Permian Sand aquifer

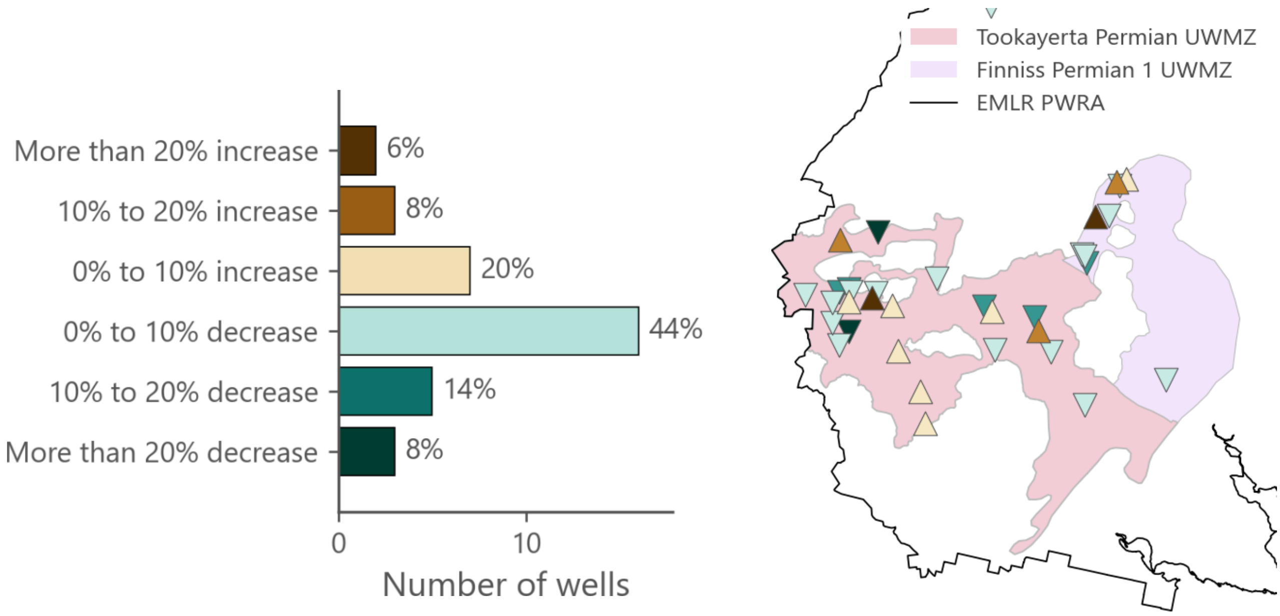

Figure 5.13. Salinity trend in the five years to 2020 for wells in the Permian Sand aquifer

5.5 Murray Group Limestone aquifer

5.5.1 Currency Limestone UWMZ - water level

During 2019–20, the winter-recovered water level in all monitoring wells was classified as 'Average' to 'Very much above average' (Section 2.3.1) compared to their historical record (including the Millennium drought) (Figure 5.14). In six wells, the change in water level over the past 20 years ranges from a decline of 2.17 m to a rise of 0.03 m; the median is a rise of 0.22 m.

Five-year trends show declining water levels for 46% of wells; 31% of wells are rising. Rates of decline range from 0.02 m/y to 0.07 m/y (median 0.04 m/y), while rates of rise range from 0.03 m/y to 0.11 m/y (median 0.09 m/y; Figure 5.15).

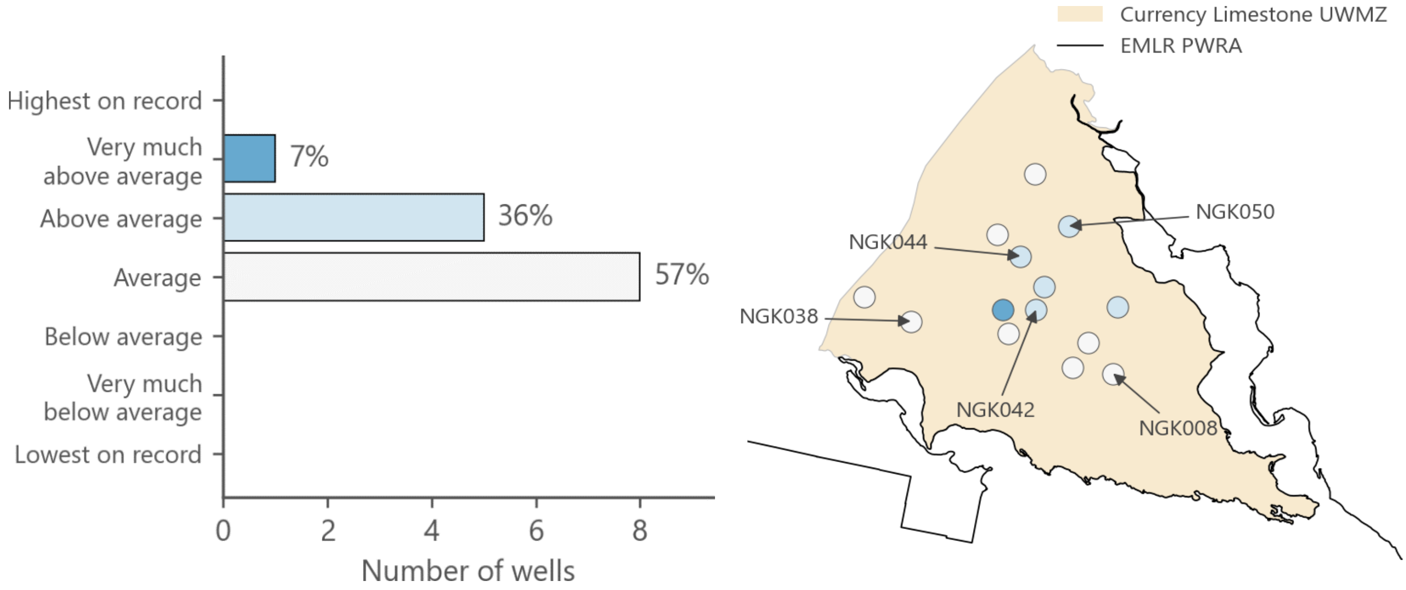

Figure 5.14. 2020 recovered water levels for wells in the Murray Group Limestone aquifer

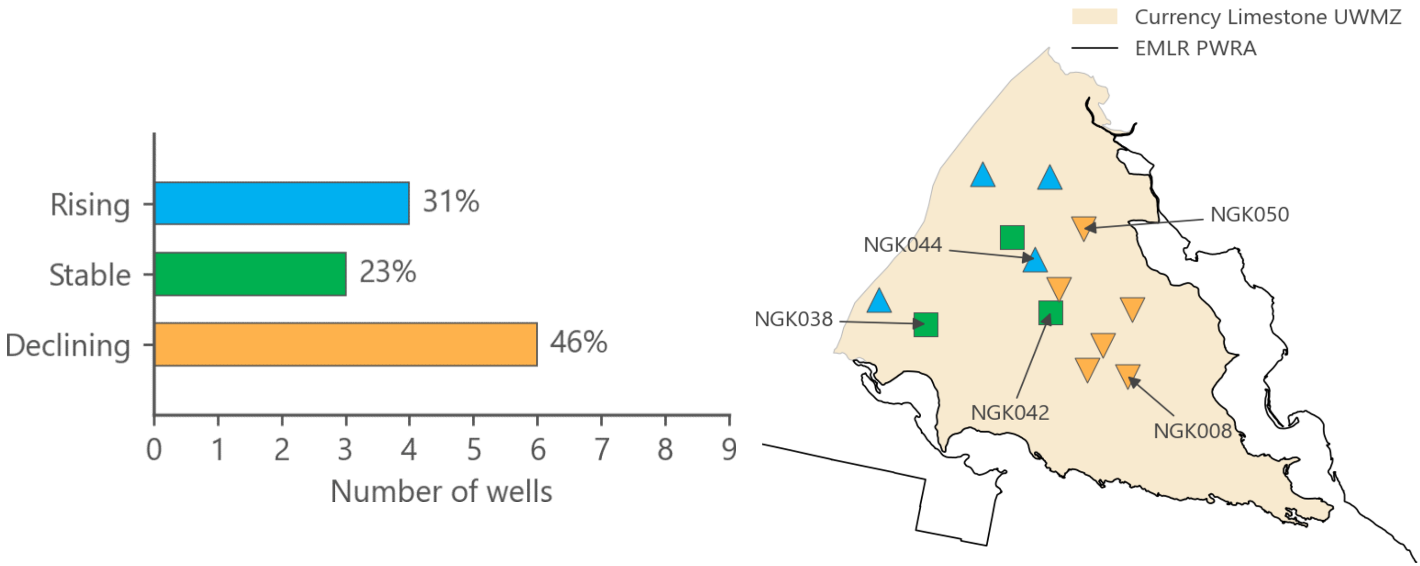

Figure 5.15. 2016–20 trend in recovered water levels for wells in the Murray Group Limestone aquifer

All Murray Group Limestone monitoring wells in the Currency Limestone UWMZ are generally showing consistent declines from the mid-2000s to 2010 (Figure 5.16). Since 2010, groundwater levels have been gradually recovering to pre-drought levels with some monitoring wells classified 'Above average' (e.g. NGK044). However, the length of the monitoring record is short, mainly beginning 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.

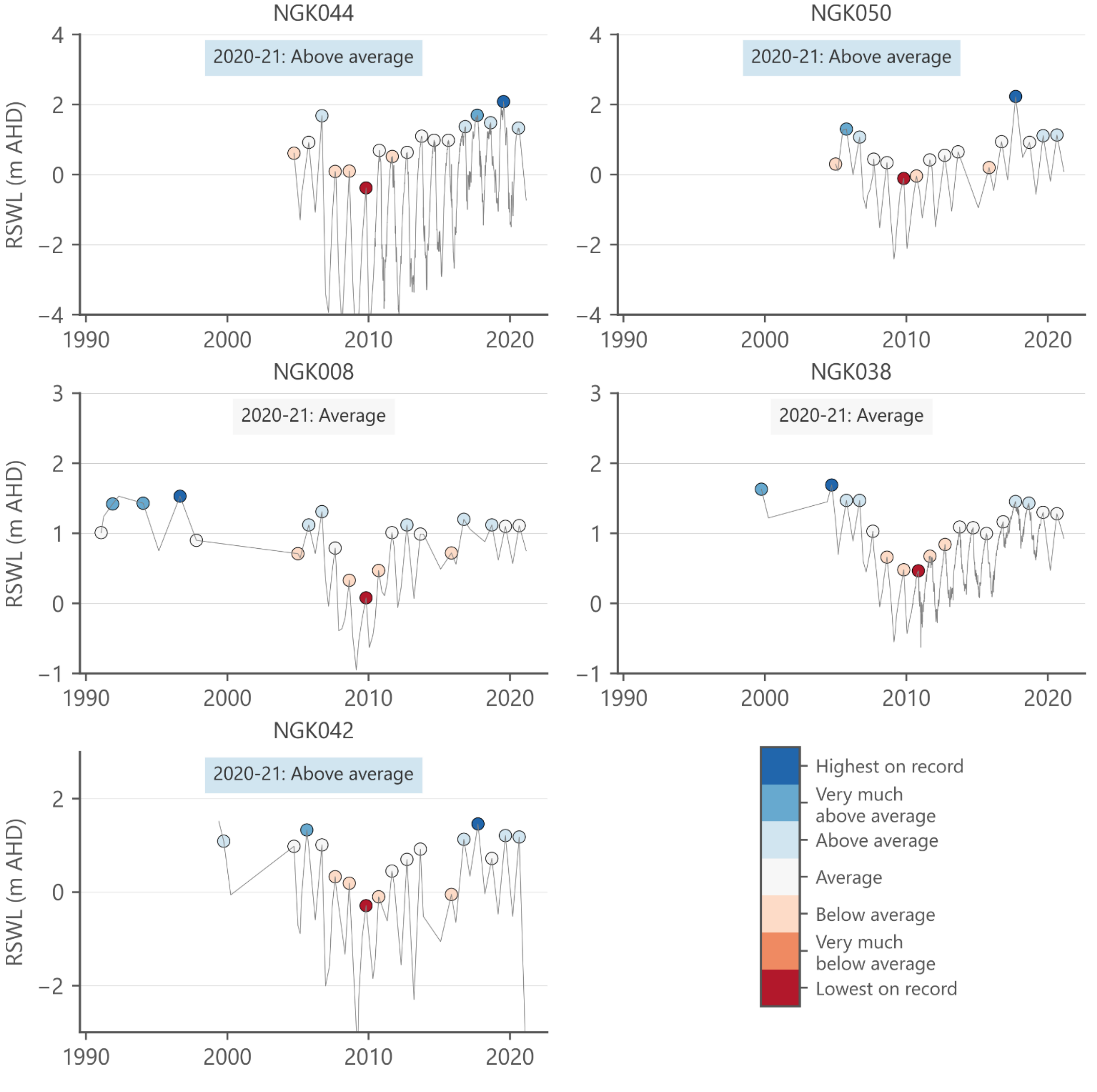

Figure 5.16. Selected hydrographs for wells in the Murray Group Limestone aquifer

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 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 is high. Salinity in the Currency Limestone UWMZ has been monitored since 2015 using water samples which have been submitted by irrigators. In 2020, salinity from 20 irrigation wells ranged between 428–4367 mg/L (median 1423 mg/L; Figure 5.17).

In the 15 years to 2020, the majority of wells (82%) show an increase in salinity levels (Section 2.3.2). Trends in salinity over this period vary from a decrease of 2.25% per year to an increase of 5.21% per year, with a median rate of 0.10% decrease per year (Figure 5.18).

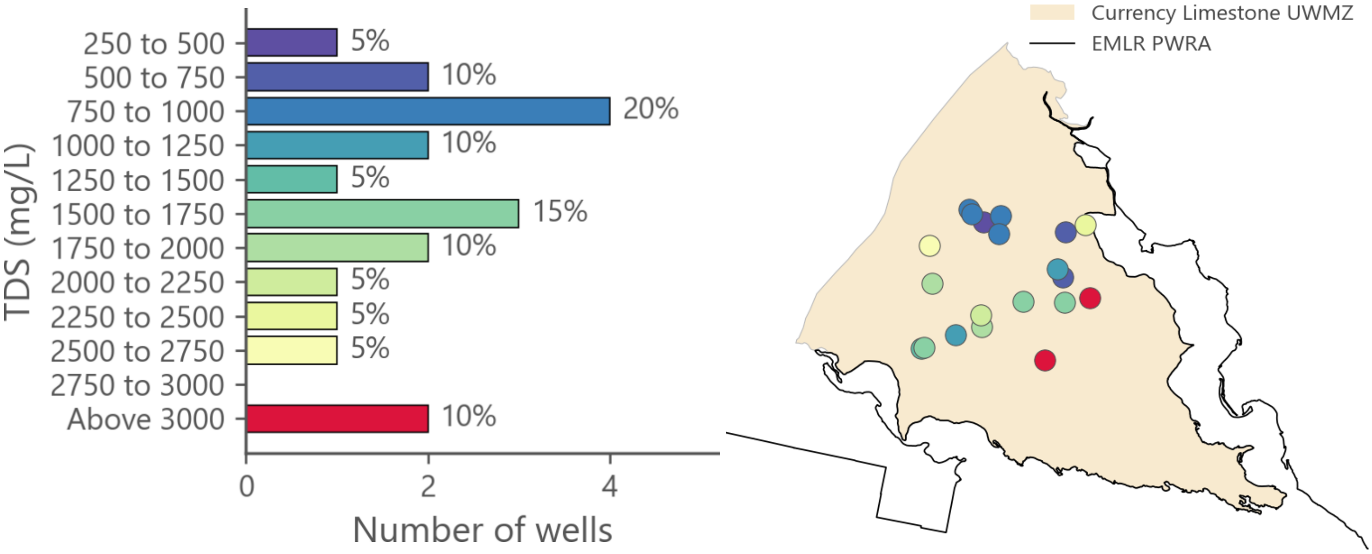

Figure 5.17. 2020 salinity observations from Murray Group Limestone aquifer wells in the Currency Limestone UWMZ

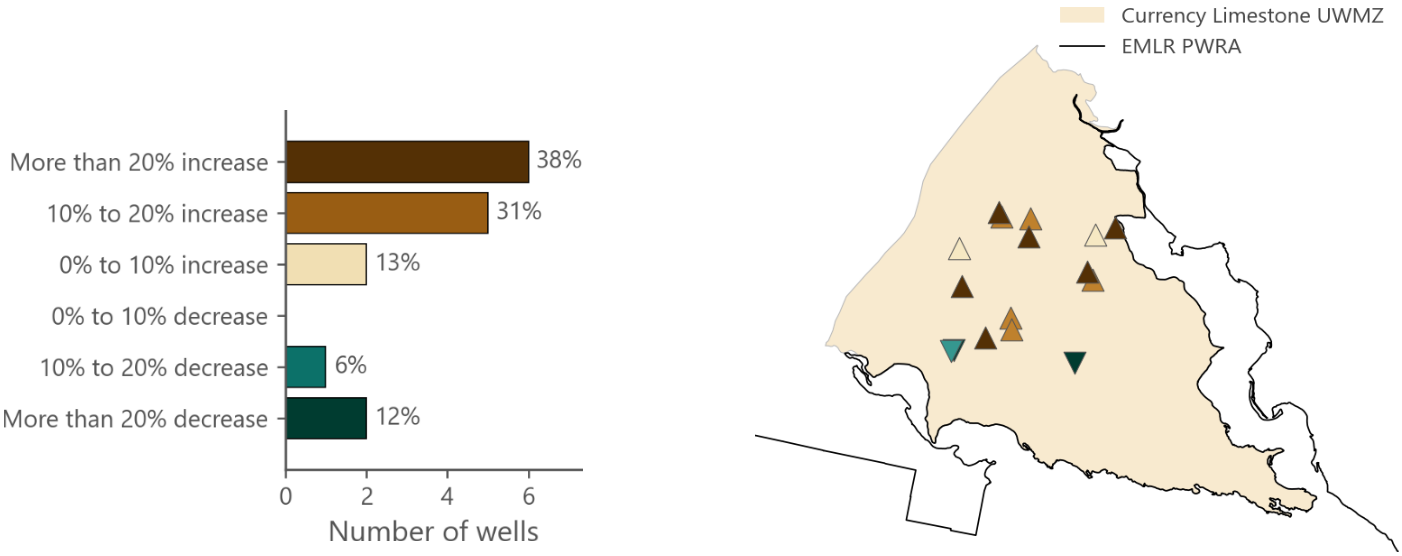

Figure 5.18. Salinity trend in the 15 years to 2020 for wells in the Murray Group Limestone wells in the Currency Limestone UWMZ

5.5.3 Angas Bremer PWA - water level

During 2019–20, the winter-recovered water level in the majority of monitoring wells (97%) are classified 'Average' or greater compared to their respective historical record (Figure 5.19). The change in water level in Murray Group Limestone aquifer wells over the past 20 years (Section 2.3.1) ranged from a decline of 01.40 m to a rise of 3.86 m (the median change is a rise of 0.28 m).

Five-year trends in water levels show declining levels for 67% of wells; 24% of wells are rising (Figure 5.20). Rates of declining water levels range from 0.03 m/y to 0.73 m/y (median 0.20 m/y), while rates of rise range from 0.02 m/y to 0.45 m/y (median 0.11 m/y).

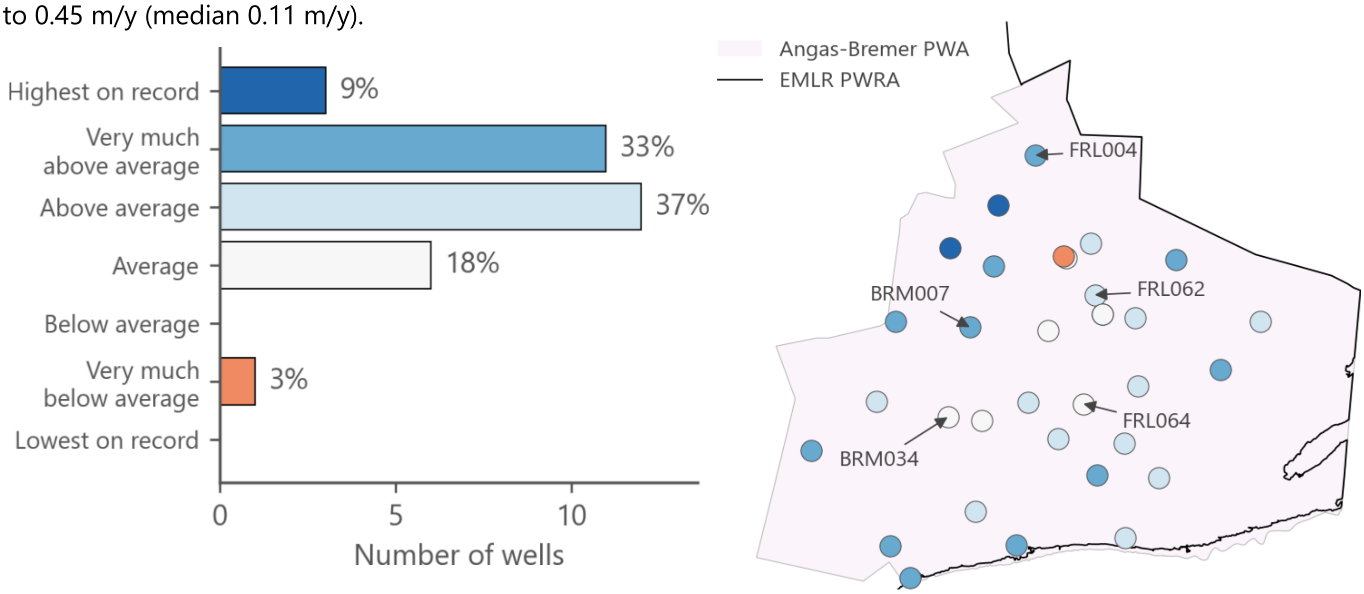

Figure 5.19. 2020 recovered water levels for the Murray Group Limestone aquifer of the Angas Bremer PWA

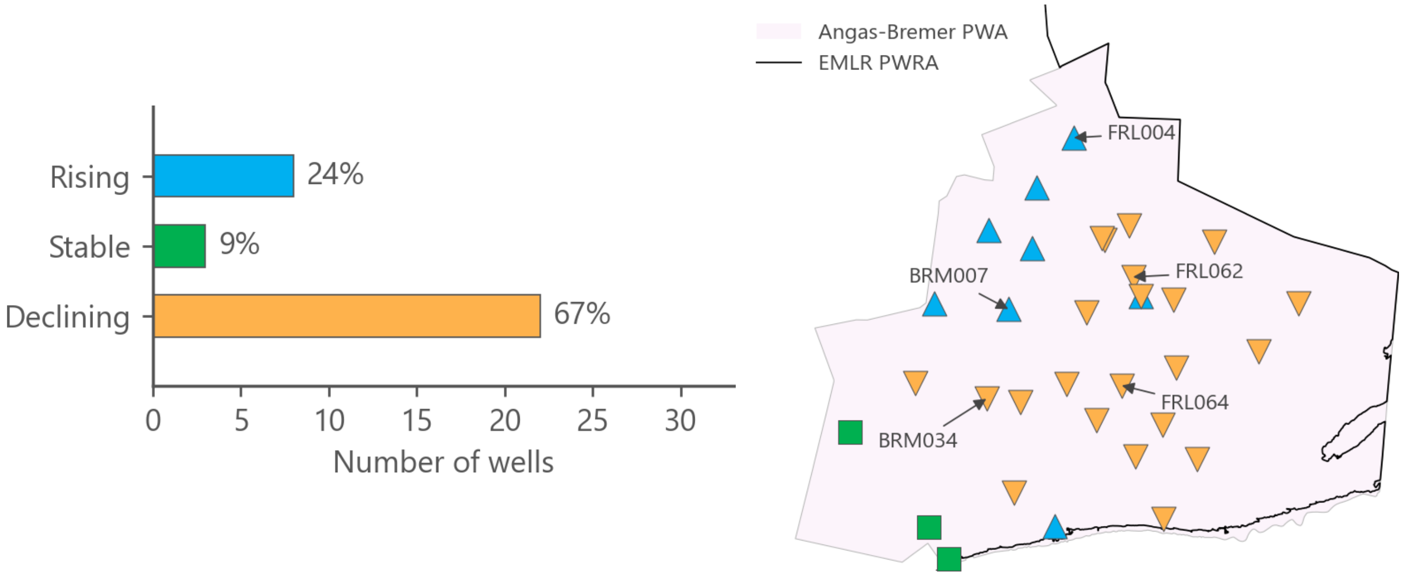

Figure 5.20. 2016–20 trend in recovered water levels for wells in the Murray Group Limestone aquifer of the Angas Bremer PWA

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 decreasing trends in water levels throughout the PWA, prior to the significant reduction in groundwater extraction in the early 1990s.

The reduction in groundwater extraction was in response to the increased availability of River Murray allocations sourced via Lake Alexandrina that led to a substantial recovery in groundwater levels, which continued until the Millennium drought. Groundwater extractions 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 water mix and aided in the recent recovery in water levels.

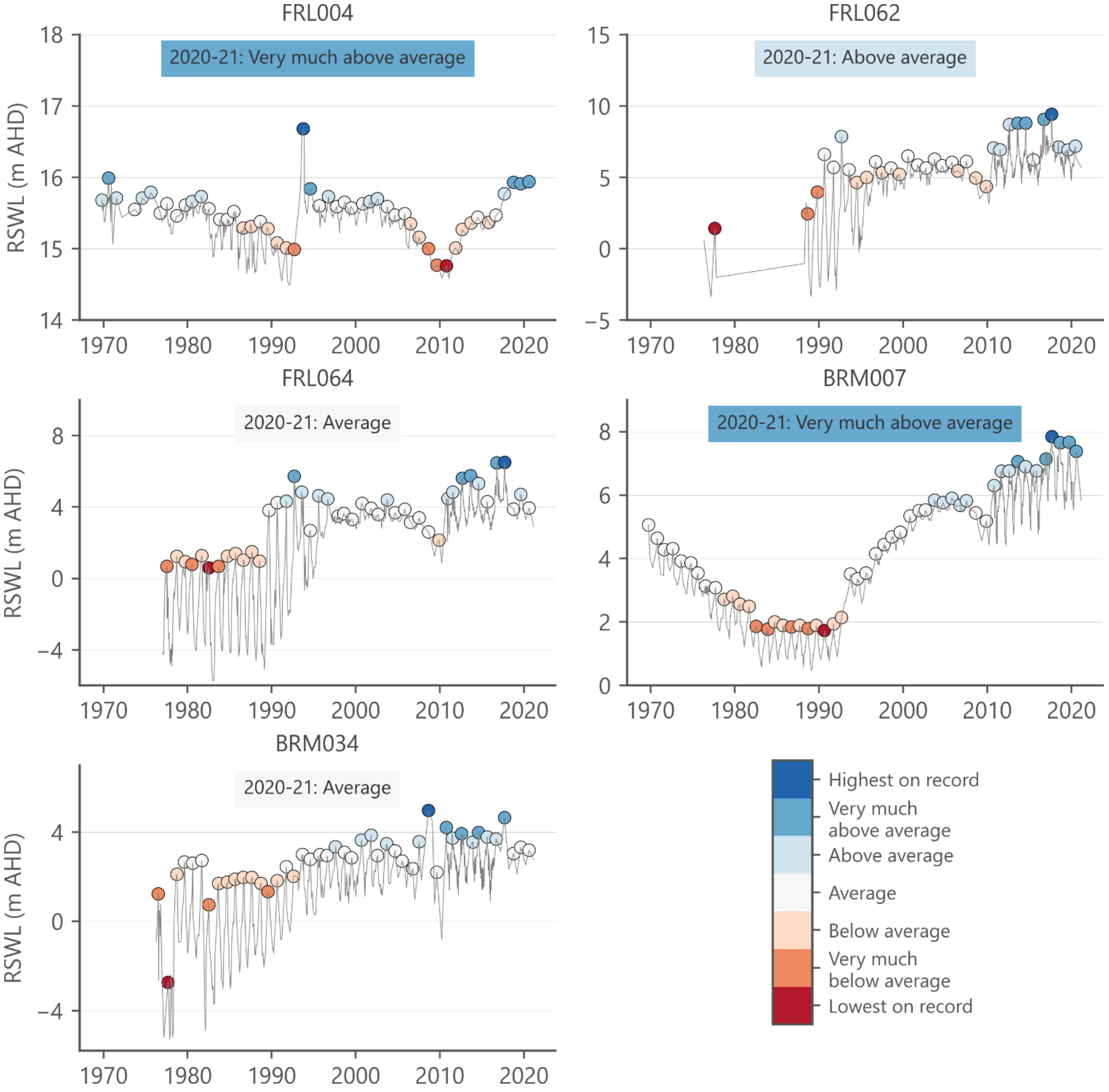

Figure 5.21. Selected hydrographs for Murray Group Limestone aquifer wells in the Angas Bremer PWA

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 2020, salinity results from 36 irrigation wells (Section 2.3.2) ranged between 194–5569 mg/L (median 1945 mg/L; 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 2020, the majority of monitoring wells (70%) recorded an increase in groundwater salinity. The salinity trends over the ten-year period varies from a decrease of 6.79% per year to an increase of 11.21% per year, with a median rate of 0.90% increase per year (Figure 5.23). Increases in groundwater salinities are due to extensive MAR operations in the beginning of the ten-year period in 2010-11 (see Figure 6.3), which resulted in artificial freshening of groundwater in many irrigation bores. Conversely, wells with considerable decreases in salinity may have been impacted by fresher MAR water in the final years of the ten-year trend period.

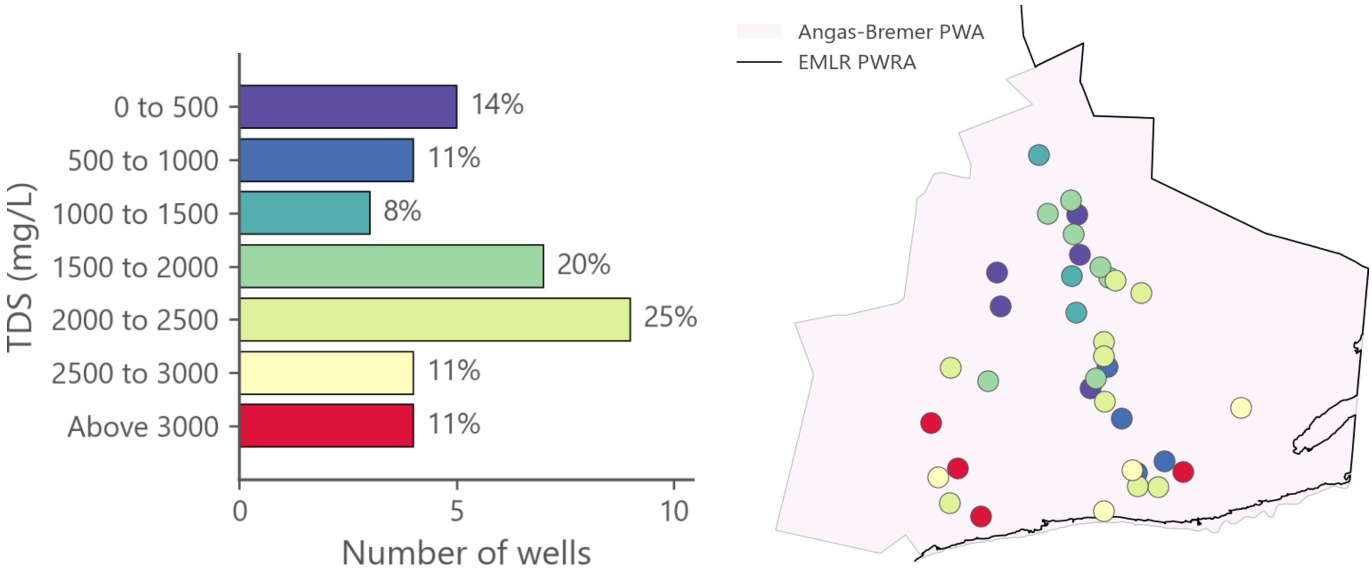

Figure 5.22. 2020 salinity observations in Murray Group Limestone aquifer wells in the Angas Bremer PWA

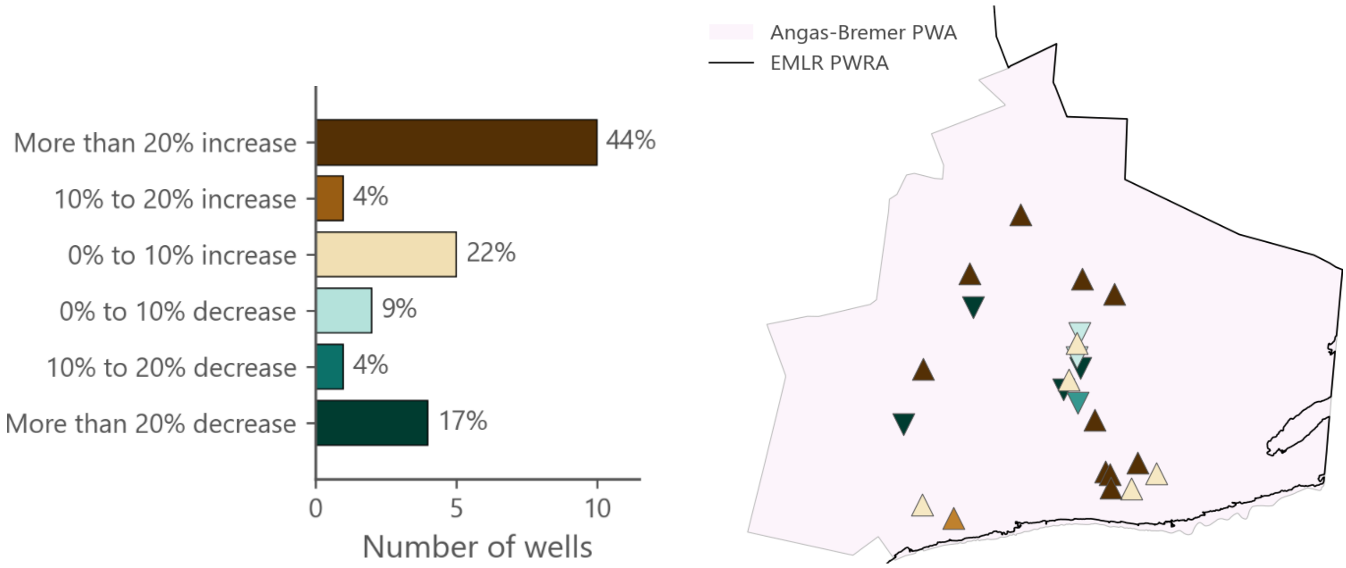

Figure 5.23. Salinity trend in the 10 years to 2020 for wells in the Murray Group Limestone aquifer of Angas Bremer PWA

6 Water use

Demand for water in the EMLR can be broadly divided into consumptive use, social uses (including, but not limited to, Indigenous and cultural values, recreation, fisheries, tourism and amenity) and environmental water provisions. The main consumptive uses in the EMLR PWRA are non-licensed (stock and domestic uses), forestry and licensed purposes (e.g. irrigation, industrial use and intensive animal production). 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, therefore licenced allocations are used in this assessment to provide an indication of usage volumes.

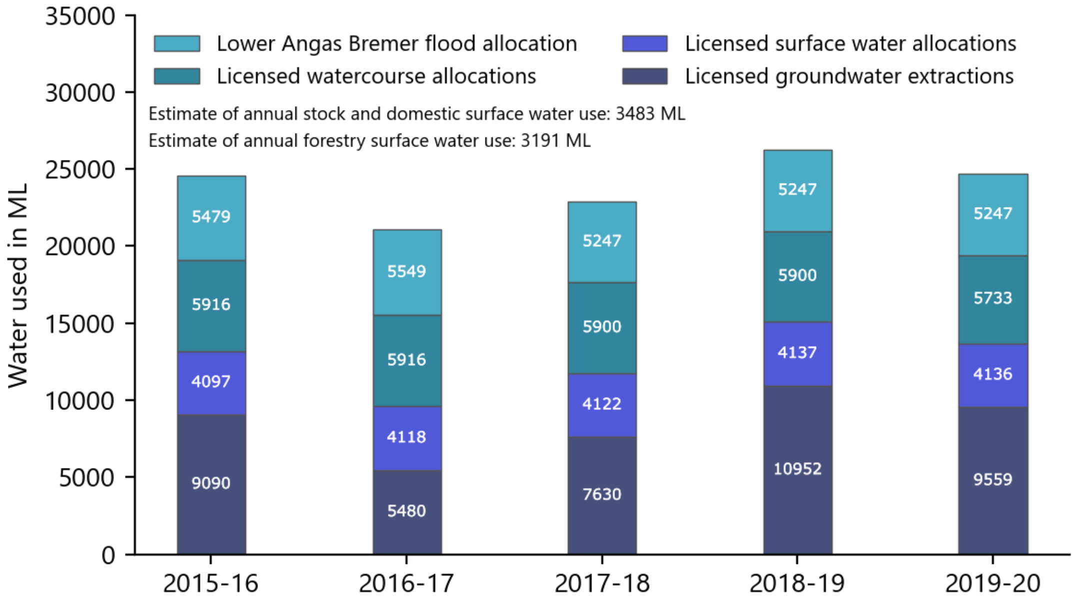

Figure 6.1. Water used from 2015–16 to 2019–20 for the EMLR PWRA, including the Angas Bremer PWA

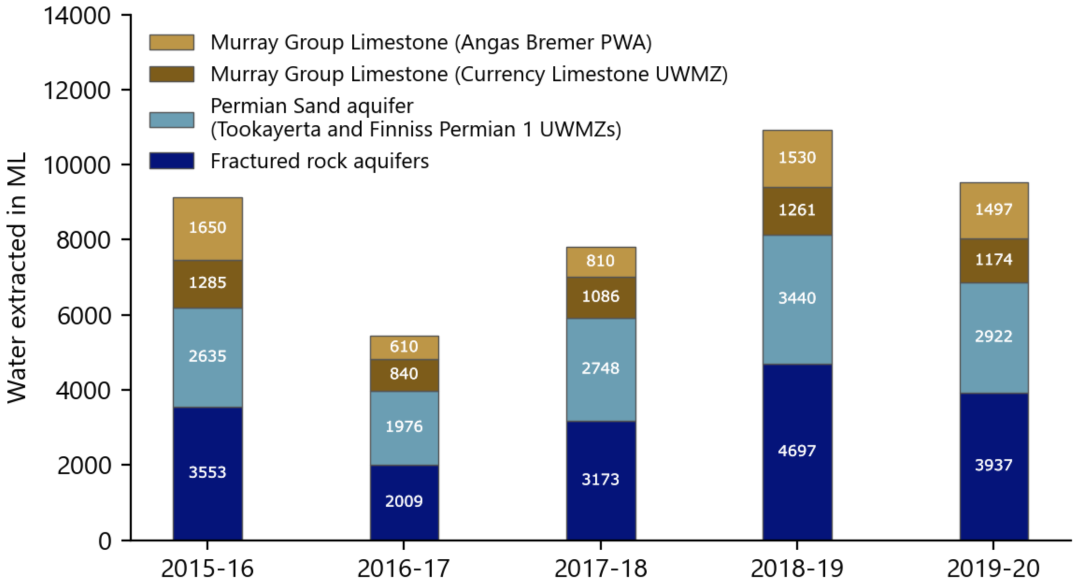

Figure 6.2. Metered groundwater extraction in aquifers of the EMLR PWRA

The total volume of water used in 2019–20 was 31 349 ML (Figure 6.1). This includes surface water volumes (Section 6.1) and metered groundwater extraction across both the EMLR PWRA and Angas-Bremer PWA (Figure 6.2).

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. Water Allocation Plan for the Eastern Mount Lofty Prescribed Water Resources Area (SAMDB NRM Board, 2013).

In 2019–20, a total volume of 9559 ML has been extracted from all groundwater resources across the PWRA (Figure 6.2), proportionally:

- 41% was extracted from fractured rock aquifer UWMZs.
- 31% from the Permian Sand aquifer in the Tookayerta and Finniss Permian 1 UWMZs.
- 28% was from the Murray Group Limestone (16% from Angas Bremer PWA, and 12% 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.

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 totalled 1497 ML in the 2019–20 water-use year (Figure 6.3), which represents a 2% decrease from the previous water-use year.

Increases in extraction during 2005–10 was due to Lake Alexandrina being unsuitable because of high salinity and access difficulties due to the receding shoreline (Section 5.5.3). As a consequence, demand for groundwater increased significantly. The recent decrease in 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 amount of surface water injected into the confined limestone aquifer from these sources varies significantly, depending on the availability of stream flow with salinities less than 1500 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. In 2020, the total volume of injected water was commensurate with 2019, but considerably lower than historical injection volumes due to less surplus river water being available for injection. Over 2016–18, injection volumes were greater than extraction which may have reduced the impact on groundwater levels from higher rates of groundwater extraction over the past two years (Figure 5.21).

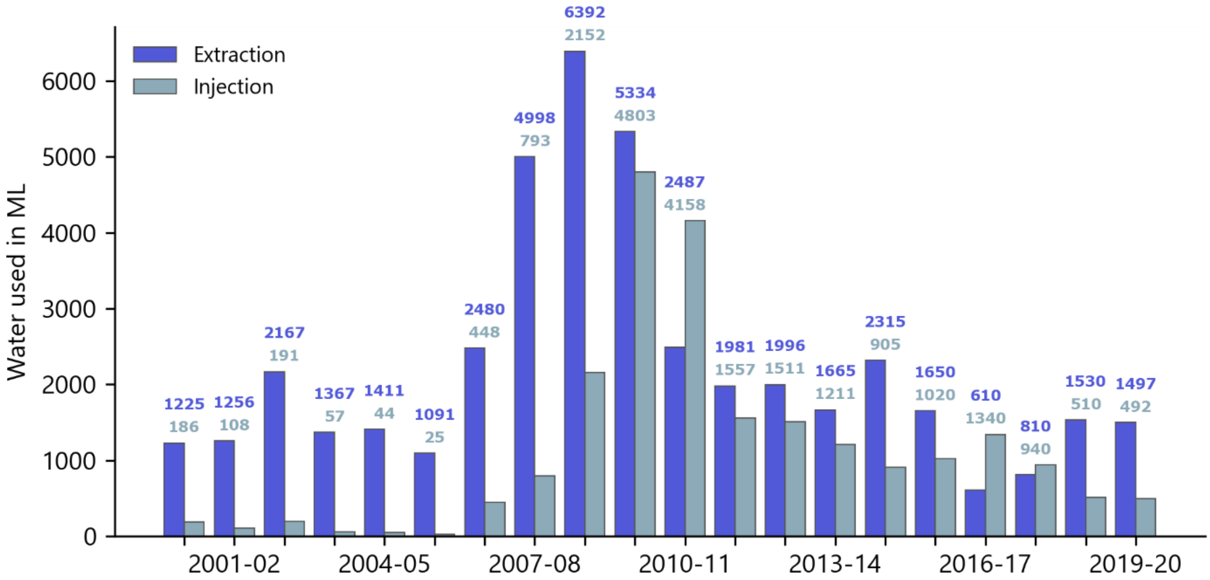

Figure 6.3. Metered groundwater extraction and injection in the Murray Group Limestone aquifer in the Angas Bremer PWA

6.2 Surface water use

In 2019–20, the total water allocation for the EMLR PWRA was 21 790 ML (compared to 21 959 ML in 2018–19). This consists of (Figure 6.1):

- 5247 ML for the Lower Angas Bremer flood allocation (excluding the volume allocated for delivery of flood diversions);
- 4136 ML from licensed surface water sources (dams);
- 5733 ML from licensed watercourse sources (excluding flood diversions);
- 3191 ML from plantation forestry. This is based on analysis in the water allocation plan (SAMDB NRM Board, 2013);
- 3483 ML water demand for stock and domestic, which is not required to be licensed. This is approximated at 30% of dam capacity and is 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 the information contained in the EMLR WAP, there are approximately 7000 farm dams in the prescribed area 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 storage capacity. The Currency Creek catchment contains 8% of the dams and storage capacity and the Finniss River catchment has 30% of the total farm dams and storage capacity.

Non-licensed dams make up the majority of 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 the farm dams in the Bremer River catchment (Figure 6.4 inset) shows that there are 2294 farm dams (139 of these are licensed) with a total storage capacity of 5473 ML. Across the Bremer catchment, smaller dams (capacity less than 5 ML) account for the majority of the number 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 of the EMLR PWRA as a whole and the Bremer catchment is 9 ML/km^2. The higher dam concentrations are typically found in the headwater catchments and high rainfall areas (Figure 6.4).

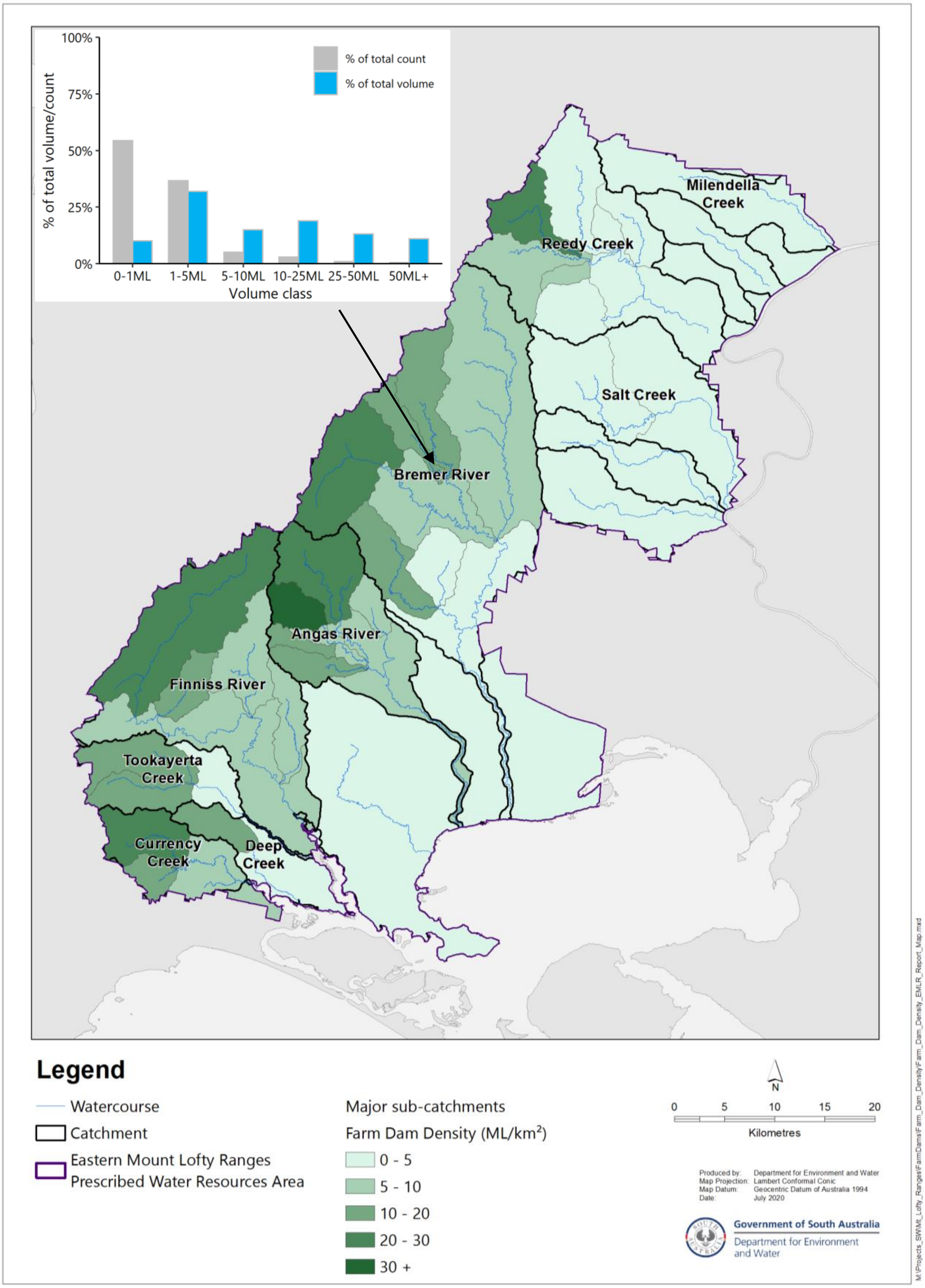

Figure 6.4. Farm dam density in the EMLR PWRA (Inset: farm dam volume and count in the Bremer River catchment)

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