# Barossa Prescribed Water Resources Area 2020–21 water resources assessment

Department for Environment and Water
December, 2022

DEW Technical Note 2022/10

Government of South Australia

Department for Environment and Water

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# 1 Summary

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| Barossa PWRA | Fractured rock aquifers | |
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**LEGEND**

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

**Rainfall**

- Rainfall at Tanunda measures 394 mm in 2020–21, which is lower than the 1977 to 2021 reporting period annual average of 527 mm/y. The trend for the reporting period is stable, but the last four years have been below average; only 3 years from the past decade are above average.
- Rainfall in 2020–21 is higher over the Tanunda and Jacobs Creek sub-catchments, decreasing to the north-east and south-west, and this is typically the case.
- A wetter-than-average early winter (June and July) and a drier late-winter (August and September) is observed in 2020–21, consistent with the high seasonal variability observations across other areas in the state.

**Surface water**

- Four principal streamflow gauging stations are operational, two of which recorded 'Average' streamflow in 2020–21.
- Annual streamflow recorded at Penrice and Yaldara gauging stations are 'Very much below average' and 'Below average' respectively in 2020–21. Minimal or no flow was experienced between January 2021 to May 2021 at all four stations. Data for the 1977 to 2021 period of record show a declining trend in streamflow.
- The highest salinity at Yaldara in 2020–21 was 2,526 mg/L. This value remains within the historical range measured at the site.

**Groundwater**

- Water levels in 82% of groundwater wells are classified 'Below-average' or lower.
- In 2021, 34% of wells have a recovered water level of 'Lowest on record'. These comprised 53% of wells in the Upper Aquifer, 37% in the Lower Aquifer and 18% of wells in fractured rock aquifers.
- Five-year trends in water level indicate that the majority of wells (81%) show declining water levels.
- Salinity is increasing in 67% of wells over the past 15 years.

**Water use**

- Water is used for a variety of licensed purposes (irrigation, industrial, intensive animal production, environmental and recreational uses) and non-licensed purposes such as stock and domestic and plantation forestry. Water sources include groundwater, watercourses, farm dams, imported water from the SA Water mains network and water supply from Barossa Infrastructure Ltd (BIL) via SA Water infrastructure. Imported water is transferred from the River Murray to the PWRA and in 2020–21, constitutes approximately 70% of water use.
- Estimated water consumption in 2020–21 (July to June) is 19,801 ML. This includes metered groundwater extraction (3,563 ML), licensed surface water dams (251 ML), licensed watercourse extractions (1,207 ML), estimated surface water demand from non-licensed dams (1,100 ML), imported water from the BIL scheme (11,368 ML, including 310 ML of treated recycled water from the Community Wastewater Management System) and imported water from SA water (2,312 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 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**: provides summary information for the main water resources across most regions in a quick-reference format.

This document is the Technical Note for the Barossa Prescribed Water Resources Area (PWRA) and collates rainfall, surface water, groundwater and water-use data for 2020–21.

## 1.2 Regional context

The Barossa PWRA includes both the highland areas of the Mount Lofty Ranges and the Barossa Valley (Figure 1.1). It is located approximately 60 km north-east of Adelaide and lies within the Northern and Yorke Landscape region and includes both groundwater and surface water resources. These are prescribed resources under the *Landscape South Australia Act 2019*. A water allocation plan adopted in 2009 provides rules for their management.

Groundwater occurs in three main groundwater systems: two sedimentary aquifers (Upper and Lower) and fractured rock aquifers. The sedimentary aquifers are largely contained within central Barossa Valley between Nuriootpa and Lyndoch (Figure 1.1). The largest volume of groundwater extraction occurs from the fractured rock aquifers that extend across the entire PWRA.

The North Para River is the main watercourse in the PWRA. All streams are ephemeral, and feature seasonally isolated permanent pools sustained by groundwater.

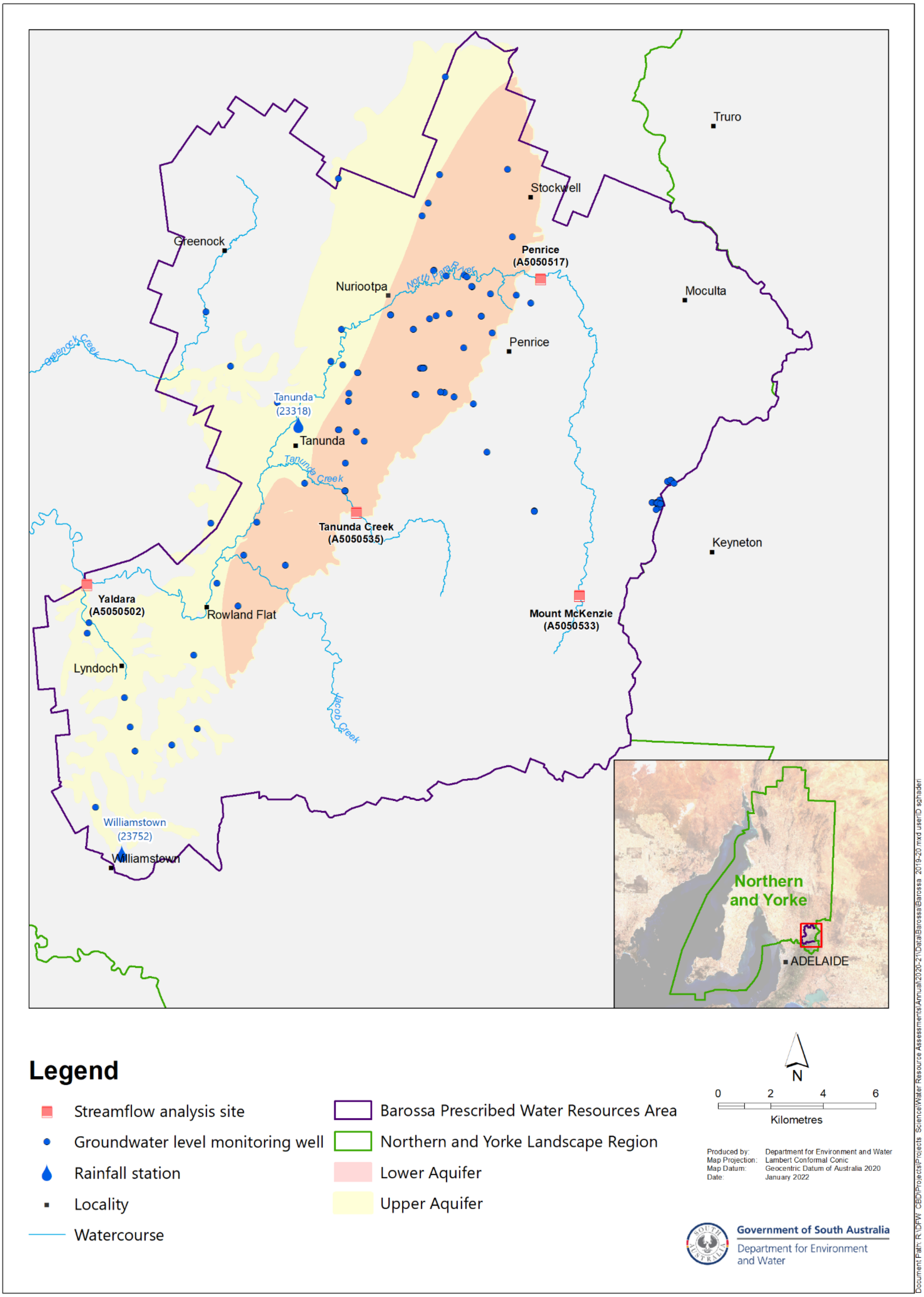


**Figure 1.1 Location of Barossa PWRA**

# 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 and Figure 3.3).

Rainfall maps were compiled using gridded datasets obtained from the BoM (Figure 3.1). The latest available long-term annual rainfall map (1986 to 2015) 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/decadal-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 stations is determined by expressing the 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 Yaldara streamflow gauging station is 1977 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) 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 2.2

### 2.2.2 Monthly streamflow

Monthly streamflow for the reporting year is assessed alongside the long-term average monthly streamflow (Figure 4.3A and Figure 4.3B) for the period 1977 to 2021 and long-term monthly statistics including (a) high flows (75$^{th}$ percentile), (b) median flows (50$^{th}$ percentile) and low flows (25$^{th}$ percentile). Monthly data is presented for an extended period (July to September) 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).

### 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.

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

[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

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-June), measured as the number of days with total flow greater than 0.05 ML (50,000 litres), and
- The annual number of flow days above the threshold flow rate (TFR) for the reporting year (July to June). Days above the TFR are defined as a 24-hour period with flow equal to or greater than the TFR (expressed as ML/day). The recommended ecologically significant TFR is the 20th percentile exceedance non-zero daily flow. TFR is defined in the Water Allocation Plan for the Barossa PWRA 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 reporting period (Figure 4.4 and Figure 4.5). A reporting period trend and the number of years in the last decade above the reporting-period 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 long-term monthly salinity statistics including (a) high salinities ($75^{th}$ percentile), (b) median salinities ($50^{th}$ percentile) and (c) low salinities ($25^{th}$ percentile). 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 observation 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 Barossa PWRA return to a recovered maximum level between June and January of the following year.

For those wells that meet the selection criteria (see below), the annual recovered water levels are ranked from lowest to highest according to their decile range (Table 2.2) and given a description in a similar way to annual streamflow. The thresholds for criteria by which wells are selected varies depending on the history of monitoring activities in different areas; for the Barossa 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 (e.g., Figure 5.1). Hydrographs are shown for a selection of wells to illustrate common or important trends (e.g., Figure 5.3).

[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).

Five-year trends are calculated using annual recovered water levels for those wells that 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 (e.g., Figure 5.2).

Moderately sized, sedimentary, confined and unconfined aquifers such as the Upper and Lower Aquifers 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 (or thirty-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., 2001 to 2003) and the average water level in 2021.

### 2.3.2 Salinity

Since 2018, water samples from pumping irrigation wells are provided to DEW by licence holders in the Barossa PWRA. 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.

Fifteen-year salinity trends are calculated where there are at least six 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).

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

## 2.4 Water use

Meter readings are used to report licensed extraction volumes for both surface water and groundwater sources for the financial year (1 July 2020 to 30 June 2021). Where meter readings are not available, licensed or allocated volumes are used for surface water sources (Figure 6.1 and Figure 6.2).

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 (Figure 6.3). 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 in the Barossa PWRA are:

- Summary reports are available on the surface water (DEWNR 2011) and groundwater resources of the Barossa PWRA (DEWNR 2014), as well as annual surface water status reports such as DEW (2019a) and groundwater level and salinity status reports such as DEW (2019b, c and d).
- The Water Allocation Plan for the Barossa Prescribed Water Resources Area is available (AMLR NRM Board 2009).
- Jones-Gill and Savadamuthu (2014) describe the development of a hydrological model of the PWRA (i), to assess the impacts of current water use and potential future water management scenarios on the flow regime and (ii) provide model outputs for ecological water requirement analysis within the PWRA
- Cranswick et al. (2015) provide a detailed background and conceptual model of the hydrogeology of the Barossa PWRA. Hancock, Stewart and Green (2014) provide a study of interactions between groundwater and surface water systems in the Barossa PWRA. These studies were completed to support water planning in the Barossa PWRA.
- The report: *Modelling the impacts of current water use, urban development and climate projections on surface water resources in the Barossa Prescribed Water Resources Area* (DEW 2022a) is available.
- The report: *Modelling management options that improve streamflow pattern within the Barossa Prescribed Water Resources Area* (DEW 2022b) is available.
- The *Water Security Statement 2022 – Water for Sustainable Growth* is also available (DEW 2022c)

[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 Barossa PWRA has mild, wet winters and hot, dry summers which are typical of a Mediterranean climate. Average annual rainfall (1986 to 2015) ranges from 750 mm at the highest elevations along the Barossa Ranges in the south to 500 mm north-east of Tanunda (Figure 3.1)[9].

Rainfall in 2020–21 is markedly lower in all parts of the PWRA compared to average annual rainfall patterns. The 1986 to 2015 average annual rainfall shows the higher rainfall bands (>650 mm/y) extending north to the Tanunda Creek catchment, whereas these higher bands are absent in the PWRA in 2020–21 (Figure 3.1).

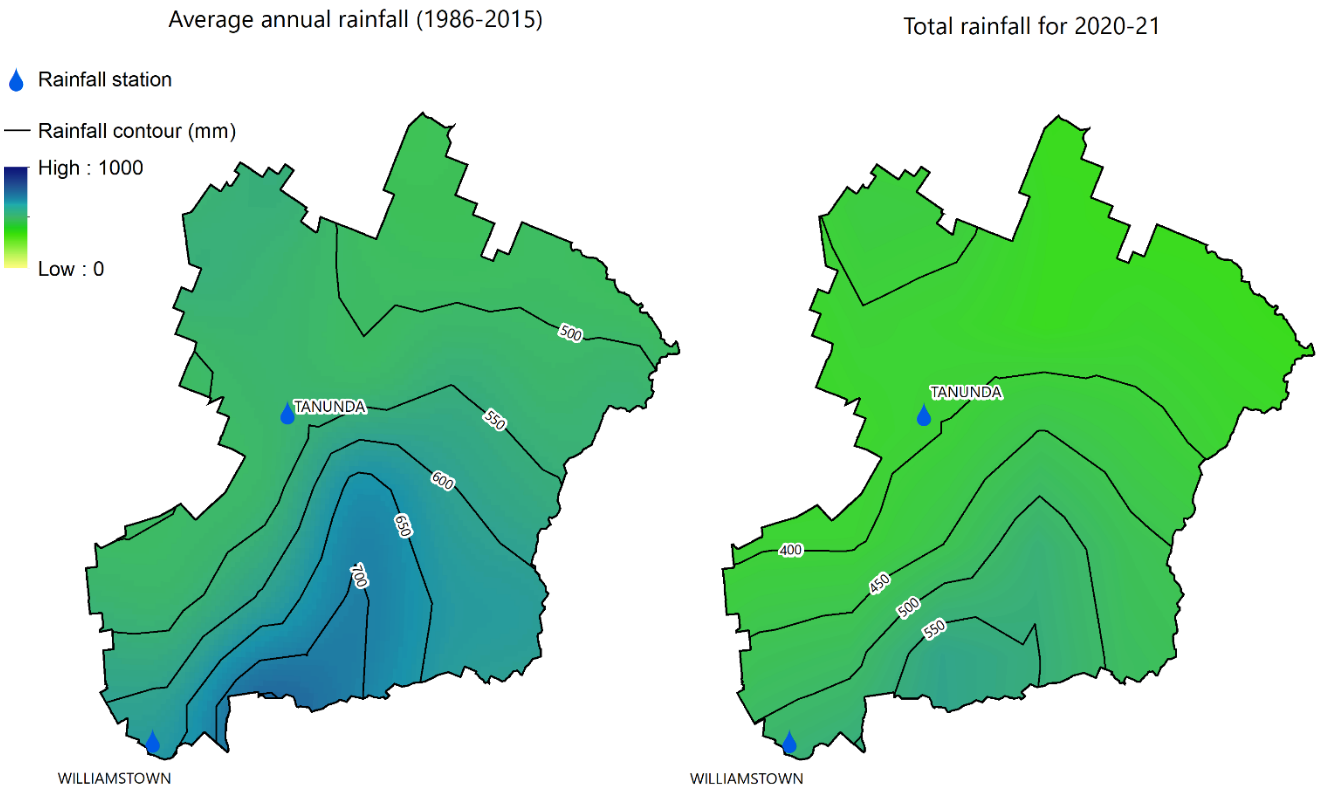


**Figure 3.1 Rainfall in the Barossa PWRA for 2020–21 compared to the standard 30-year climatological average (1986 to 2015)**

Two stations were selected to capture the variation of precipitation across the Barossa PWRA. The Tanunda rainfall station (BoM station 23318) represents the lower rainfall areas in the central and northern parts of the Barossa PWRA. The Williamstown rainfall station (BoM station 23725) represents higher rainfall areas in the southern part (Figure 3.1).

Total annual rainfall recorded for 2020–21 (July – June) at Tanunda is 394 mm (Figure 3.2), which is 25% (133 mm) below the 1977 to 2021 average annual rainfall of 527 mm. Similarly, the total annual rainfall at Williamstown is 555 mm (Figure 3.4), which is 17% (110 mm) below the 1977 to 2021 average annual rainfall of 664 mm. Below-average rainfall is also observed at other rainfall stations in the PWRA.

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; further detail is provided in Section 2.1.

Despite both stations recording below-average annual rainfall in the past 4 years, the Tanunda station shows a stable long-term annual rainfall trend while the Williamstown station shows a slight decline in the long-term annual rainfall trend (Figure 3.2 and Figure 3.4).

Dry conditions are prevalent throughout most of the year at both stations. In Tanunda, only August and October 2020 and February, June and July 2021 have above-average monthly rainfall, while in Williamstown above-average values are observed from August to October 2020 and in February, June and July 2021 (Figure 3.3 and Figure 3.5).

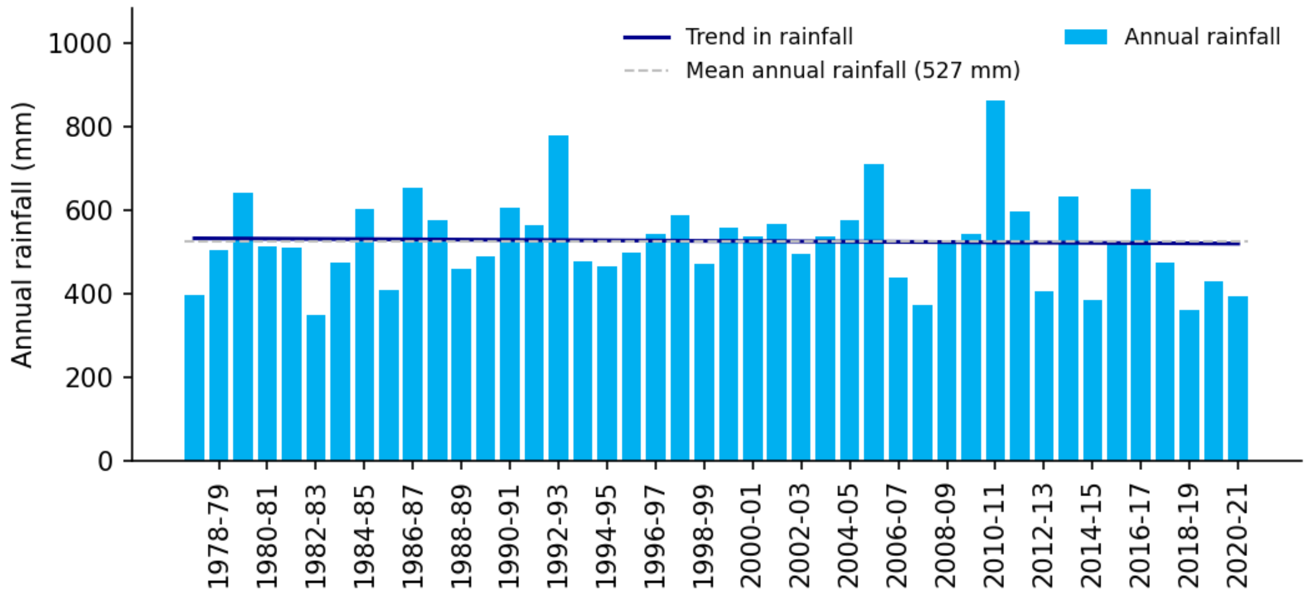


**Figure 3.2 Annual rainfall for 1977–78 to 2020–21 at the Tanunda rainfall station (BoM station 23318)**

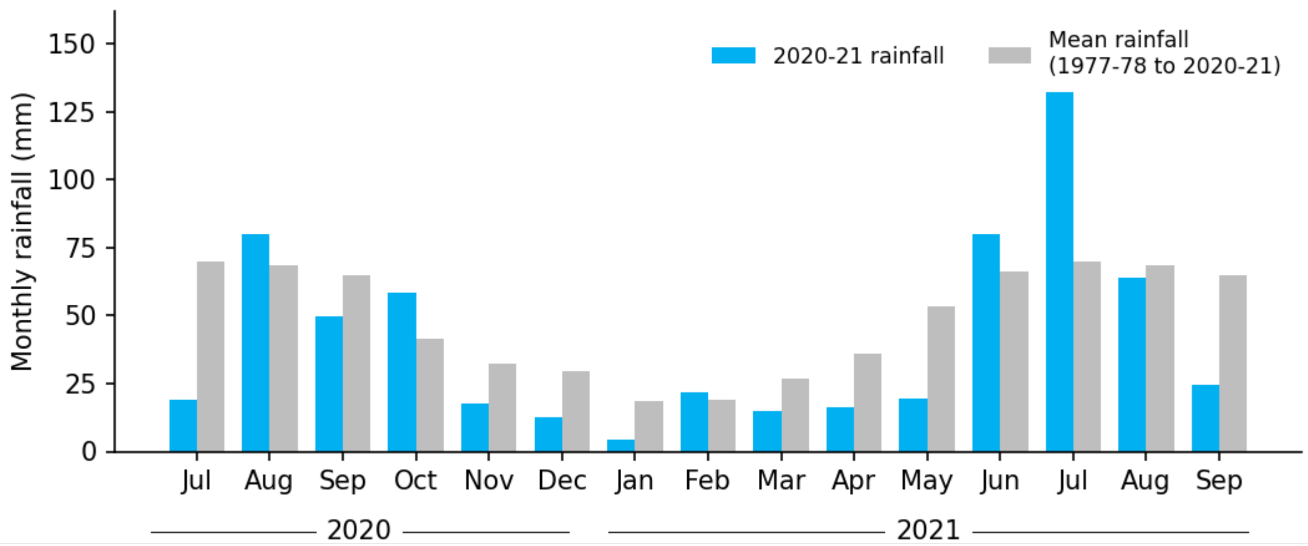


**Figure 3.3 Monthly rainfall between July 2020 and September 2021, compared to the long-term monthly average at the Tanunda rainfall station (BoM station 23318)**

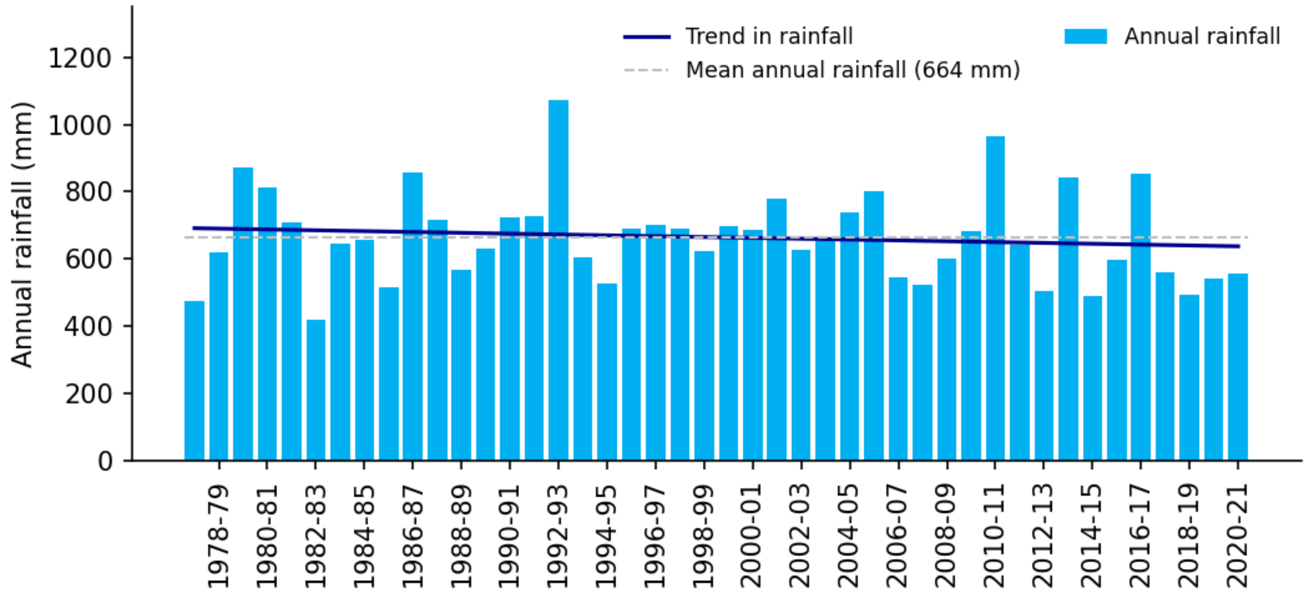


**Figure 3.4 Annual rainfall for 1977–78 to 2020–21 at the Williamstown rainfall station (BoM station 23752)**

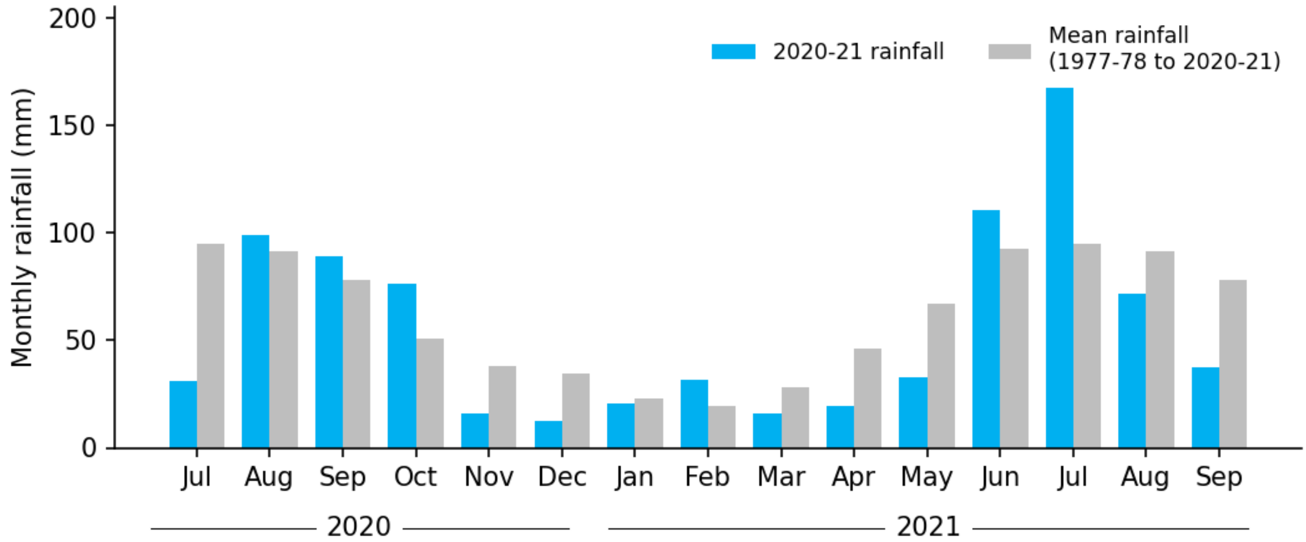


**Figure 3.5 Monthly rainfall between July 2020 and September 2021, compared to the long-term monthly average at the Williamstown rainfall station (BoM station 23752)**

# 4 Surface water

## 4.1 Streamflow

The North Para River is the main watercourse in the Barossa PWRA and flows south to north in the eastern side of the PWRA between Mount McKenzie and Penrice streamflow gauging stations (Figure 1.1). The river then heads in a south-westerly direction between the Penrice and Yaldara streamflow gauging stations. Major tributaries include Tanunda Creek and Jacobs Creeks. All streams are ephemeral and feature seasonally disconnected permanent pools, sustained predominantly by groundwater. 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.

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 Barossa PWRA (Figure 4.1):

- three stations on the North Para River: Mount McKenzie (A5050533), Penrice (A5050517) and Yaldara (A5050502)
- one station on the Tanunda Creek: Bethany (A5050535).

The common period of streamflow data availability across the stations is 1977 to 2021. Further detail on the methods and data used in this analysis can be found in Section 2.2.1. Streamflow data in the charts are displayed with a dashed outline when the records are incomplete. Periods when data are missing for the 2020–21 reporting period for Yaldara are during the first 17 days in June 2021 and over the months with below monthly average streamflow. Therefore, the impact of missing data on the annual streamflow is considered minimal.

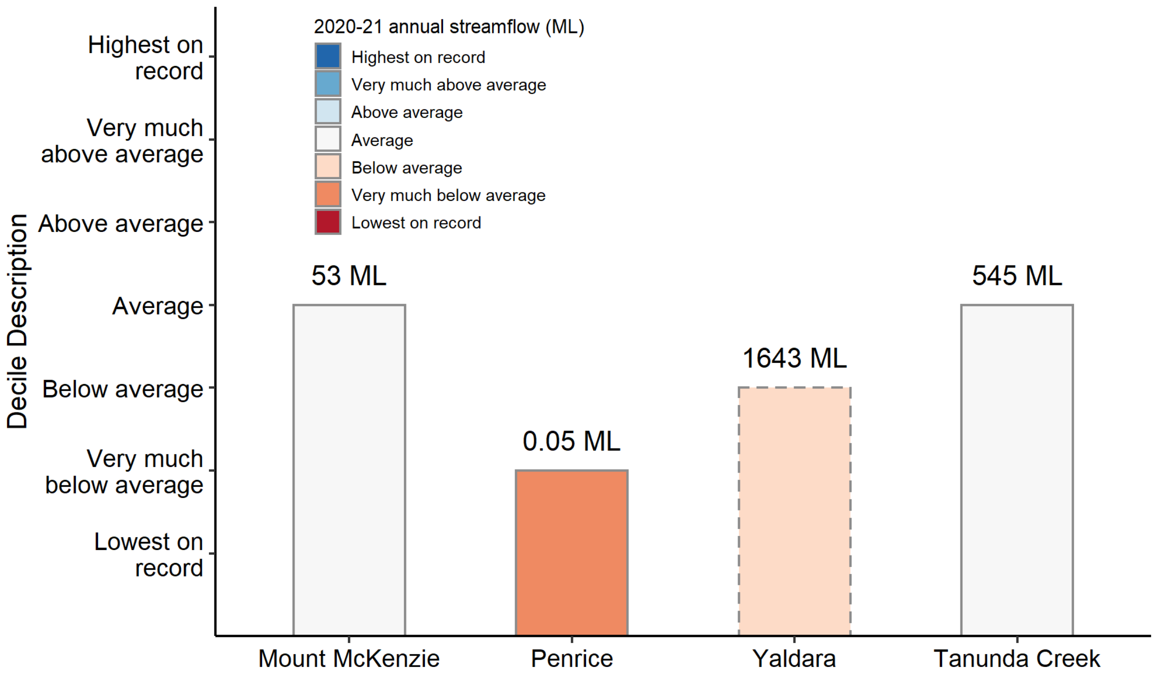


**Figure 4.1 Barossa PWRA annual streamflow summary 2020–21**

### 4.1.1 North Para River: Yaldara (A5050502)

The principal long-term streamflow gauging station for the PWRA is located at Yaldara, at the outlet of the North Para catchment, and covers a catchment area of 376 km$^2$.

Total annual streamflow recorded at the station for 2020-21 (July-June) is 1,643 ML, 86% less than the 1977 to 2021 annual average of 12,013 ML. The deviation of each year's streamflow from the longer-term average for Yaldara is shown in Figure 4.2. Note that incomplete streamflow records are displayed with a dashed outline.

The 2020–21 annual streamflow decile for Yaldara is ranked as 'Below average' (between 10th and 30th percentile – refer to Table 2.2) calculated from the 1977 to 2021 period of record. Long-term annual streamflow data shows a declining trend, with annual streamflow values lower than the long-term average for 4 out of the last 5 years and decile ranking of 'Below average' for 3 out of the last 5 years (Figure 4.2).

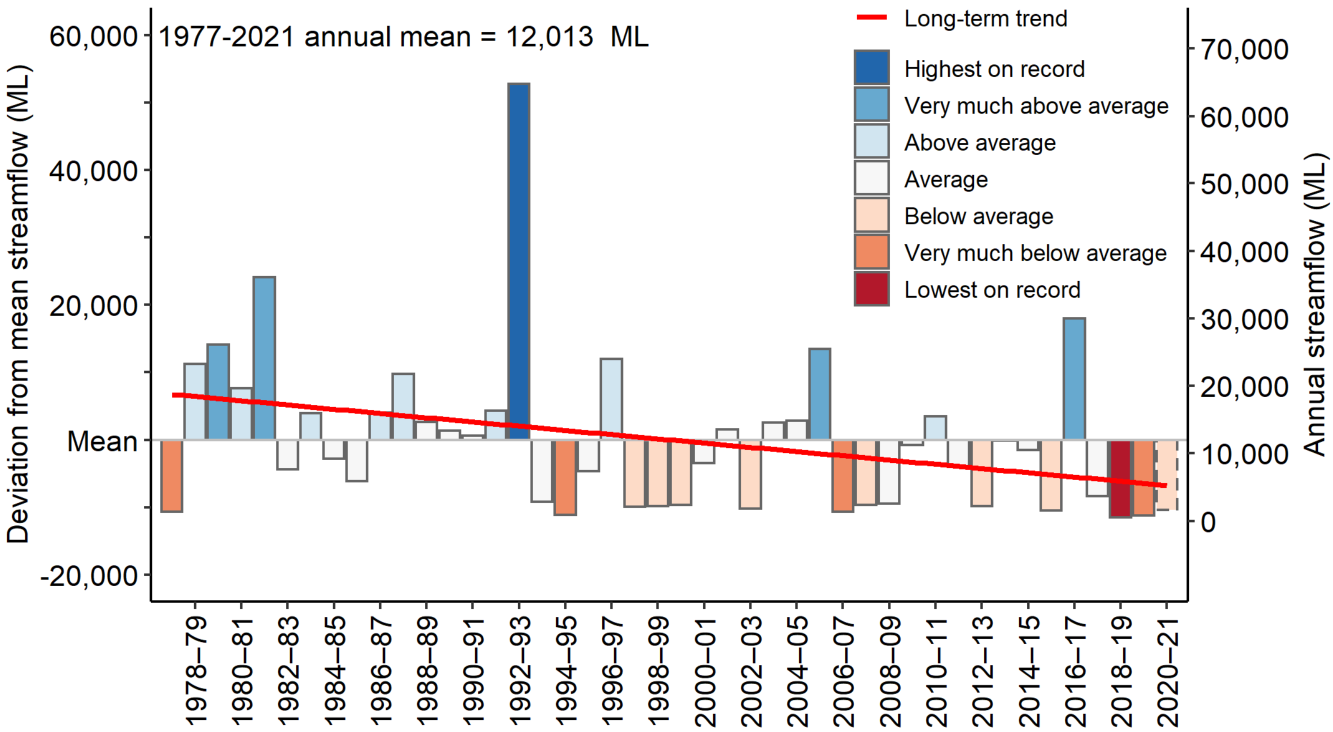


**Figure 4.2 Annual deviation from mean streamflow at Yaldara (1977–78 to 2020–2021)**

Figure 4.3A shows the Yaldara monthly streamflow for the extended 2020–21 reporting period (July to September, grey bars) relative to the 1977 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 are below the 1977 to 2021 median flow (50$^{th}$ percentile). Periods of zero flow are present from mid-December 2020 to mid-June 2021. The majority of streamflow typically occurs between August and October, accounting for roughly 91% of total annual flow in any given year.

Figure 4.3B presents the 1977 to 2021 average monthly streamflow and daily flows for the extended 2020–21 reporting period for Yaldara. Maximum daily flows are recorded in August 2021.

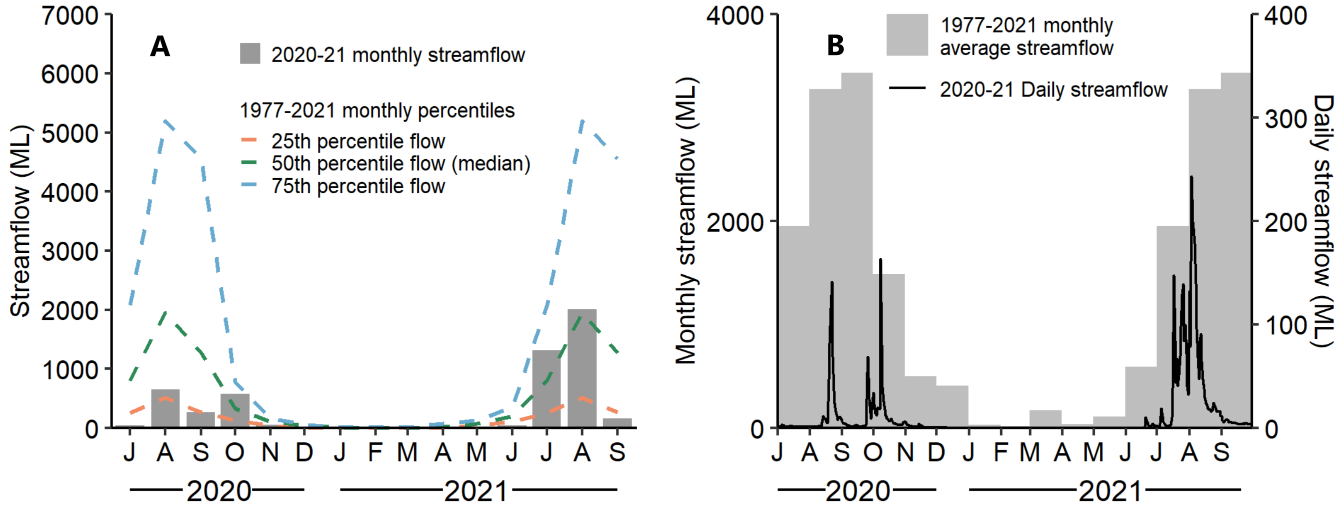


**Figure 4.3** **(A) Long-term monthly statistics and 2020–21 monthly streamflow at Yaldara; (B) Long-term average monthly streamflow and 2020–21 daily streamflow at Yaldara**

## 4.2 Flow regime

Analysis of the flow regime was undertaken for the Barossa PWRA watercourses mentioned in Section 4.1. Flow data collected at streamflow gauging stations are used in this assessment to complement the streamflow analysis. Further detail on the methods and data used in this analysis can be found in Section 2.2.4. Note that years with more than 5% missing data were removed from the assessment (Figure 4.4 and Figure 4.5).

**North Para River: Yaldara (A5050502)**

The assessment of the flow regime information from the Yaldara station for 2020–21 (July to June) shows a total of180 flowing days. This is 110 days fewer than the 1976 to 2021 reporting-period average of 290 days (Figure 4.4). The number of days with flows above the threshold flow rate (TFR) is 175 days, 93 fewer days than the reporting-period average of 267 days (Figure 4.5).

Over the last decade (2011–12 to 2020–21), 3 out of 10 years (with sufficient data) had an above average number of flowing days. In the past decade there have been 4 years when the number of days above the TFR have been above the reporting-period average.

**North Para River: Penrice (A5050517)**

The assessment of the flow regime information from the Penrice for 2020–21 (July to June) shows only one flow day and zero days with flows above the TFR, with 363 zero flow days recorded. Penrice recorded a 1976 to 2021 reporting-period average of 253 flowing days (Figure 4.4), and an average of 56 days with flow above TFR (Figure 4.5).

Over the last decade (2011–12 to 2020–21), ten years (with sufficient data) had a less than average number of flowing days. In the past decade there have been 2 years when the number of days above the TFR are above the long-term reporting-period average.

**North Para River: Mount McKenzie (A5050533)**

The assessment of the flow regime information from the Mount McKenzie for 2020–21 (July to June) shows 78 flowing days. This is 106 days lower than the 1976 to 2021 reporting-period average of 184 flowing days (Figure 4.4). The number of days with flow above TFR is 12 days, 63 days lower than the reporting-period average of 75 days (Figure 4.5).

Over the last decade, 4 years had a higher than average number of flowing days and there have been 3 years where the numbers of days above the TFR have been above the reporting-period average.

**Tanunda Creek: Bethany (A5050535)**

The assessment of the flow regime information from the Bethany station for 2020–21 (July to June) shows 155 total flowing days. This is 45 days fewer than the 1976 to 2021 reporting-period average of 200 days (Figure 4.4). The number of days with flows above the TFR is 2 days, 6 fewer days than the reporting-period average of 8 days (Figure 4.5).

Over the last decade (2011–12 to 2020–21), 3 out of 10 years (with sufficient data) had above average number of flowing days; there have been 4 years when the number of days above the TFR have been above the reporting-period average.

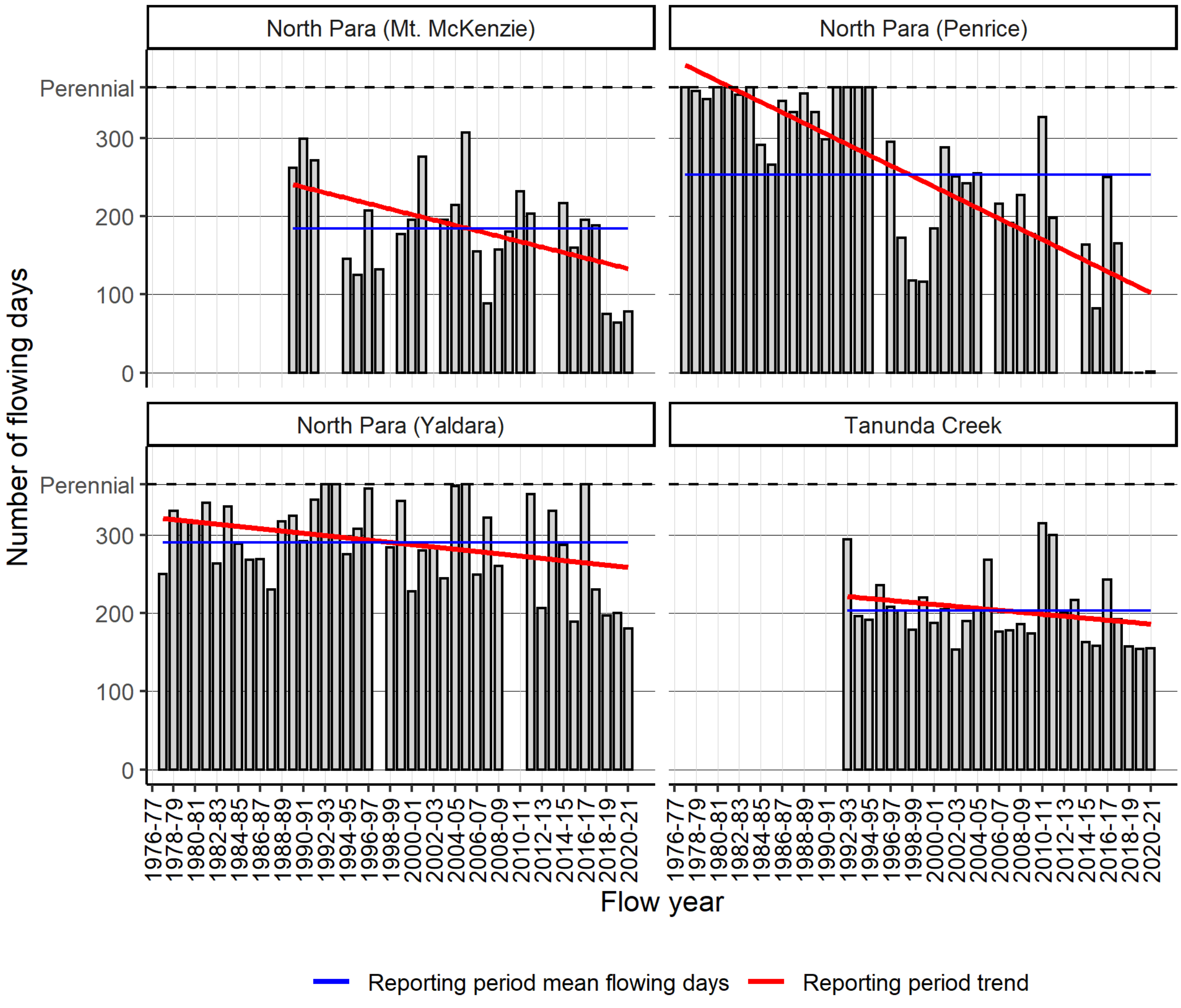


**Figure 4.4 The number of flowing days (flow >0.05ML/day) for the stations assessed in the Barossa PWRA including the average and trend over the long-term reporting period**

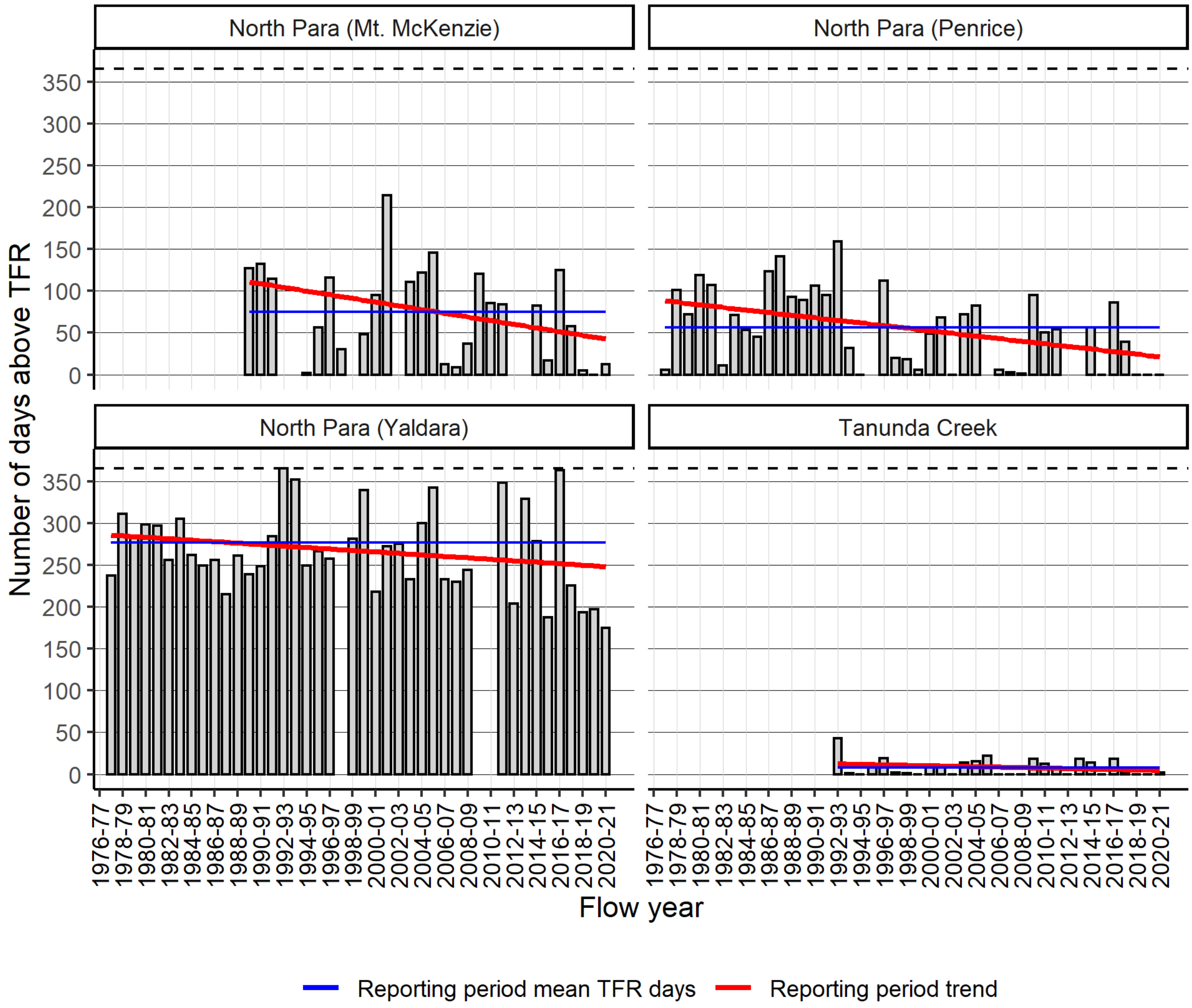


**Figure 4.5 The number of days with flow above the TFR for the stations assessed in the Barossa PWRA including the average and trend over the reporting period**

### Implications of flow regime for aquatic ecosystems in 2020–21

The flow regime across the Barossa PWRA shows deteriorating conditions for aquatic ecosystems compared with what has been observed in the previous few years. All sites are observed to have fewer flow days and number of days above TFR, which poses a threat to the aquatic species distribution and diversity.

## 4.3 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.

Salinity is recorded routinely at gauging stations within the Barossa PWRA. North Para River at Yaldara (A5050502) was selected to represent salinity trends across the PWRA. Figure 4.6 shows the Yaldara monthly median salinities for 2020–21 (bars) with the long-term (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 Yaldara is 2,160 mg/L, which is higher than the 1994 to 2021 median salinity of 1,995 mg/L. The longer-term monthly data for the Yaldara station shows that higher salinities are generally observed during drier months from December through to May and lower salinities during the wetter months from July through to October. All the available median monthly salinity values for Yaldara for 2020–21 are higher than the 1994 to 2021 median values.

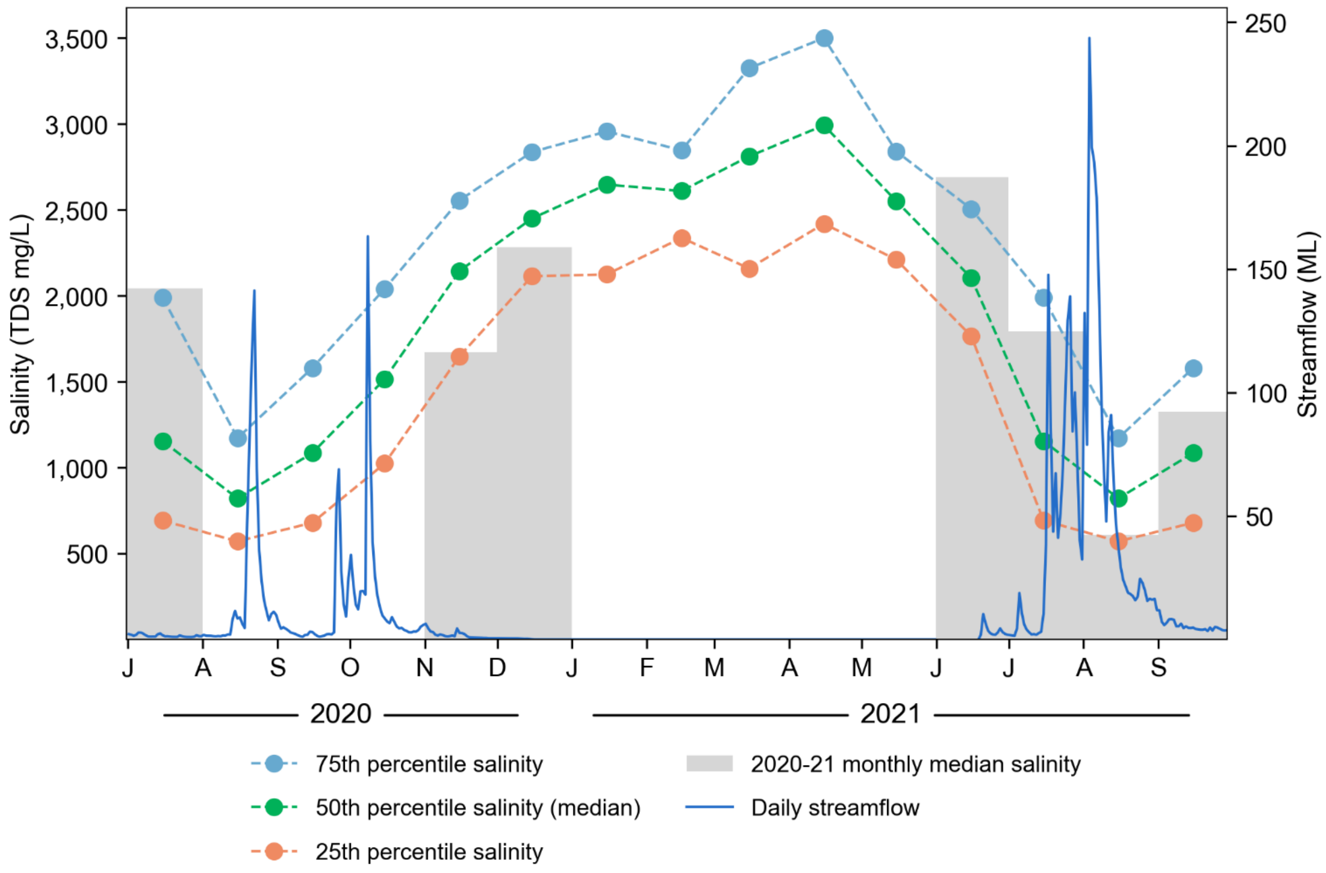


**Figure 4.6 Long-term and 2020–21 monthly median salinity at Yaldara streamflow gauging station (A5050502)**

# 5 Groundwater

## 5.1 Hydrogeology

The Barossa PWRA consists of 3 main groundwater systems: 2 sedimentary aquifers (Upper Aquifer and Lower Aquifer) that are located within the region's largest valley, and fractured rock aquifers of the Mount Lofty Ranges that form the eastern and western margins of the valley.

### 5.1.1 Upper Aquifer

The Upper Aquifer consists of sediments that are often referred to as the middle, upper gravel and watertable aquifers. They overlie a carbonaceous clay, confining layer. The Upper Aquifer includes Tertiary non-carbonaceous sands, lenticular sands and gravels within Quaternary clays and Holocene gravels and sands associated with drainage channels incised into the Quaternary clay. This aquifer is generally unconfined; however, some of the sub-aquifers can be confined. In addition to the main valley, aquifers belonging to this groundwater system also occur in a broad valley to the south of Lyndoch.

### 5.1.2 Lower Aquifer

The Lower Aquifer is generally confined and consists of Tertiary carbonaceous clays, gravels, sands and silts that were deposited in the deepest part of the basin and form a complex system of interconnected sub-aquifers. It is separated from the overlying Upper Aquifer by a carbonaceous clay confining layer. Pressure levels in the Lower Aquifer are subject to large seasonal fluctuations in response to pumping. In general, groundwater in the Lower Aquifer flows towards the south and south-west.

### 5.1.3 Fractured rock aquifers

Pre-Cambrian and Palaeozoic sandstones, siltstones and schists form fractured rock aquifers where groundwater is stored and flows through fractures and fissures in the rock. Wells completed in this aquifer generally have low yields, although there are some exceptions. Beneath the valley sediments, the upper parts of the fractured rock aquifers are generally a highly weathered clay-rich layer, which can act as a confining layer between the fractured rock aquifers and the overlying sedimentary aquifers. Groundwater in the fractured rock aquifers beneath the valley floor generally flows to the south and south-west; in some areas steep hydraulic gradients can occur. The fractured rock aquifers are the most widely used in the PWRA.

## 5.2 Upper Aquifer water levels

In 2021, winter-recovered water levels in 14 out of 17 (82%) monitoring wells in the Upper Aquifer are classified 'Below average' or lower (Figure 5.1).

Over the past 20 years, variations in water level in 17 wells range from a decline of 7.44 m to a rise of 0.46 m (median is a decline of 1.5 m).

Five-year trends show declining water levels in the majority of wells (87%), with rates of decline ranging between 0.72 to 0.06 m/y (median is a decline of 0.41 m/y) (Figure 5.2).

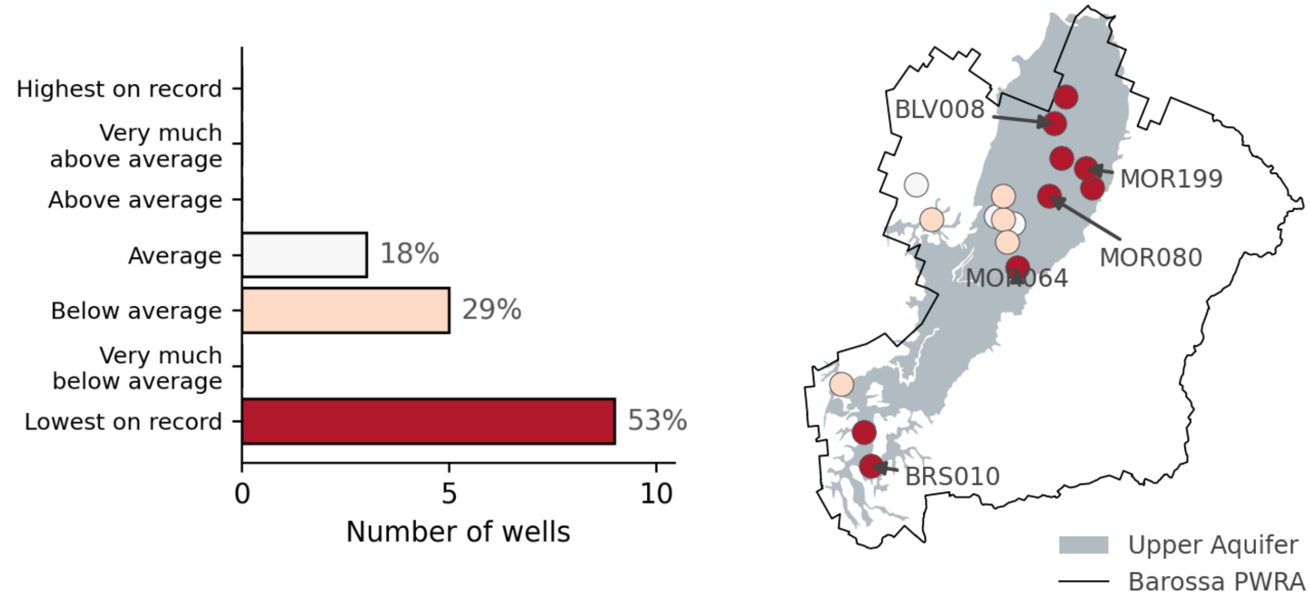


**Figure 5.1 2021 recovered water levels for wells in the Upper Aquifer**

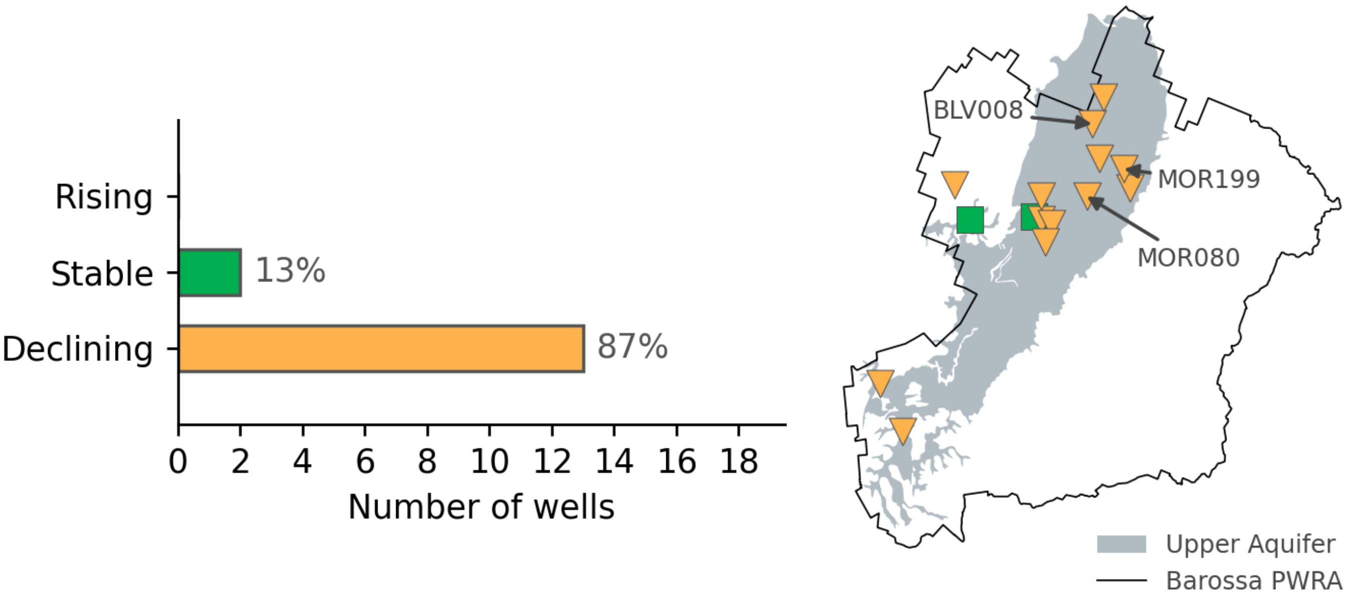


**Figure 5.2 2017–21 trend in recovered water levels for wells in the Upper Aquifer**

Hydrographs from a selection of representative monitoring wells illustrate common or important trends in the Upper Aquifer (Figure 5.3). The majority of groundwater use from the Upper Aquifer occurs to the east and south of Nuriootpa where the Upper Aquifer is thickest and is recharged from the North Para River (e.g., MOR080). Water levels in the majority of monitoring wells in this area are classified 'Lowest on record' or 'Below average'.

Further south, near Tanunda and Lyndoch (e.g., MOR064 and BRS010), water levels have been declining gradually since the 1990s and are classified 'Lowest on record' in 2021.

In the north of the PWRA, shallow groundwater is more saline and is not suitable for irrigation. Gradual declines in level (e.g., BLV008) may be caused by a decline in rainfall over the past 15 years and declining water levels in the underlying fractured rock aquifers.

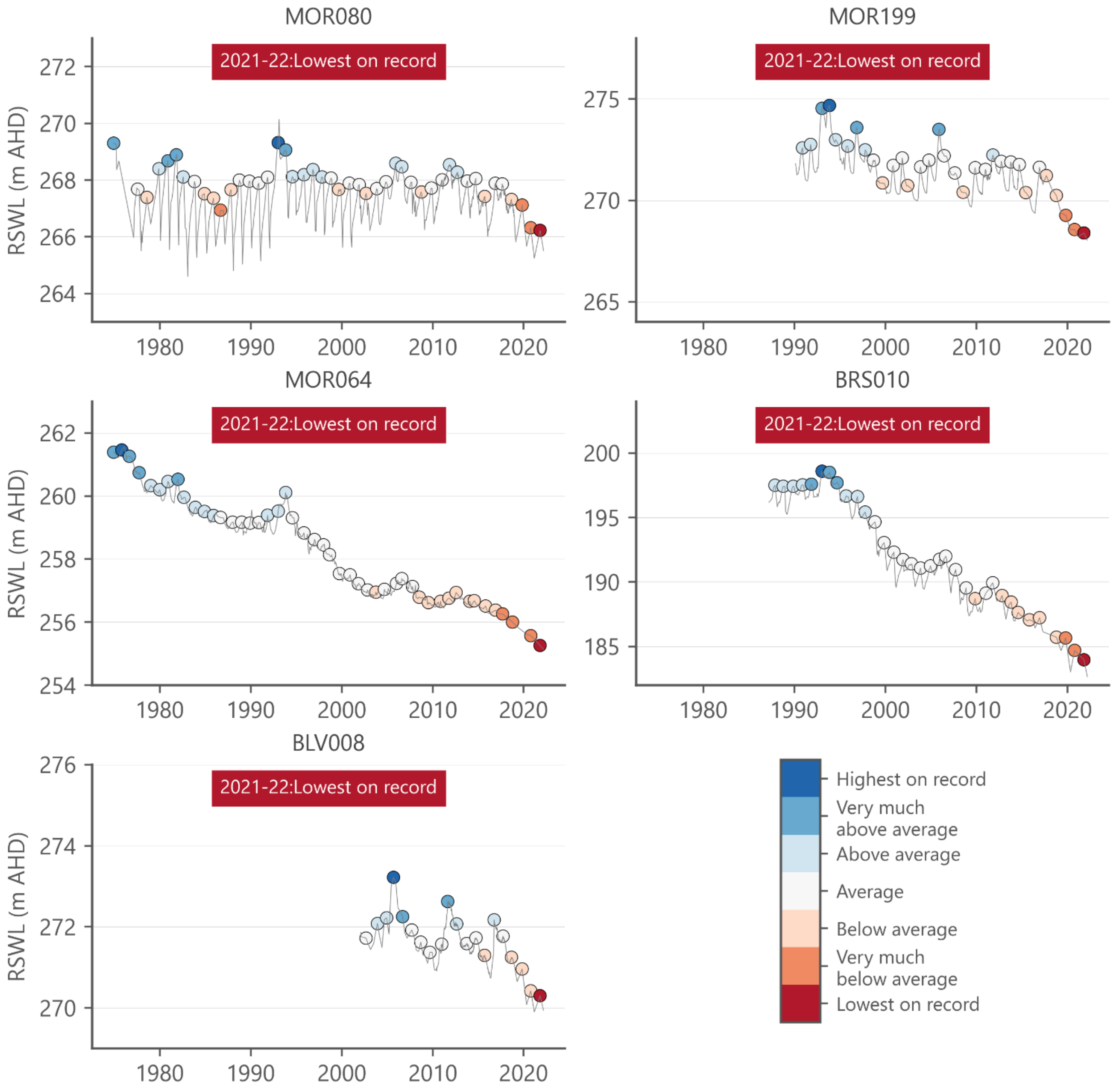


**Figure 5.3 Selected Upper Aquifer hydrographs**

## 5.3 Upper Aquifer salinity

Groundwater salinity is highly variable in the Upper Aquifer, ranging from 960 to 12,000 mg/L. The lowest salinities are found in the vicinity of the North Para River as it flows into the Barossa Valley, near Angaston Creek and in the Lyndoch Valley. Generally, higher salinity groundwater is found to the north and west of the North Para River and to the east of Tanunda. Since 2018, irrigators in the Barossa PWRA have submitted groundwater salinity samples, to augment DEW's state-wide monitoring network. In 2021, sampling results from 12 wells in the Upper Aquifer range between 930 mg/L and 2,824 mg/L with a median of 1,514 mg/L (Figure 5.4).

In the fifteen years to 2021, 7 of 8 wells (88%) show trends of increasing salinity (See Section 2.3.2 for details of the calculation). Fifteen-year trends show that rates of change in salinity vary from a decrease of 0.8% per year to an increase of 0.8% per year, with a median rate of 0.2% increase per year.

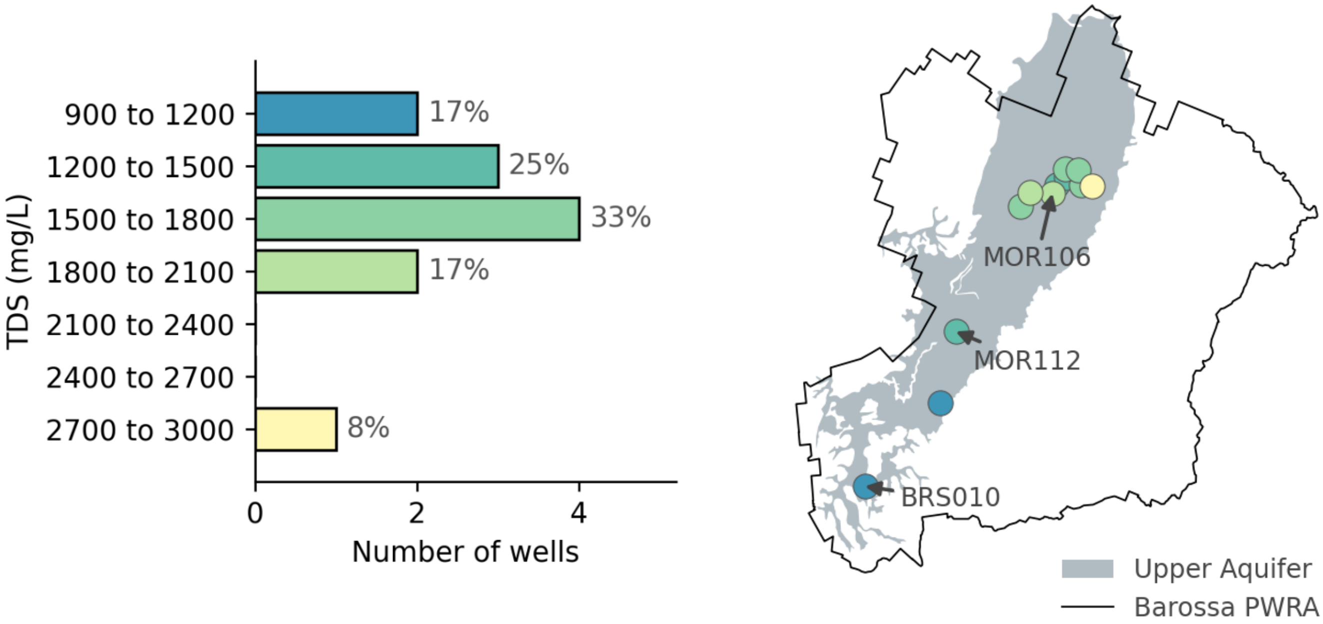


**Figure 5.4** **2021 salinity observations from wells in the Upper Aquifer**

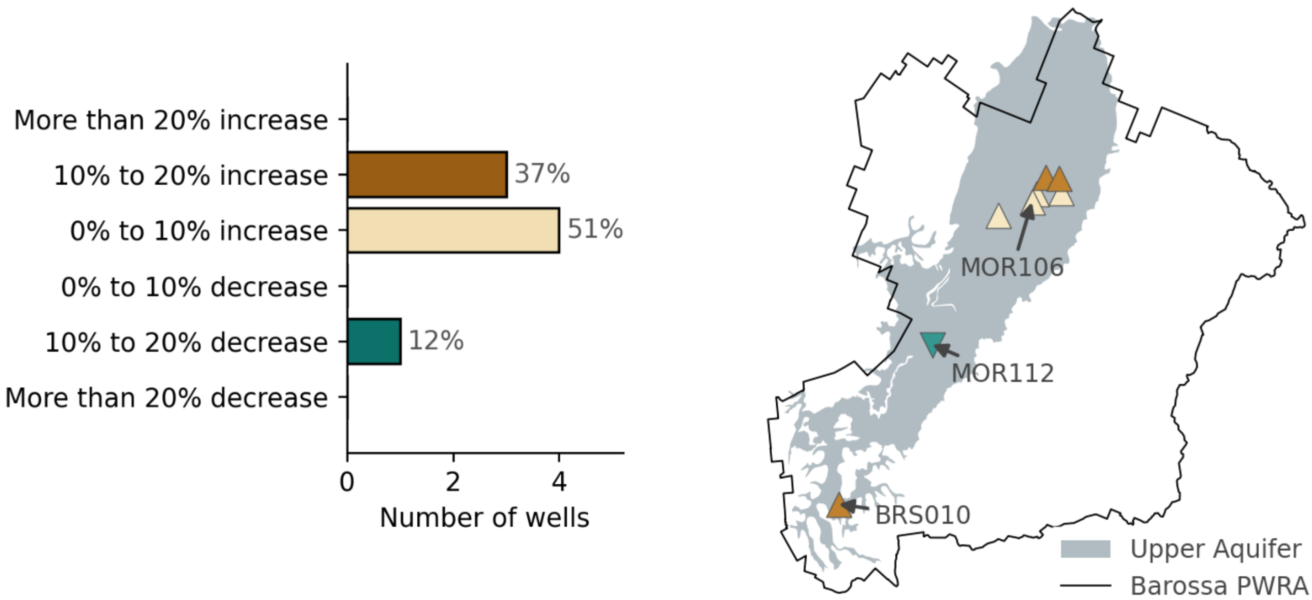


**Figure 5.5** **Salinity trend in the 15 years to 2021 in the Upper Aquifer**

Hydrographs from a selection of representative monitoring wells illustrate common or important trends in the Upper Aquifer (Figure 5.6). In order to improve water quality for irrigation purposed, some irrigators are mixing water sourced from the Upper Aquifer with water from the Barossa Infrastructure Limited (BIL) scheme.

Long-term monitoring data at MOR106 shows a gradual increase in groundwater salinity at Nuriootpa since the early 2000s. Further south, MOR112 shows a decrease in salinity in the late 2000s and has since remained stable.

To the south of the PWRA, near Lyndoch, BRS010 is showing an increase in groundwater salinity since 2005.

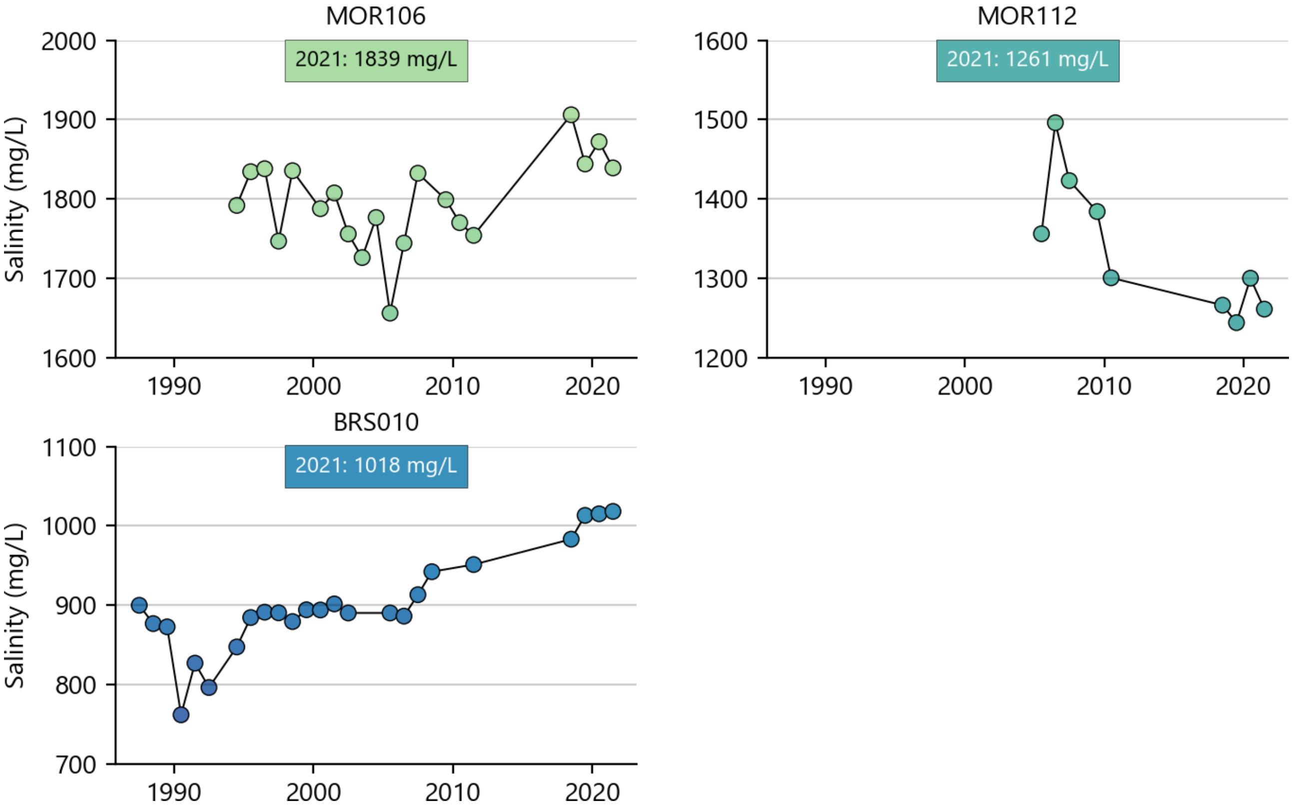


**Figure 5.6 Selected Upper Aquifer salinity graphs**

## 5.4 Lower Aquifer water levels

In 2021, winter-recovered water levels in 17 out of 19 (90%) monitoring wells in the Lower Aquifer are classified 'Below average' or lower (see Section 2.3.1 for details of the classification; Figure 5.7).

Over the past 30 years, variations in water level in 16 wells range from a decline of 5.88 m to a rise of 3.51 m (median is a decline of 3.0 m).

Five-year trends show declining water levels in the majority of wells (88%), with rates of decline ranging between 1.27 to 0.13 m/y (median is a decline of 0.59 m/y) (Figure 5.8).

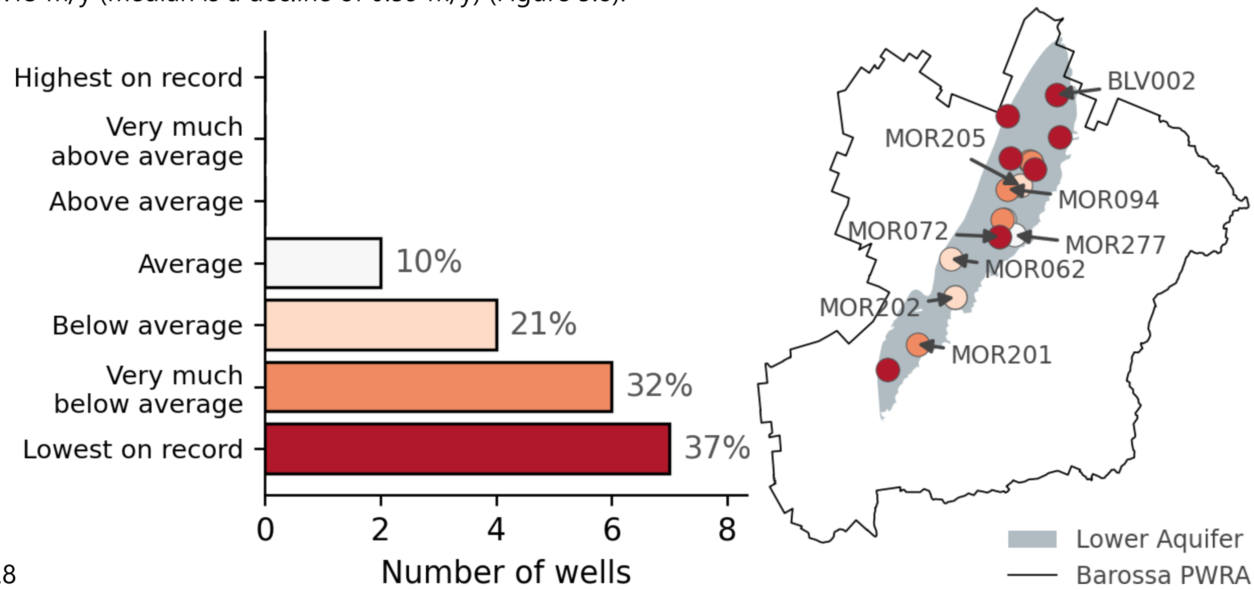


Figure 5.8

**Figure 5.7 2021 recovered water levels for wells in the Lower Aquifer**

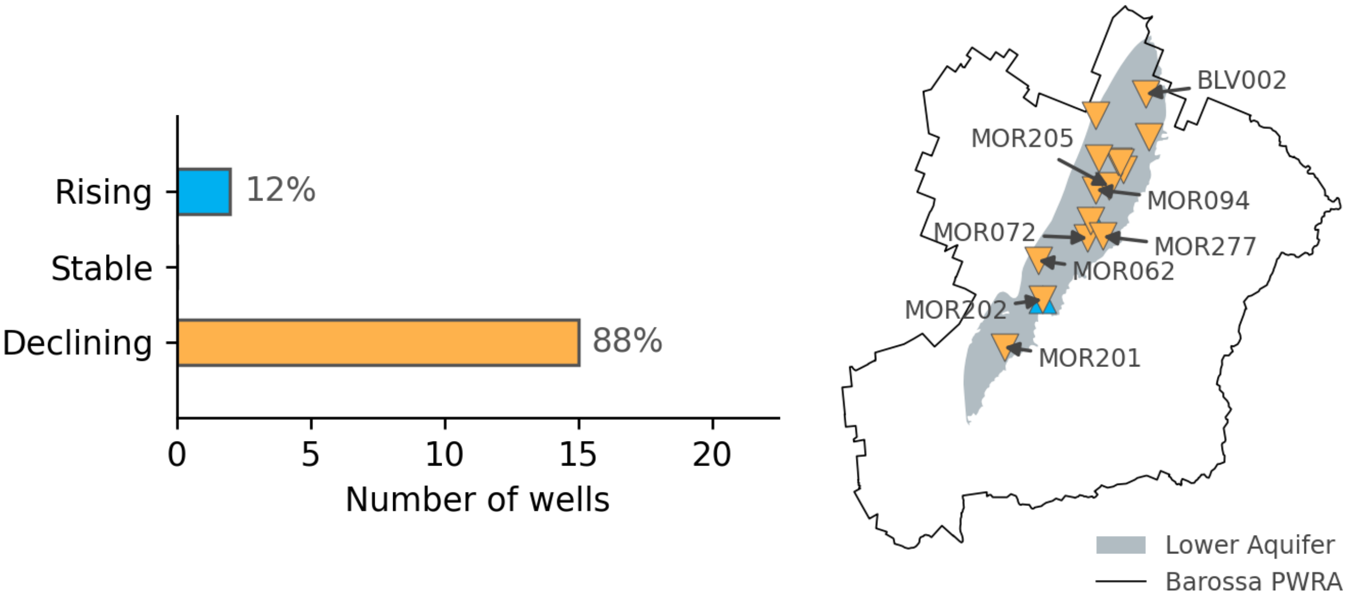


**Figure 5.8 2017 to 2021 trend in recovered water levels for wells in the Lower Aquifer**

Hydrographs from a selection of representative monitoring wells illustrate common or important trends in the Lower Aquifer (Figure 5.9). The majority of groundwater extraction from the Lower Aquifer occurs in the floor of the Barossa Valley from Light Pass to Rowland Flat. Where the aquifer is confined, monitoring wells show large seasonal drawdowns in response to groundwater pumping, followed by rapid recoveries after the irrigation season (e.g., MOR094, MOR062 and MOR201).

MOR072 is completed in the shallower part of the Lower Aquifer where the aquifer can be semi-confined and not as responsive to pumping and winter recovery. Nonetheless, the total decline in water levels over the past 30 years is in excess of 5 m.

In the northern part of the PWRA, a smaller volume of groundwater is extracted from the Lower Aquifer and water levels are declining more gradually (e.g., BLV002).

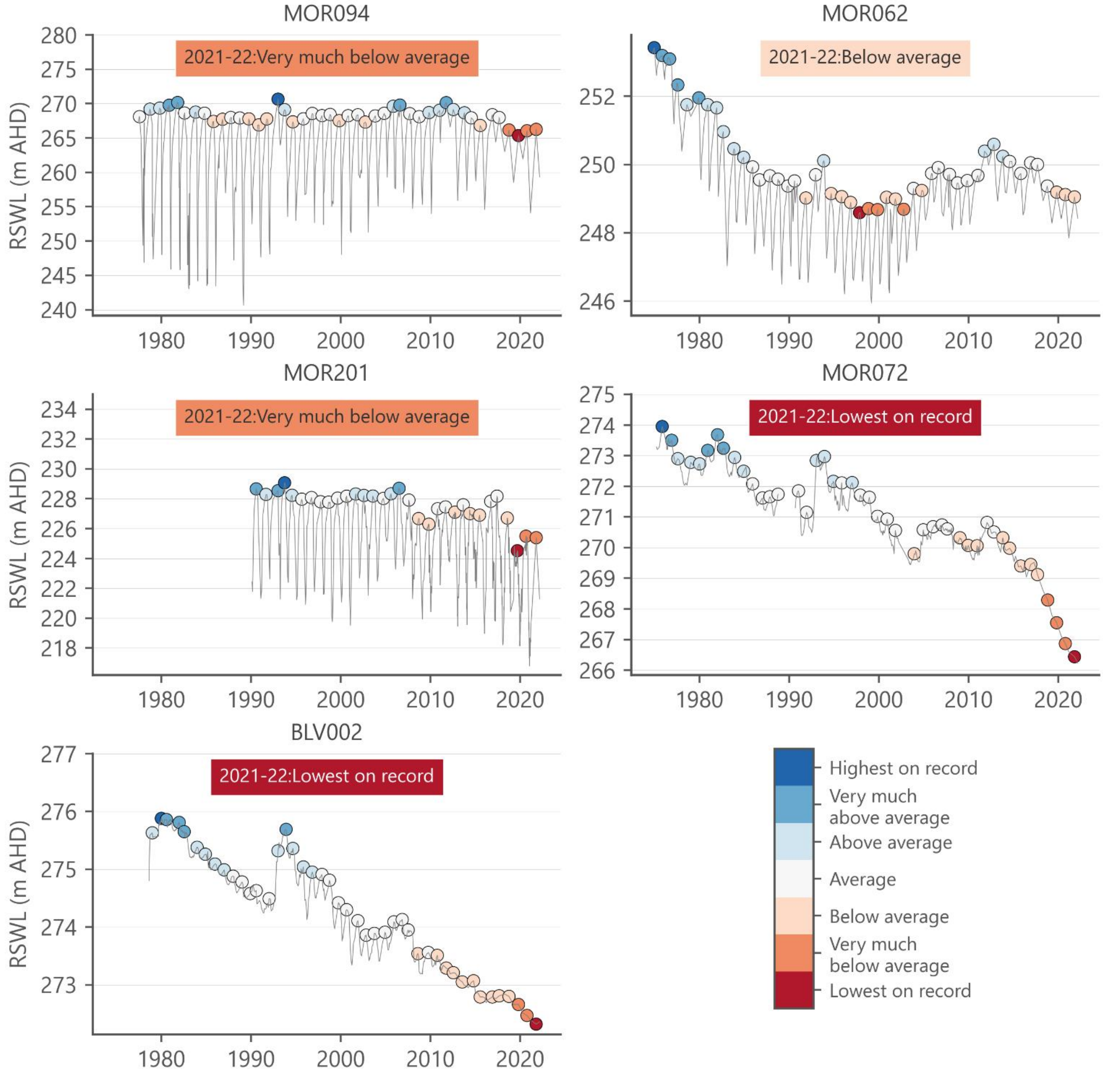


**Figure 5.9 Selected Lower Aquifer hydrographs**

## 5.5 Lower Aquifer salinity

Since 2018, irrigators in the Barossa PWRA have submitted groundwater salinity samples. In 2021, sampling results from 15 wells in the Lower Aquifer range between 637 mg/L and 2,205 mg/L with a median of 1,373 mg/L (Figure 5.10).

In the fifteen years to 2021, 5 of 8 wells (63%) show trends of decreasing salinity. Fifteen-year trends show that rates of change in salinity vary from a decrease of 1.9% per year to an increase of 0.9% per year, with a median rate of 0.1% decrease per year (Figure 5.11).

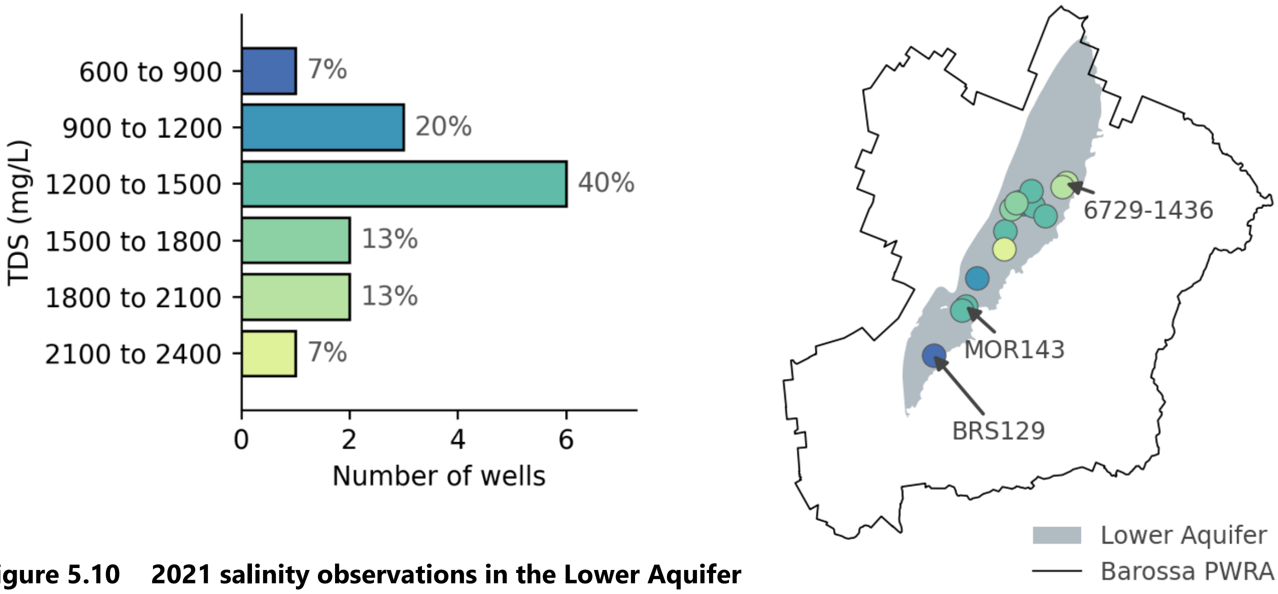


**Figure 5.10 2021 salinity observations in the Lower Aquifer**

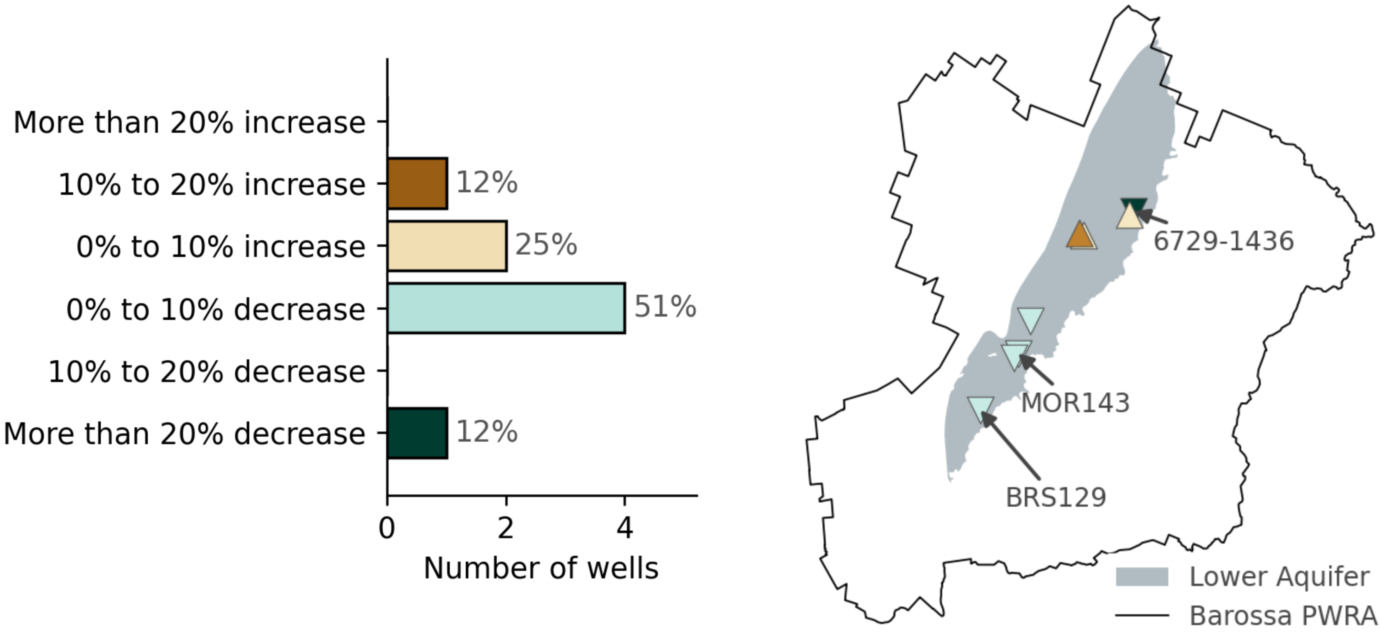


**Figure 5.11 Salinity trend in the 15 years to 2021 in the Lower Aquifer**

The salinity of the Lower Aquifer is generally below 3,000 mg/L with wells showing higher salinity usually located to the north of the PWRA. Salinity graphs from a selection of representative monitoring wells illustrate common or important trends in the Lower Aquifer (Figure 5.12).

To the north of the PWRA, 6729-1436 shows a relatively stable or decreasing long-term trend. Decreases in groundwater salinity at 6729-1436 are likely to be due to managed aquifer recharge operations coincident with this well's location.

To the south, MOR143 and BRS129 show a relatively stable salinity over the monitoring period.

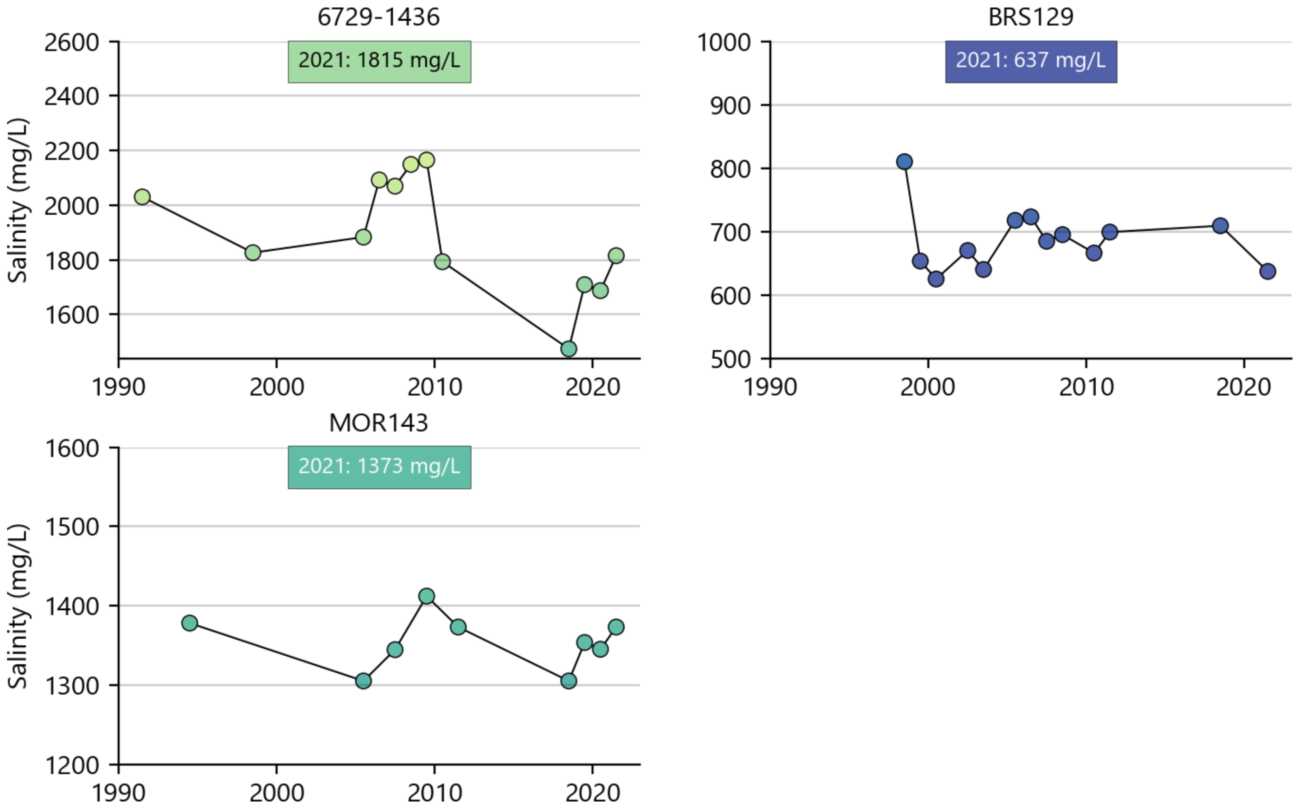


**Figure 5.12 Selected Lower Aquifer salinity graphs**

## 5.6 Fractured rock aquifer water levels

In 2021, winter-recovered water levels in 17 out of 23 (75%) monitoring wells in the fractured rock aquifers are classified 'Below average' or lower (Figure 5.13).

Over the past 20 years, variations in water level in 22 wells range from a decline of 15.42 m to a rise of 2.98 m (median is a decline of 2.8 m).

Five-year trends show declining water levels in the majority of wells (67%), with rates of decline ranging between 1.15 to 0.04 m/y (median is a decline of 0.50 m/y) (Figure 5.14).

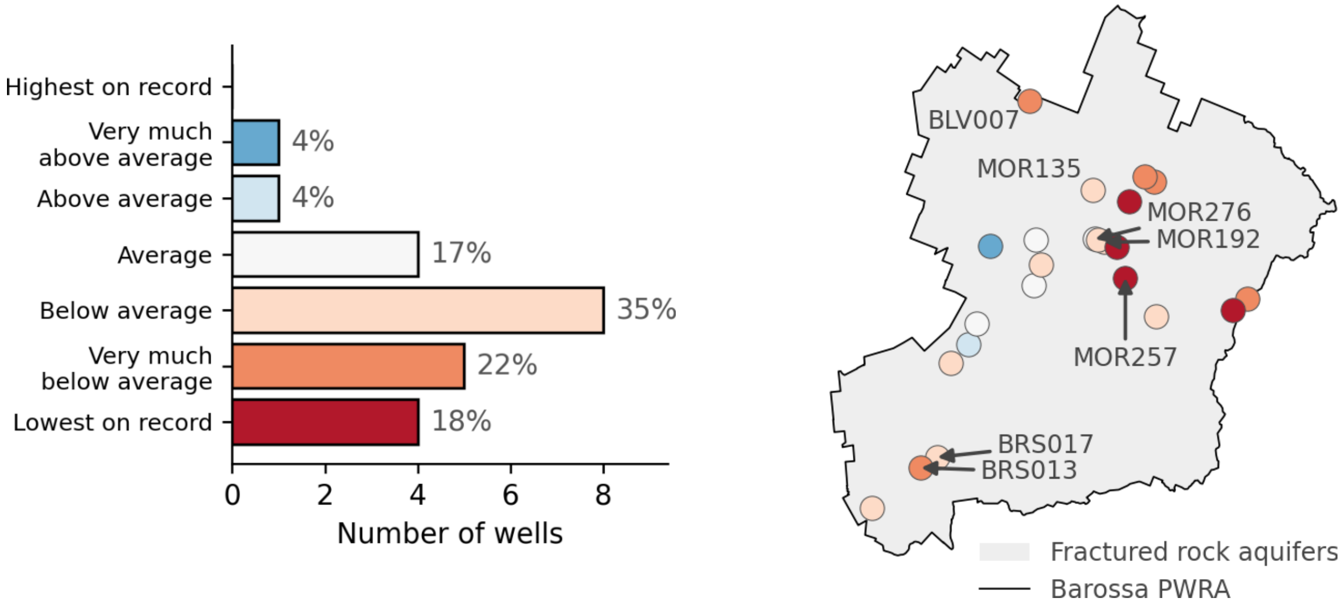


**Figure 5.13 2021 recovered water levels for fractured rock aquifers**

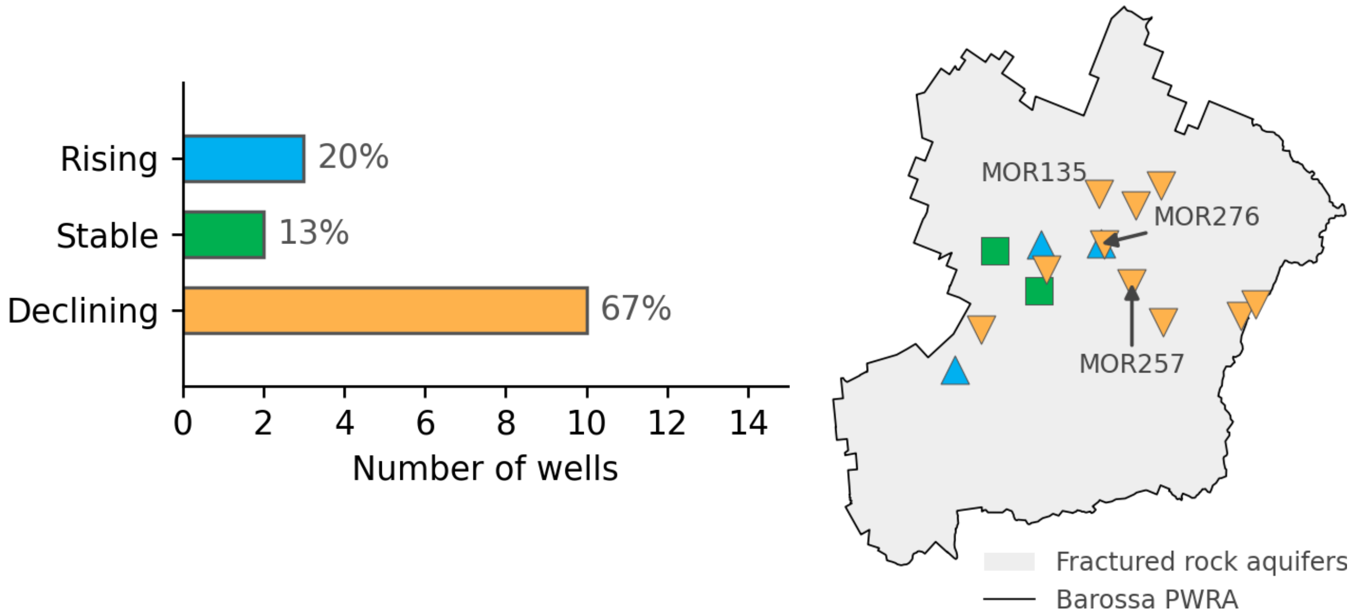


**Figure 5.14 2017–21 trend in recovered water levels for wells in fractured rock aquifers**

Hydrographs from a selection of representative monitoring wells illustrate common or important trends in fractured rock aquifers (Figure 5.15). Groundwater is extracted from these aquifers across the PWRA with many users in the vicinity of Angaston and Lyndoch where sedimentary aquifers are absent. South of Angaston, at e.g., MOR257, water levels have declined more than 7 m in the past 20 years. This may be due to a combination of sustained groundwater pumping and below-average rainfall in the area (e.g., at BoM rainfall station 23300 at Angaston). To the west of Angaston, groundwater levels are generally stable, possibly due to increased use of imported water since 2002 via the BIL scheme (e.g., MOR192). Near Lyndoch, most observation wells show trends of declining water levels (e.g., BRS013).

Fractured rock aquifers are used less frequently where shallower sedimentary aquifers are present and consequently, observation wells generally show stable water levels or gradual declines in these areas (MOR135).

Further north, fractured rock aquifers show higher salinities and as such, rates of groundwater extraction are low. In this area, BLV007 shows a consistent trend of declining water levels since monitoring began in 1980.

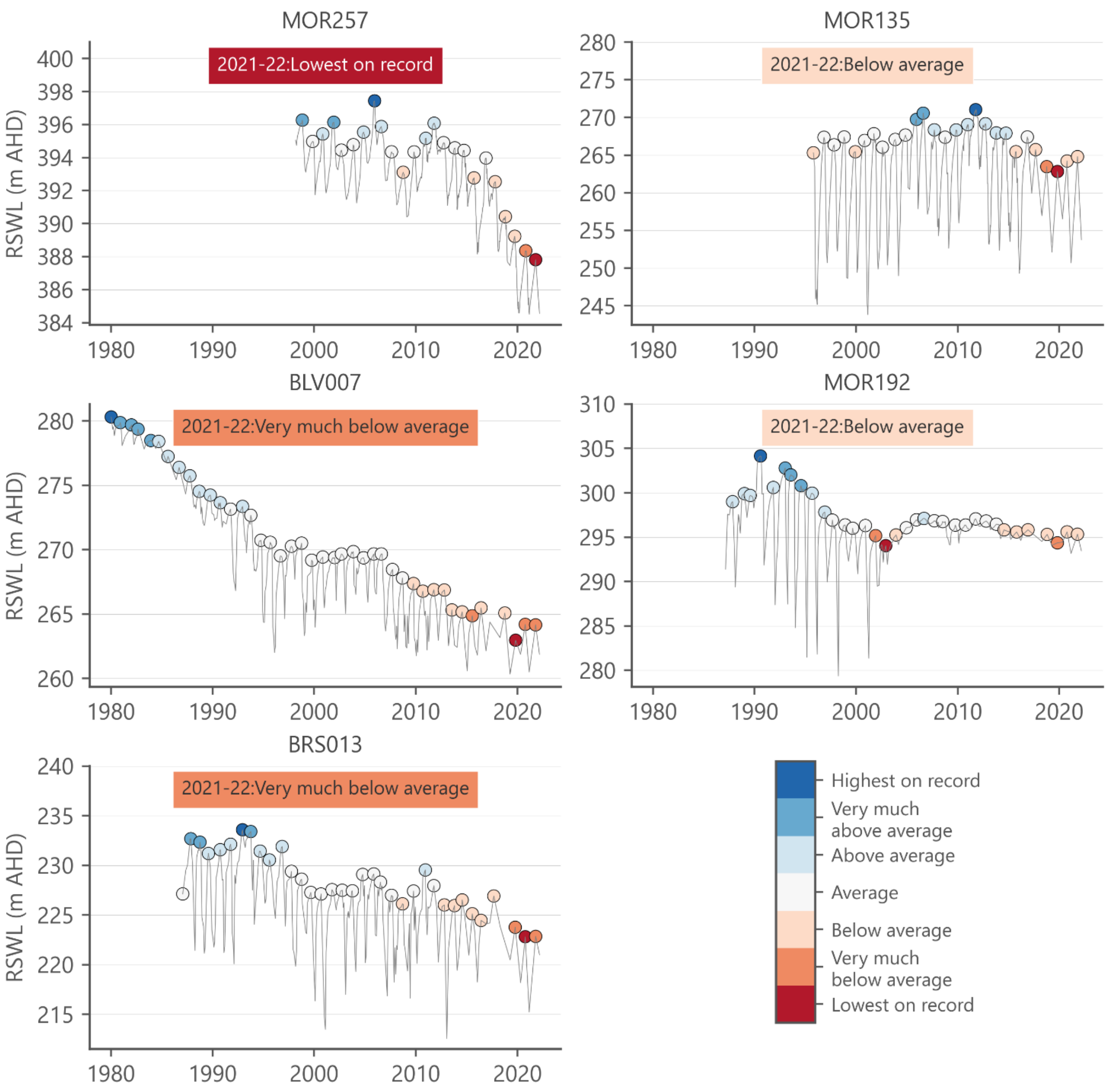


**Figure 5.15 Selected hydrographs for wells in fractured rock aquifers**

## 5.7 Fractured rock aquifer salinity

Since 2018, irrigators in the Barossa PWRA have submitted groundwater salinity samples. In 2021, sampling results from 12 wells in the fractured rock aquifers range between 461 mg/L and 2,973 mg/L with a median of 1,407 mg/L (Figure 5.16).

In the fifteen years to 2021, 4 of 6 wells (67%) show an increasing trend in salinity (see Section 2.3.2 for details of the calculation). Fifteen-year trends show that rates of change in salinity vary from a decrease of 0.2% per year to an increase of 2.3% per year, with a median rate of 0.2% increase per year (Figure 5.17).

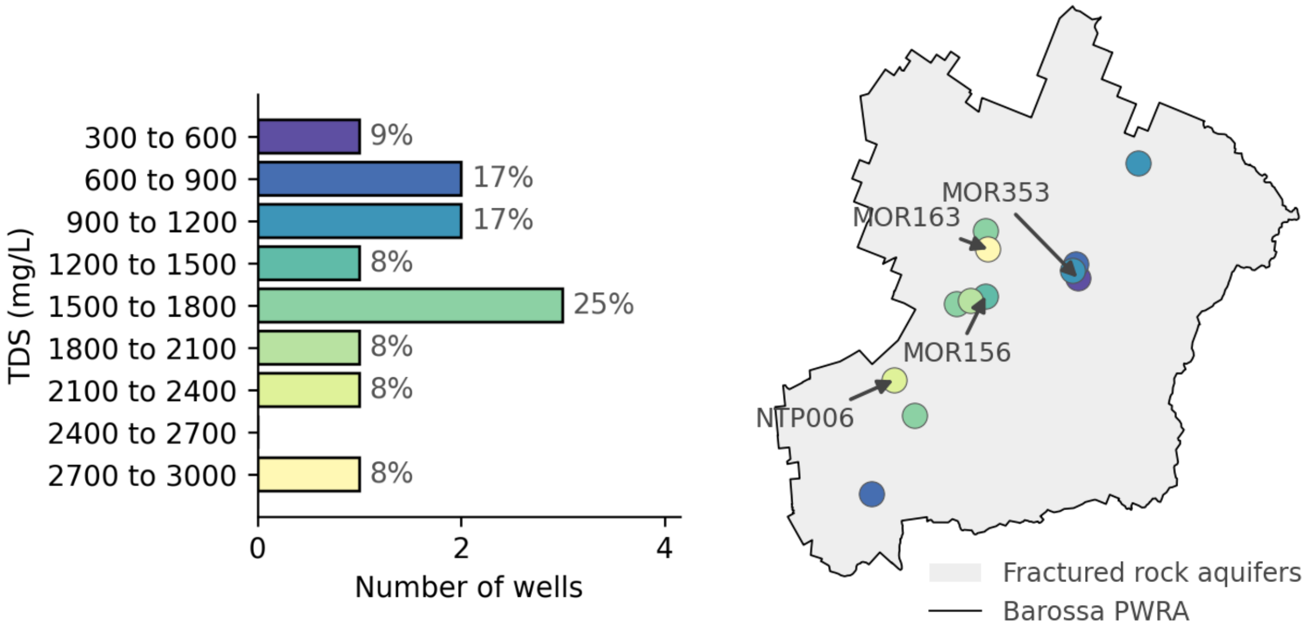


**Figure 5.16 2021 salinity observations in fractured rock aquifers**

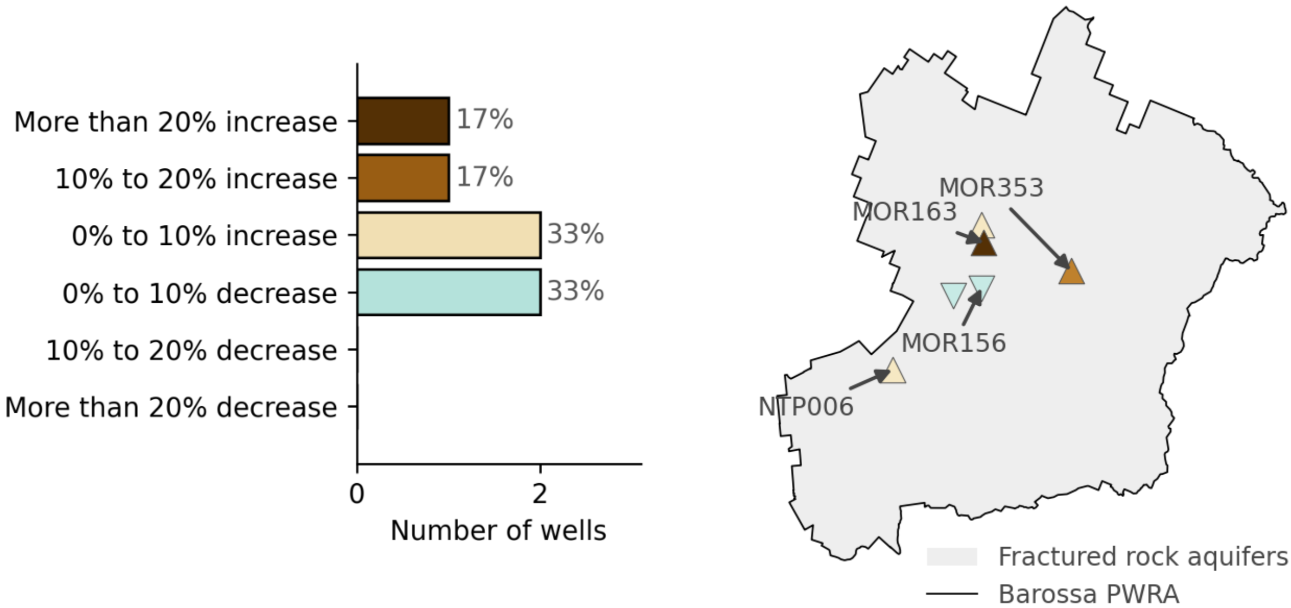


**Figure 5.17 Salinity trend in the 15 years to 2021 in fractured rock aquifers**

Groundwater salinity in fractured rock aquifers can be highly variable due to complex systems of preferential flow paths that affect recharge and movement of water through the aquifer. Groundwater salinity in the fractured rock aquifers of the Barossa PWRA is typically less than 3,000 mg/L but can be greater than 6,000 mg/L.

Salinity graphs from a selection of representative monitoring wells illustrate common or important trends in the fractured rock aquifers (Figure 5.18). In areas of intensive irrigation, and since the early-2000s, monitoring wells typically show increases in groundwater salinity (e.g., MOR163 and NTP006). Further south at Rowland Flat, NTP006 shows a rapid increase in groundwater salinity in the 1990's but, since the early-2000s salinity has been relatively stable.

MOR353 south of Angaston and MOR156 located to the east of Tanunda show relatively stable salinity since groundwater monitoring commenced.

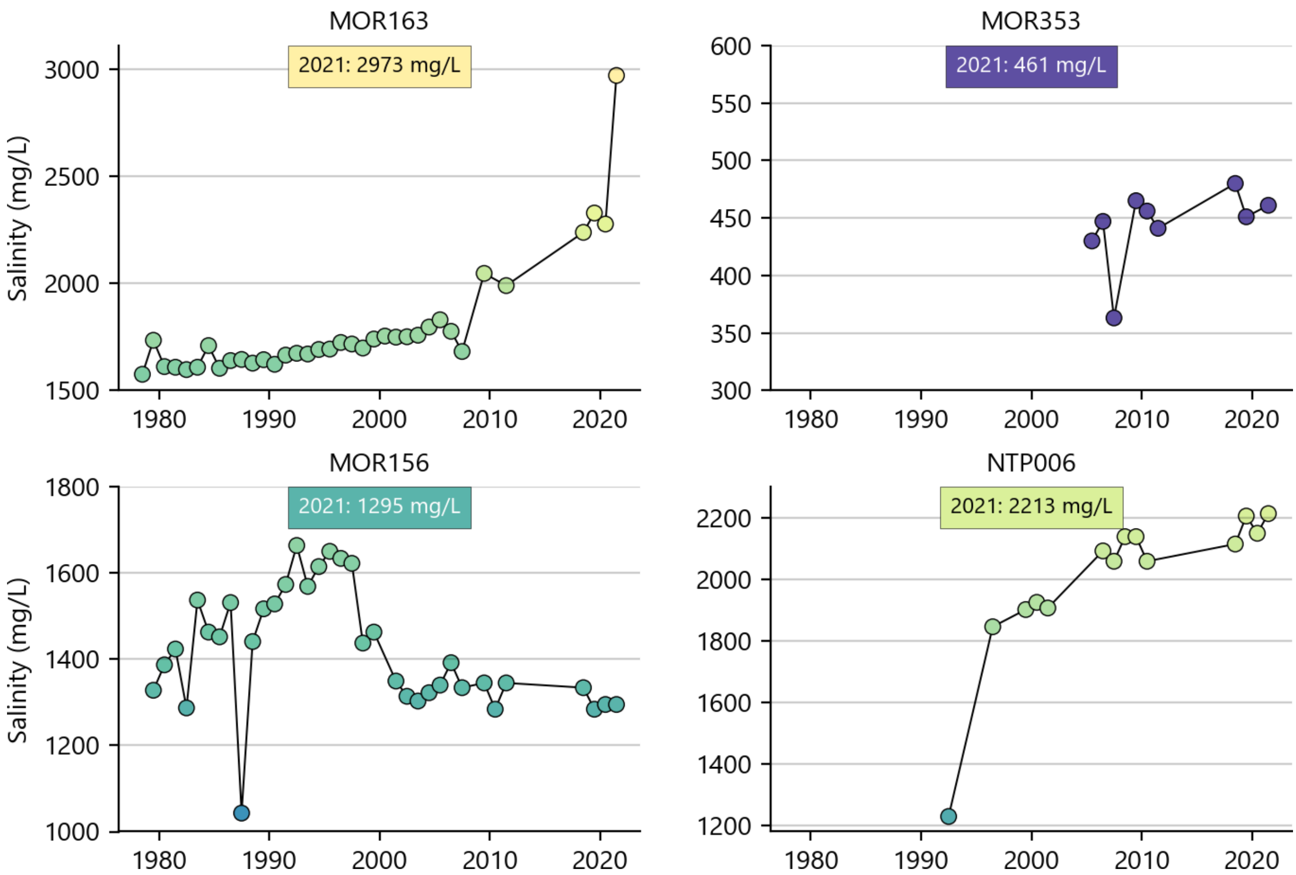


**Figure 5.18 Selected fractured rock aquifers salinity graphs**

# 6 Water use

The main consumptive uses in the Barossa PWRA are divided into non-licensed (stock and domestic uses), and licensed purposes (e.g., irrigation and industrial use). Water sources include groundwater, watercourses, farm dams, imported water from the SA Water mains network and water supply from Barossa Infrastructure Ltd (BIL) via SA Water infrastructure. Imported water is transferred from the River Murray to the PWRA.

The total volume of water used in 2020–21 (1 July to 30 June) is 19,801 ML (Figure 6.1). This includes metered groundwater extraction across the Barossa PWRA (Section 6.1) and surface water volumes, which includes water imported into the PWRA via the BIL scheme and SA Water (Section 6.2).

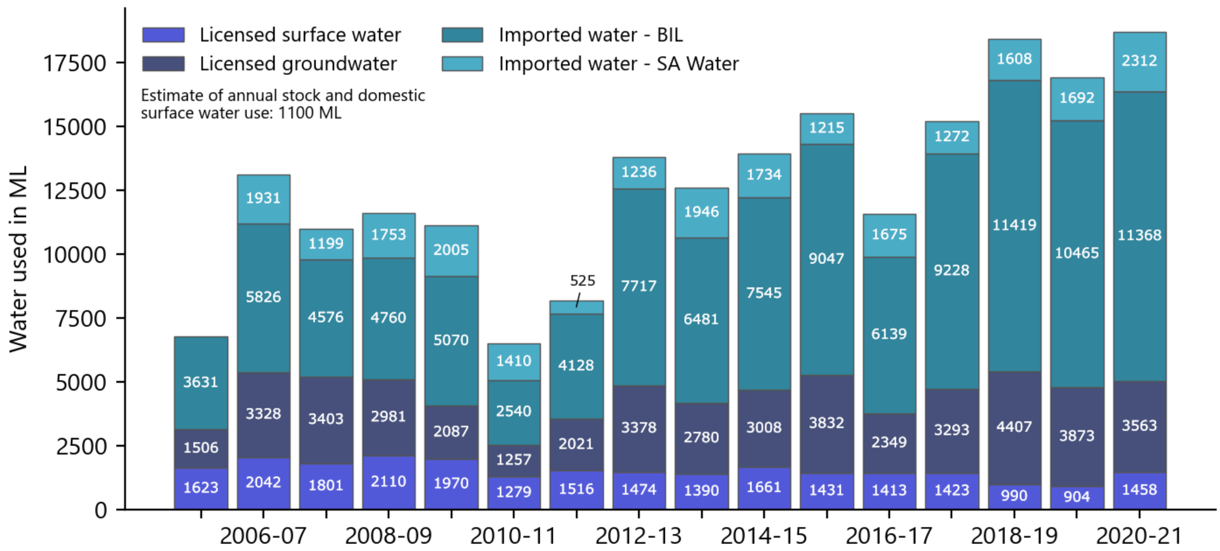


**Figure 6.1 Water used from 2005–06 to 2020–21 for the Barossa PWRA**

## 6.1 Groundwater use

In 2020–21, licensed groundwater extractions (from fractured rock aquifers, the Lower Aquifer, and Upper Aquifer) are 3,563 ML, compared to 3,873 ML in 2019–20 (Figure 6.2). The greatest extractions are from the fractured rock aquifers (54%).

The Lower Aquifer also provides a considerable volume (35%), although the aquifer has a limited spatial extent. The smallest volumes are extracted from the Upper Aquifer (11%) due to its smaller spatial extent, the limited thickness of the aquifer in some areas and the unsuitability for irrigation due to higher salinity towards the north of the PWRA., There have been no significant changes in the relative distribution of the total extracted volumes between the three main aquifers since comprehensive extraction data became available.

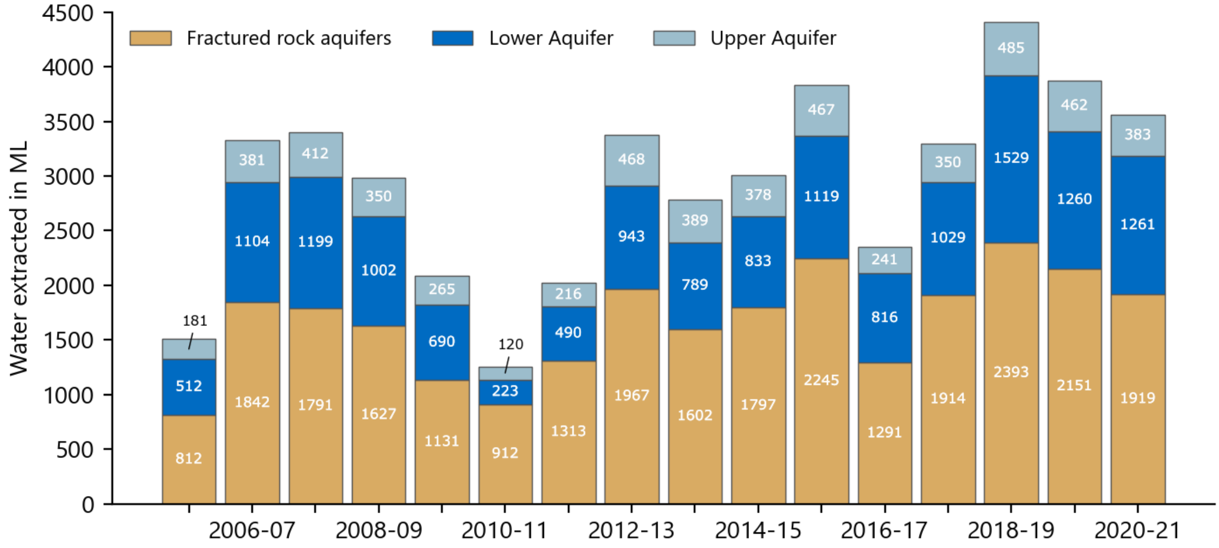


**Figure 6.2 Metered groundwater extraction for the Barossa PWRA**

## 6.2 Surface water use

Total surface water allocation for the Barossa PWRA in 2020–21 is 16,238 ML (compared to 14,161 ML in 2019–20). This consists of (Figure 6.1):

- 251 ML from licensed surface water sources (dams)
- 1,207 ML from licensed watercourse sources
- 11,368 ML from the Barossa Infrastructure Limited (BIL) Scheme, including 310 ML of treated recycled water from the Community Wastewater Management System
- 2,312 ML imported water from the SA Water mains network
- 1,100 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].

### 6.2.1 Farm dams

There are a total of 1,780 farm dams in the Barossa PWRA, 14% of which are licensed. Licensed dams represent 68% of the total estimated storage capacity of 8,692 ML (Jones-Gill and Savadamuthu 2014; DEW 2022). Across the PWRA, smaller dams (capacity less than 5 ML) account for the majority of the number of dams (84%) but represent only a small proportion (18%) of the total storage capacity of dams. Larger dams (5 ML or greater capacity) make up only 16% of the total dam count but contribute to 82% of the total storage capacity (Figure 6.3). The average farm dam density (i.e., ML of dam storage per km$^2$) in the PWRA is 17 ML/km$^2$, with the higher rainfall headwaters having a higher density in comparison to the lower rainfall areas (Figure 6.3).

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[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.

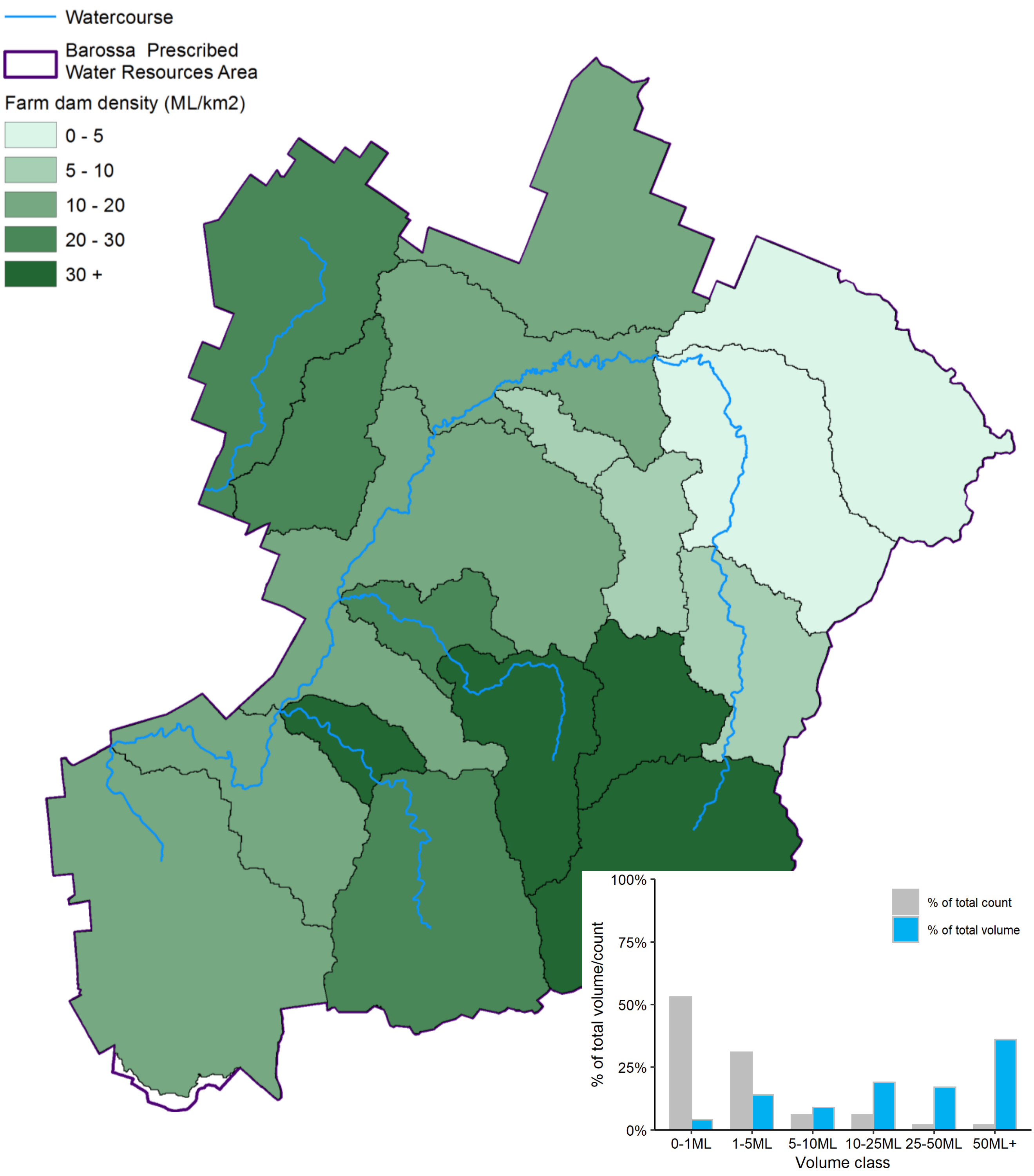


**Figure 6.3 Farm dam density, count and volume analysis in the Barossa PWRA**

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