Limestone Coast Prescribed Areas 2020–21 water resources assessment

Department for Environment and Water
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DEW Technical Note 2022/13

Government of South Australia
Department for Environment and Water

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1 Summary

Lower Limestone Coast PWA	Confined aquifer		
	Unconfined aquifer	Highlands	
		Lowlands	
Morambro PA	Surface water	Morambro Creek	
Padthaway PWA	Unconfined aquifer	Flats	
		Range	
Tatiara PWA	Confined aquifer		
	Unconfined aquifer	Highlands	
		Plains	
Tintinara-Coonalpyn PWA	Confined aquifer		
	Unconfined aquifer	Mallee Highlands	
		Plains	

LEGEND

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

Rainfall

- Rainfall totals are typically higher in southern coastal areas and decrease towards the north of the Limestone Coast prescribed areas. Rainfall across the region in 2020–21 (July to June) is below the 1970 to 2021 period of record annual average for most stations.
- Annual rainfall is 697 mm at Mount Gambier in the Lower Limestone Coast Prescribed Wells Area (PWA) and 416 mm at Frances in the Morambro Creek Prescribed Surface Water Area (PSWA), both below their 1970 to 2021 annual averages of 716 mm/y and 512 mm/y, respectively.
- Annual rainfall is 394 mm in the Tatiara PWA and 392 mm in the Tintinara-Coonalpyn PWA, both below their 1970 to 2021 annual averages of 454 mm/y and 427 mm/y, respectively.
- Annual rainfall is 499 mm in the Padthaway PWA, commensurate with the 1970 to 2021 annual average of 508 mm/y.

Surface water

- In 2020–21 (July to June), streamflow is classified 'Lowest on record' (i.e., no flow) for the gauging station in the Morambro Creek PSWA. Streamflow data for 1979 to 2021 shows a declining trend for this site.
- Salinity data reported for the Morambro creek gauging station is unavailable for 2020–21 due to the lack of streamflow at the site.

Groundwater

- In the Lower Limestone Coast PWA, unconfined aquifer water levels in the coastal plains are mainly classified 'Average' (46%) or 'Below average' (38%). In the highlands area, levels are mostly classified 'Below average' or lower (96%). In the confined aquifer, pressure levels are mainly classified 'Average' or higher (70%).
- In the Padthaway PWA, water levels in the unconfined Padthaway Flats Groundwater Management Area (GMA) are mainly classified 'Below average' (60%), while those in the eastern Padthaway Range GMA are classified mainly 'Average' or higher (64%).
- In the Tatiara PWA, water levels in the unconfined aquifer in the plains and highland areas are classified mostly 'Below average' or lower (93% and 92% respectively). Pressure levels in the confined aquifer are mostly classified 'Lowest on record' (80%).
- In the Tintinara-Coonalpyn PWA, in the unconfined aquifer, water levels are mostly classified 'Below average' or lower (52%) in the plains area and 'Lowest on record' (57%) in the Mallee highlands area. In the confined aquifer, pressure levels are classified mostly 'Below average' or lower (65%).

Water use

- Groundwater is the source of almost all consumptive water in the Limestone Coast Landscape region – it is used for irrigation, industry, stock and domestic uses and town water supplies. Typically only small volumes of surface water are diverted from Morambro Creek and in 2020–21, a lack of streamflow prevented any watercourse extraction.
- Licensed groundwater extraction from all aquifers in 2020–21 is 358,690 ML (excluding estimated forest water use from the Lower Limestone Coast PWA of 240,000 ML).

1.1 Purpose

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

- **Technical Notes**: (this document) provides detailed information and assessment for each resource area, helping to identify resource condition in further detail.
- **Fact sheets**: provides 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 prescribed areas of the Limestone Coast Landscape region and collates rainfall, surface water, groundwater, and water-use data for 2020–21.

1.2 Regional context

The Limestone Coast Landscape Region encompasses much of the south-eastern part of South Australia, stretching southwards and eastwards from the area near Lake Albert to the Victorian border (Figure 1.1). The area incorporates coastal plains, dunes and inter-dunal flats, with highlands and ranges in the eastern areas. There is also an extensive network of drains across the landscape to assist in the management of water, soils, and biodiversity. There are seven different areas and watercourses that are prescribed under the *Landscape South Australia Act 2019*, which together constitute this assessment. These prescribed water resources are managed by principles in five separate water allocation plans, namely the:

- Water Allocation Plan for the Lower Limestone Coast PWA (SE NRM Board, 2013), which covers an area of approximately 14,500 km^2 between Kingston South East (SE), Naracoorte and Mount Gambier
- Water Allocation Plan for the Padthaway PWA (SE NRM Board, 2009), which covers an area of approximately 700 km^2 and is centred on the township of Padthaway
- Water Allocation Plan for the Tatiara PWA (SE NRM Board, 2010), which covers an area of approximately 3,500 km^2 between Keith and Bordertown, extending north to Ngarkat Conservation Park
- Water Allocation Plan for the Tintinara-Coonalpyn PWA (SE NRM Board, 2012), which covers an area of approximately 3,400 km^2 between Tintinara and Coonalpyn, extending eastward across the southern part of Ngarkat Conservation Park
- Water Allocation Plan for the Morambro Creek and Nyroca Channel Prescribed Watercourses including Cockatoo Lake and the Prescribed Surface Water Area (SE NRM Board, 2006), which covers the two prescribed watercourses, and the Morambro Creek Prescribed Surface Water Area (PSWA) that is located approximately 20 km south-east of Padthaway, encompassing an area of around 225 km^2 and extending to South Australia's state border with Victoria.

Groundwater is the source of almost all consumptive water in the Limestone Coast Landscape region and uses include irrigation, industry, stock and domestic, and town water supplies. In the Lower Limestone Coast Water Allocation Plan, plantation forests are also recognised to be using groundwater where depth to groundwater is less than 6 m below ground. There are two main groundwater systems: the upper unconfined Tertiary Limestone Aquifer (known generally as the unconfined aquifer) and the underlying Tertiary Confined Sand Aquifer (known generally as the confined aquifer) (SE NRM Board, 2013). The confined and unconfined aquifers are generally separated by a low-permeability aquitard.

Morambro Creek is the only prescribed surface water resource in the Lower Limestone Coast PWA. The headwaters of Morambro Creek are located in the Wimmera region in western Victoria. The topography of the Morambro Creek area is predominantly characterised by coastal plains that become increasingly undulating in the highlands, towards the north-western margin of the PWA (Figure 1.1).

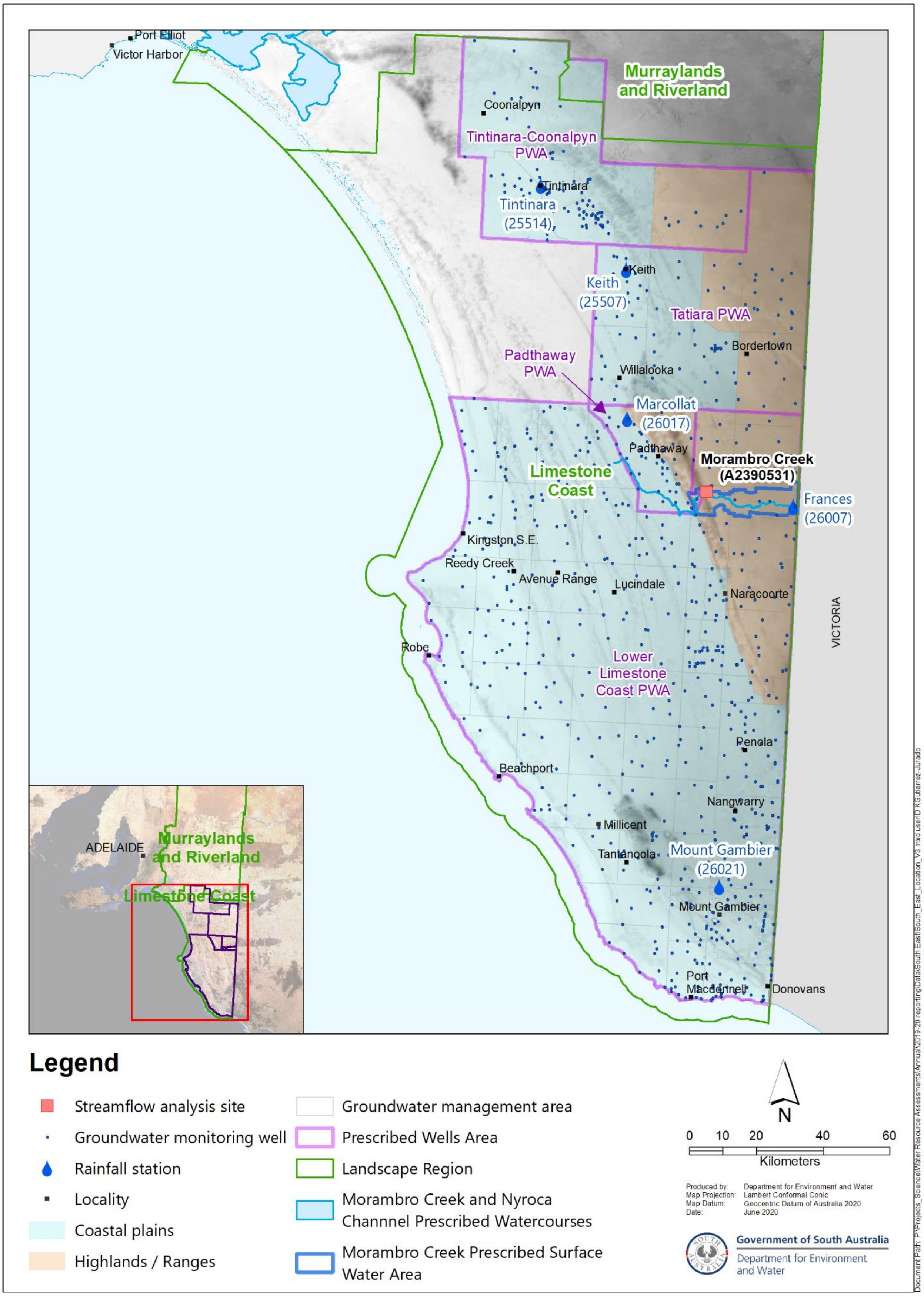


Figure 1.1 Location of prescribed areas of the Limestone Coast Landscape region

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. The data were obtained from the SILO Patched Point Dataset[1] service provided by the Queensland Government, which provides interpolated values to fill any gaps in observations (Figure 3.2 to Figure 3.11).

Rainfall maps were compiled using gridded datasets obtained from the BoM (Figure 3.1). The latest available long-term average 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

Low reliability of streamflow in Morambro Creek has meant there has been no systematic development of the surface water resource and consequently, there is limited surface water monitoring in the prescribed area. The status of the sole streamflow gauging station on the Morambro Creek (A2390531) is determined by expressing the annual streamflow for the reporting year as a percentile[4] of the total period of data availability. The period of data availability for the Morambro Creek gauging station is 1979 to 21. Streamflow data were then given a description based on their percentile and decile[4] (Table 2.2 and Figure 4.1).

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 1979 to 2021 period of record average with the bars shaded using the BoM classification shown in Table 2.2.

2.2.2 Monthly streamflow

Monthly streamflow for the reporting year is assessed alongside the 1979 to 2021 average monthly streamflow and monthly statistics including (a) high flows (75th percentile), (b) median flows (50th percentile) and (c) low flows (25th percentile) (Figure 4.3A). Monthly data is presented for an extended period (July 2020 to September 2021) to capture the full flow season.

2.2.3 Daily streamflow

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

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

[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

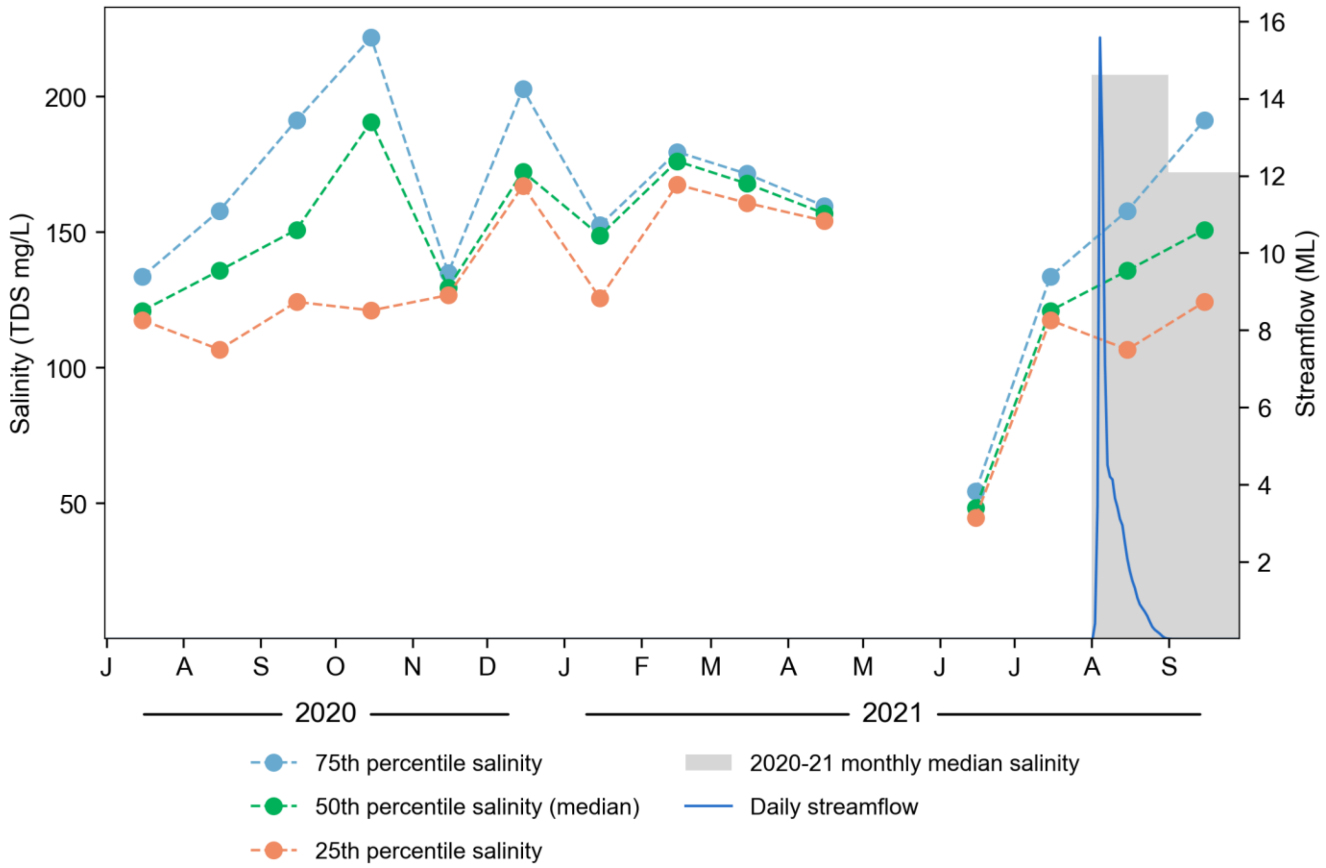
and supporting more sensitive species. Physical and chemical processes such as nutrient transport and groundwater-surface water interactions are also heavily influenced by the flow regime.

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 flow rate (TFR) are the two flow regime metrics commonly assessed. The Morambro Creek Water Allocation Plan (WAP) has no provision for threshold flow rates; therefore, flow days above TFR was left out for this assessment and only number of flowing days are reported in this document. Evaluation of flow days provides a simple yet effective assessment of the waterways flow regime.

The annual number of flow days for the reporting year (July to June) is measured as the number of days with total flow greater than 0.05 ML (50,000 litres). The annual number of flow days is presented for the 1979 to 2021 period of record (Figure 4.4). The 1979 to 2021 trend and the number of years in the last decade above the period of record average are provided. For the assessment of flow days, 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 2006 to 2021 monthly salinity statistics including (a) high salinities (75th percentile), (b) median salinities (50th percentile), and (c) low salinities (25th 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 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 return to a maximum level varies across the area, but mostly occurs between July and December, although some wells do not recover until as late as March of the following year depending on irrigation patterns.

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 as annual streamflow. The thresholds for criteria by which wells are selected varies depending on the history of monitoring activities in different areas; for the Limestone Coast Landscape region PWAs, any well with 10 years or more of recovered water level data is included with the exception of unconfined aquifer monitoring wells in the Lower Limestone Coast PWA and in the coastal plains of the Tatiara PWA, where only those wells with 20 years or more of data are included. This is due to more extensive historical monitoring data in those areas. 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).

Five-year trends are calculated using annual recovered water levels for those wells which have at least 5 measurements (i.e., at least one measurement a year). The trend line is calculated by linear regression and the well is given a status of 'declining', 'rising', or 'stable', depending on whether the slope of this trend line is below, above, or within a given tolerance threshold. This threshold allows for the demarcation of wells where water levels are changing at very low rates and the water level can therefore be considered stable. The threshold also accommodates for very small measurement errors. The number of rising, declining and stable wells are then summarised for each aquifer (e.g., Figure 5.2). Sedimentary confined and unconfined aquifers such as those in the Limestone Coast Landscape region are given tolerance thresholds of 2 cm/y.

Thirty-year changes in water level are calculated as the difference between the average water level in a three-year period 30 years ago (i.e., 1991 to 1993) and the average water level in 2021. Twenty-year changes in water level were calculated in a similar way, using a comparison from the average water level in a three-year period 20 years ago (i.e. 2001 to 2003).

2.3.2 Salinity

Water samples are collected from monitoring wells located across the four PWAs by a variety of methods. Samples are collected from operating irrigation pumps, from flowing artesian wells in the confined aquifer, or by pumping samples from wells where necessary. 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 multiple samples were submitted from a well in a calendar year, the mean salinity is used for analysis. The results are shown for each aquifer (e.g., Figure 5.4).

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[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).

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 (e.g., Figure 5.5).

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 reporting year (1 July to 30 June). Where meter readings are not available, licensed allocated volumes are used for surface water sources (Figure 6.1 to Figure 6.4).

Non-licensed water use (stock and domestic) from farm dams is not metered and is estimated at 30% of dam capacity. Further information on the number and type of farm dams in the prescribed surface water area is provided in Section 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 Limestone Coast Landscape region are:

- summary reports on the surface water (DEWNR 2014) and groundwater resources (DEWNR 2012a, b, c and d) of the South East NRM region, and annual groundwater level and salinity status reports (e.g., DEW 2019a, b, c, d and e) and the annual surface water status report (e.g., DEW 2019f)
- the Water Allocation Plan for the Lower Limestone Coast PWA, as amended in June 2019 (SE NRM Board 2013)
- Wood (2017), Cranswick (2018), Cranswick and Herpich (2018), Harding, Herpich and Cranswick (2018) and Simmons et al. (2019), which provide detailed assessments of the hydrogeology and interaction between groundwater and surface water resources in the Lower Limestone Coast PWA
- the Water Allocation Plan for the Padthaway PWA (SE NRM Board 2009)
- the Water Allocation Plan for the Tatiara PWA (SE NRM Board 2010)
- Li and Cranswick (2017) and Cranswick and Li (2018), which provide details of the hydrogeology and groundwater modelling for the Tatiara WAP
- the Water Allocation Plan for the Tintinara-Coonalpyn PWA (SE NRM Board 2012)
- Cranswick and Barnett (2017), which provides details of the conceptual groundwater system in the Tintinara-Coonalpyn and Tatiara PWAs
- the Water Allocation Plan for the Morambro Creek and Nyroca Channel Prescribed Watercourses, including Cockatoo Land and the Prescribed Surface Water Area (SE NRM Board 2006)
- Whiting and Savadamuthu (2018), which provides a technical review of the current farm dam policy in the South East NRM Plan and reviews and revises other hydrological principles underlying this plan
- the Water Security Statement 2022 – Water for Sustainable Growth (DEW 2022).

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

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

3 Rainfall

Average annual rainfall in the Limestone Coast Landscape region ranges from approximately 750 mm in the southern coastal areas to >400 mm in the north (Figure 3.1). The highest annual rainfall totals can be up to 1,000 mm around Mount Burr in the south.

Rainfall in 2020–21 (July to June) is similar to the long-term (1986 to 2015) average annual rainfall in the southern part of the Limestone Coast Landscape region, however, lower than average rainfall bands are observed in the central and northeast parts of the region (Figure 3.1)[9].

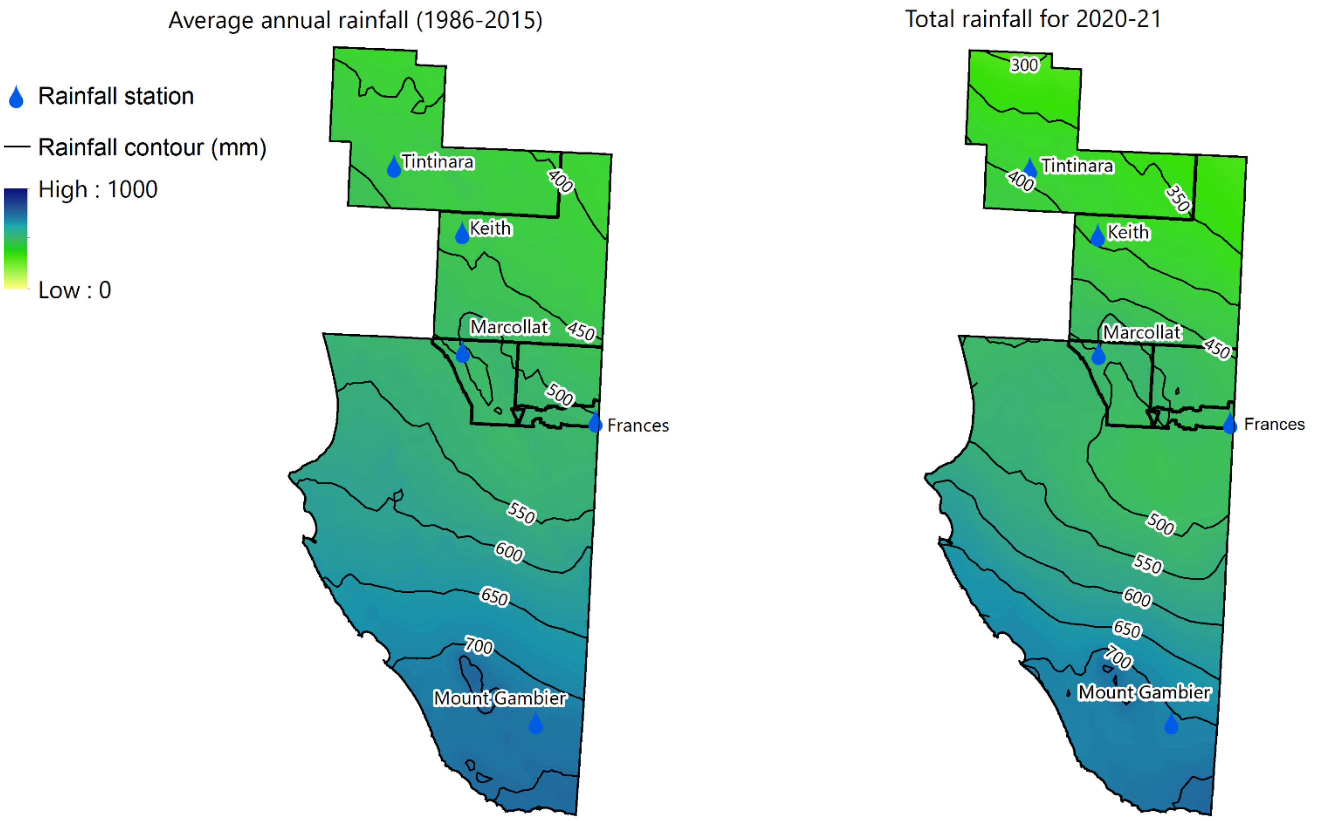

Figure 3.1 Rainfall in the Limestone Coast prescribed areas for 2020–21 compared to the standard 30-year climatological average (1986 to 2015)

A set of five stations were selected to represent the spatial variation of precipitation across the different prescribed areas on the Limestone Coast Landscape region (Figure 3.1). The common period of record used for these stations is 1970 to 2021. The Mount Gambier station in the Lower Limestone Coast PWA (Figure 3.2 and Figure 3.3), Frances station in the Morambro Creek Prescribed Surface Water Area (PSWA) (Figure 3.4 and Figure 3.5), Marcollat station in the Padthaway PWA (Figure 3.6 and Figure 3.7), Keith station in the Tatiara PWA (Figure 3.8 and Figure 3.9), and Tintinara in the Tintinara-Coonalpyn PWA (Figure 3.10 and Figure 3.11).

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

3.1 Lower Limestone Coast PWA and Morambro Creek PSWA

The Mount Gambier airport rainfall station (BoM station 26021) represents the higher rainfall areas at the southern part of the Lower Limestone PWA. The Frances rainfall station (BoM station 26007) is located 30 km north-east of Naracoorte and represents the Morambro Creek PSWA and the lower rainfall areas in the northern part of the Lower Limestone Coast PWA (Figure 3.1).

Total annual rainfall recorded in 2020–21 is 697 mm at Mount Gambier and 416 mm at Frances, both below the 1970 to 2021 average annual rainfall (Figure 3.3 and Figure 3.5). Total annual rainfall (1970 to 2021) for the Mount Gambier station is mostly stable, primarily due to above-average and average annual values for 4 out of the past 5 years, while for the Frances station the data indicates a declining trend.

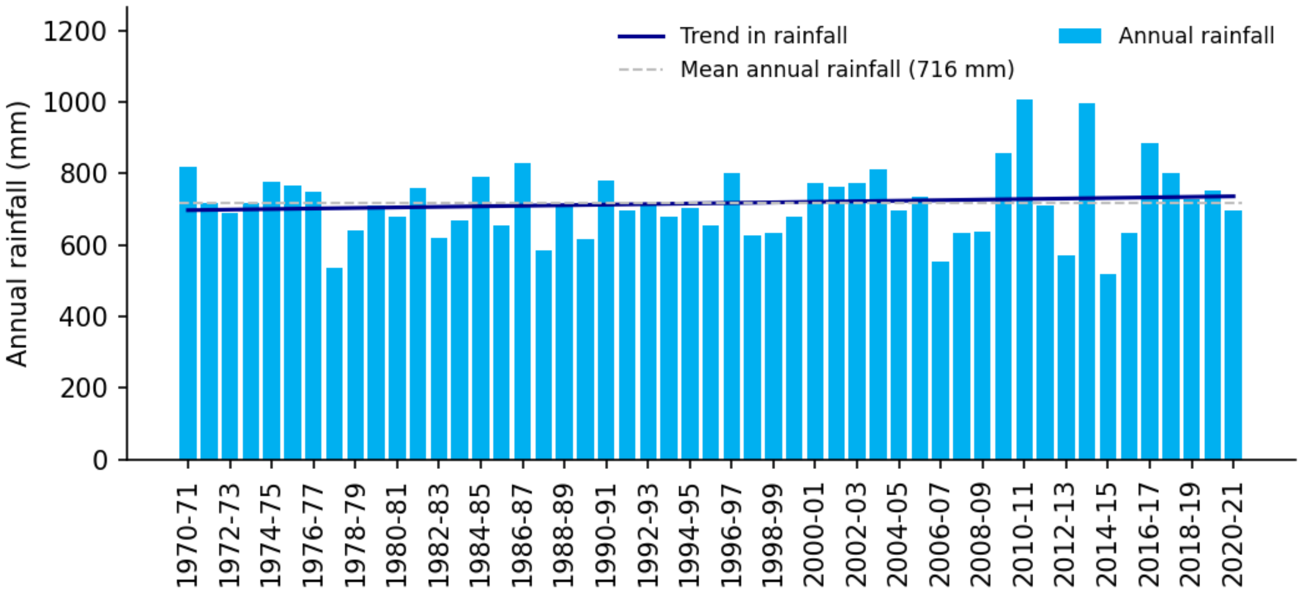

Figure 3.2 Annual rainfall for 1970–71 to 2020–21 at the Mount Gambier rainfall station (BoM station 26021)

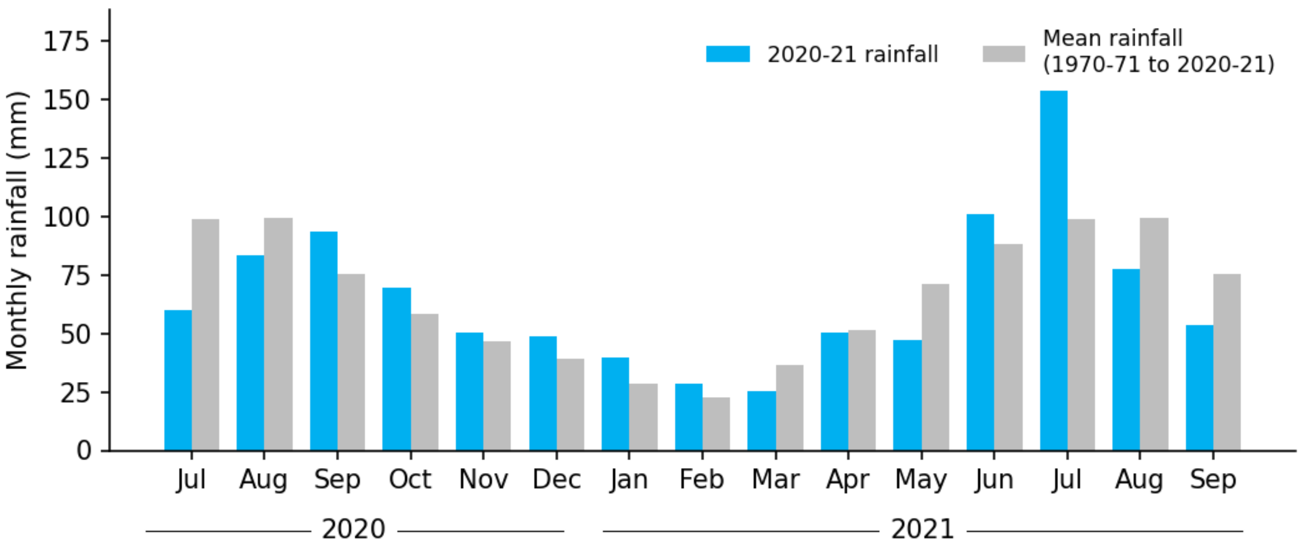

Figure 3.3 Monthly rainfall between July 2020 and September 2021, compared to the 1970–71 to 2020–21 monthly average at the Mount Gambier rainfall station (BoM station 26021)

Above-average monthly rainfall is observed in Mount Gambier during September to December 2020 and during June and July 2021 (Figure 3.3). In Frances, above-average monthly rainfall is observed during September and October 2020 and February, June and July 2021 (Figure 3.5). Drier than average autumn months (March, April and May) are observed at both stations in 2021.

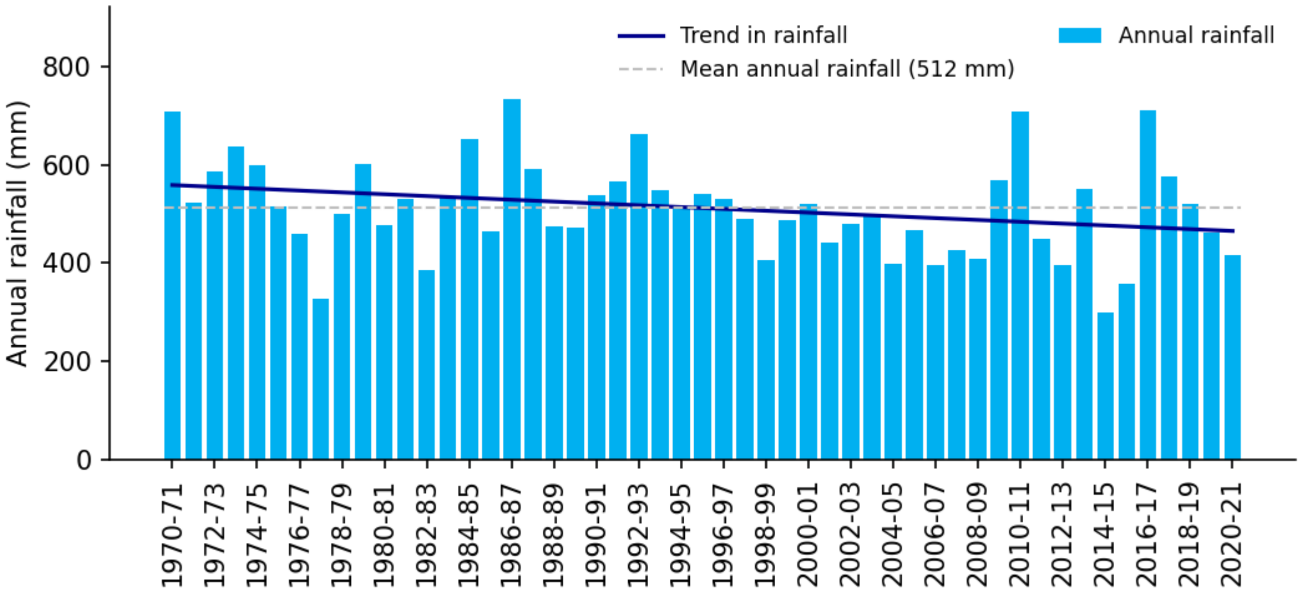

Figure 3.4 Annual rainfall for 1970–71 to 2020–21 at the Frances rainfall station (BoM station 26007)

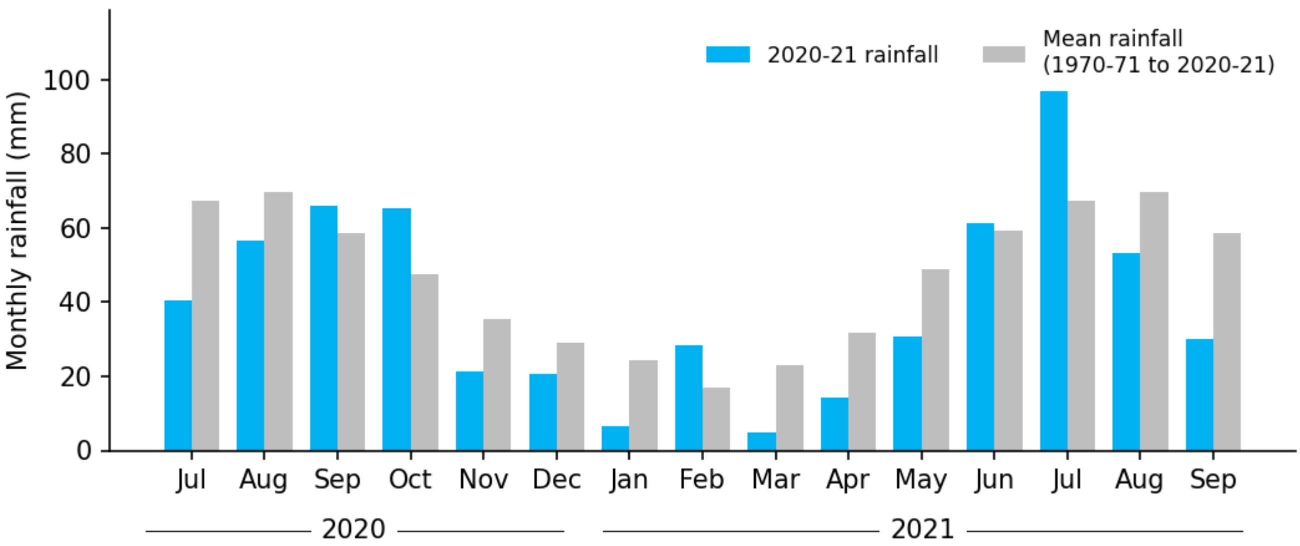

Figure 3.5 Monthly rainfall between July 2020 and September 2021, compared to the 1970–71 to 2020–21 monthly average at the Frances rainfall station (BoM station 26007)

3.3 Padthaway PWA

The Marcollat rainfall station (BoM station 26017) is located 15 km north-west of Padthaway and represents the Padthaway PWA. Total annual rainfall recorded in 2020–21 is 499 mm which is commensurate with the 1970 to 2021 annual average (Figure 3.6). The trend in annual rainfall (1970 to 2021) for the Marcollat station is declining (Figure 3.6)Figure 3.8.

Above-average monthly rainfall is observed during September and October 2020, and January, February, June and July 2021, with the remaining months drier than average (Figure 3.7).

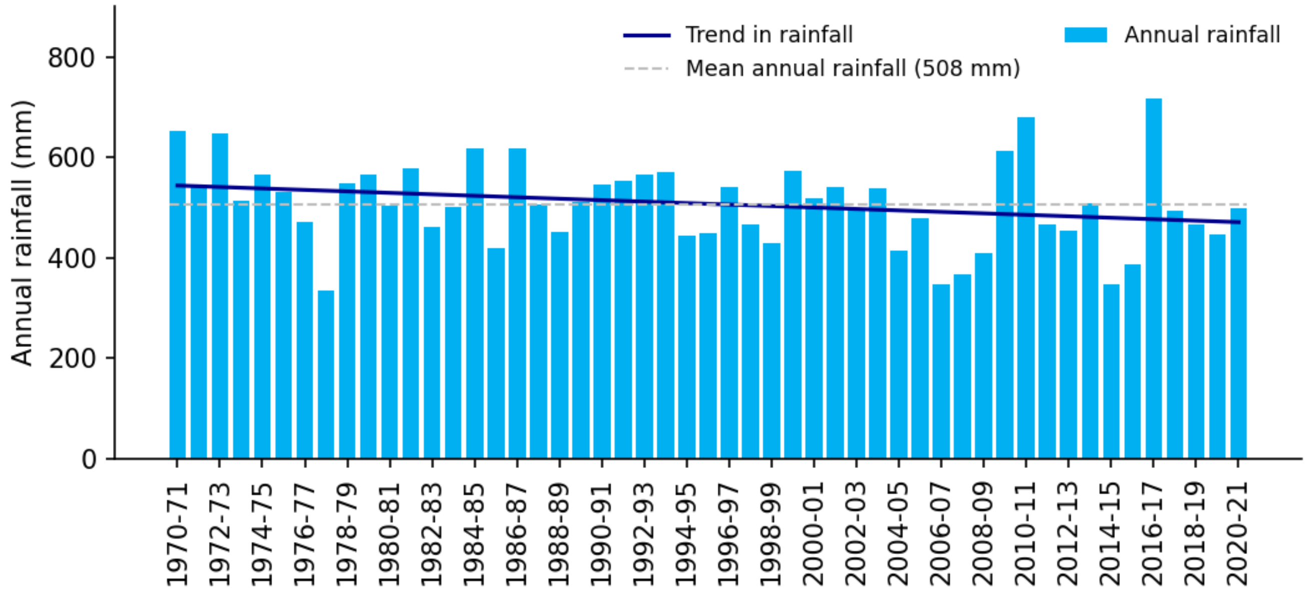

Figure 3.6 Annual rainfall for 1970–71 to 2020–21 at the Marcollat rainfall station (BoM station 26017)

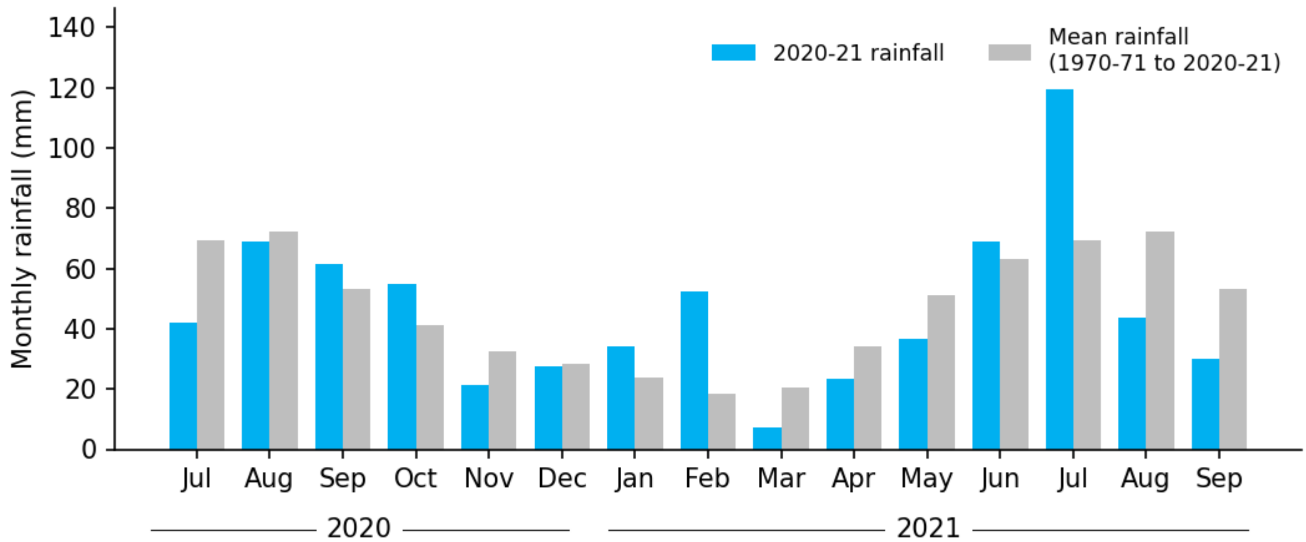

Figure 3.7 Monthly rainfall between July 2020 and September 2021, compared to the 1970–71 to 2020–21 monthly average at the Marcollat rainfall station (BoM station 26017)

3.4 Tatiara PWA

The Keith rainfall station (BoM station 22507) represents the Tatiara PWA. Total annual rainfall recorded in 2020–21 is 394 mm which is below the 1970 to 2021 average annual rainfall (Figure 3.8). The trend in annual rainfall (1970 to 2021) for the Keith station is declining with the last 3 years showing below-average annual rainfall (Figure 3.8).

Above-average monthly rainfall is observed during September and October 2020, and February, June and July 2021, while the remaining months are below-average (Figure 3.9).

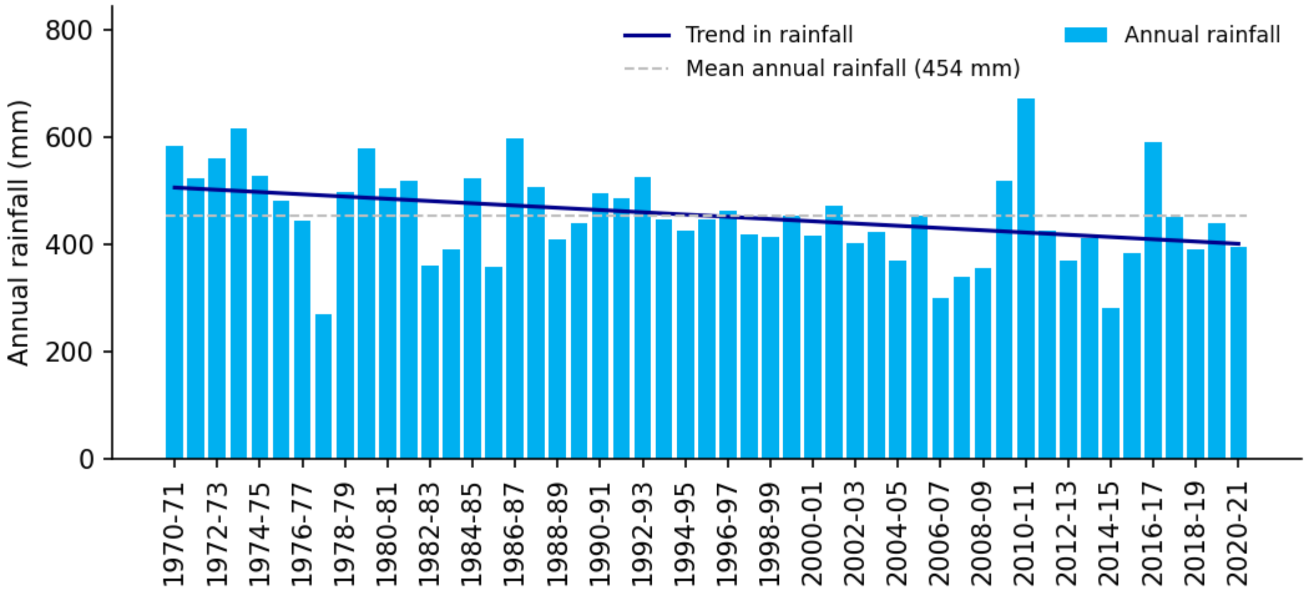

Figure 3.8 Annual rainfall for 1970–71 to 2020–21 at the Keith rainfall station (BoM station 25507)

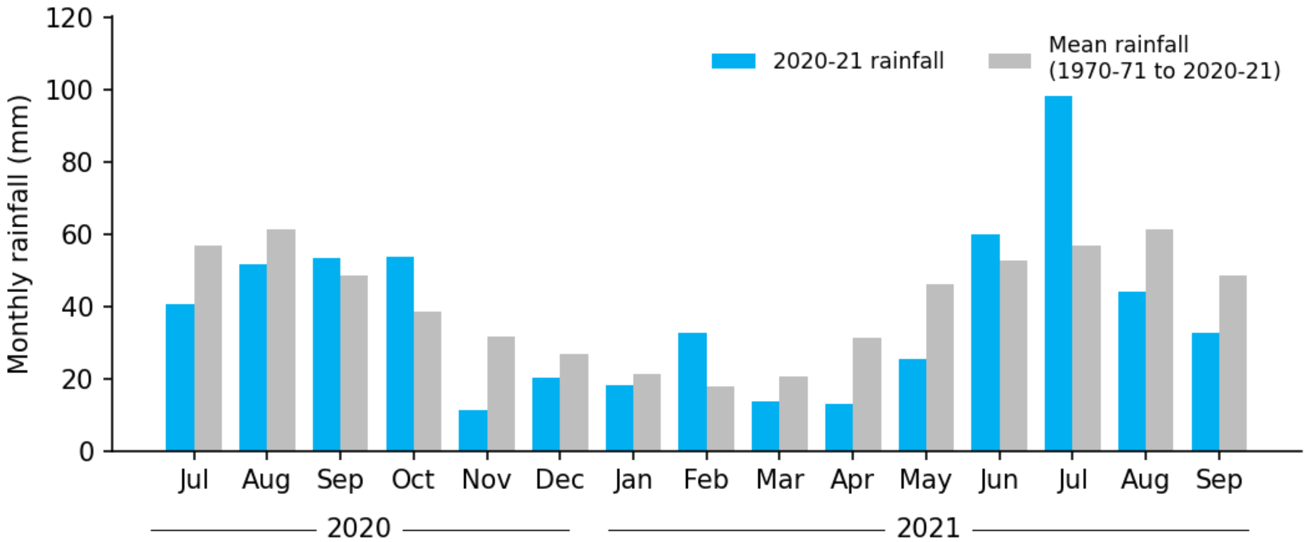

Figure 3.9 Monthly rainfall between July 2020 and September 2021, compared to the 1970–71 to 2020–21 monthly average at the Keith rainfall station (BoM station 25507)

3.6 Tintinara-Coonalypn PWA

The Tintinara rainfall station (BoM station 25514) represents the Tintinara-Coonalpyn PWA. Total annual rainfall recorded in 2020–21 is 392 mm at Tintinara (Figure 3.10) which is below the 1970 to 2021 average annual rainfall. The trend in annual rainfall (1970 to 2021) for Tintinara is declining (Figure 3.10).

Above-average monthly rainfall is observed during August, September and October 2020, and February, June and July 2021, while the remaining months are average or below-average (Figure 3.11).

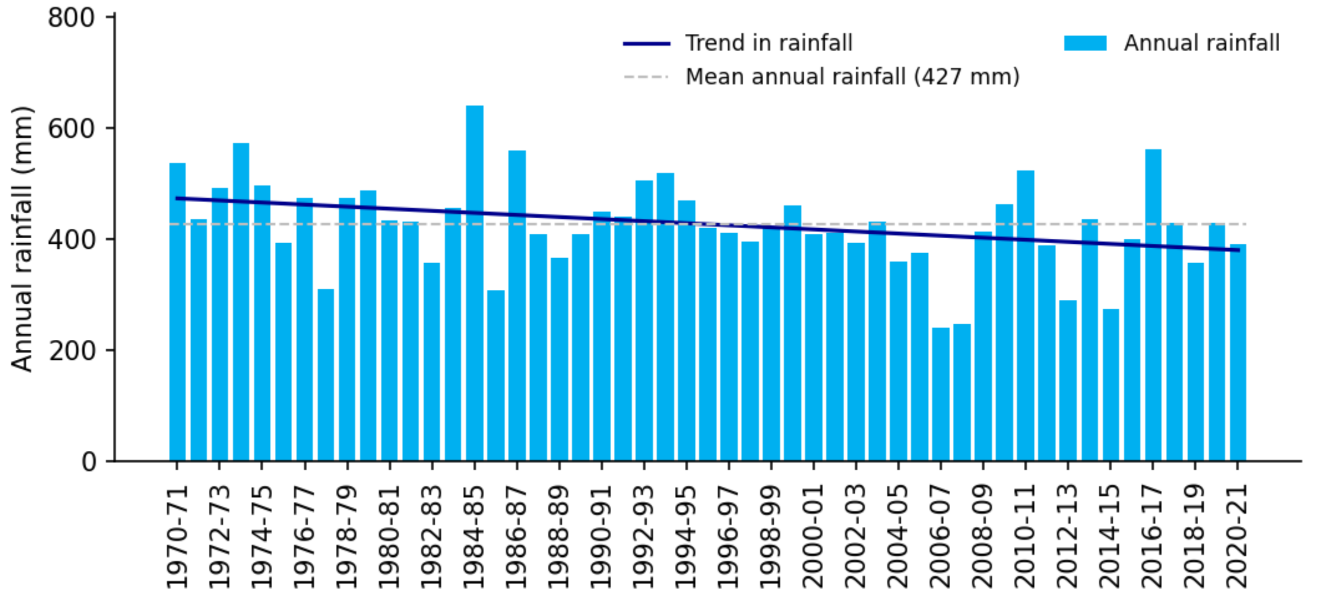

Figure 3.10 Annual rainfall for 1970–71 to 2020–21 at the Tintinara rainfall station (BoM station 25514)

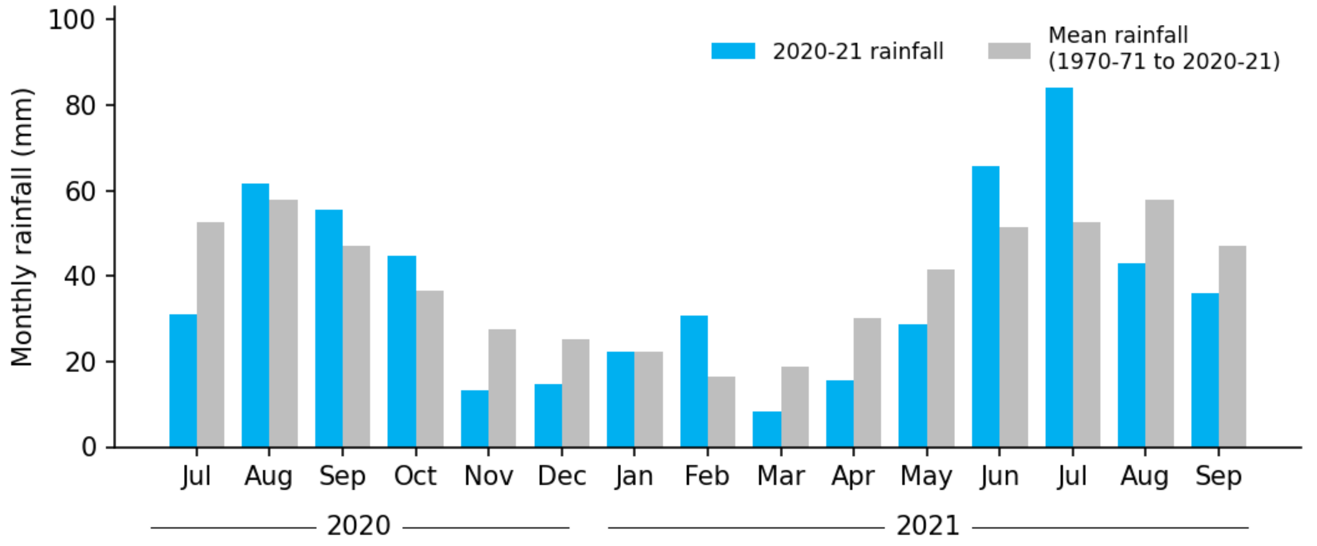

Figure 3.11 Monthly rainfall between July 2020 and September 2021, compared to the 1970–71 to 2020–21 monthly average at the Tintinara rainfall station (BoM station 25514)

4 Surface water

4.1 Streamflow

The main watercourse in the prescribed surface water area (PSWA) is the Morambro Creek, an ephemeral system with headwaters originating in the Wimmera region of western Victoria, which travels east to west through the prescribed area before terminating in Cockatoo Lake. From the lake, a spillway allows water to enter the Nyroca Channel, flowing for approximately 30 km in a north-westerly direction before discharging into the Marcollat watercourse. Analysis of available data indicates that 70-90% of Morambro Creek's flow originates from the headwater catchment area in Victoria. The characteristics of creek flows are influenced by the occurrence of dams, drainage wells and natural runaway holes west of Frances. Surface water resources in the Morambro Creek PSWA are highly dependent on rainfall, with trends in streamflow being primarily climate-driven, i.e., lower than average winter rainfall generally will result in reduced annual streamflow. Conversely, higher rainfall will generally result in increased surface water availability.

Morambro Creek streamflow gauging station (A2390531) at the Bordertown-Naracoorte Road bridge is the only station located within the PSWA. Streamflow was historically recorded at Cockatoo Lake, 15 km downstream of the Morambro Creek gauging station, but the lake site has been decommissioned. Historical data from the lake site is not presented in this report.

The period of streamflow data availability for Morambro Creek is 1979 to 2021. Further detail on the methods and data used in this analysis can be found in Section 2.2.

In 2020–21, there is no recorded streamflow in Morambro Creek, and this was classified as 'Lowest on record' (Figure 4.1).

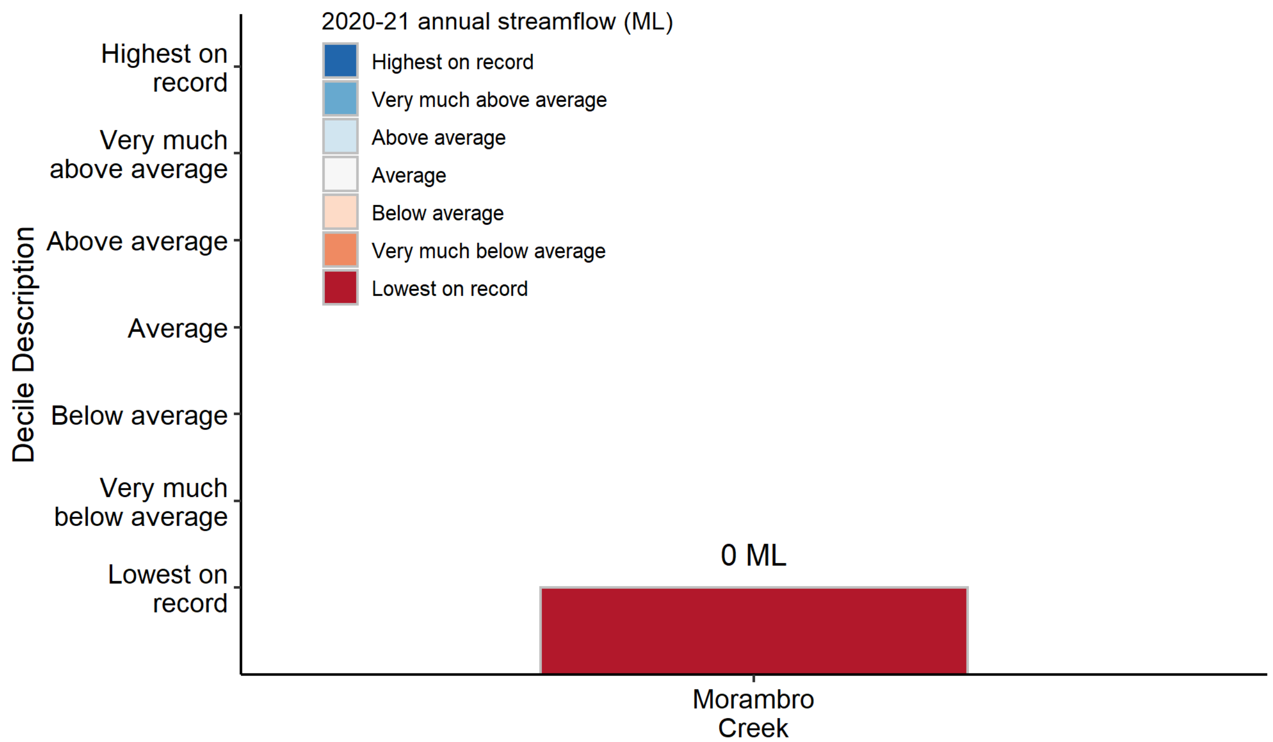

Figure 4.1 Morambro Creek PSWA annual streamflow summary 2020–21

4.1.1 Morambro Creek (A2390531)

The Morambro Creek streamflow gauging station has a catchment area of 1,169 km^2 (301 km^2 is located within South Australia) and is located towards the western boundary of the PSWA before Morambro Creek enters Cockatoo Lake.

Streamflow was observed at the Morambro Creek station for the first time in several years during 2021 (calendar year). Prior to August 2021, no flow was observed at the station since 2018. The deviation of each year's annual streamflow from the 1979 to 2021 average is shown in Figure 4.2.

The 2020-21 annual streamflow decile for Morambro Creek is ranked as 'Lowest on record', with no streamflow recorded for the reporting period (July to June), calculated from the 1979 to 2021 period of record. Annual streamflow data (1979 to 2021) shows a declining trend with the last 2 years ranking as the 'Lowest on record' with no flows recorded (Figure 4.2). Since 1994, there have only been 6 years where 'Above average' flow has occurred.

Figure 4.3A shows monthly streamflow data for the extended 2020–21 reporting period (July to September, grey bars) relative to the 1979 to 2021 monthly streamflow for (a) high flows (75th percentile), (b) median flows (50th percentile), and (c) low flows (25th percentile). Morambro Creek is an ephemeral system and flows are not typically recorded between November and May. The majority of streamflow occurs between July and October, accounting roughly for over 90% of the total annual flow in any given year. Streamflow was recorded only during August 2021, outside of the reporting months for 2020–21 (July to June).

Figure 4.3B presents the average monthly streamflow (1979 to 2021) and the daily flows for the extended 2020–21 reporting period. As mentioned above, streamflow was recorded only during August and based on unverified telemetry data, no streamflow was recorded for the rest of 2020–21.

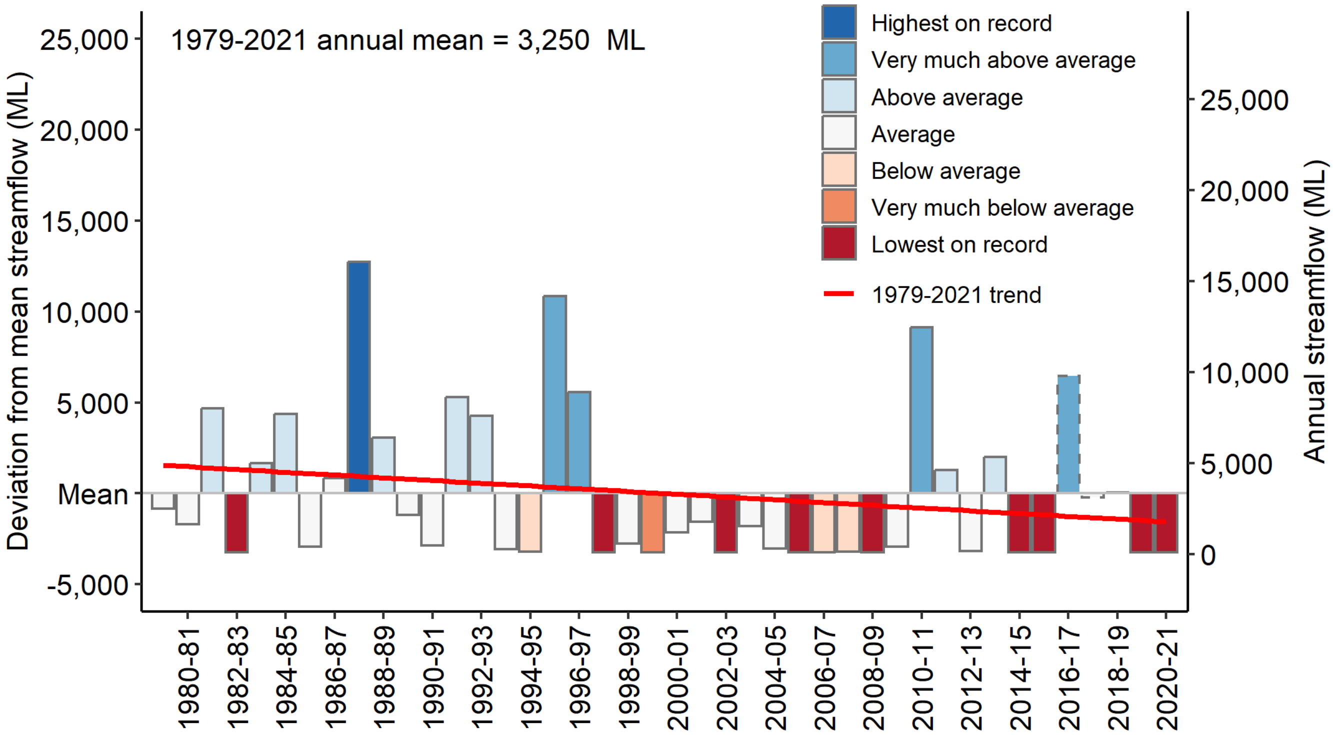

Figure 4.2 Annual deviation from mean streamflow at Morambro Creek (1979–80 to 2020–21)

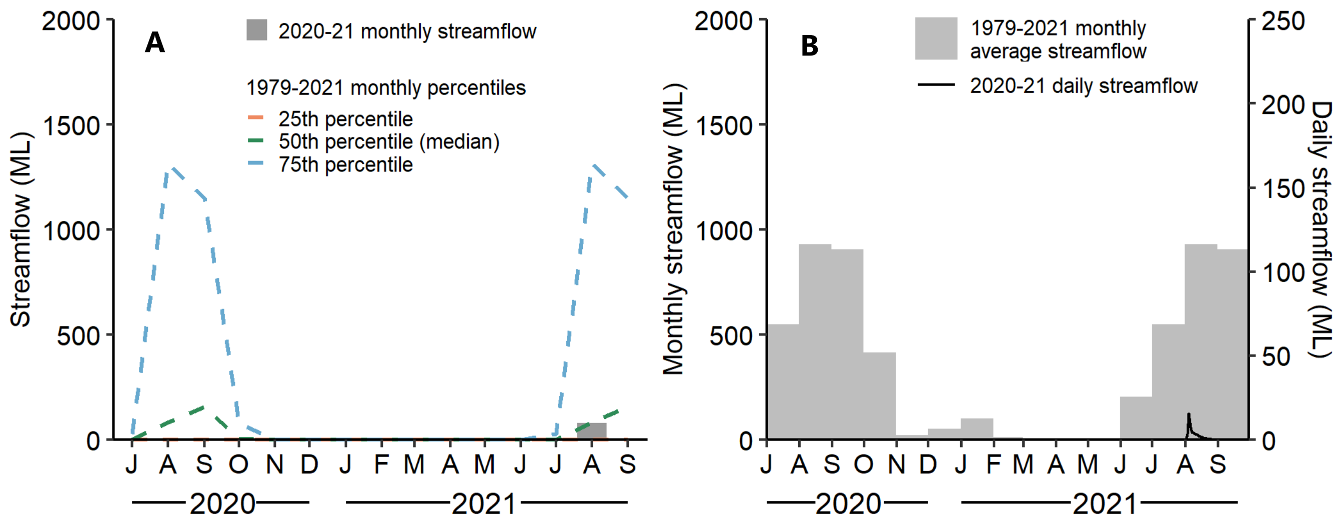

Figure 4.3 **(A) 1979 to 2021 monthly statistics and 2020–21 monthly streamflow at Morambro Creek; (B) 1979 to 2021 average monthly streamflow and 2020–21 daily streamflow at Morambro Creek**

4.2 Flow regime

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

Morambro Creek (A2390531)

The assessment of the flow regime information from the Morambro Creek station for 2020–21 (July to June) shows zero flowing days. The 1976 to 2021 reporting period average is 58 flow days (Figure 4.4). Over the last decade (2011–12 to 2020–21), 3 out of 8 years (with sufficient data) had an above-average number of flowing days. Note that years with more than 5% missing data were removed from the assessment.

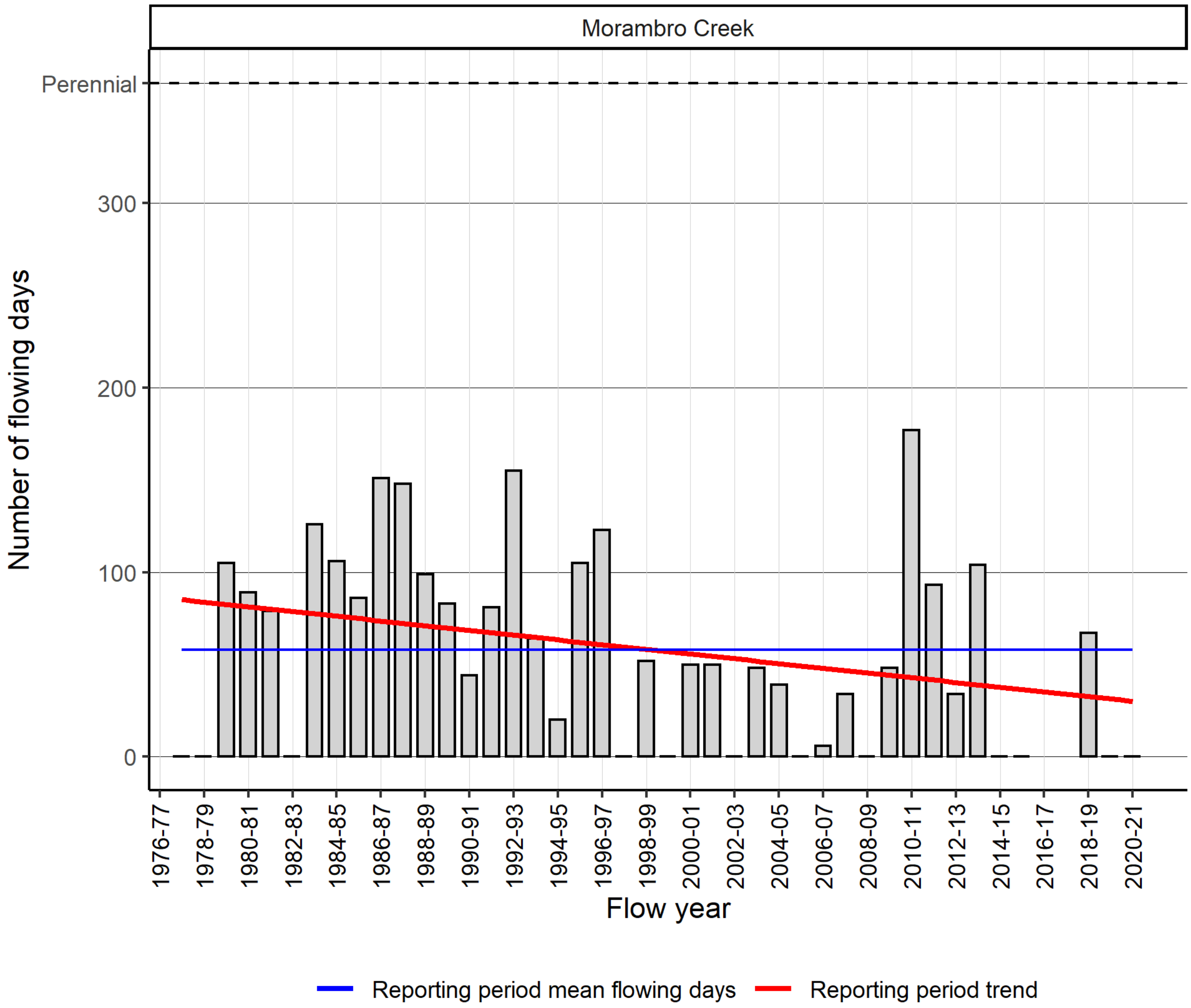

Figure 4.4 The number of flowing days (flow >0.05ML/day) for Morambro Creek including the average and trend over the 1976 to 2021 reporting period

Implications of flow regime for aquatic ecosystems in 2020–21

The flow regime for Morambro Creek PSWA shows continued worsening conditions for aquatic ecosystems over the previous few years. Lack of flow hinders the habitat for still water and flowing water species of fish and macroinvertebrates. The flow regime observed in 2020–21 is likely to have worsened current aquatic species distribution and diversity.

4.3 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.

Salinity is recorded routinely in the PSWA at the Morambro Creek streamflow gauging station (A2390531). Salinity data for the Morambro Creek station is available from 2006, however due to the ephemeral nature of Morambro Creek, at times the watercourse is dry or below the recordable range and salinity cannot be recorded.

Figure 4.4 shows the Morambro Creek monthly median salinities for the extended 2020–21 period (bars) with the 2006 to 2021 period of record data for (a) low salinities (25th percentile), (b) median salinities (50th percentile), and (c) high salinities (75th percentile). Streamflow data is provided for context. The period of record do not have salinity data for the month of May (as the river is commonly dry) and no percentile information is provided for this month.

Salinity at the Morambro Creek streamflow gauging station is typically less than 250 mg/L over the period of record, indicating a very fresh section of the watercourse. Monthly data for the period of record at the Morambro station are mostly stable throughout the year, with lower median salinities generally observed during the wetter months from June through to September.

Salinity values at Morambro for 2020–21 are only recorded for the extended period of August to September 2021 as no flow is observed for the rest of the period.

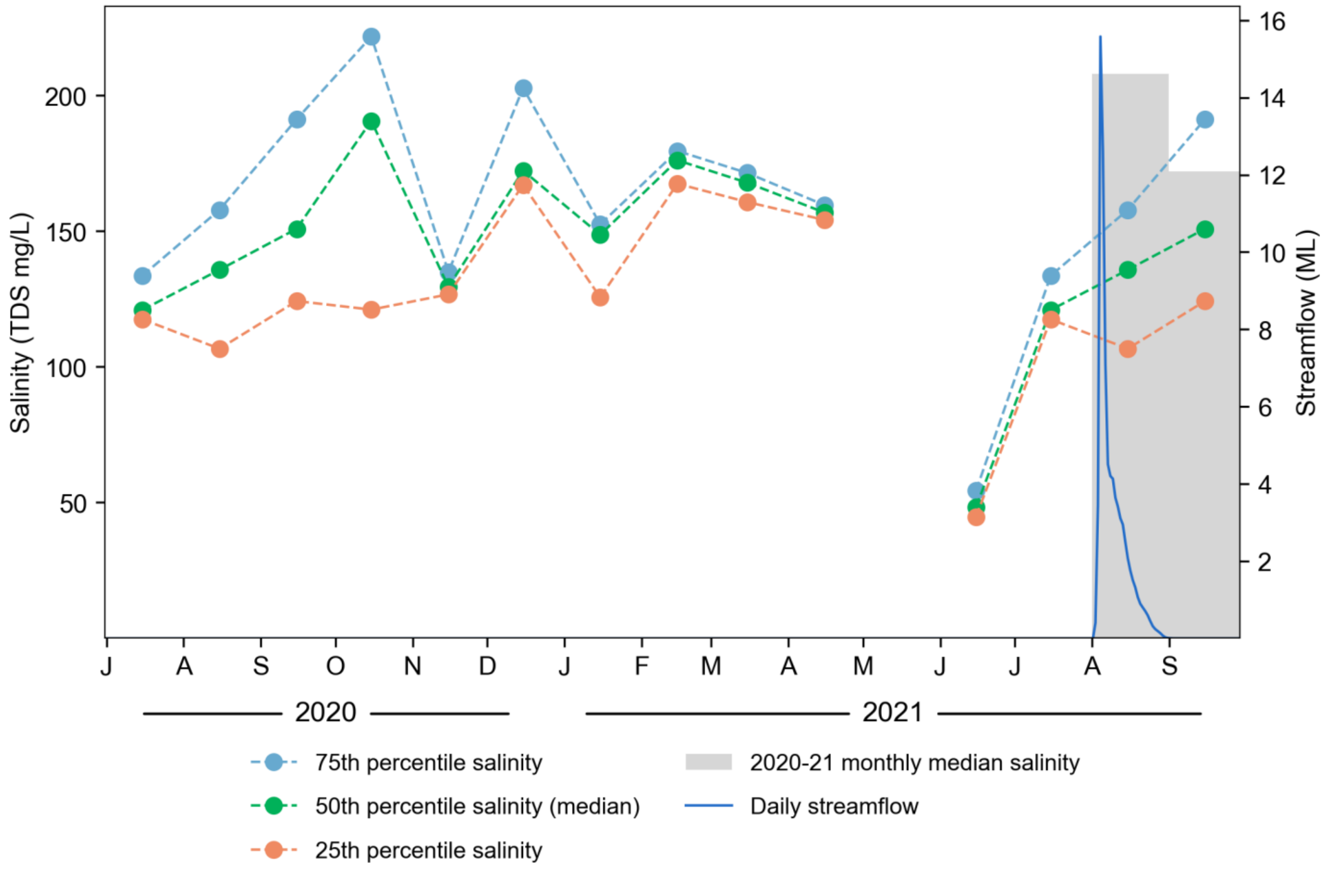

Figure 4.5 **2006 to 2021 and 2020–21 monthly salinity at the Morambro Creek streamflow gauging station**

5 Groundwater

5.1 Hydrogeology

The Limestone Coast Landscape region is underlain by Tertiary sediments of the Otway Basin in the south, with a continuous transition to equivalent sediments of the Murray Basin in the north. Groundwater occurs within two regional-scale sedimentary groundwater systems (SE NRM Board, 2013):

- the upper unconfined Tertiary Limestone Aquifer (known generally as the unconfined aquifer), which comprises Quaternary and Tertiary limestone
- the underlying Tertiary Confined Sand Aquifer (known generally as the confined aquifer), which consists of quartz sands, interbedded with dark brown carbonaceous clays.

The confined and unconfined aquifers are generally separated by a low permeability aquitard. The main source of recharge to the unconfined aquifer is the direct infiltration of local rainfall. Groundwater in both systems flows from the topographic high of the Dundas Plateau, located in western Victoria, to the south-east in a radial direction, heading westward and southward towards the coast.

The Limestone Coast Landscape region can be divided topographically into two landforms with different hydrogeological characteristics, with each requiring a tailored approach to groundwater management. There are low-lying coastal plains or flats in the south and west, with highlands or ranges to the east and north. The northern and central parts of the Lower Limestone Coast PWA are characterised by northwest-trending remnants of former coastal dunes, separated by inter-dunal flats.

For the purpose of this assessment, each prescribed area is split into plains and highlands sub-areas based on unconfined aquifer groundwater management areas (Table 5.1).

Table 5.1 Groundwater management areas used for the plains and highlands areas

Prescribed Wells Area	Sub-area	Groundwater management areas (GMAs)
Lower Limestone Coast	Highlands	Comaum, Joanna, Zone 5A, Hynam East, Frances, Beeamma, Bangham, Western Flat
	Coastal Flats and Donovans	*All other unconfined management areas*
Padthaway	Flats	Padthaway Flats
	Ranges	Padthaway Range
Tatiara	Coastal Plain	Willalooka, Stirling, North Pendleton, Wirrega
	Highlands	Cannawigara, Shaugh, Zone 8A Senior, Tatiara
Tintinara-Coonalpyn	Coastal Plain	Coonalpyn, Boothby, Tintinara
	Mallee highlands	Sherwood

5.1.1 Unconfined aquifer

The Quaternary Padthaway, Coomandook and Bridgewater Formations form the unconfined aquifer in the northern and central parts of the Limestone Coast Landscape region. In the southern part of the Lower Limestone Coast PWA, the Tertiary Gambier Limestone forms the main unconfined aquifer and generally comprises a creamy bryozoal limestone which varies in thickness and is up to 400 m thick offshore to the south. The permeability of the aquifer is highly variable, with very high transmissivities that are associated with karstic solution features. Beneath the highlands, the unconfined aquifer is contained in the Tertiary Murray Group Limestone, which is in the Murray Basin and is equivalent to the Gambier Limestone of the Otway Basin.

5.1.2 Confined aquifer

The confined aquifer in the Murray Basin, which is located towards the north of the Lower Limestone Coast PWA, occurs in the Renmark Group. Here, the confined aquifer consists of interbedded sands, silt and carbonaceous clay up to 100 m in thickness.

In the northern part of the Lower Limestone Coast PWA, the confined aquifer is thin or absent due to the presence of shallow basement rocks around the Padthaway Ridge. In these areas it is not widely used due to comparatively low well yields of 10 to 20 L/s and the greater availability of groundwater in the overlying unconfined aquifer.

Over most of the southern and central parts of the Lower Limestone Coast PWA, the main confined aquifer occurs in the Dilwyn Formation, which consists of quartz sands interbedded with dark brown carbonaceous clays. The confined aquifer in these areas is a complex multi-aquifer system; however, for management and reporting purposes at the regional scale, it is considered a single aquifer.

5.2 Unconfined aquifer

5.2.1 Lower Limestone Coast PWA, Coastal Flats and Donovans area – water level

In 2021, and in the unconfined aquifer of the Donovans and Coastal Plains areas of the Lower Limestone Coast PWA, winter recovered water levels in 49% of 217 monitoring wells are classified 'Below average' or lower (Figure 5.1). The majority of these wells are located where the watertable is shallow (i.e., less than 10 m below ground level) and within the inter-dunal flats. A small number of wells (6%) show their lowest winter-recovered water level on record; these were generally located south of Mount Gambier near areas of intensive irrigation and forestry plantations or near drainage networks.

Variations in water level in 181 wells over the past 30 years range from a decline of 6.62 m to a rise of 0.93 m (median decline of 0.72 m).

Five-year trends show declining water levels in the majority of wells (82%), with rates ranging from a decline of 0.95 m/y to a decline of 0.02 m/y (median decline of 0.12 m/y; Figure 5.2).

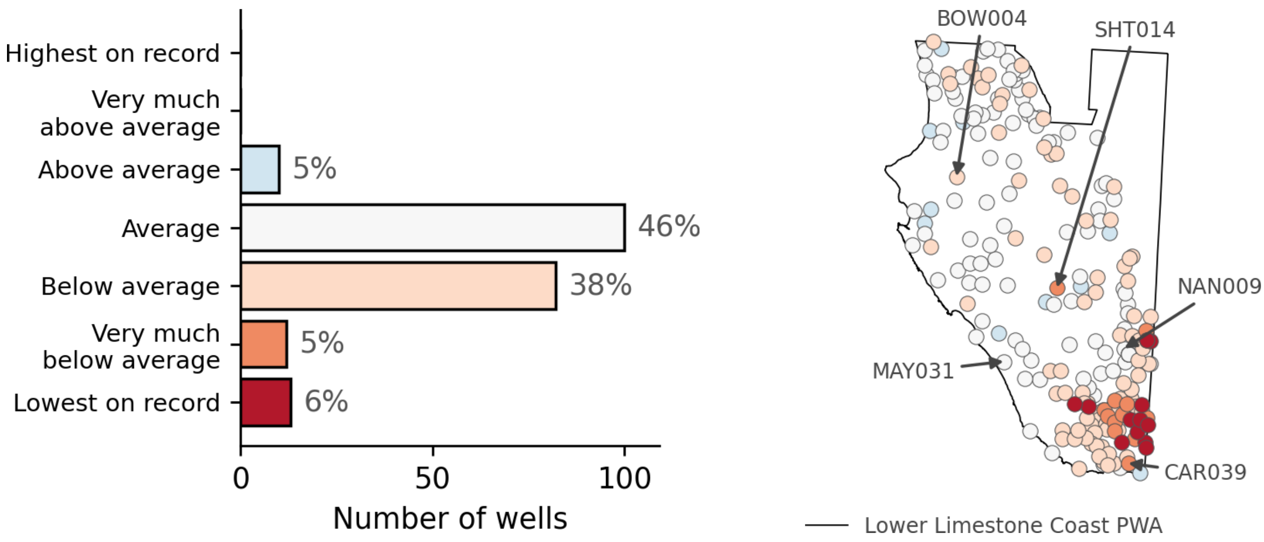

Figure 5.1 2021 winter-recovered water levels for wells in the unconfined aquifer in the Coastal Flats and Donovans area of the Lower Limestone Coast PWA

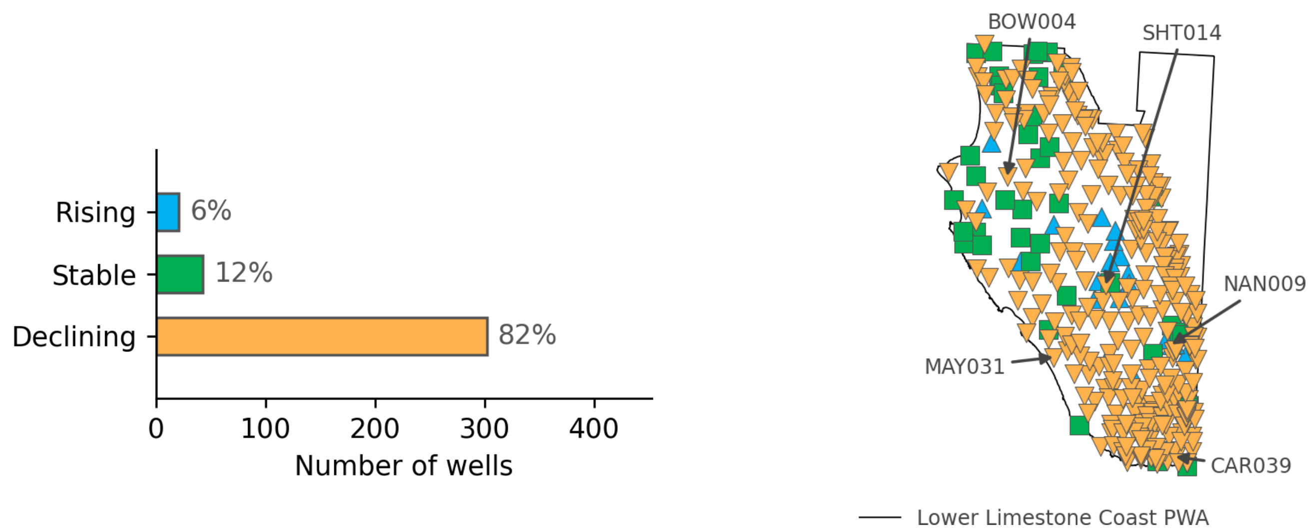

Figure 5.2 Five-year trend in winter-recovered water levels (2017 to 2021) for wells in the unconfined aquifer in the Coastal Flats and Donovans area of the Lower Limestone Coast PWA

Since 1993, groundwater levels from monitoring wells located in those parts of the coastal plain with a shallow watertable show a consistent decline in groundwater levels (e.g., MAY031; Figure 5.3). Wetter conditions since 2009 have led to recovery of some water levels in these areas (e.g., BOW004). CAR039 is located in an area where high rates of irrigation of pasture for dairies developed after 2000, resulting in increased seasonal fluctuations due to extraction that occurs mainly during summer (DEW 2021).

Monitoring wells SHT014 and NAN009 are located near commercial forestry plantations and show water table declines of several metres. NAN009 shows a rise in water level, which is likely due to increased recharge after the 1983 Ash Wednesday bushfires (Harrington and Lamontagne 2013).

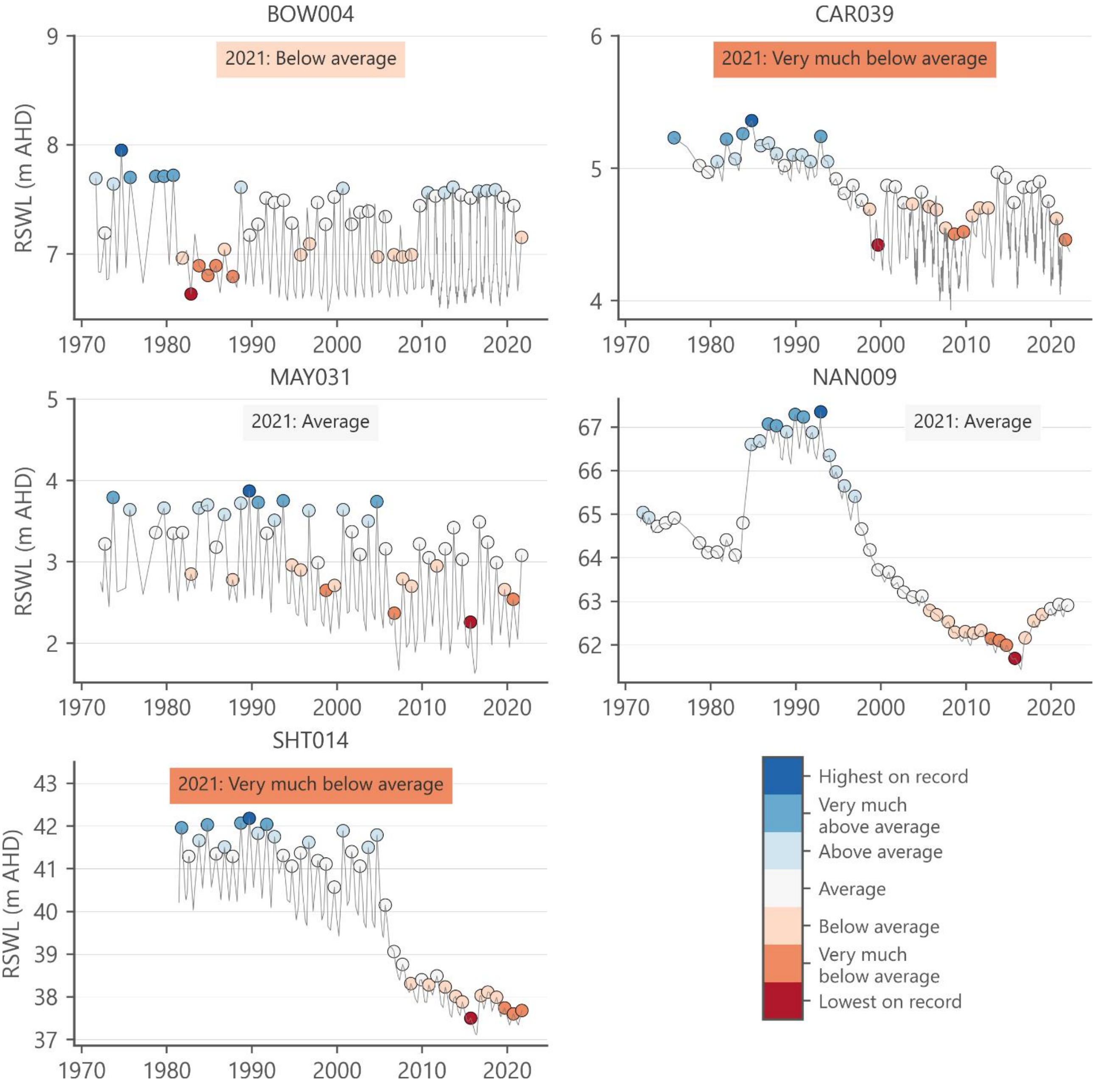

Figure 5.3 Selected hydrographs for wells in the unconfined aquifer in the Coastal Flats and Donovans area of the Lower Limestone Coast PWA

5.2.2 Lower Limestone Coast PWA, Coastal Flats and Donovans area – salinity

In 2021, and in the unconfined aquifer of the Donovans and Coastal Plains areas of the Lower Limestone Coast PWA, sampling results from 157 wells range between 188 mg/L and 32,480 mg/L with a median of 674 mg/L (Figure 5.4).

In the 10 years to 2021, 75 of 143 wells (53%) show an increasing trend in salinity (Figure 5.5). The 10-year salinity trends vary from a decrease of 18.3% per year to an increase of 5.4% per year, with a median rate of 0.1% decrease per year.

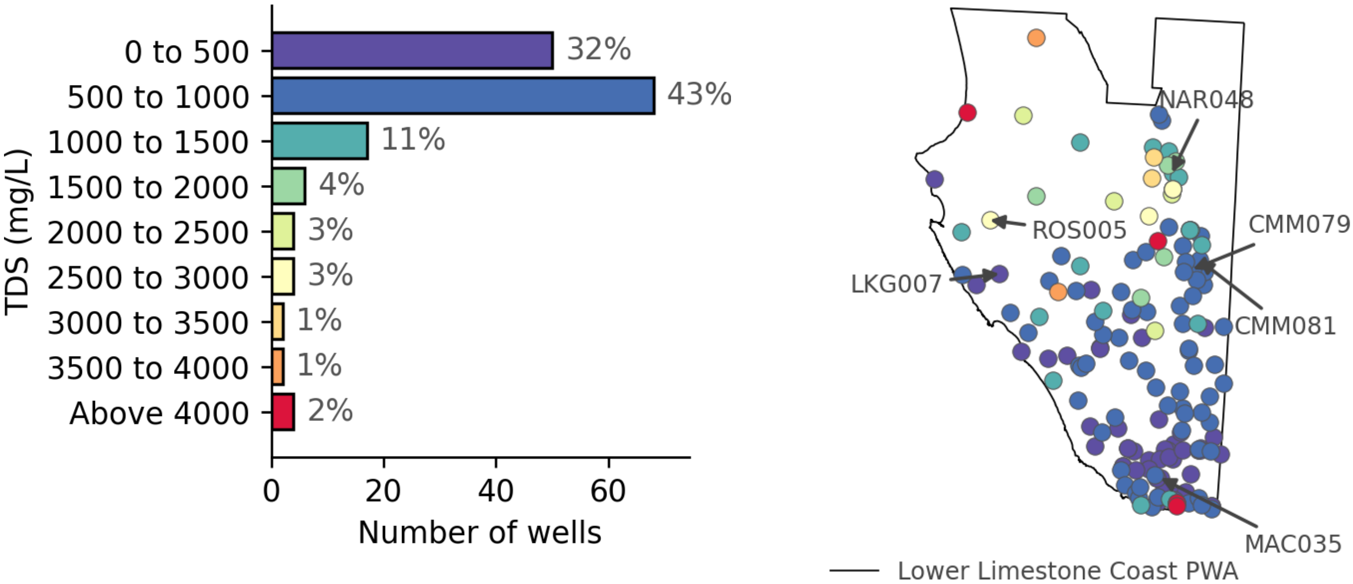

Figure 5.4 2021 salinity observations from wells in the unconfined aquifer in the Coastal Flats and Donovans area of the Lower Limestone Coast PWA

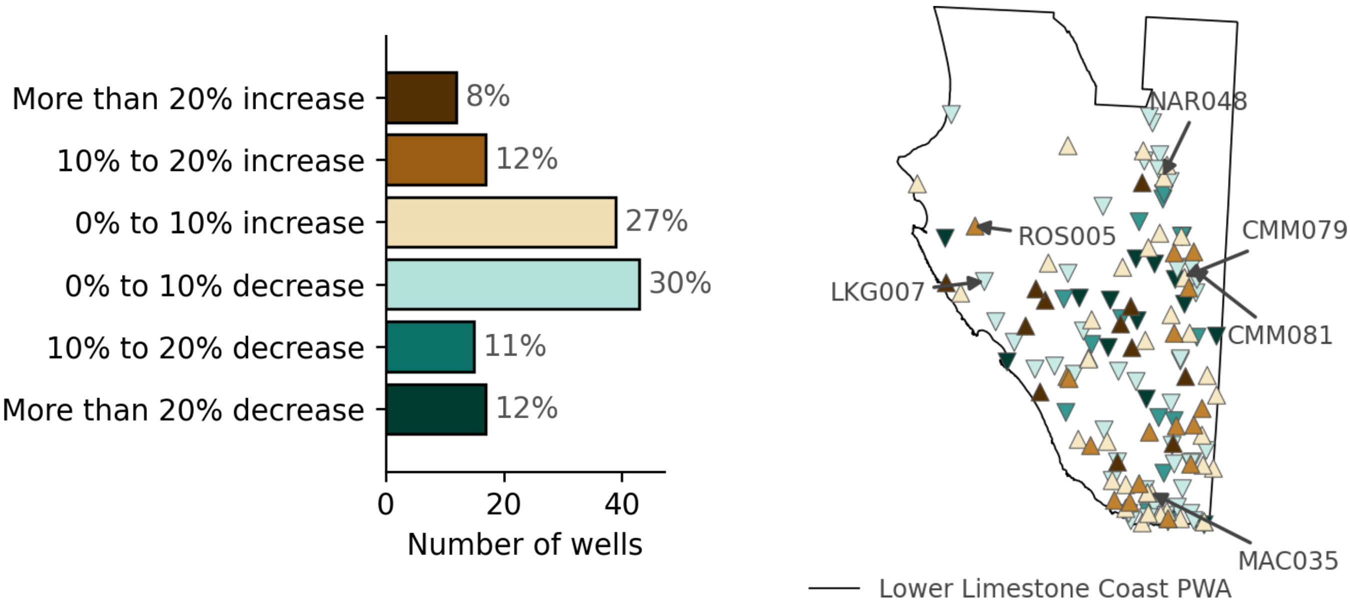

Figure 5.5 Salinity trend in the 10 years to 2021 for wells in the unconfined aquifer in the Coastal Flats and Donovans area of the Lower Limestone Coast PWA

Groundwater salinity in the unconfined aquifer around the inter-dunal flats is generally stable (e.g., NAR048, Figures 5.5 and 5.6) or decreasing. Areas of flood irrigation (e.g., ROS005) may increase groundwater salinity at the local scale, through the evapoconcentration of irrigation drainage water in processes such as those studied on the Padthaway Flat (Harrington, Van den Akker and Brown 2006).

Where stresses on the groundwater system are absent (e.g., from intensive extraction or land use change), salinity is generally stable.

Observation well CMM079 is located near Coonawarra within an area of intensive irrigation. Long-term monitoring data show increasing salinity, primarily from the late-1990s. This increase could be due to flushing of concentrated salt in the soil profile down to the watertable. However, CMM081 (located north of Coonawarra) and MAC035 (located north of Port MacDonnell) show relatively stable salinity over the same period, despite also being in areas of intensive irrigation.

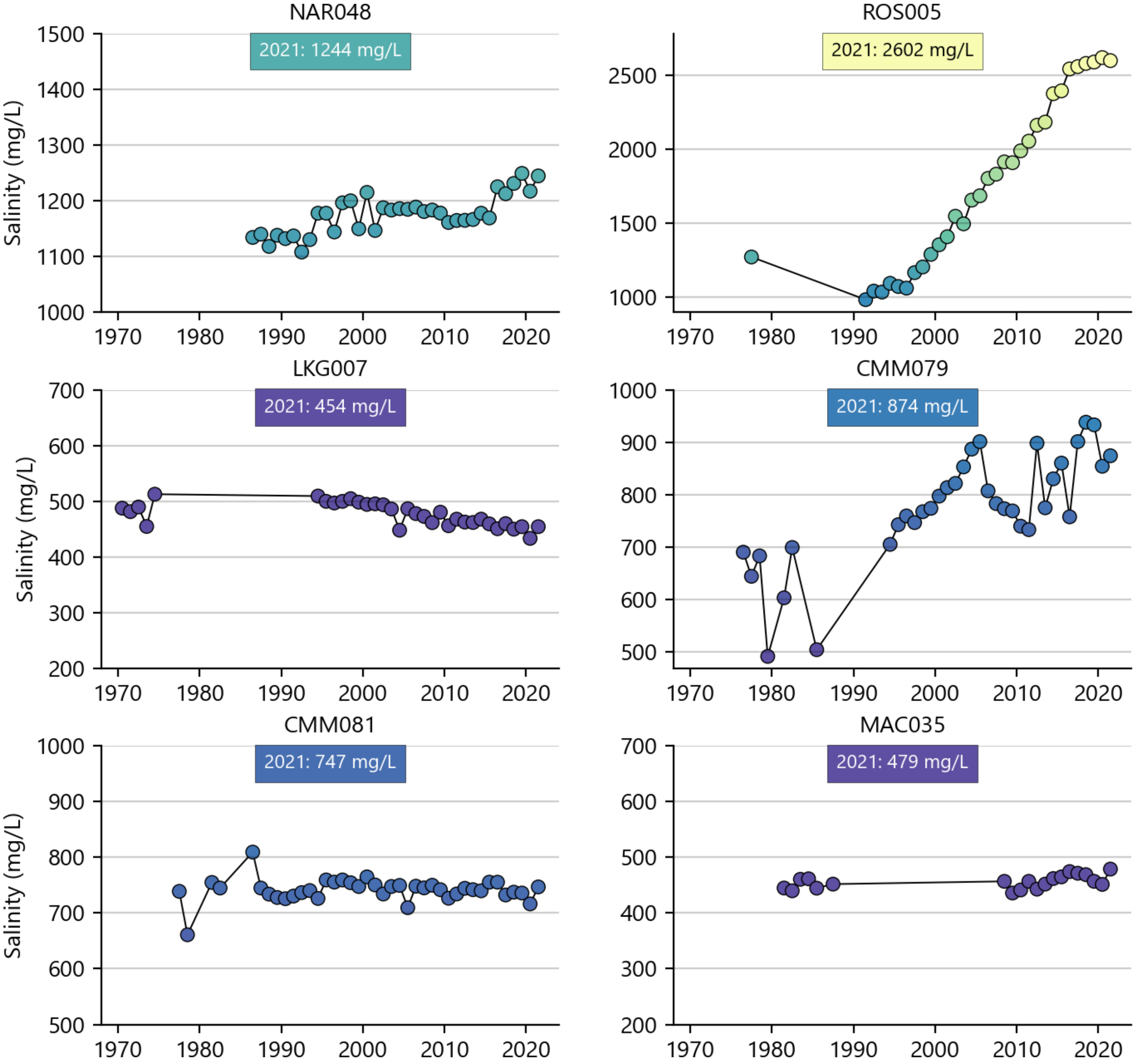

Figure 5.6 **Selected salinity graphs for wells in the unconfined aquifer in the Coastal Flats and Donovans area of the Lower Limestone Coast PWA**

5.2.3 Lower Limestone Coast PWA, Highlands area – water level

In 2021, winter-recovered water levels in 96% of monitoring wells in the unconfined aquifer of the highlands in the Lower Limestone Coast PWA are classified 'Below average' or lower (see Section 2.3.1 for details of the classification; Figure 5.7).

Variations in water level in 20 wells over the past 30 years range from a decline of 4.33 m to a decline of 0.28 m (median decline of 2.03 m).

Five-year trends show declining water levels in the majority of wells (95%), with rates ranging from a decline of 0.38 m/y to a decline of 0.04 m/y (median decline of 0.12 m/y; Figure 5.8).

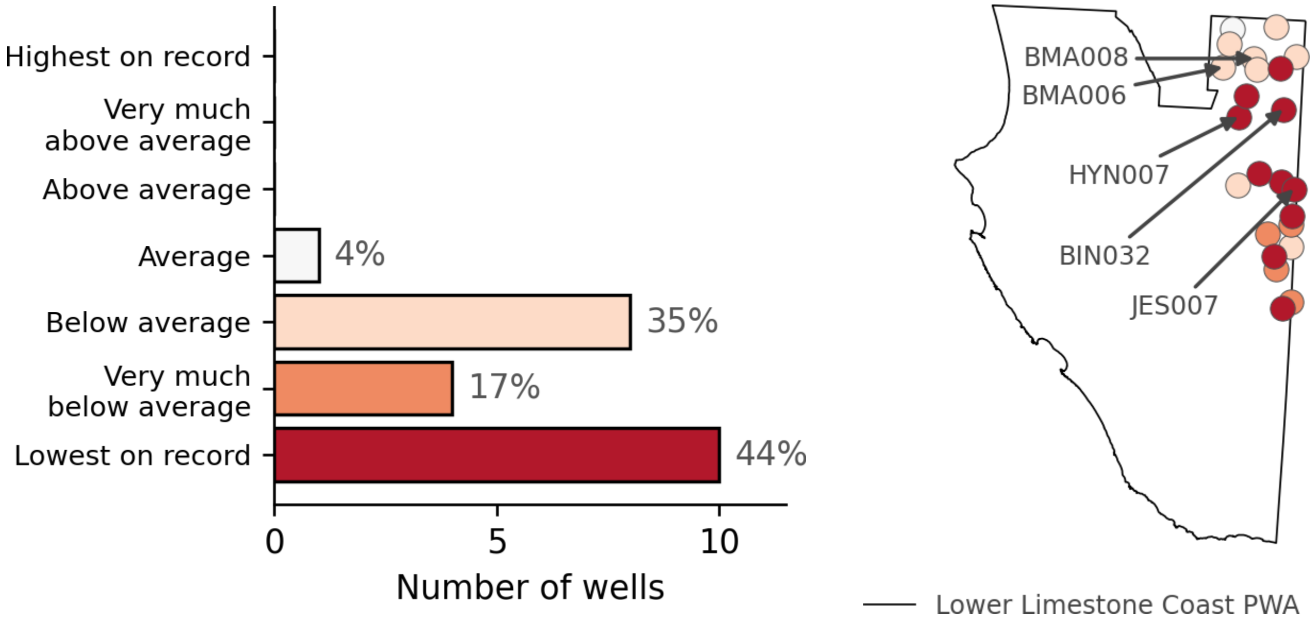

Figure 5.7 **2021 winter-recovered water levels for wells in the unconfined aquifer in the highlands area of the Lower Limestone Coast PWA**

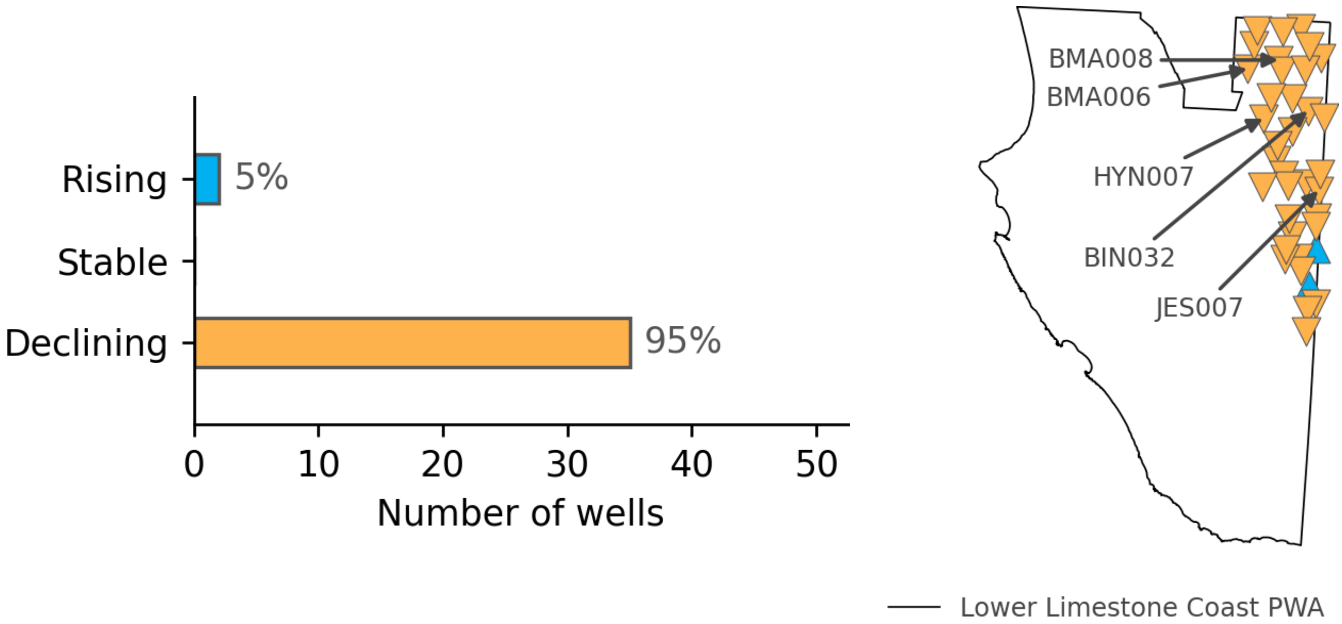

Figure 5.8 **2017 to 2021 trend in winter-recovered water levels for wells in the unconfined aquifer in the highlands area of the Lower Limestone Coast PWA**

In the unconfined aquifer beneath the Highlands area, where the depth to the watertable is generally greater than 10 m, groundwater levels were rising prior to early 2000. This may be in response to widespread clearance of native vegetation, which can result in increased rates of groundwater recharge. Prior to the mid to late-1990s, rising water levels of up to 0.2 m/y are apparent in several representative wells (e.g., BMA006, BMA008, HYN007, JES007) (Figure 5.9). This rising trend persisted for several years after the commencement of a prolonged period of below-average rainfall around 1997 (Figure 3.4) but subsequently, water levels have typically been declining.

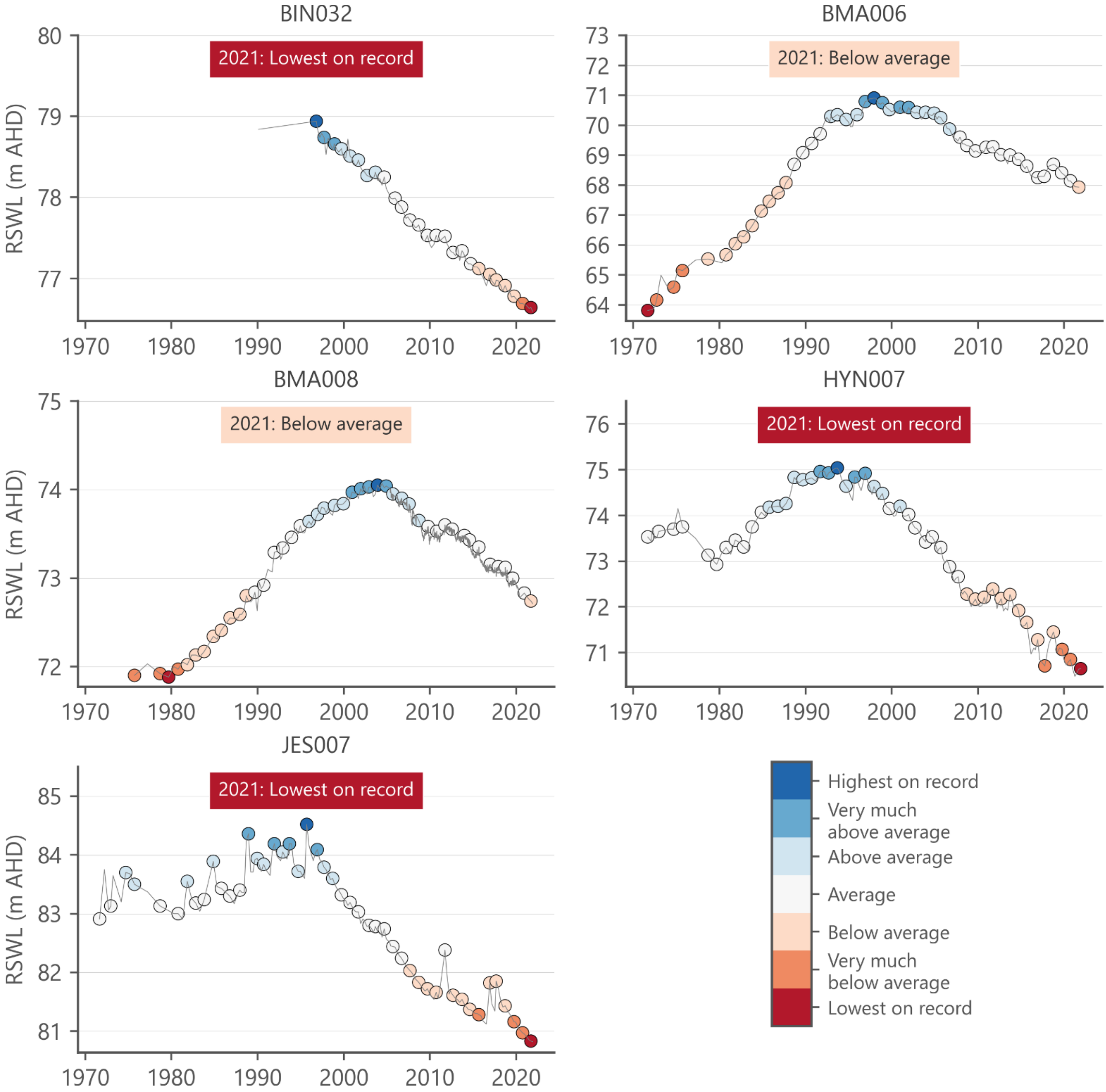

Figure 5.9 **Selected hydrographs for wells in the unconfined aquifer in the highlands area of the Lower Limestone Coast PWA**

5.2.4 Lower Limestone Coast PWA, Highlands area – salinity

Regular groundwater salinity monitoring in this area began in 1987. The widespread clearance of native vegetation has resulted in increased recharge rates and the flushing of salt down to the watertable, which was previously stored in the root zones of native vegetation (Wohling 2007). This process is occurring independent of any irrigation activity, although deep drainage beneath irrigated areas is likely to accelerate the process at the local scale.

In 2021, and from 29 wells in the unconfined aquifer of the highlands in the Lower Limestone Coast PWA, salinity ranges between 390 mg/L and 2,354 mg/L with a median of 1,376 mg/L (Figure 5.10).

In the 10 years to 2021, 16 of 28 wells (57%) show an increasing trend in salinity (Figure 5.11). The 10-year salinity trends vary from a decrease of 3.5% per year to an increase of 3.8% per year, with a median rate of 0.2% increase per year.

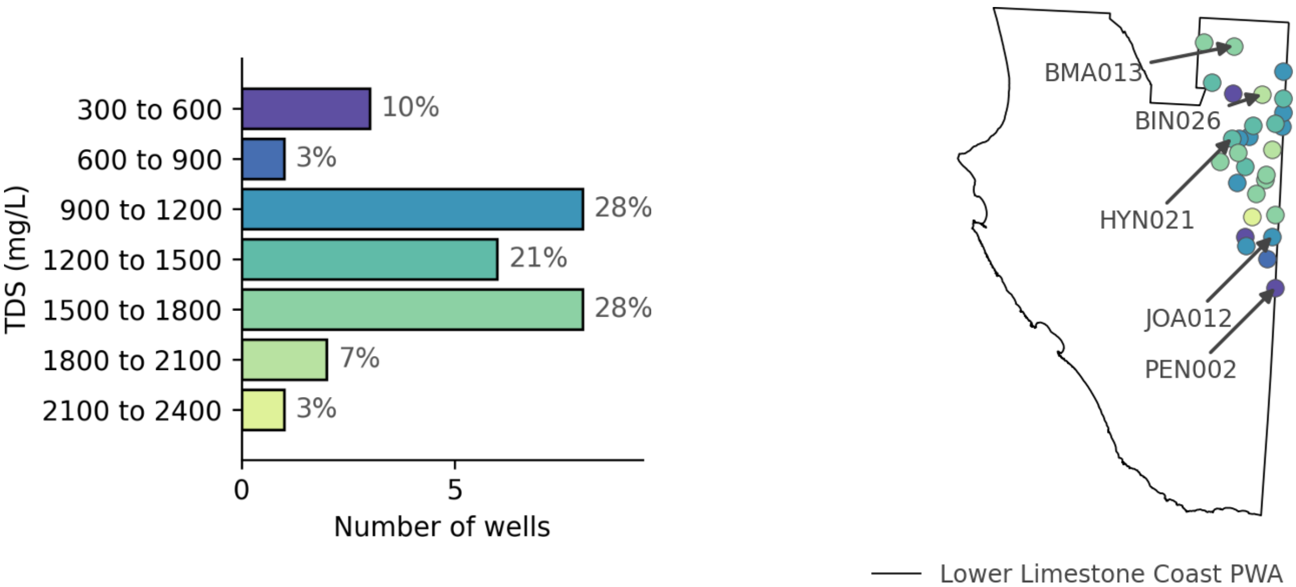

Figure 5.10 2021 salinity measurements from wells in the unconfined aquifer in the Highlands area of the Lower Limestone Coast PWA

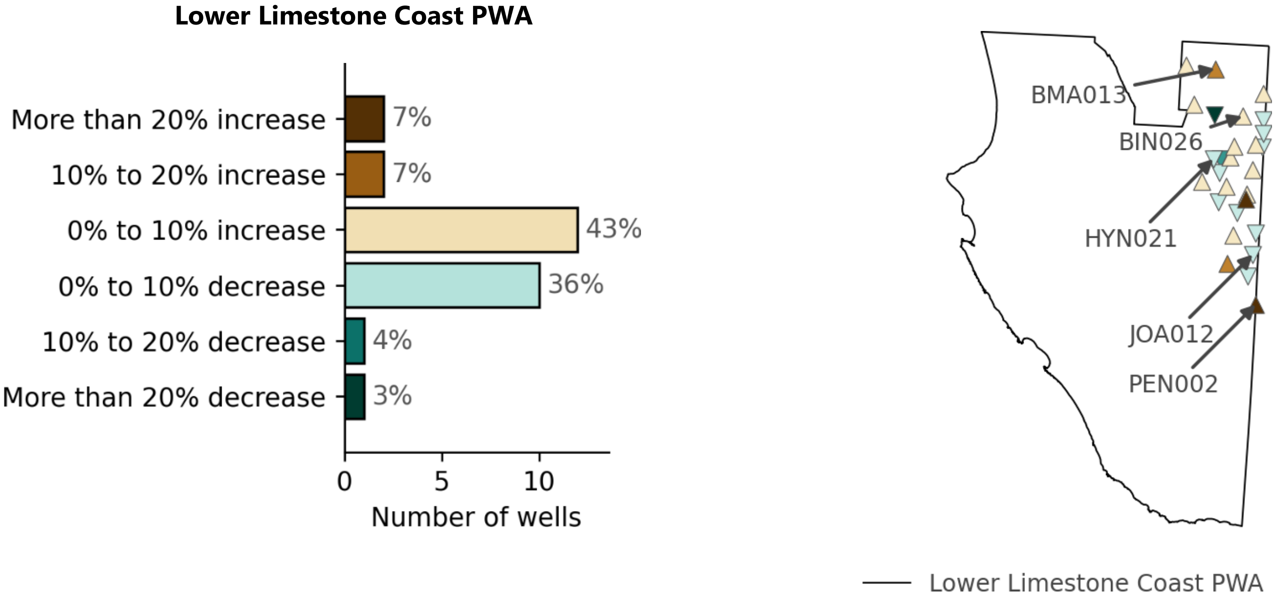

Figure 5.11 Salinity trend in the 10 years to 2021 for wells in the unconfined aquifer in the Highlands area of the Lower Limestone Coast PWA

Observation well BMA013 (Figure 5.12) shows continuously increasing salinity since monitoring began in 1986. At JOA012, an increase in salinity is apparent prior to 2000, but salinity has remained relatively stable since. Observation wells BIN026 and HYN021 show very small variations in salinity over the past 30 years of around ±100 mg/L.

Observation well PEN002, which is located within a forestry and native vegetation area, shows a decrease in salinity from around 800 mg/L in the early-2000s to around 200 mg/L in 2019, after which salinity has increased to around 400 mg/L.

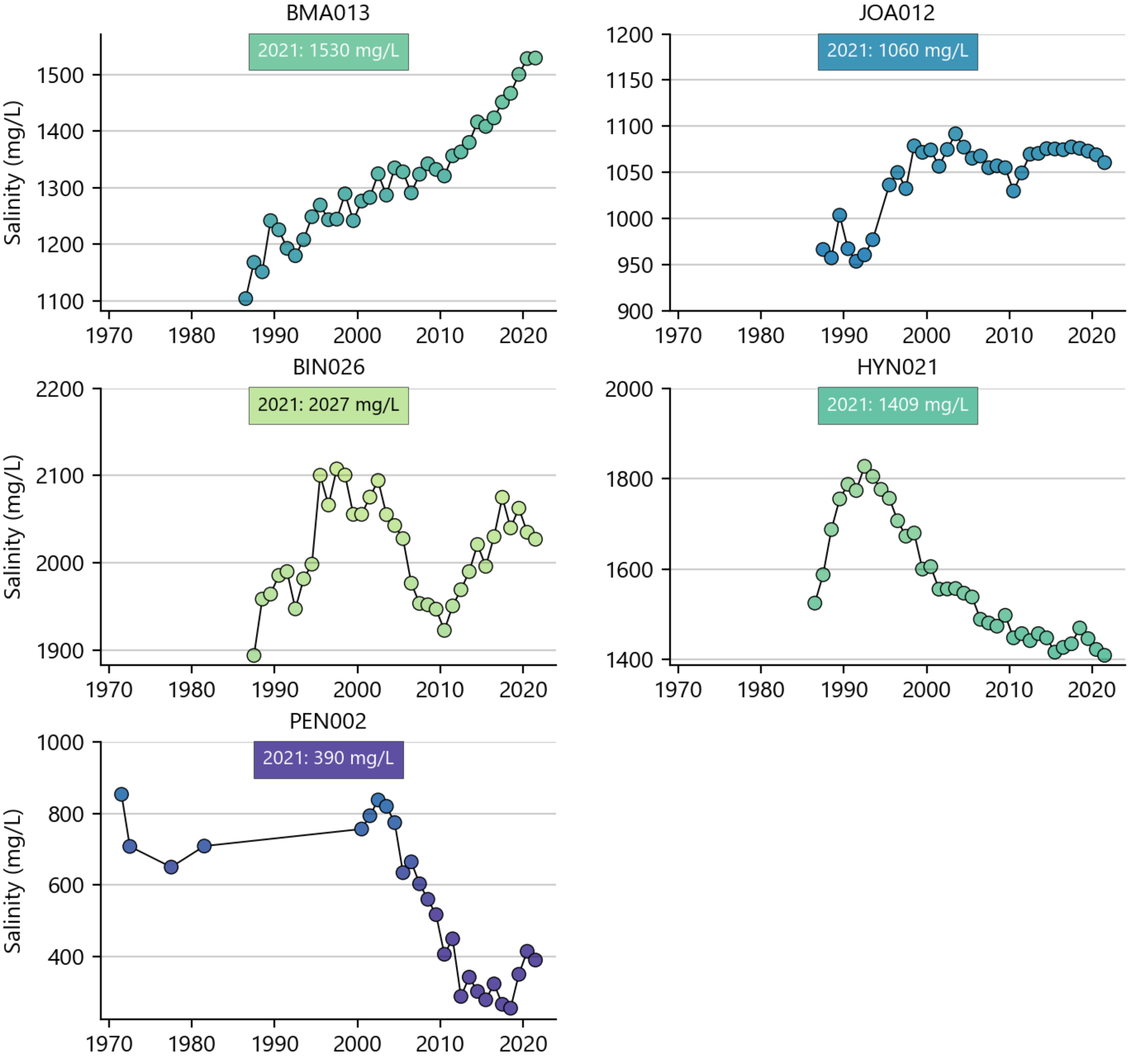

Figure 5.12 Selected salinity graphs for wells in the unconfined aquifer in the Highlands area of the Lower Limestone Coast PWA

5.2.5 Padthaway PWA, Padthaway Flats GMA – water level

In 2021, winter recovered water levels in 60% of monitoring wells in the unconfined aquifer of the Padthaway Flats GMA are classified 'Below average'(see Section 2.3.1 for details of the classification; Figure 5.13).

Variations in water level in 20 wells with available data over the past 30 years range from a decline of 2.09 m to a decline of 0.91 m (median decline of 1.47 m).

Five-year trends show declining water levels in all wells, with rates ranging from a decline of 0.33 m/y to a decline of 0.09 m/y (median decline of 0.18 m/y).

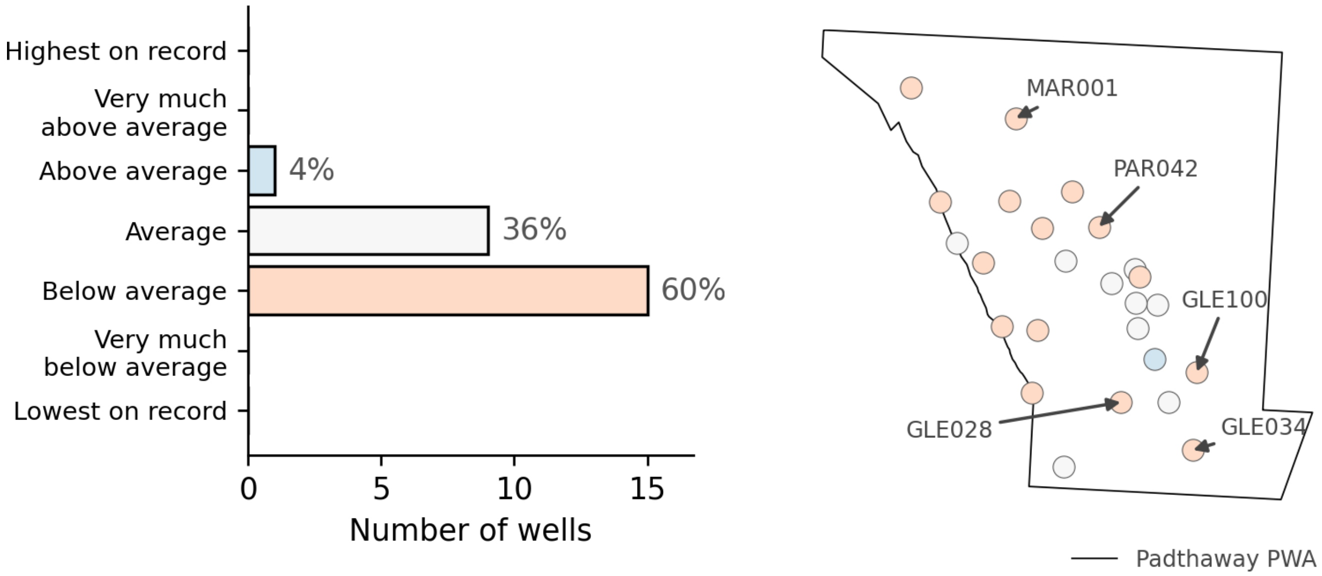

Figure 5.13 2021 winter-recovered water levels for wells in the unconfined aquifer in the Padthaway Flats management area of the Padthaway PWA

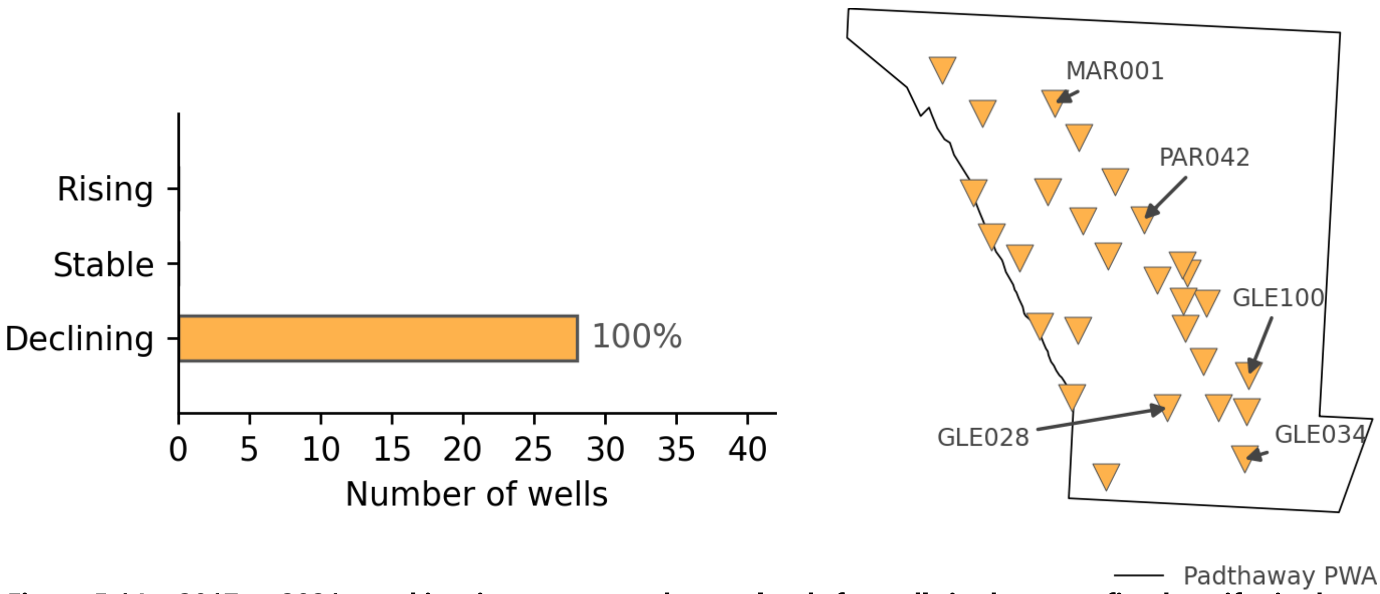

Figure 5.14 2017 to 2021 trend in winter-recovered water levels for wells in the unconfined aquifer in the Padthaway Flats management area of the Padthaway PWA

The depth to the watertable over much of the Padthaway Flats management area is less than 5 m and consequently, groundwater levels are very responsive to rainfall. Long-term water level data from representative monitoring wells such as MAR001, PAR042, GLE028, GLE100, and GLE034 (Figure 5.15) show a close correlation with rainfall. Below-average rainfall since 1993 (Figure 3.6) aligns with declines in water levels of around 1 to 2 m. In the periods 2009 to 2011 and 2016–17, above-average annual rainfall aligns with sharp recoveries in water levels.

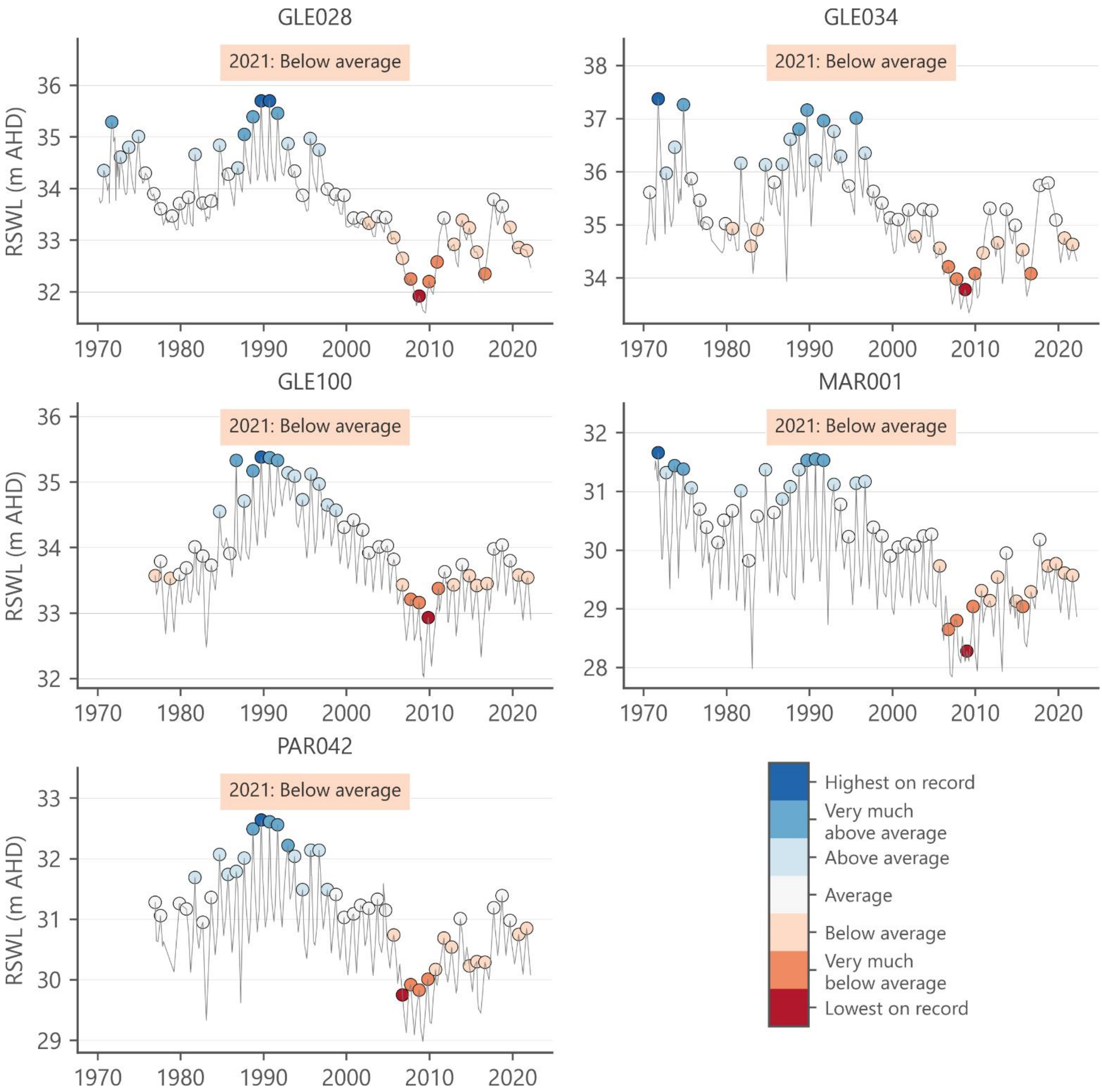

Figure 5.15 Selected hydrographs for wells in the unconfined aquifer in the Padthaway Flats management area of the Padthaway PWA

5.2.6 Padthaway PWA, Padthaway Flats GMA – salinity

In 2021, sampling results from 40 wells in the unconfined aquifer of the Padthaway Flats GMA range between 975 mg/L and 9,046 mg/L with a median of 1,668 mg/L (Figure 5.16)

In the 10 years to 2021, 15 of 19 wells (79%) show an increasing trend in salinity (

Figure 5.17). The 10-year salinity trends vary from a decrease of 2.2% per year to an increase of 3.0% per year, with a median rate of 0.8% increase per year.

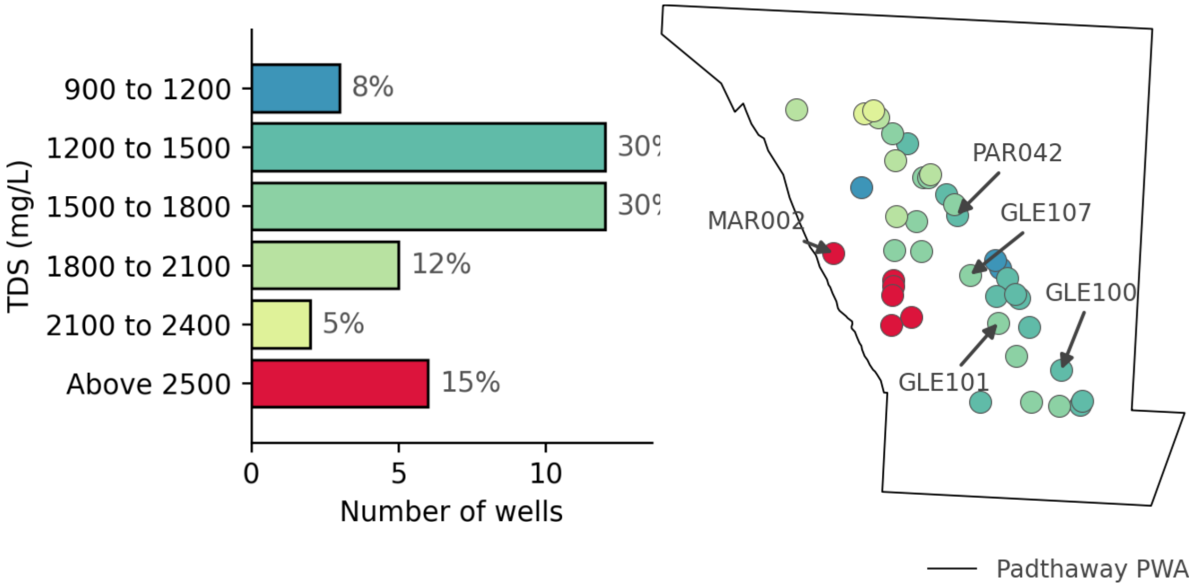

Figure 5.16 2021 salinity observations from wells in the unconfined aquifer in the Padthaway Flats management area of the Padthaway PWA

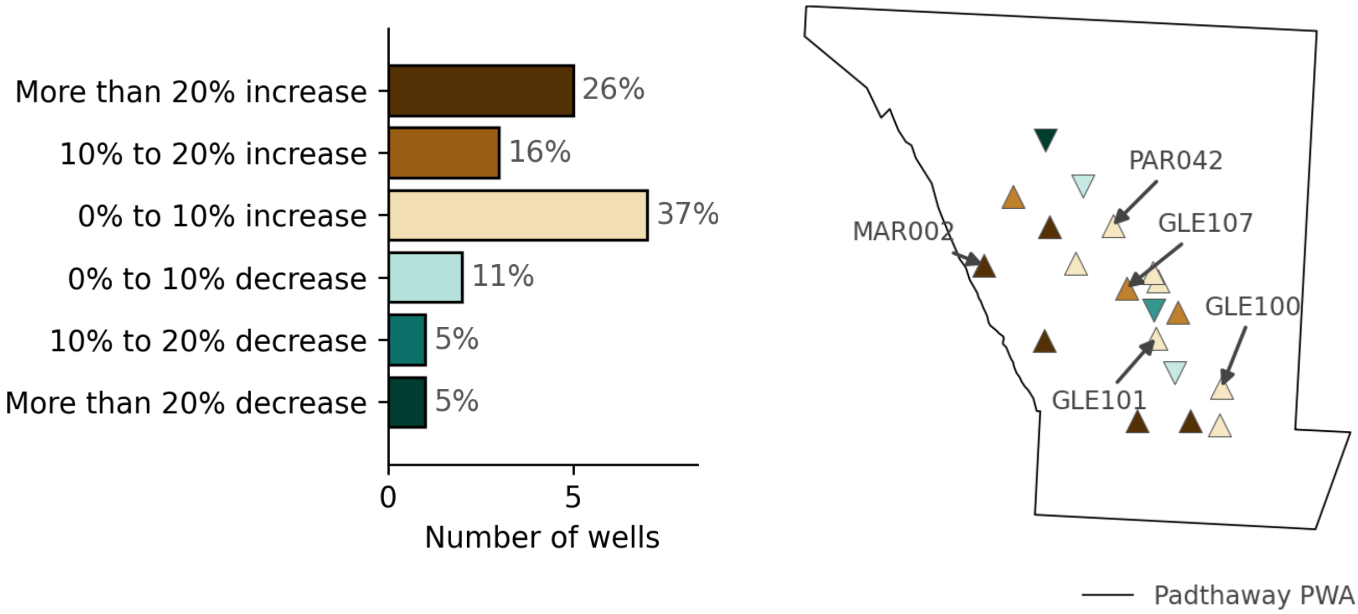

Figure 5.17 Salinity trend in the 10 years to 2021 for wells in the unconfined aquifer in the Padthaway Flats management area of the Padthaway PWA

In the shallow unconfined aquifer, rates of change in groundwater salinity can be variable and may be influenced by rainfall patterns and irrigation practices. PAR042, GLE107 and GLE100 (Figure 5.18) all show a consistent trend of increasing salinity, which corresponds to an extended period of below-average rainfall since around 2004 (Figure 3.6). Variations in salinity in GLE101 show an inverse correlation with rainfall (Figure 3.6).

To the west of the PWA, increases in salinity over the past 10 years are greatest (e.g., MAR002;

Figure 5.17), which may be explained by the recycling of irrigation water in the shallow aquifer.

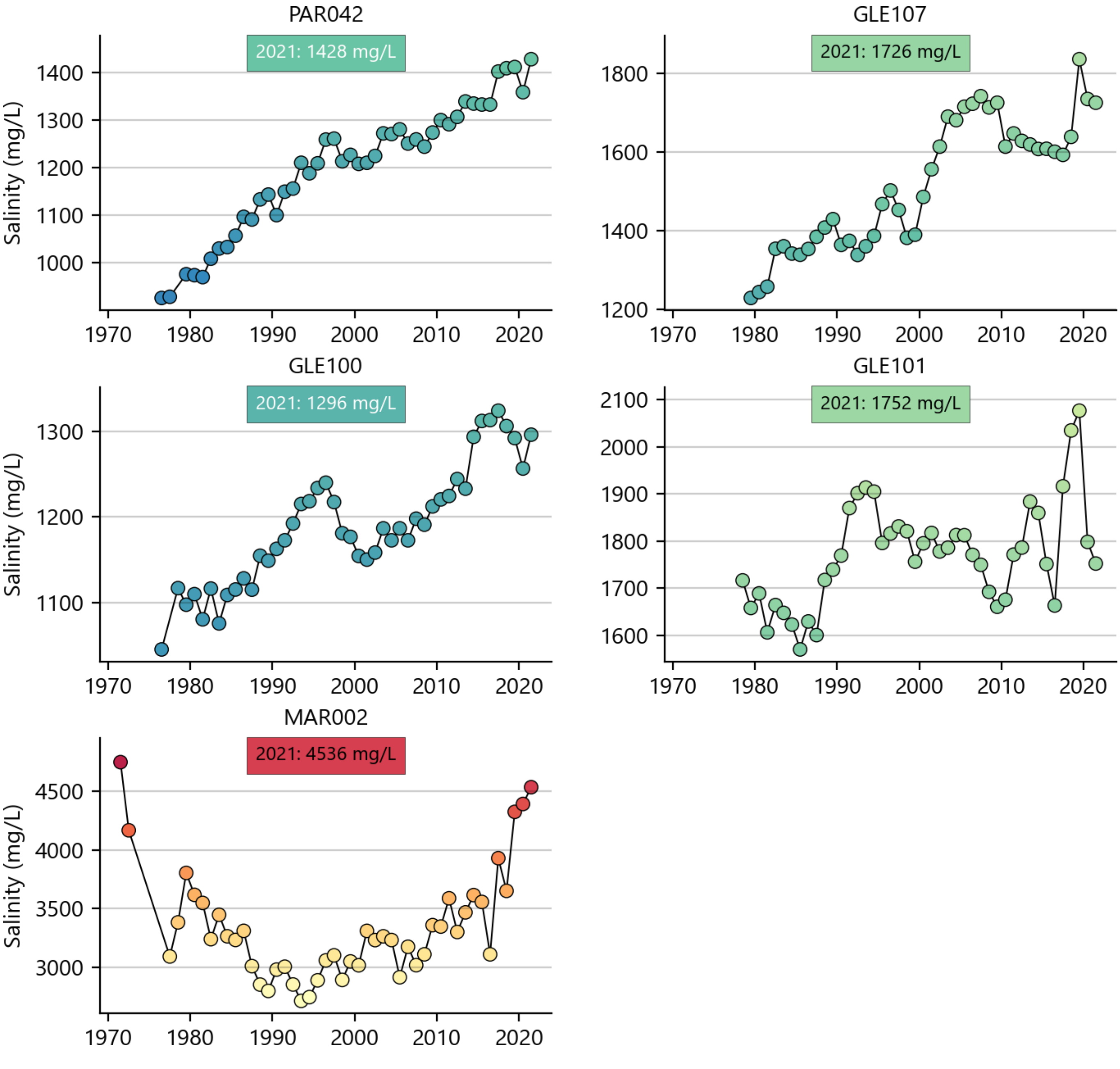

Figure 5.18 Selected salinity graphs for wells in the unconfined aquifer in the Padthaway Flats management area of the Padthaway PWA

5.2.7 Padthaway PWA, Padthaway Range GMA – water level

In 2021, winter-recovered water levels in 64% of monitoring wells in the unconfined aquifer of the Padthaway Range GMA are classified 'Average' or higher (Section 2.3.1; Figure 5.19).

Variations in water level in 12 wells with available data over the past 30 years range from a decline of 1.76 m to a rise of 0.99 m (median rise of 0.20 m).

Five-year trends show declining water levels in the majority of wells (64%), with rates ranging from a decline of 0.30 m/y to a decline of 0.03 m/y (median decline of 0.05 m/y) (Figure 5.20)

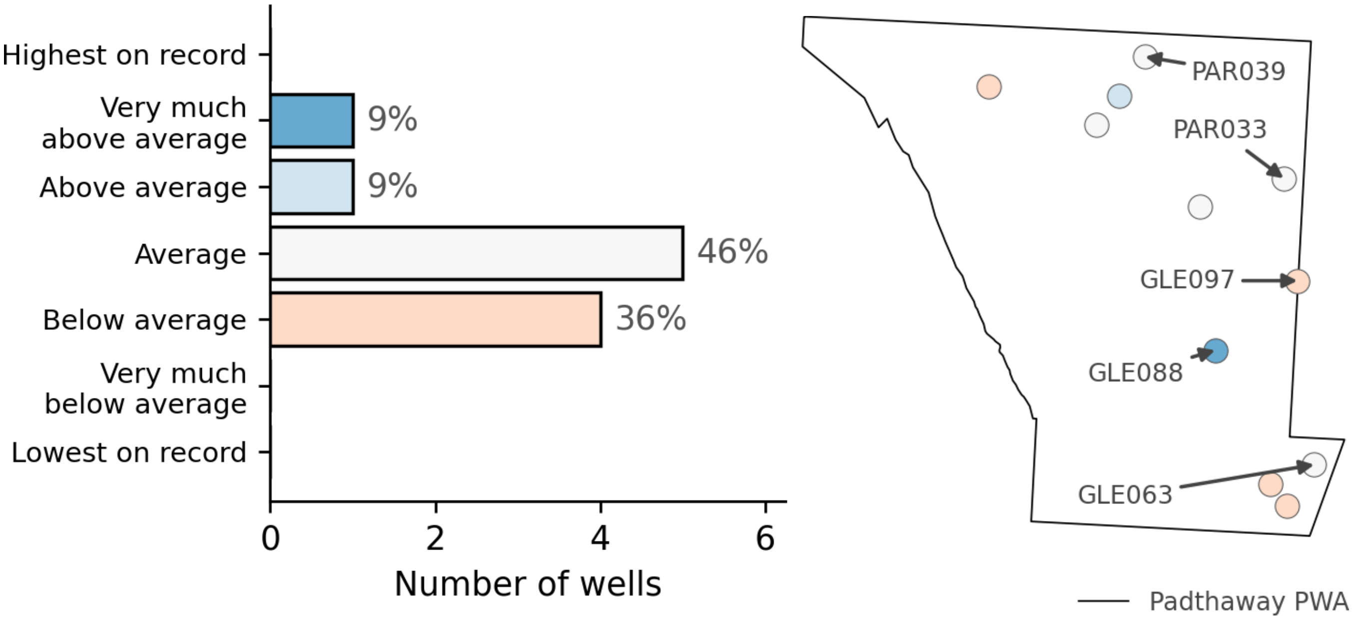

Figure 5.19 2021 recovered water levels for wells in the unconfined aquifer in the Padthaway Range management area of the Padthaway PWA

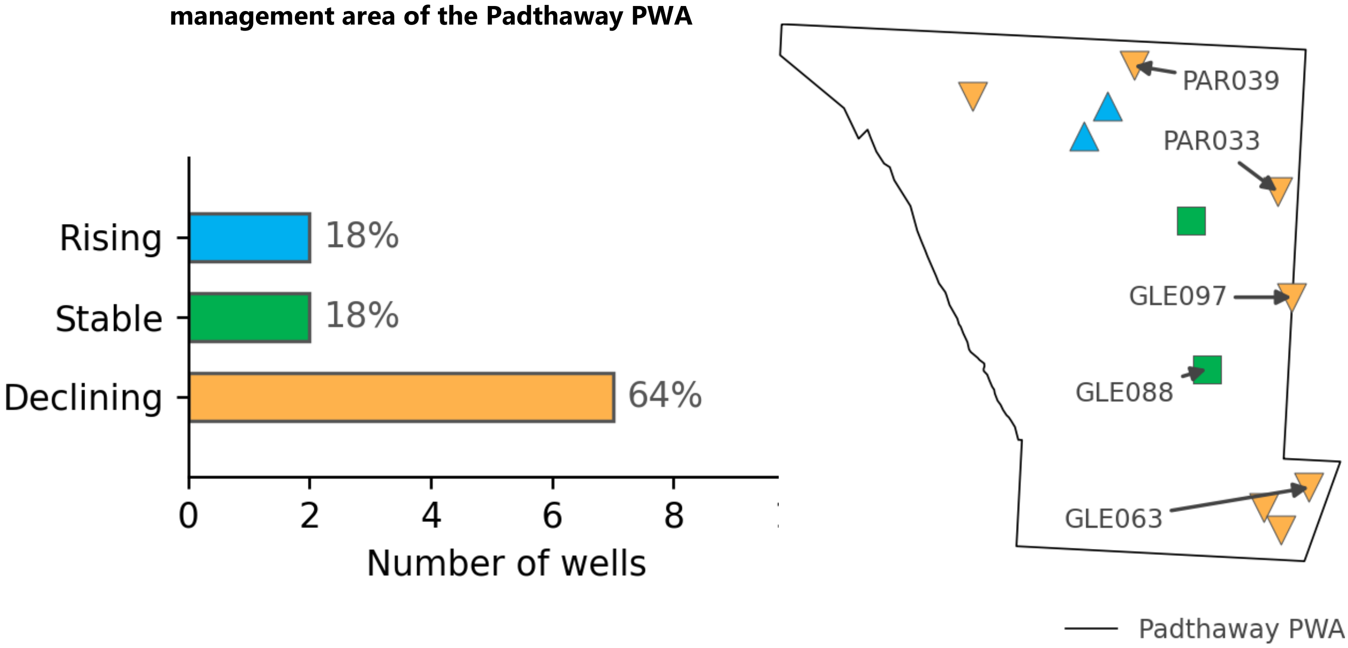

Figure 5.20 2017 to 2021 trend in recovered water levels for wells in the unconfined aquifer in the Padthaway Range management area of the Padthaway PWA

In the Padthaway Range GMA, where the depth to the watertable is generally greater than 10 m, unconfined aquifer water levels are responding to changes in land use. The widespread clearance of native vegetation has resulted in increased recharge rates and rising groundwater levels (Wohling 2007). Several representative monitoring wells (PAR039, PAR033, GLE097, GLE088, GLE063) illustrate rising water levels from the 1980s to the mid-2000s (Figure 5.21).

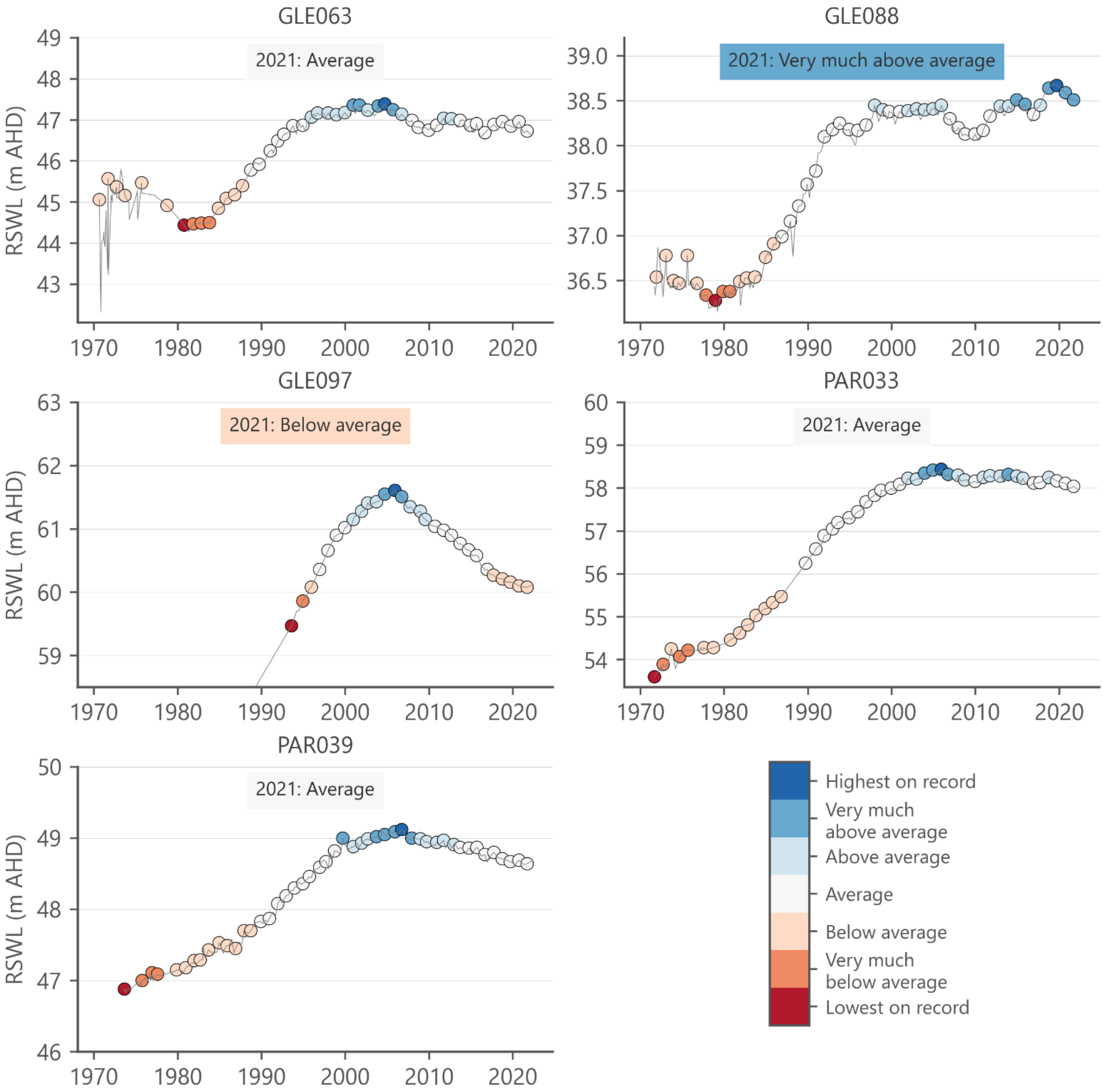

Figure 5.21 Selected hydrographs for wells in the unconfined aquifer in the Padthaway Range management area of the Padthaway PWA

5.2.8 Padthaway PWA, Padthaway Range GMA – salinity

In 2021, and from 10 wells in the unconfined aquifer of the Padthaway Range GMA, salinity ranges between 984 mg/L and 1,912 mg/L with a median of 1,354 mg/L; Figure 5.22).

In the 10 years to 2021, 5 of 8 wells (63%) show an increasing trend in salinity. The 10-year salinity trends vary from a decrease of 0.7% per year to an increase of 1.6% per year, with a median rate of 0.2% increase per year (Figure 5.23).

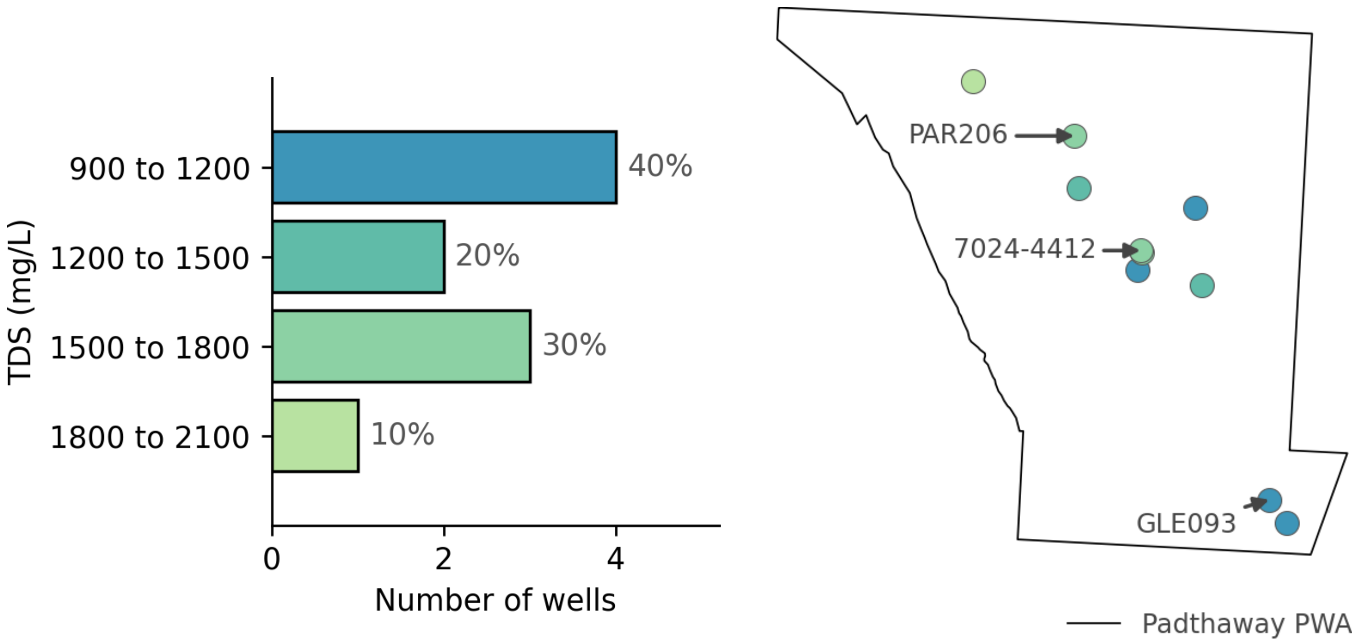

Figure 5.22 2021 salinity observations from wells in the unconfined aquifer in the Padthaway Range management area of the Padthaway PWA

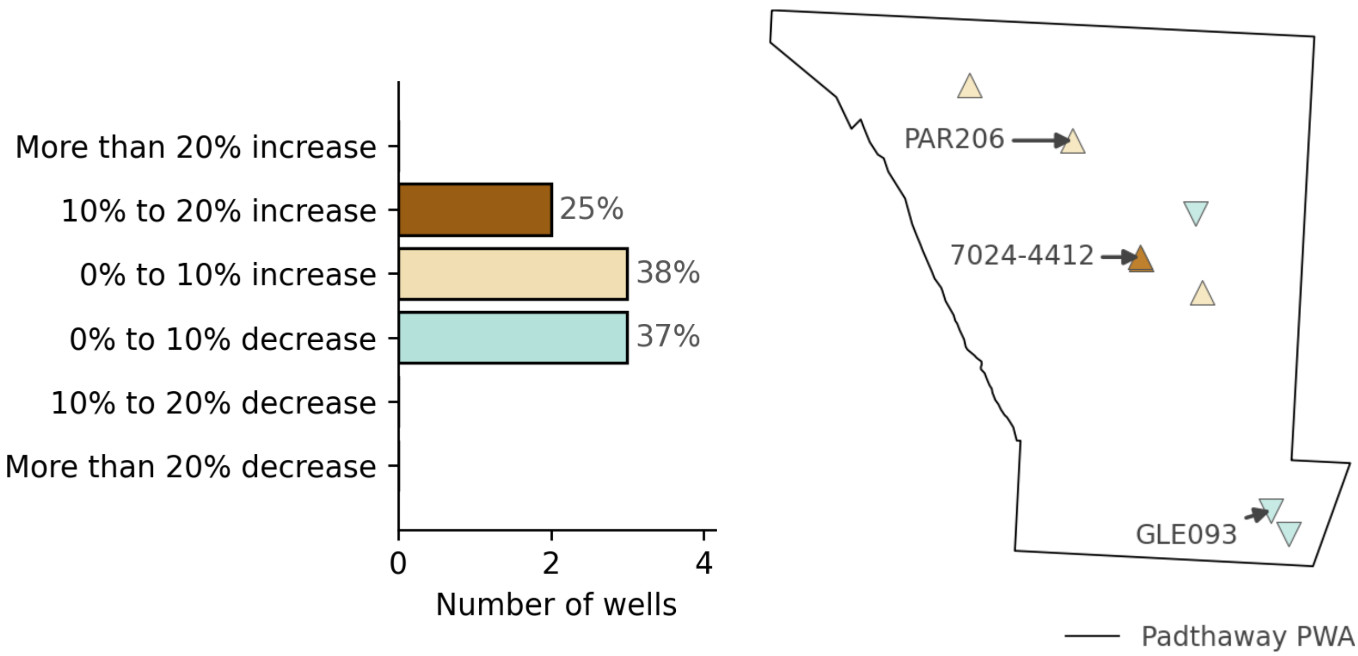

Figure 5.23 Salinity trend in the 10 years to 2021 for wells in the unconfined aquifer in the Padthaway Range management area of the Padthaway PWA

In the Padthaway Ranges, the widespread clearance of native vegetation has resulted in increased recharge rates and the flushing of salt, which was previously stored in the root zone of native vegetation, down to the watertable (Wohling 2007). This process is occurring independent of any irrigation activity, although drainage from irrigated areas is likely to accelerate this process at the local scale. Observation wells GLE093 and 7024-4412 are displaying steady increases in salinity since monitoring began in 1970 and 2000, respectively (Figure 5.24).

PAR206 shows a decreasing salinity over the past 10 years, which may be due to the unsaturated zone having been completely flushed and lower salinity water is now recharging the aquifer, or possibly throughflow of fresher groundwater flowing from the adjacent ranges.

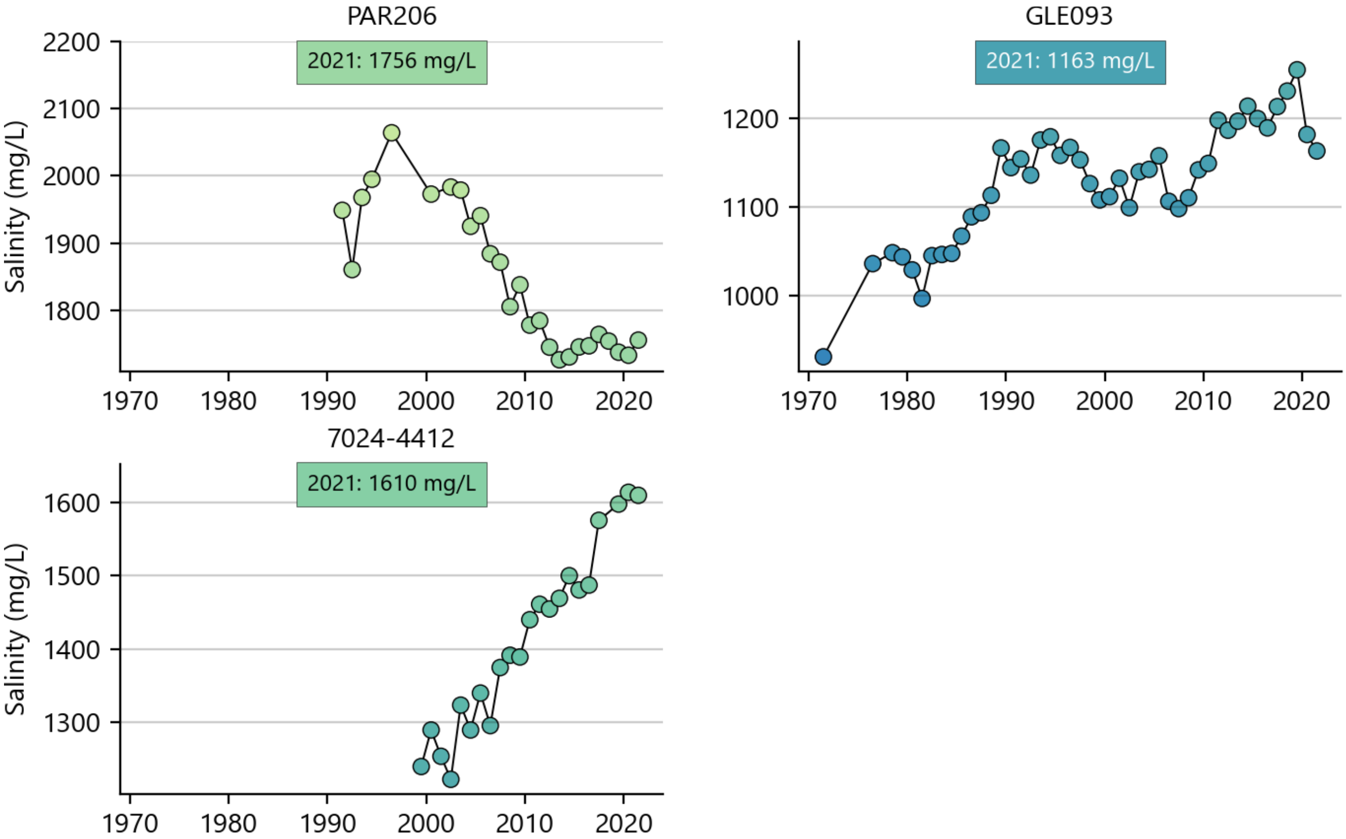

Figure 5.24 Selected salinity graphs for wells in the unconfined aquifer in the Padthaway Range management area of the Padthaway PWA

5.2.9 Tatiara PWA, Plains area – water level

In 2021, winter recovered water levels in 93% of monitoring wells in the unconfined aquifer of the plains in the Tatiara PWA are classified 'Below average' or lower (Section 2.3.1; Figure 5.25).

Variations in water level in 43 wells over the past 30 years range from a decline of 6.65 m to a rise of 0.49 m (median decline of 3.67 m).

Five-year trends show declining water levels in all wells, with rates ranging from a decline of 1.73 m/y to a decline of 0.04 m/y (median decline of 0.11 m/y) (Figure 5.26).

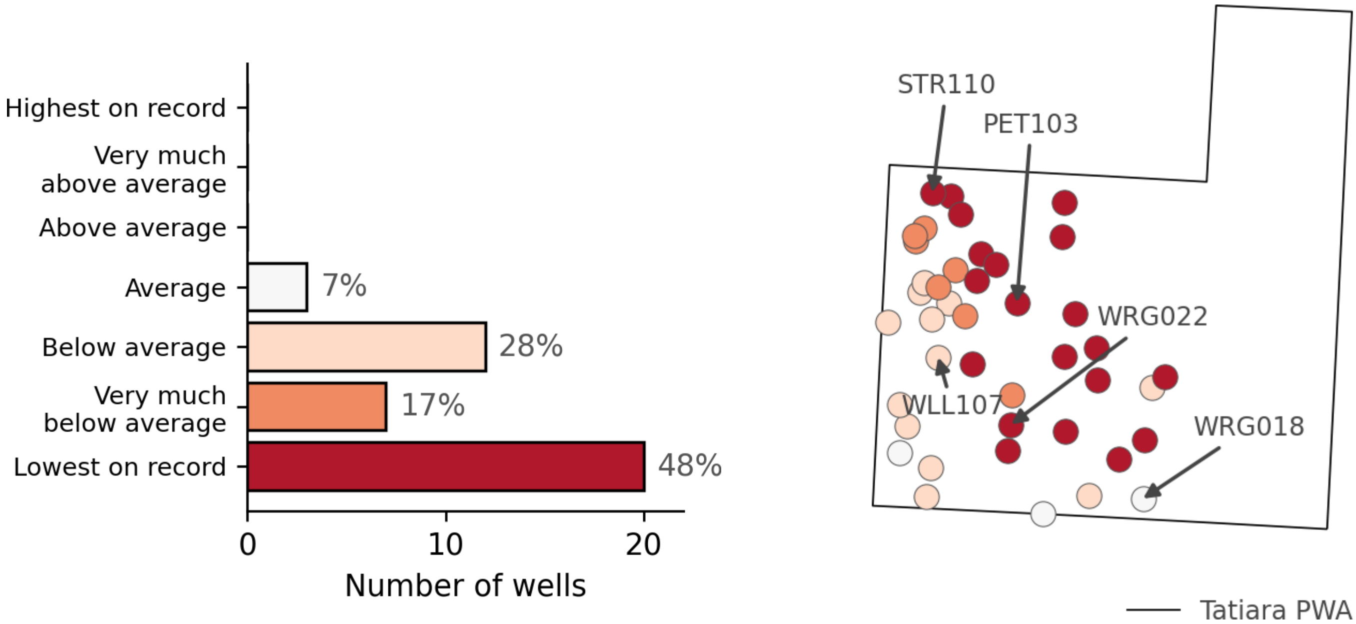

Figure 5.25 2021 winter-recovered water levels for wells in the unconfined aquifer in the Plains area of the Tatiara PWA

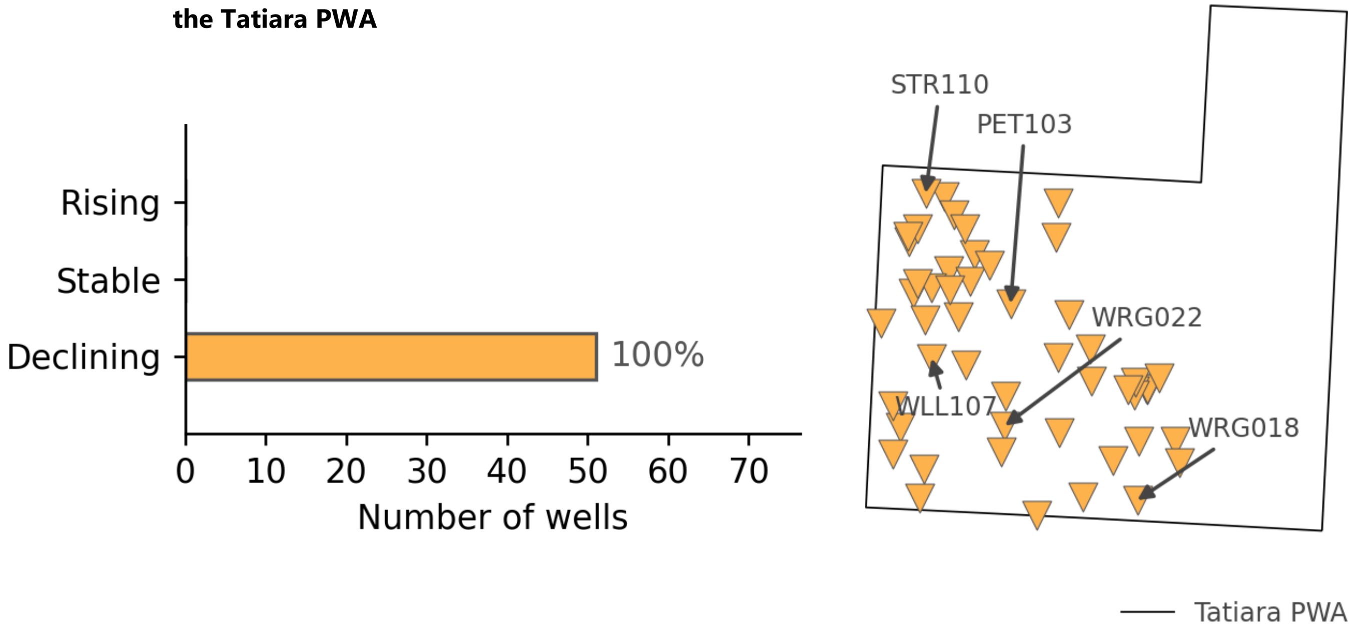

Figure 5.26 2017–21 trend in winter-recovered water levels for wells in the unconfined aquifer in the Plains area of the Tatiara PWA

The shallow depth to the watertable of 5 to 10 m in the unconfined aquifer on the low-lying plains results in groundwater levels being responsive to rainfall. Representative wells from across the Tatiara PWA Plains area (Figure 5.27) include two wells from an area of intensive irrigation near Keith (WLL107 and STR110). These wells show seasonal drawdown and winter recovery due to pumping for irrigation in summer. A steady and consistent declining trend in water levels of around 0.2 m/y is apparent, which corresponds with a prolonged period of below-average rainfall since 1996 (Figure 3.8).

Further east and to the south, most wells show water levels continuing to decline in recent years, especially those located in the transitional zone between the plains and highlands (e.g., PET103 and WRG022; Figure 5.27).

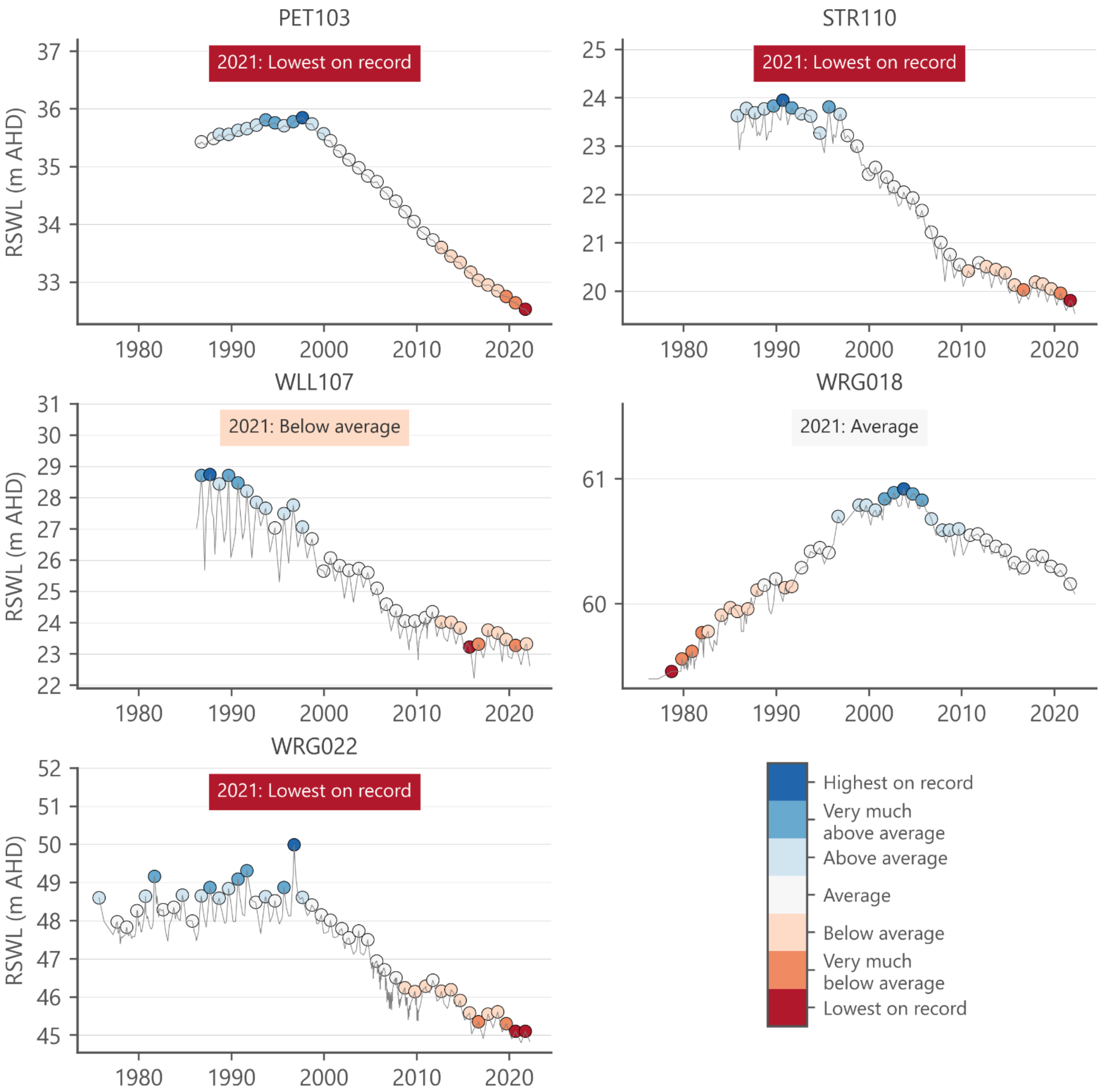

Figure 5.27 Selected hydrographs for wells in the unconfined aquifer in the Plains area of the Tatiara PWA

5.2.10 Tatiara PWA, Plains area – salinity

In 2021, and from 44 irrigation bores in the unconfined aquifer of the plains in the Tatiara PWA, salinity ranges between 267 mg/L and 8,641 mg/L with a median of 2,529 mg/L (Figure 5.28). Salinity greater than 4,500 mg/L is generally measured in the north-western part of the Tatiara PWA, where intensive flood irrigation is often practiced.

In the 10 years to 2021, 22 of 36 wells (61%) show a decreasing trend in salinity (Figure 5.29). The 10-year salinity trends vary from a decrease of 11.0% per year to an increase of 2.3% per year, with a median rate of 0.2% decrease per year.

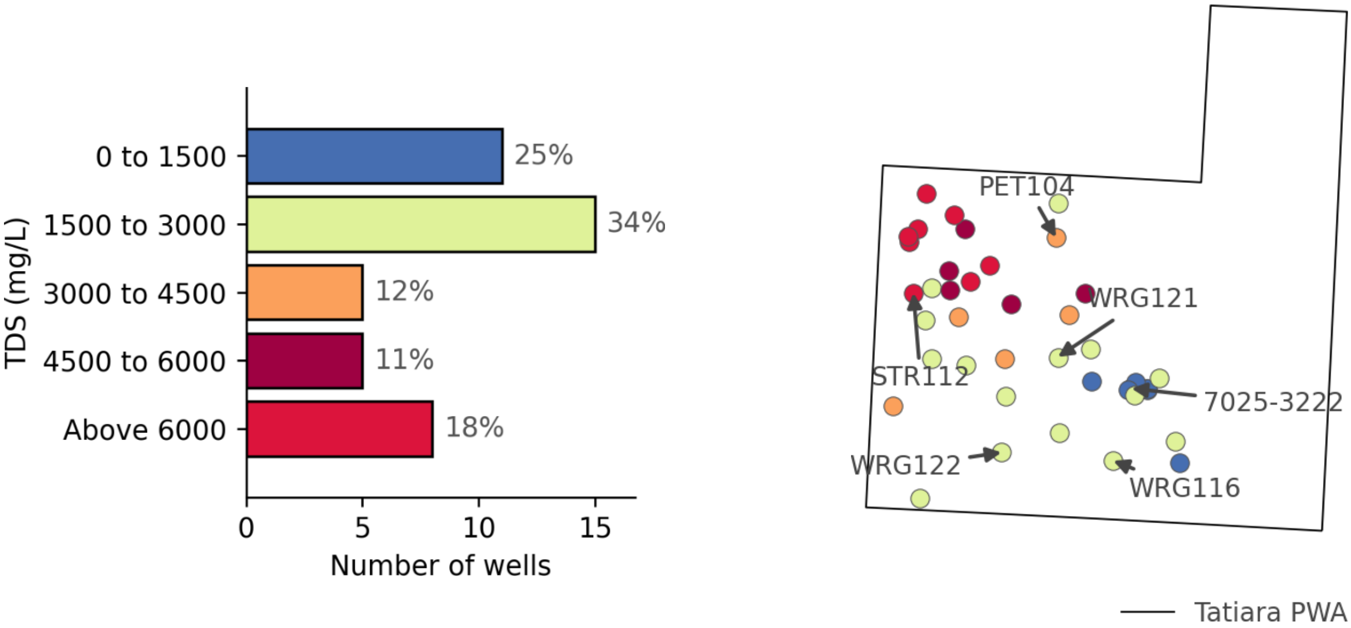

Figure 5.28 2021 salinity observations from wells in the unconfined aquifer in the Plains area of the Tatiara PWA

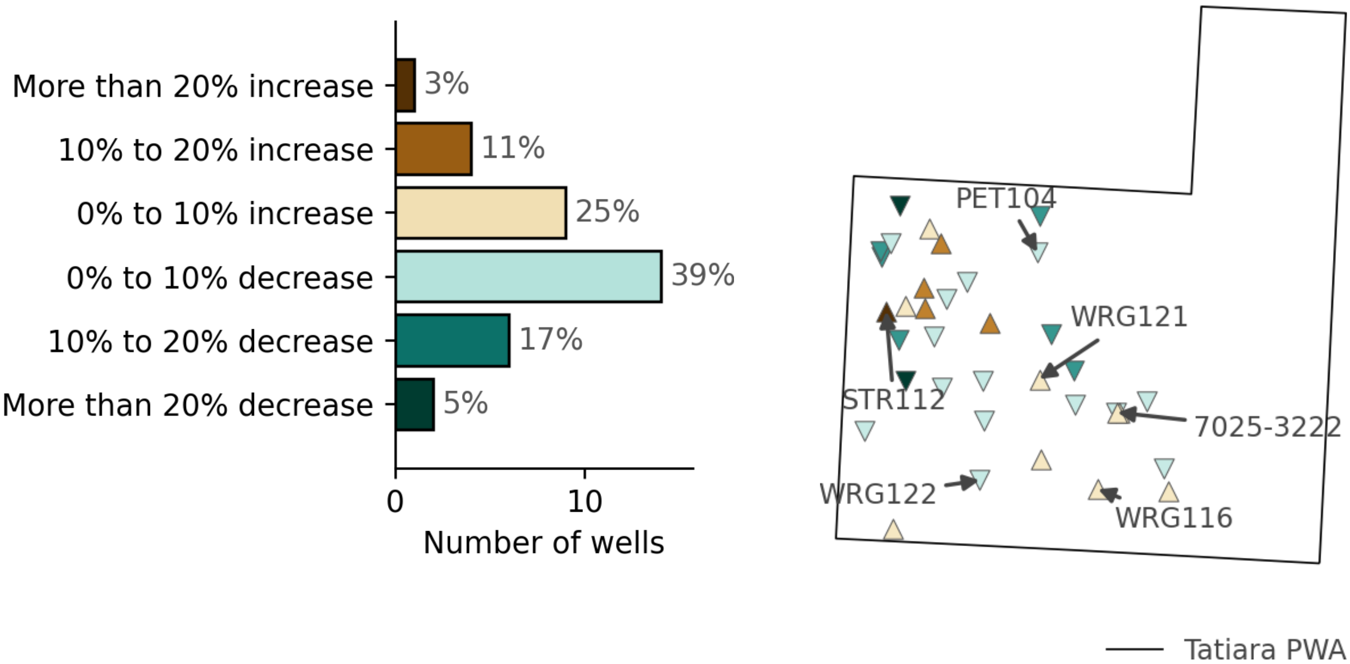

Figure 5.29 Salinity trends in the 10 years to 2021 for wells in the unconfined aquifer in the Plains area of the Tatiara PWA

Many irrigation wells in the unconfined aquifer of the Tatiara plains are showing increasing salinity (Figure 5.30) due to the recycling of irrigation drainage water in the shallow aquifer (STR112, WRG121 and WRG116) (Wohling 2007).

Decreasing salinity has been recorded in a number of observation wells since the late 1990s (e.g., WRG122 and PET104) although the processes leading to aquifer freshening are uncertain.

One of the Bordertown water supply wells (7025-3222) shows relatively stable salinity with some decreases in the early-2000s when monitoring began.

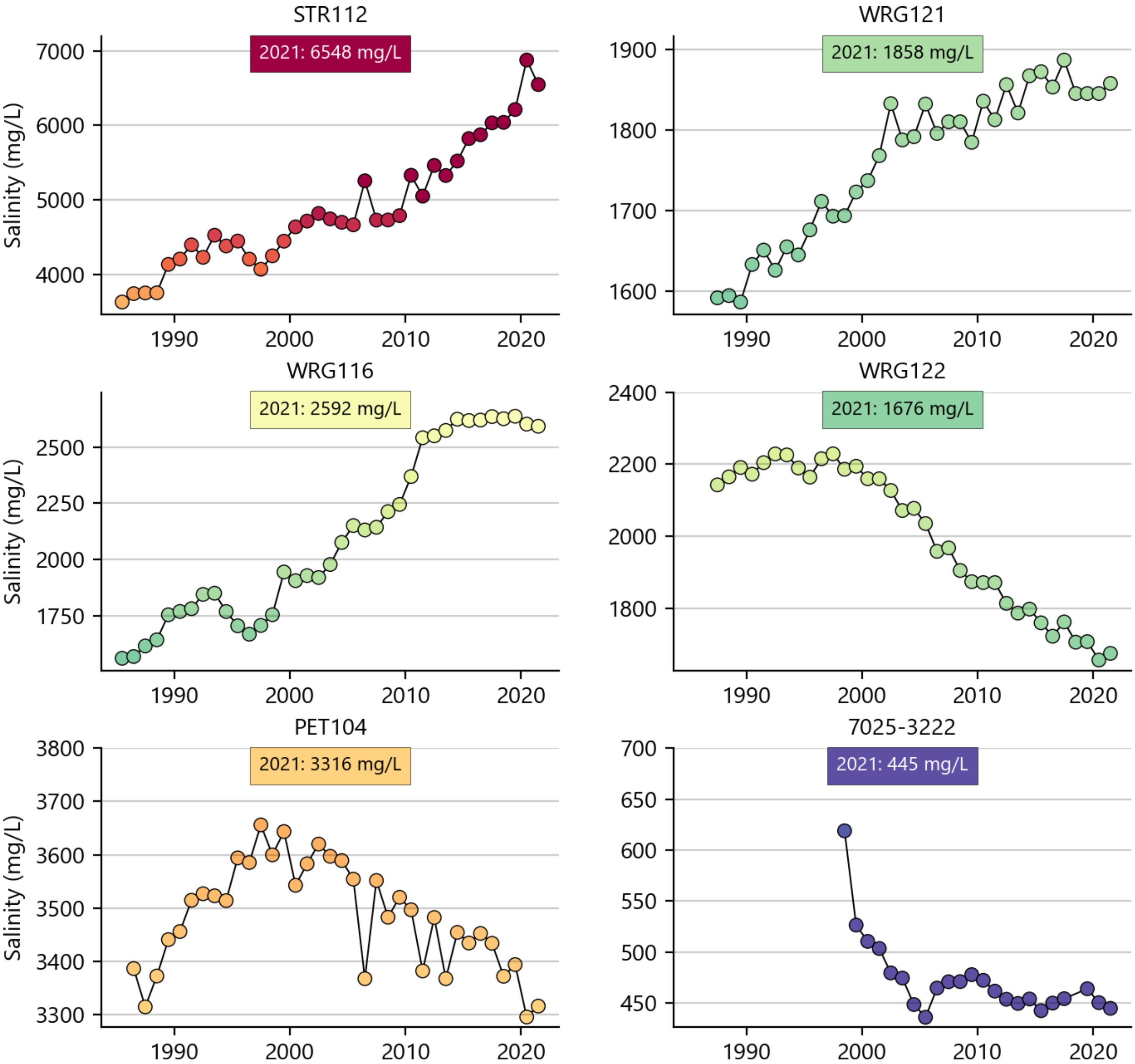

Figure 5.30 Selected salinity graphs for wells in the unconfined aquifer in the Plains area of the Tatiara PWA

5.2.11 Tatiara PWA, Highlands area – water level

In 2021, winter-recovered water levels in 92% of 24 monitoring wells in the unconfined aquifer of the highlands in the Tatiara PWA are classified 'Below average' or lower (Section 2.3.1; Figure 5.31).

Over the past 30 years, variations in water level in 24 wells range from a decline of 2.21 m to a rise of 0.08 m (median is a decline of 0.29 m).

Five-year trends show declining water levels in the majority of wells (83%), with rates ranging from a decline of 0.07 m/y to a decline of 0.02 m/y (median decline of 0.04 m/y) (Figure 5.32).

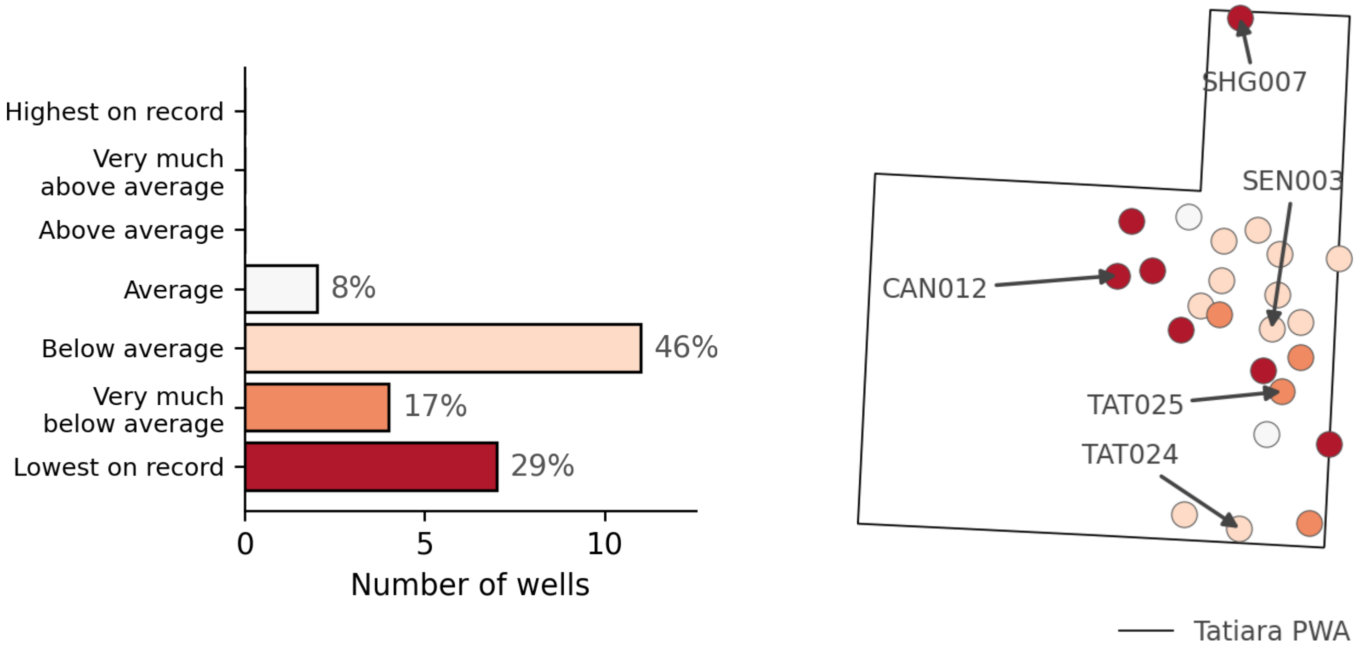

Figure 5.31 2021 winter-recovered water levels for wells in the unconfined aquifer in the Highlands area of the Tatiara PWA

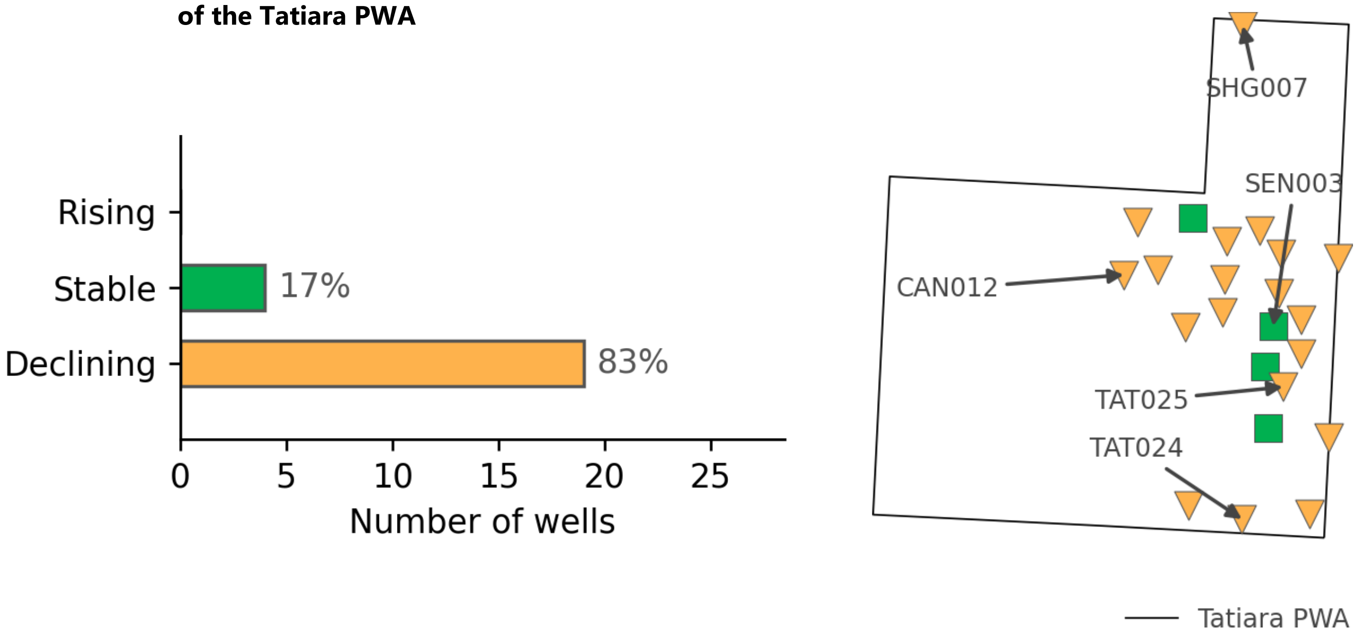

Figure 5.32 2017 to 2021 trend in winter-recovered water levels for wells in the unconfined aquifer in Highlands area of the Tatiara PWA

In the Tatiara PWA Highlands area, where the depth to the watertable is generally greater than 10 m and the saturated thickness of the unconfined aquifer is generally high, groundwater levels have generally fluctuated less than 2 m in the longer term. Subtle rises in water levels occurred throughout the 1980s and 1990s (e.g., SEN003, SHG007 and TAT024) in some wells while water levels in other wells were generally stable (CAN012 and TAT025) (Figure 5.33); subsequently, water levels have shown generally subtle declining trends.

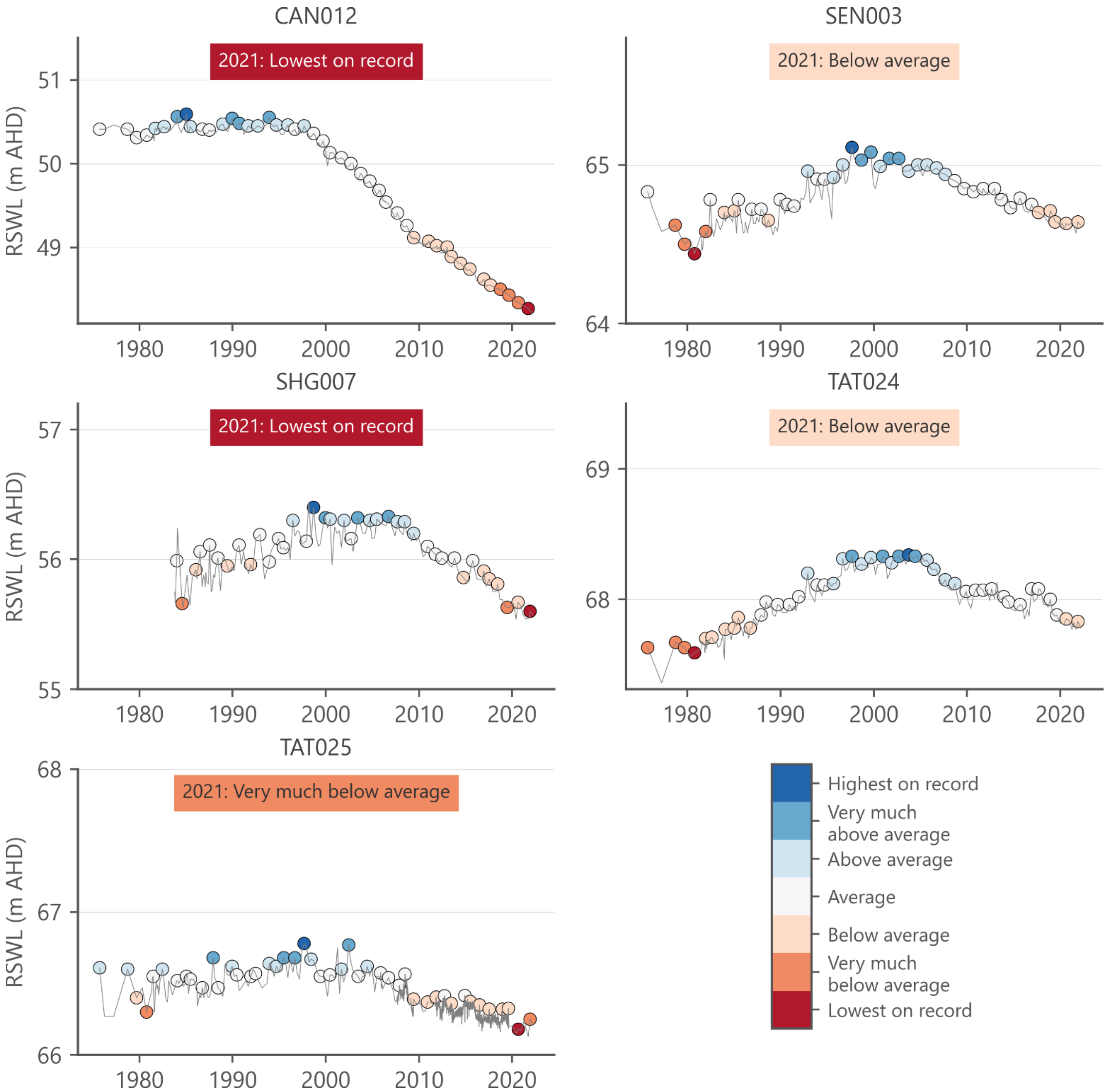

Figure 5.33 Selected hydrographs for the unconfined aquifer in the Highlands area of the Tatiara PWA

5.2.12 Tatiara PWA, Highlands area – salinity

In 2021, and from 9 wells in the unconfined aquifer of the highlands in the Tatiara PWA, salinity ranges between 1,042 mg/L and 2,356 mg/L with a median of 1,443 mg/L (Figure 5.34).

In the 10 years to 2021, all 9 wells show stable trends in salinity (±10%) (see Section 2.3.2 for details of the calculation; Figure 5.35). The 10-year salinity trends vary from a decrease of 0.5% per year to an increase of 0.4% per year, with a median rate of 0.1% decrease per year.

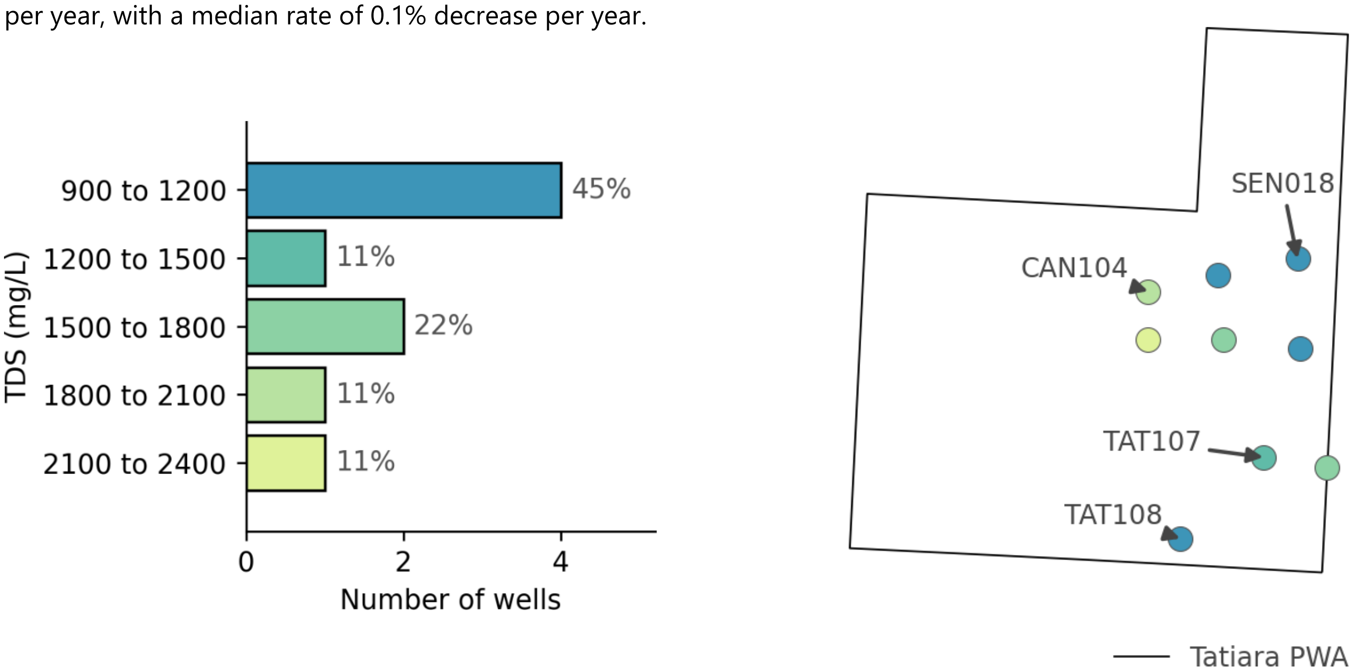

Figure 5.34 2021 salinity observations from wells in the unconfined aquifer in the Highlands area of the Tatiara PWA

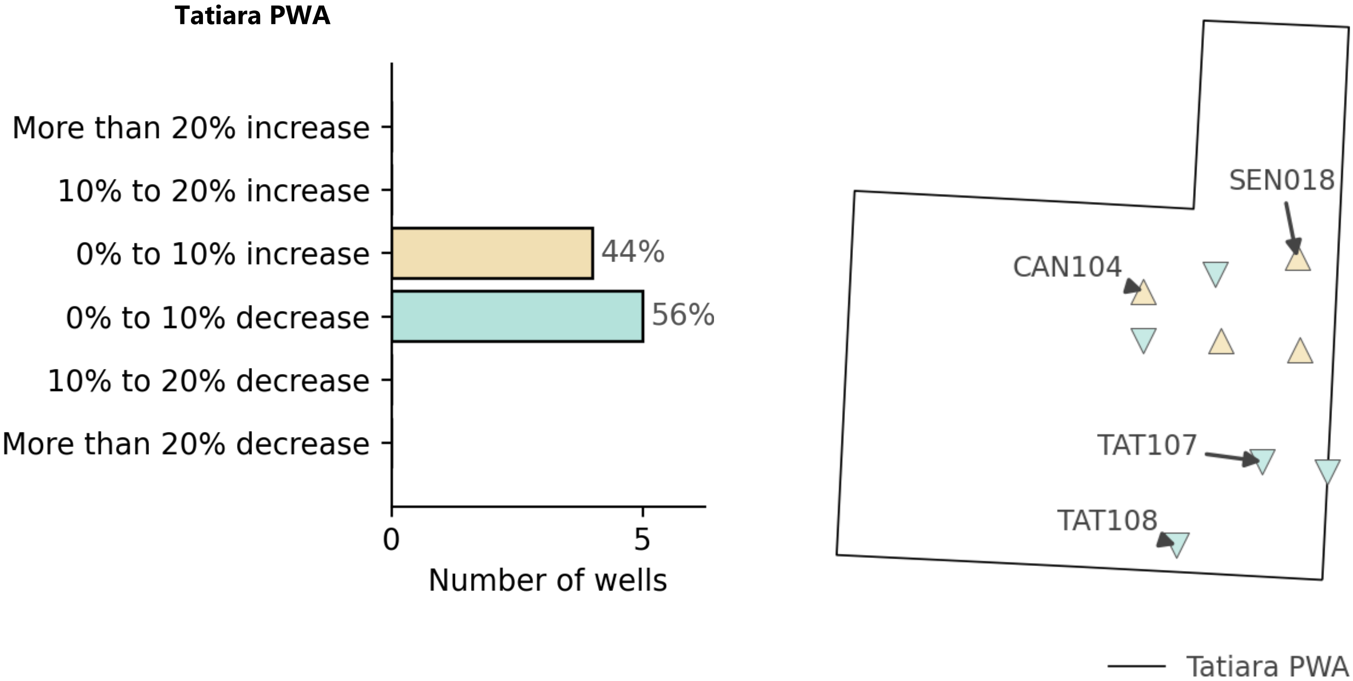

Figure 5.35 Salinity trend in the 10 years to 2021 for wells in the unconfined aquifer in the Highlands area of the Tatiara PWA

The widespread clearance of native vegetation in the Padthaway Ranges has resulted in increased recharge rates and the flushing of salt, which was previously stored in the root zone of the native vegetation, down to the watertable (Wohling 2007); this process may also be occurring in the Tatiara PWA Highlands area (Figure 5.36). Increases in groundwater salinity are observed at CAN104 since monitoring began in the 1980s, but salinity appears to have stabilised over the past few years. TAT108 shows a gradual increase in salinity up until 2000, but salinity has since stabilised.

TAT107 and SEN018 are located in the eastern part of the PWA where the depth to the watertable is over 30 m and consequently, any salt that may have been mobilised from the shallow root zone has not yet impacted the aquifer and salinity is stable.

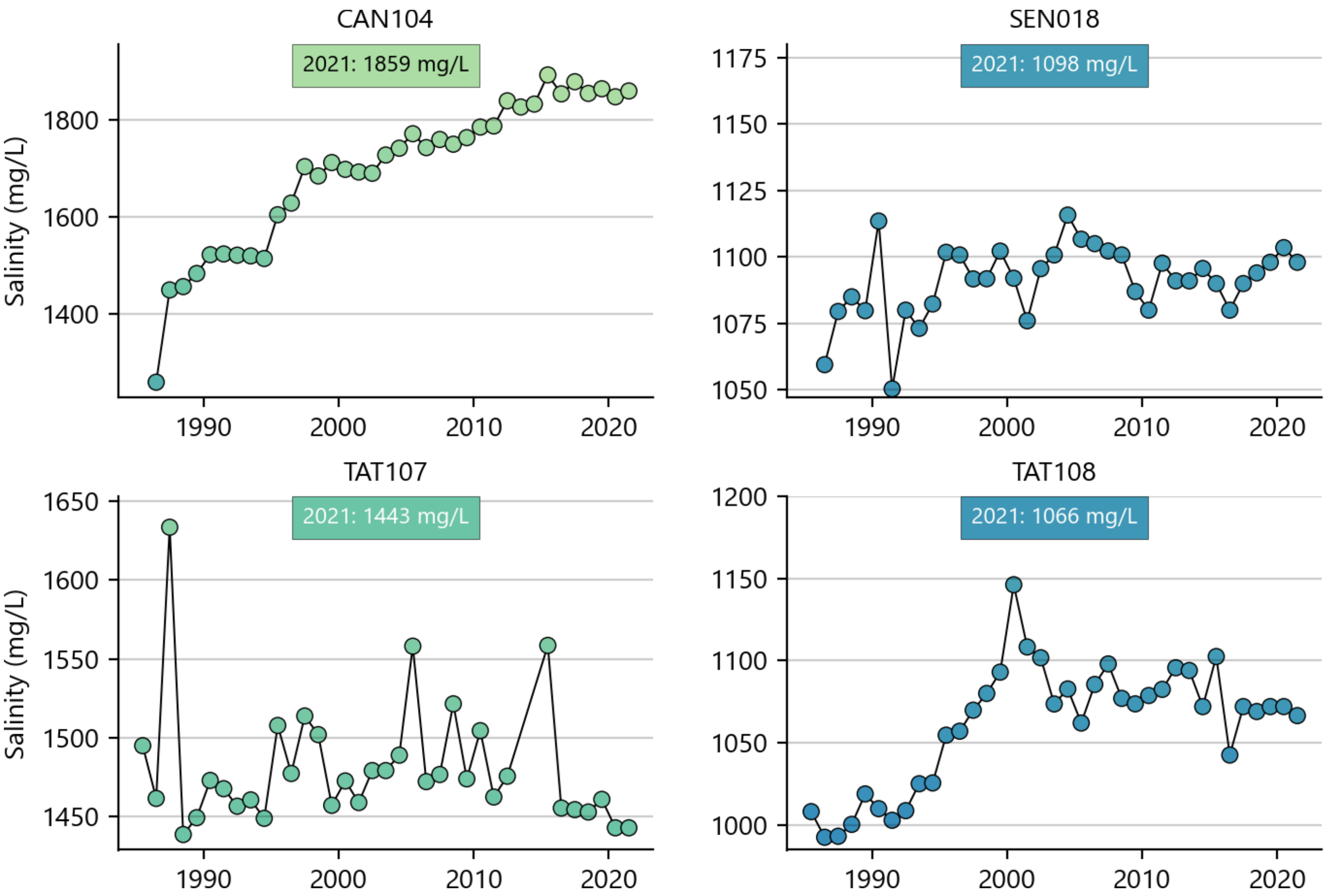

Figure 5.36 Selected salinity graphs for wells in the unconfined aquifer in the Highlands area of the Tatiara PWA

5.2.13 Tintinara-Coonalpyn PWA, Plains area – water level

In 2021, winter-recovered water levels in 52% of monitoring wells in the unconfined aquifer of the plains in the Tintinara-Coonalpyn PWA are classified 'Below average' or lower (Section 2.3.1; Figure 5.37).

Variations in water level in 18 wells over the past 20 years range from a decline of 3.42 m to a rise of 0.42 m (median decline of 0.84 m).

Five-year trends show declining water levels in the majority of wells (86%), with rates ranging from a decline of 0.22 m/y to a decline of 0.04 m/y (median decline of 0.10 m/y; Figure 5.38).

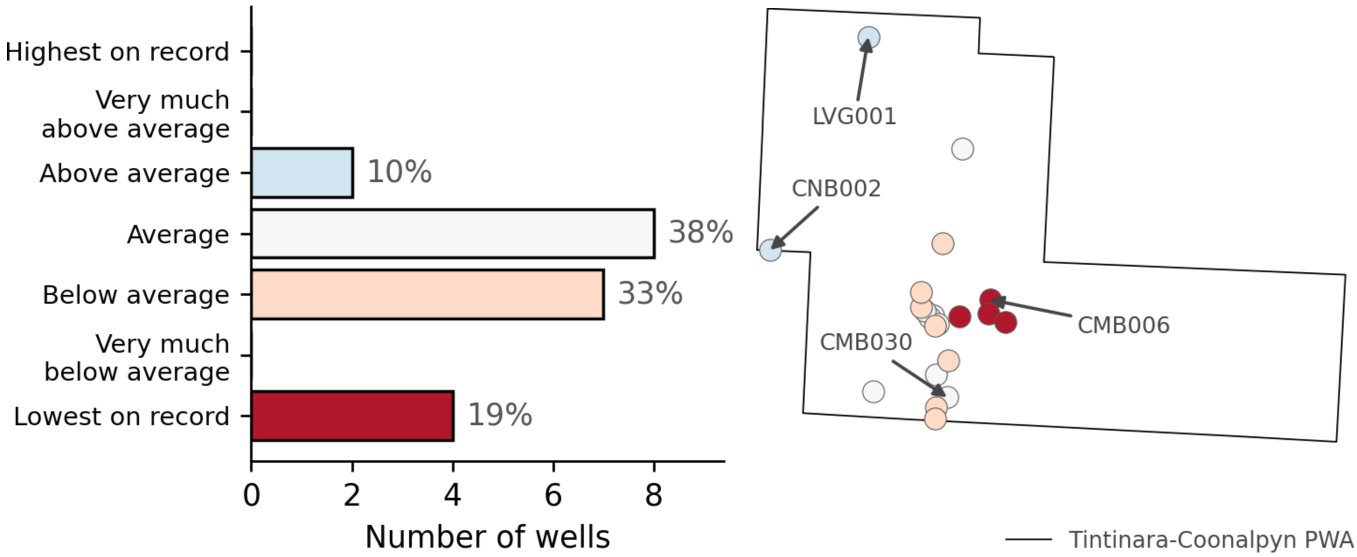

Figure 5.37 2021 winter-recovered water levels for wells in the unconfined aquifer in the Plains area of the Tintinara-Coonalpyn PWA

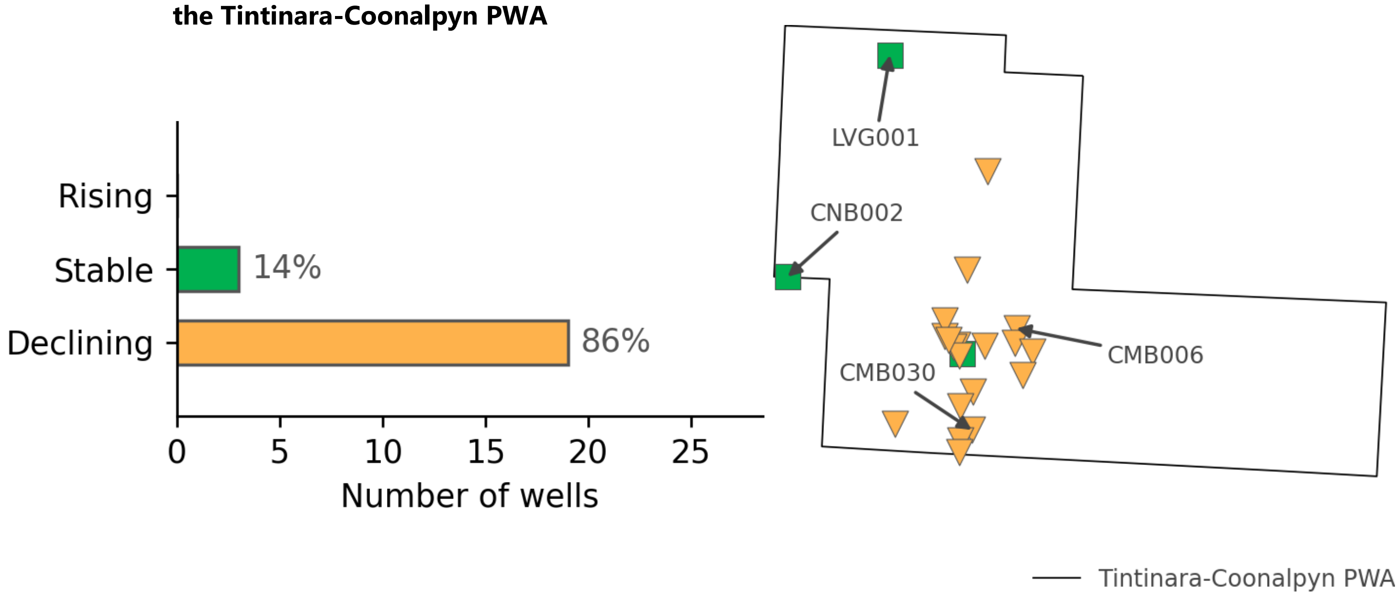

Figure 5.38 2017 to 2021 trend in winter-recovered water levels for wells in the unconfined aquifer in the Plains area of the Tintinara-Coonalpyn PWA

The shallow depth to the watertable of 5 to 10 m in the unconfined aquifer on the low-lying plains results in the groundwater level trends being very responsive to rainfall. Representative monitoring well CMB006 shows a declining trend in water levels since 1996 (Figure 5.39) that corresponds with an increase in extraction and a prolonged period of below-average rainfall, particularly since 2004–05. Monitoring well CMB030, where the depth to water in the well is less than 2 m, shows large seasonal fluctuations of around 1 m.

The water level in LVG001, which is located towards the northern boundary of the Tintinara-Coonalpyn PWA Plains area, shows a gradual rise since the late-1980s (Figure 5.39), despite very low rainfall over the period 2005 to 2016 (Figure 3.10).

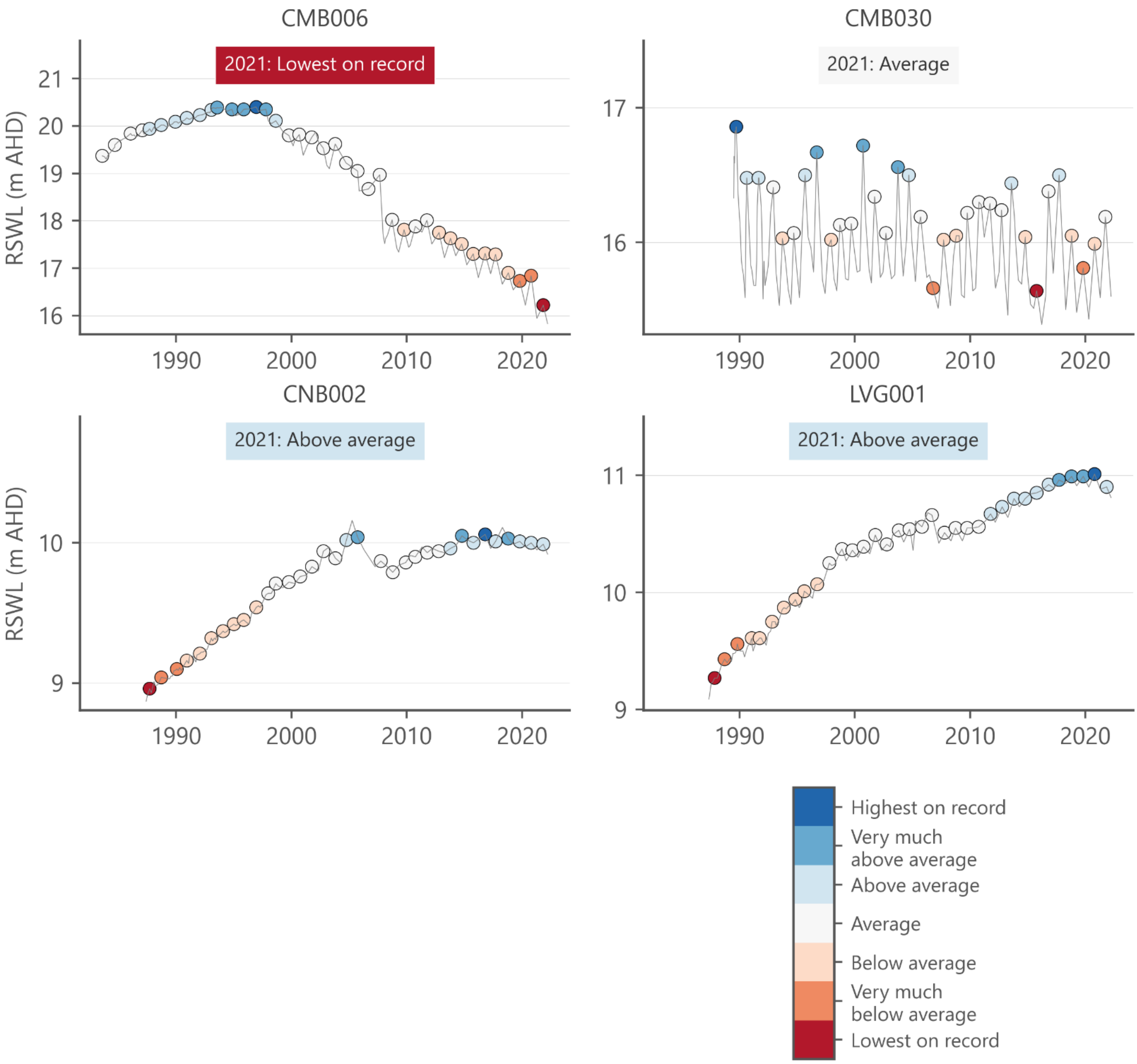

Figure 5.39 Selected hydrographs for wells in the unconfined aquifer in the Plains area of the Tintinara-Coonalpyn PWA

5.2.14 Tintinara-Coonalpyn PWA, Mallee highlands area – water level

In 2021, winter-recovered water levels in all monitoring wells in the unconfined aquifer of the Mallee Highlands in the Tintinara-Coonalpyn PWA are classified as 'Below average' or lower (Section 2.3.1; Figure 5.40).

Over the past 20 years, variations in water level in 7 wells range from a decline of 2.36 m to a decline of 0.55 m (median decline of 1.3 m).

Five-year trends show declining water levels in the majority of wells (86%), with rates of decline ranging between 0.19 to 0.06 m/y (median decline of 0.13 m/y) (Figure 5.41).

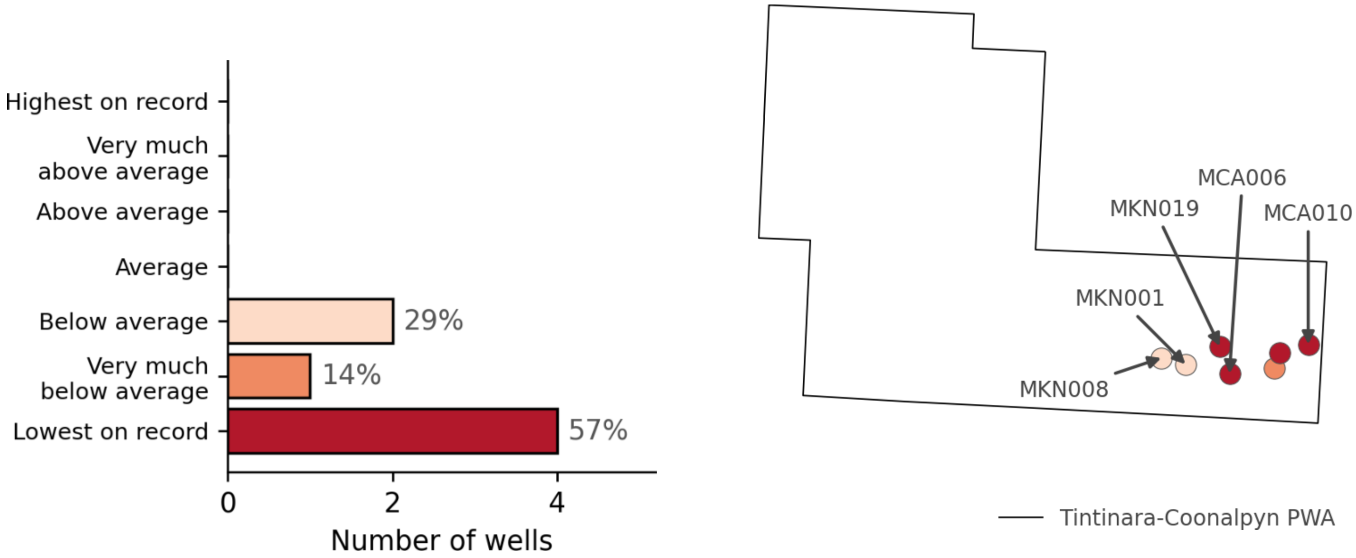

Figure 5.40 2021 winter-recovered water levels for wells in the unconfined aquifer in the Mallee highlands area of the Tintinara-Coonalpyn PWA

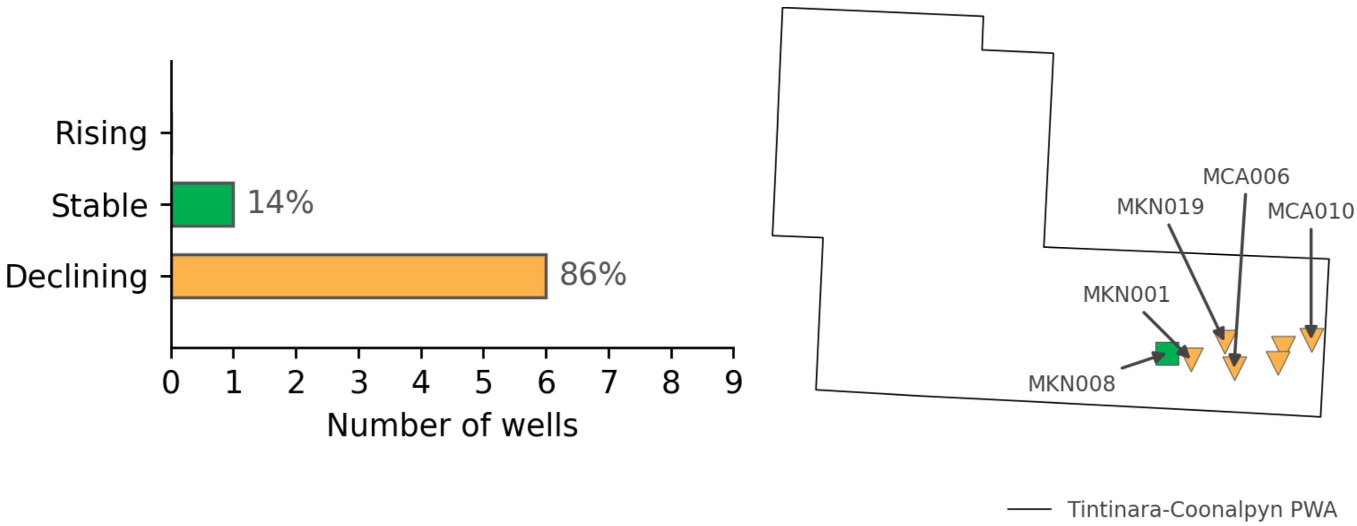

Figure 5.41 2017 to 2021 trend in winter-recovered water levels for wells in the unconfined aquifer in the Mallee highlands area of the Tintinara-Coonalpyn PWA

Historical changes in water levels in the Mallee highlands area of the Tintinara-Coonalpyn PWA (Figure 5.42) follow a similar pattern to wells in the neighbouring Tatiara PWA highlands area (Figure 5.33), with generally rising water levels from the early 1980s to the late 1990s, followed by gradual declines of 1 to 2 m (e.g. MKN019 and MKN008). However, the saturated thickness of the unconfined aquifer is generally high.

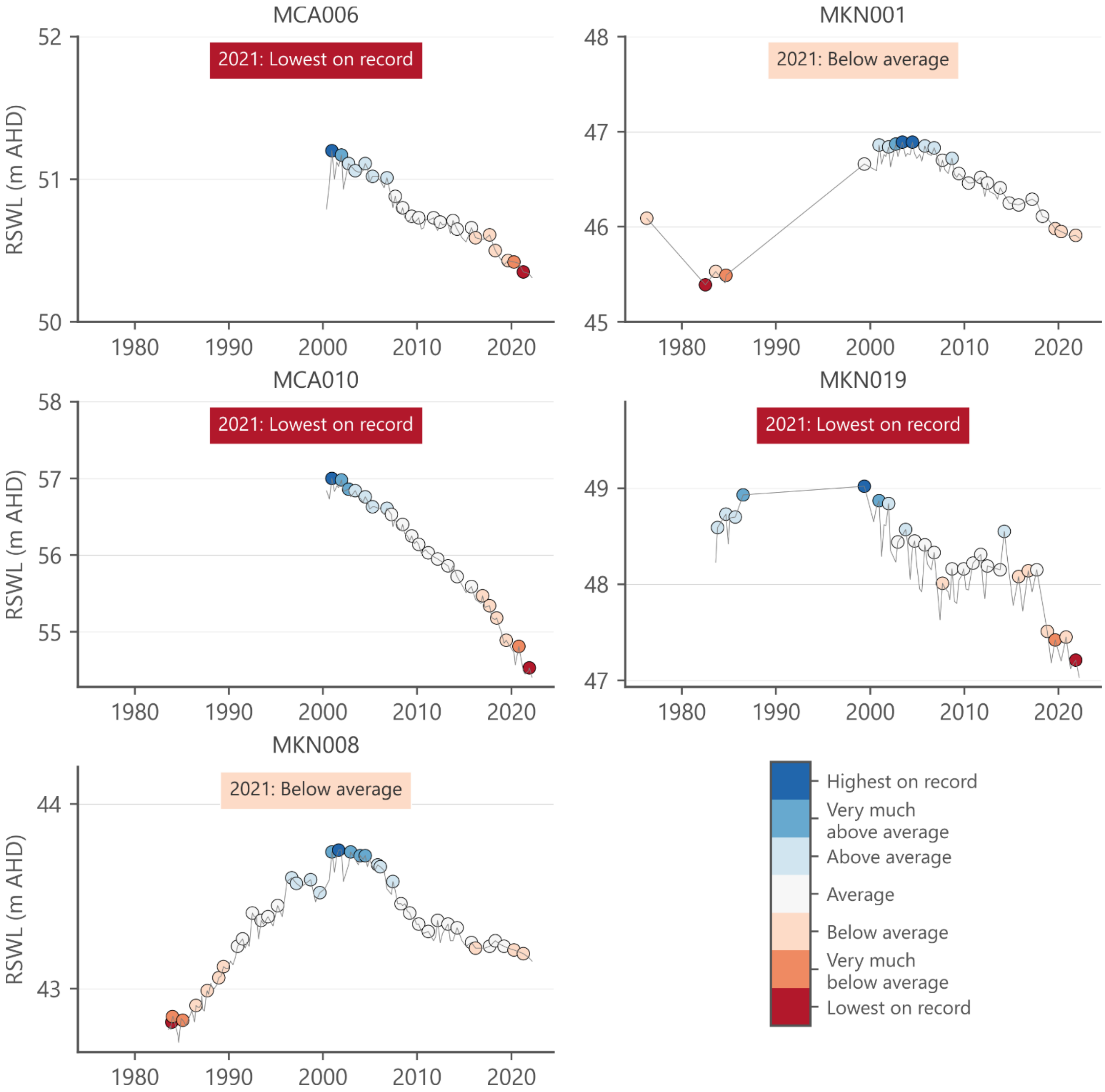

Figure 5.42 Selected hydrographs for wells in the unconfined aquifer in the Mallee highlands area of the Tintinara-Coonalpyn PWA

5.2.15 Tintinara-Coonalpyn PWA – salinity

In 2021, and from 11 irrigation bores in the unconfined aquifer of the Tintinara-Coonalpyn PWA, salinity ranges between 1,298 mg/L and 3,960 mg/L with a median of 2,326 mg/L (Figure 5.43).

In the 10 years to 2021, all wells show stable trends in salinity (±10%) (Section 2.3.2). The 10-year salinity trends vary from a decrease of 0.6% per year to an increase of 0.5% per year, with a median rate of 0.1% decrease per year (Figure 5.44).

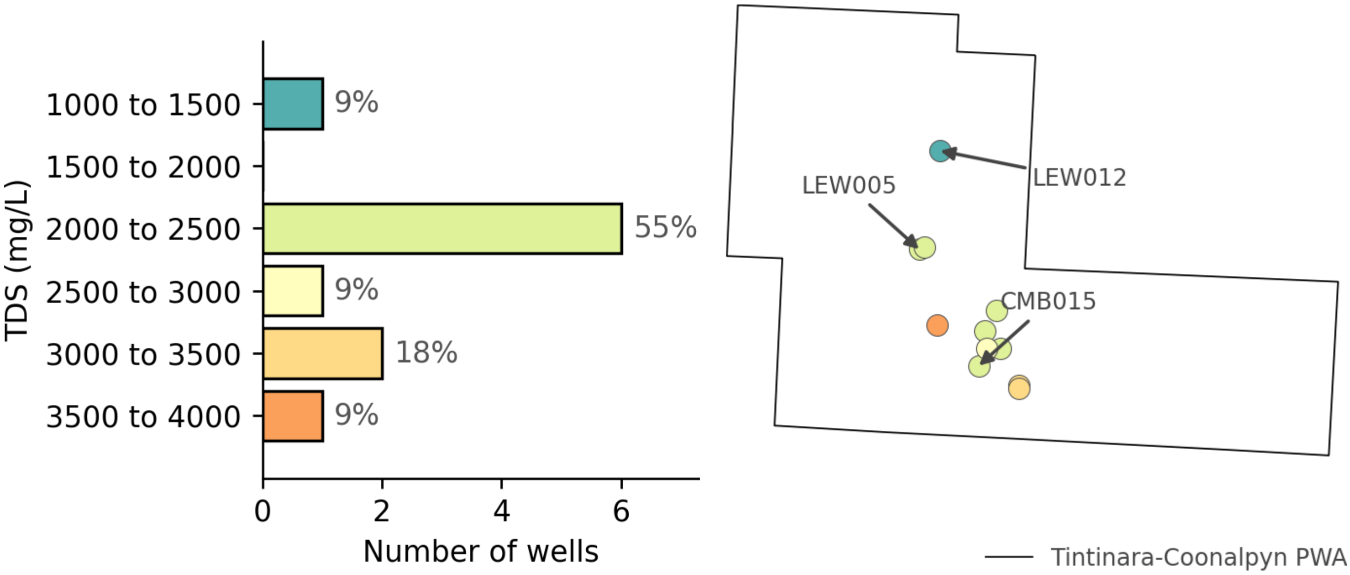

Figure 5.43 2021 salinity observations from wells in the unconfined aquifer in the Tintinara-Coonalpyn PWA

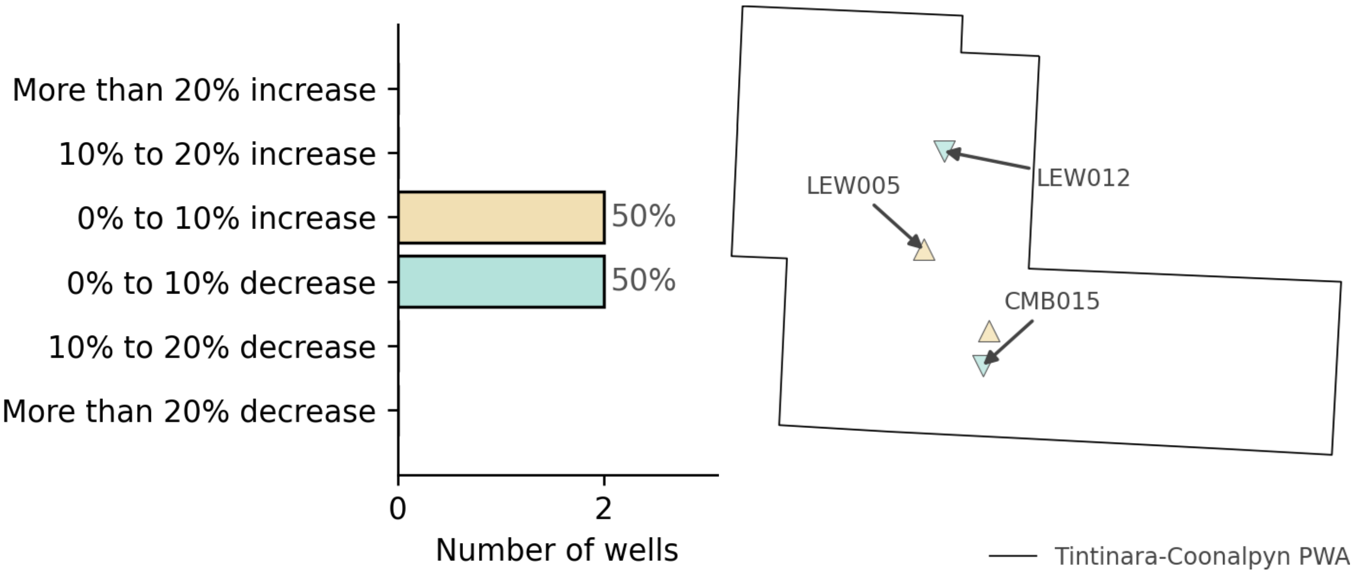

Figure 5.44 Salinity trend in the 10 years to 2021 for wells in the unconfined aquifer in the Tintinara-Coonalpyn PWA

5.3 Confined aquifer

5.3.1 Lower Limestone Coast PWA, confined aquifer – water level

In 2021, winter recovered water levels in 51 out of 85 (40%) of monitoring wells in the confined aquifer of the Lower Limestone Coast PWA are classified as 'Below average' or lower (Section 2.3.1; Figure 5.45).

Over the past 30 years, variations in water level in 39 wells range from a decline of 2.90 m to a rise of 3.48 m (median is a decline of 0.4 m).

Five-year trends show declining water levels in the majority of wells (69%), with rates of decline ranging between 0.69 to 0.02 m/y (median decline of 0.07 m/y) (Figure 5.46).

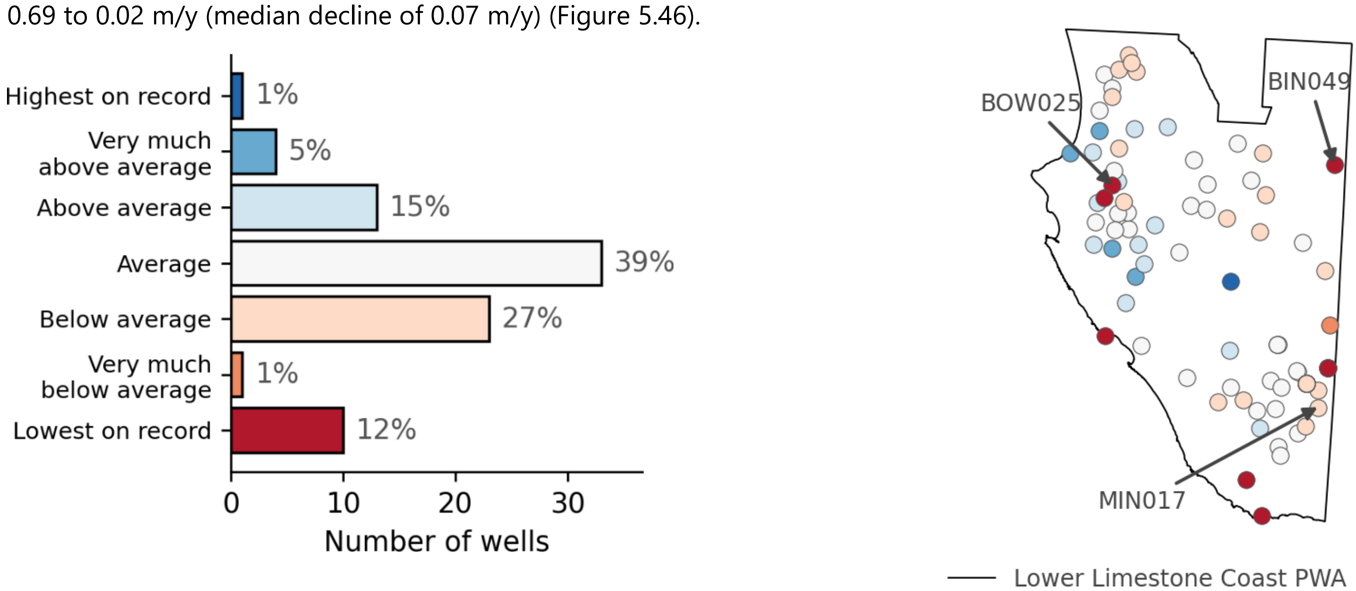

Figure 5.45 2021 winter-recovered water levels for wells in the confined aquifer in the Lower Limestone Coast PWA

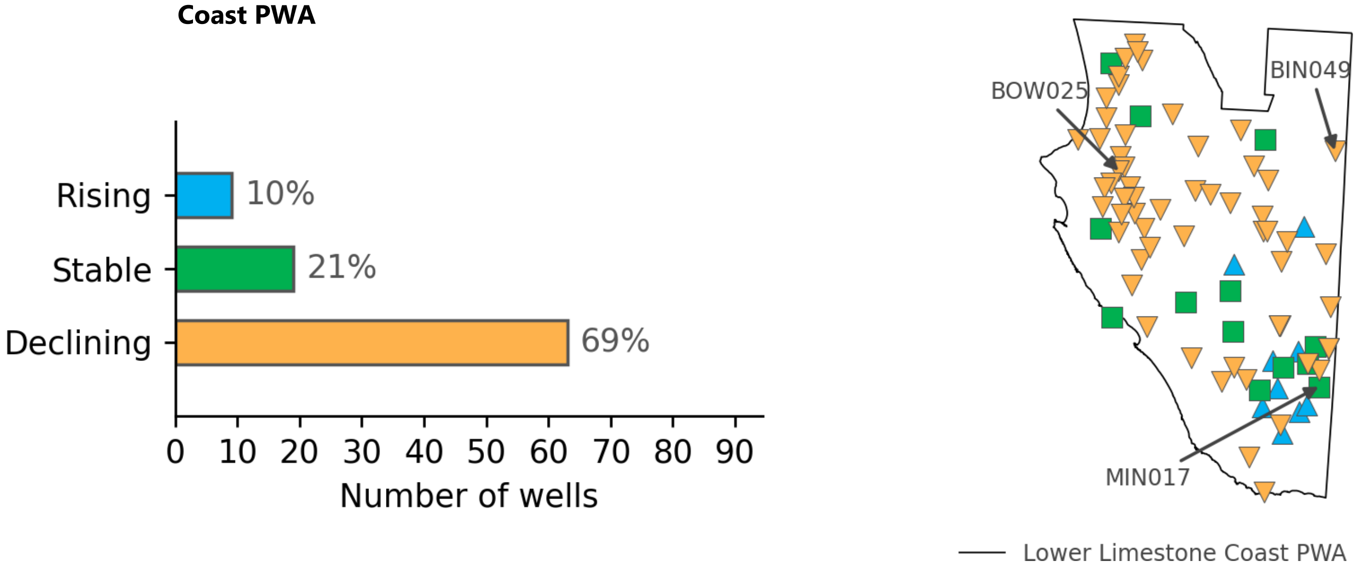

Figure 5.46 2017–21 trend in recovered water levels for wells in the confined aquifer in the Lower Limestone Coast PWA

The main area of extraction from the confined aquifer in the Lower Limestone Coast PWA is in the central artesian area, inland between Kingston SE and Beachport (e.g., BOW025; Figure 5.47). Beyond this area, extraction is generally limited, except for town water supplies and some irrigation south of Mount Gambier. Monitoring wells located near areas of extraction show pumping signals in water levels, such as BOW025 (Figure 5.47).

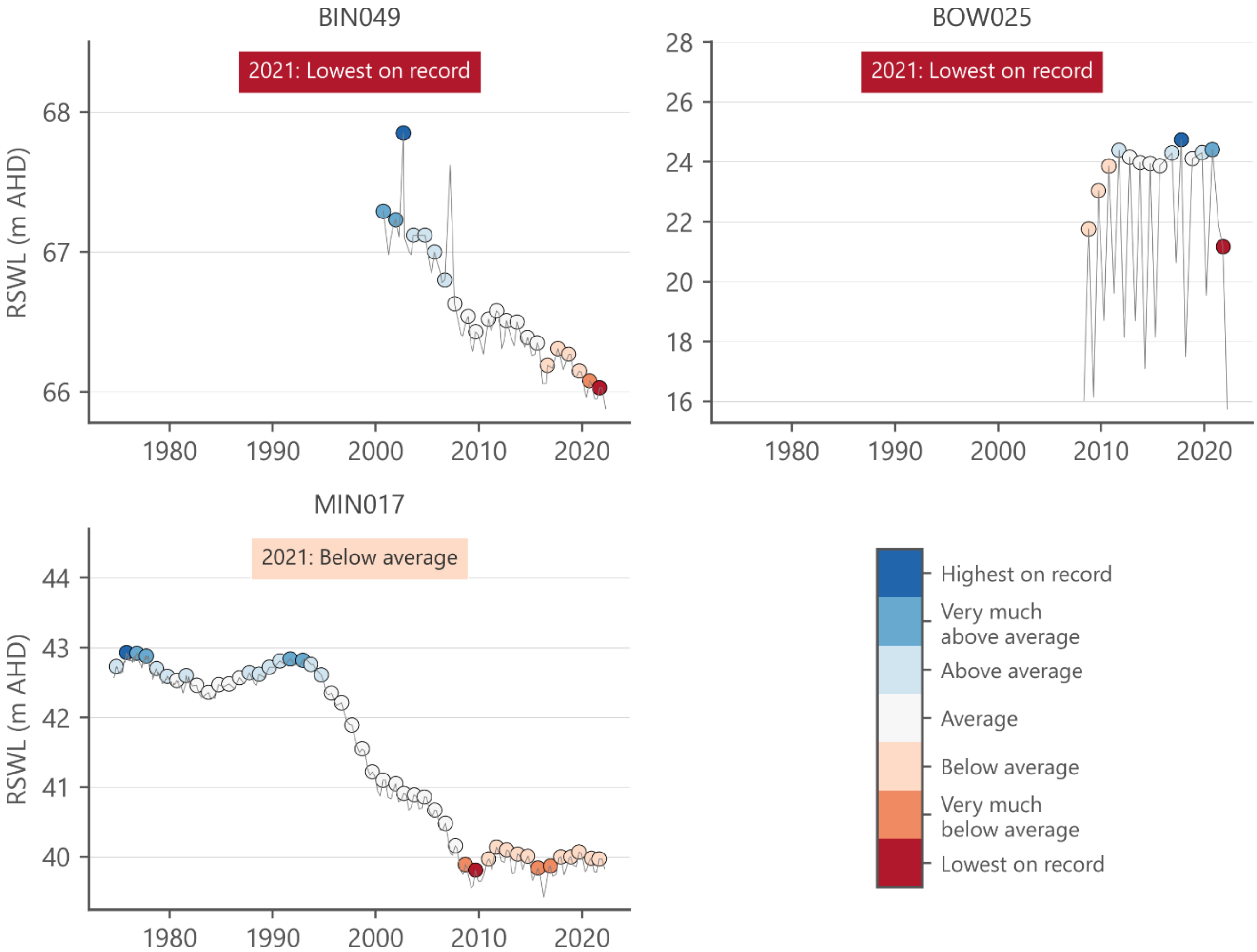

Figure 5.47 Selected hydrographs for wells in the confined aquifer in the Lower Limestone Coast PWA

5.3.2 Lower Limestone Coast PWA, confined aquifer – salinity

In 2021, and from 45 irrigation bores in the confined aquifer of the Lower Limestone Coast and Padthaway PWAs, salinity ranges between 543 mg/L and 1,300 mg/L with a median of 687 mg/L (Figure 5.48).

In the 10 years to 2021, 34 of 38 wells (90%) show a slightly increasing trend in salinity

The 10-year salinity trends vary from a decrease of 0.6% per year to an increase of 0.9% per year, with a median rate of 0.3% increase per year (Figure 5.49).

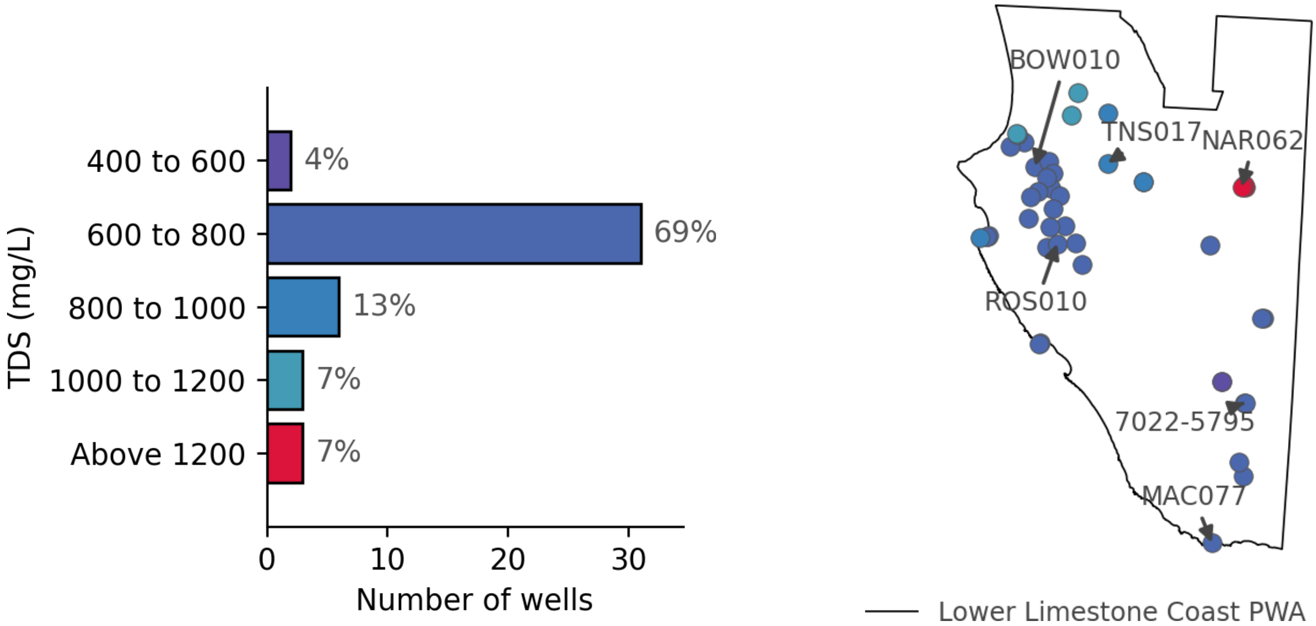

Figure 5.48 2021 salinity observations from wells in the confined aquifer in the Lower Limestone Coast and Padthaway PWAs

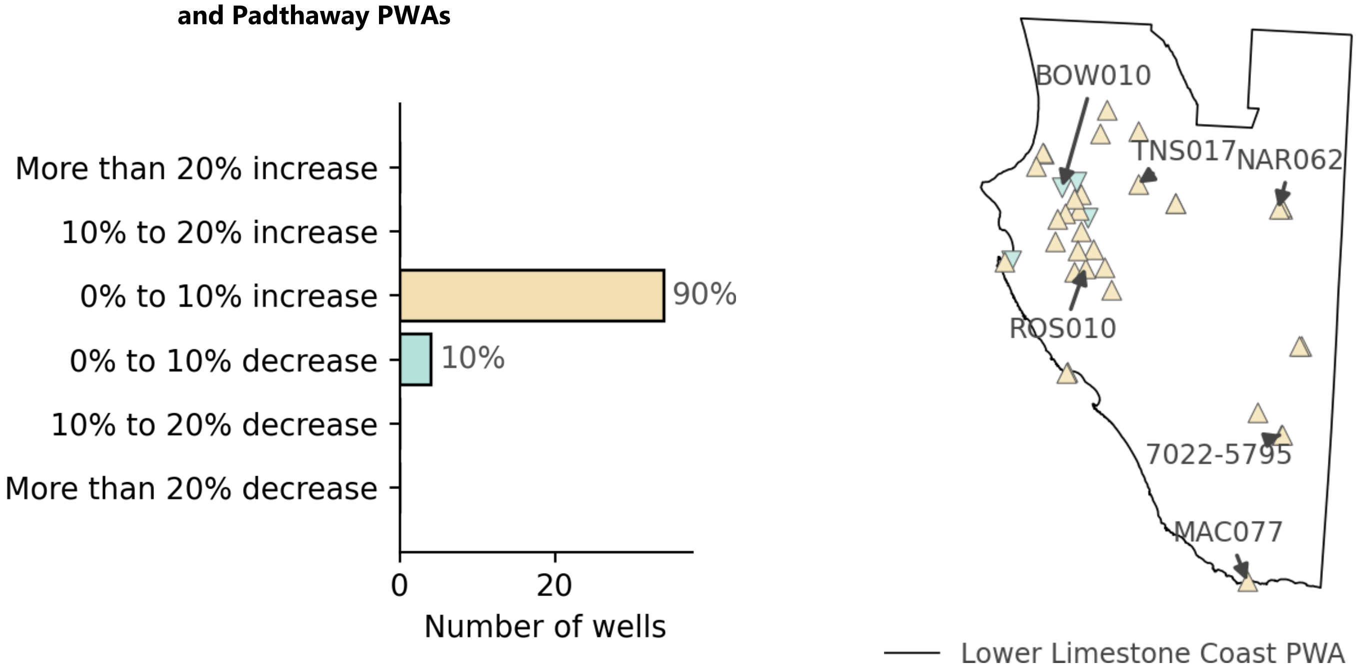

Figure 5.49 Salinity trend in the 10 years to 2021 for wells in the confined aquifer in the Lower Limestone Coast and Padthaway PWAs

Salinity from a selection of confined aquifer monitoring wells in the Lower Limestone Coast PWA illustrate common or important trends (Figure 5.50). Most of the town water supplies in the Lower Limestone Coast PWA are obtained from the confined aquifer.

Observation wells TNS017 and ROS010 are located in the artesian part of the aquifer, and this is where most groundwater extraction occurs. Groundwater salinity in these wells is slightly increasing since the early 2010's.

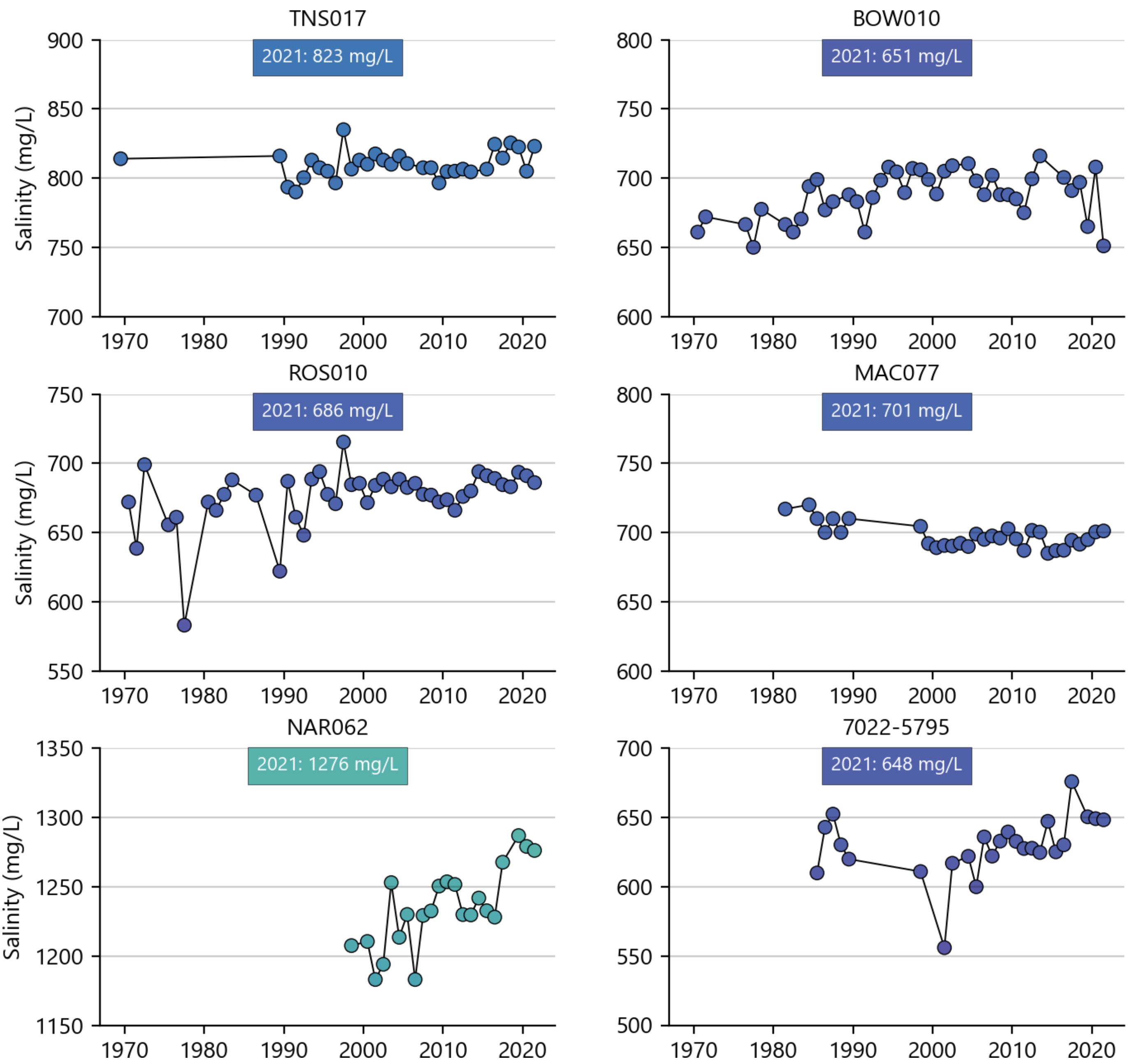

Figure 5.50 Selected salinity graphs for wells in the confined aquifer in the Lower Limestone Coast PWA

5.3.3 Tatiara PWA, confined aquifer – water level

In 2021, winter-recovered water levels in all of monitoring wells in the confined aquifer of the Tatiara PWA are classified 'Below average' or lower (Section 2.3.1; Figure 5.51).

Variations in water level in 5 wells over the past 30 years range from a decline of 3.92 m to a decline of 0.64 m (median decline of 3.87 m).

Five-year trends show declining water levels in all wells, with rates ranging from a decline of 0.12 m/y to a decline of 0.06 m/y (median decline of 0.08 m/y) (Figure 5.52).

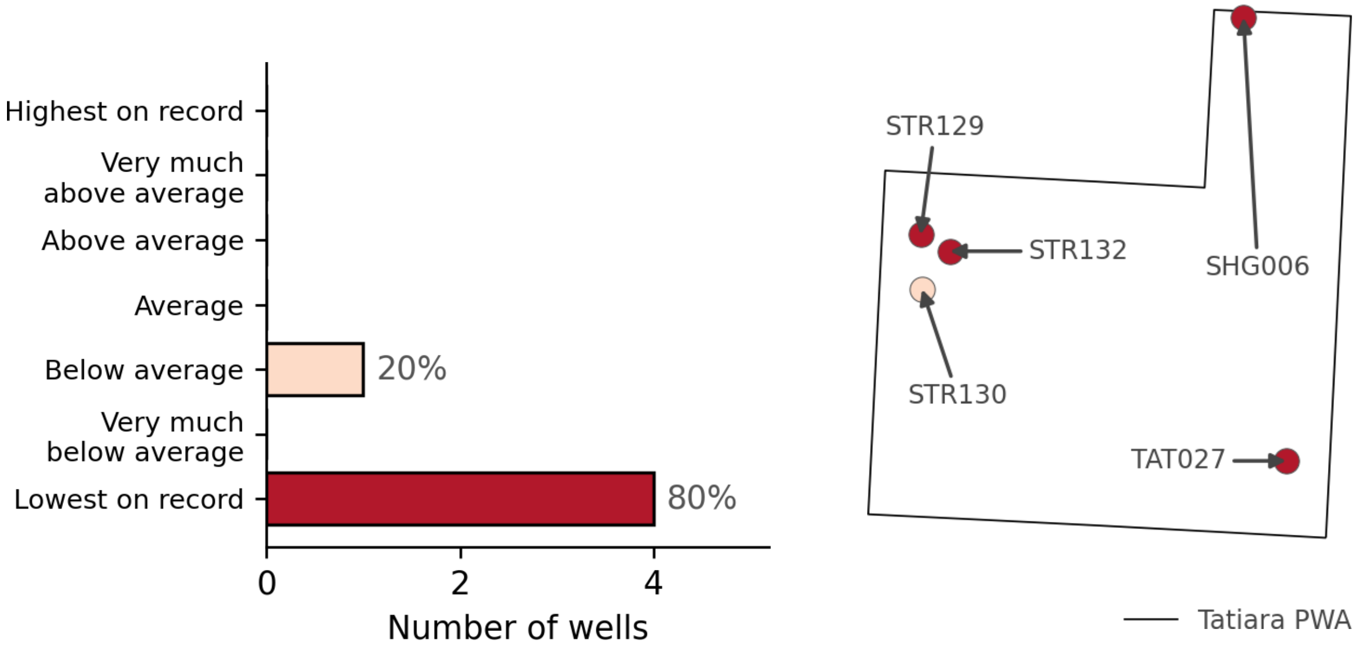

Figure 5.51 2021 winter-recovered water levels for wells in the confined aquifer in the Tatiara PWA

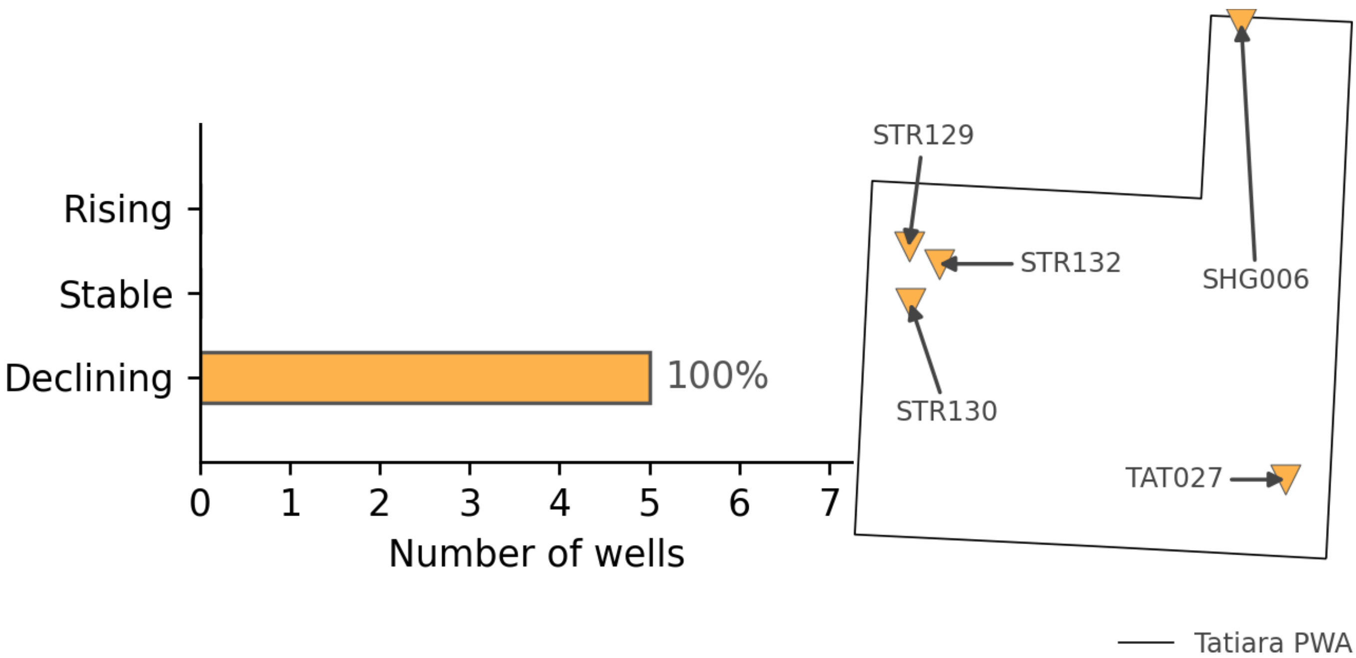

Figure 5.52 2017 to 2021 trend in winter-recovered water levels for wells in the confined aquifer in the Tatiara PWA

The groundwater level trends observed in the confined aquifer (Figure 5.53) are very similar to those observed in the overlying unconfined aquifer in both the plains (STR129, STR130, and STR132; Figure 5.27) and highlands areas (SHG006 and TAT027; Figure 5.33).

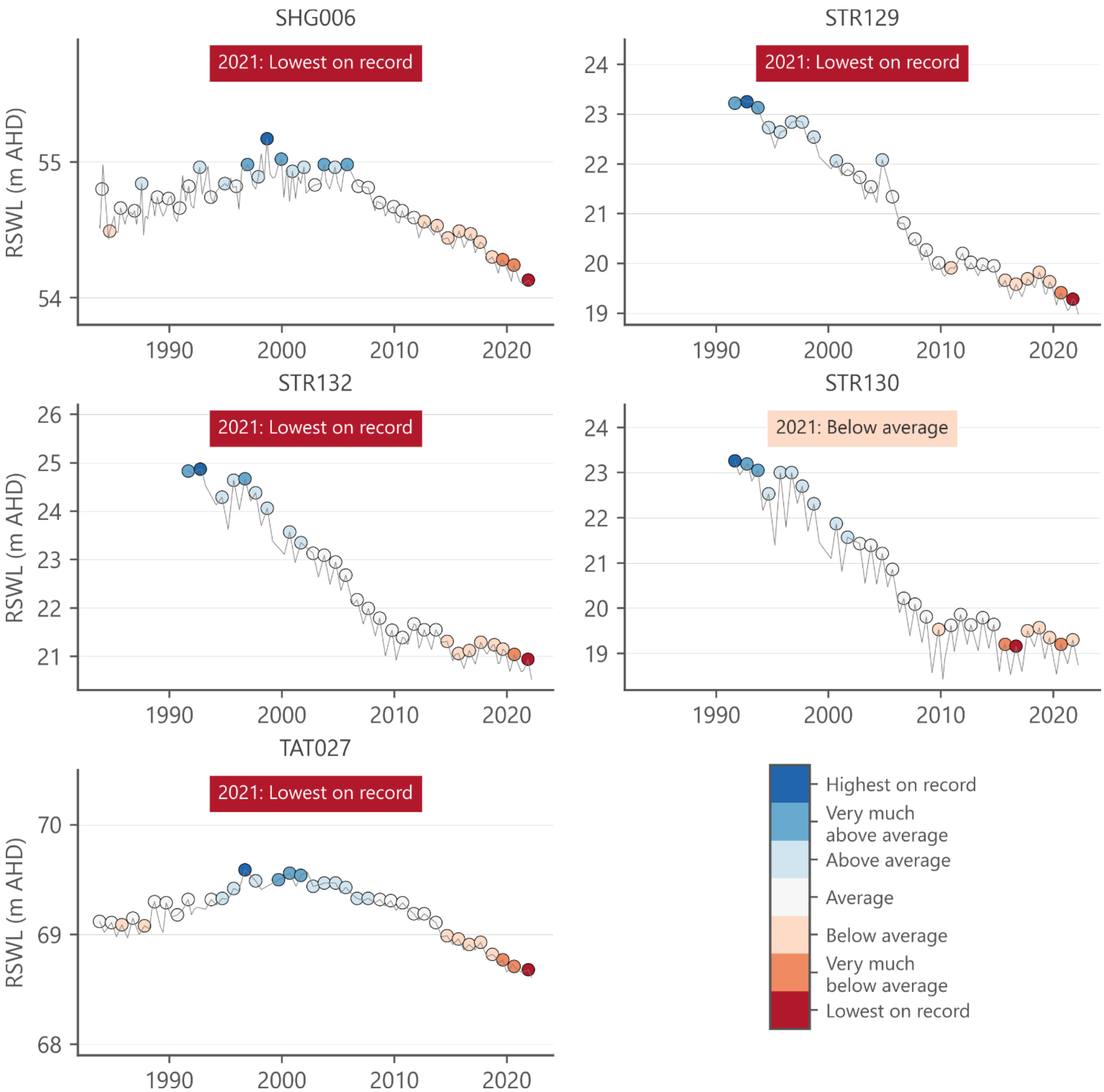

Figure 5.53 Selected hydrographs for wells in the confined aquifer in the Tatiara PWA

5.3.4 Tintinara-Coonalpyn PWA, confined aquifer – water level

In 2021, winter recovered water levels in 65% of monitoring wells in the confined aquifer of the Tintinara-Coonalpyn PWA are classified 'Below average' or lower (Section 2.3.1; Figure 5.54).

Variations in water level in 19 wells over the past 20 years range from a decline of 10.04 m to a decline of 0.30 m (median decline of 4.65 m).

Five-year trends show declining water levels in the majority of wells (61%), with rates ranging from a decline of 0.61 m/y to a decline of 0.15 m/y (median decline of 0.42 m/y) (Figure 5.55).

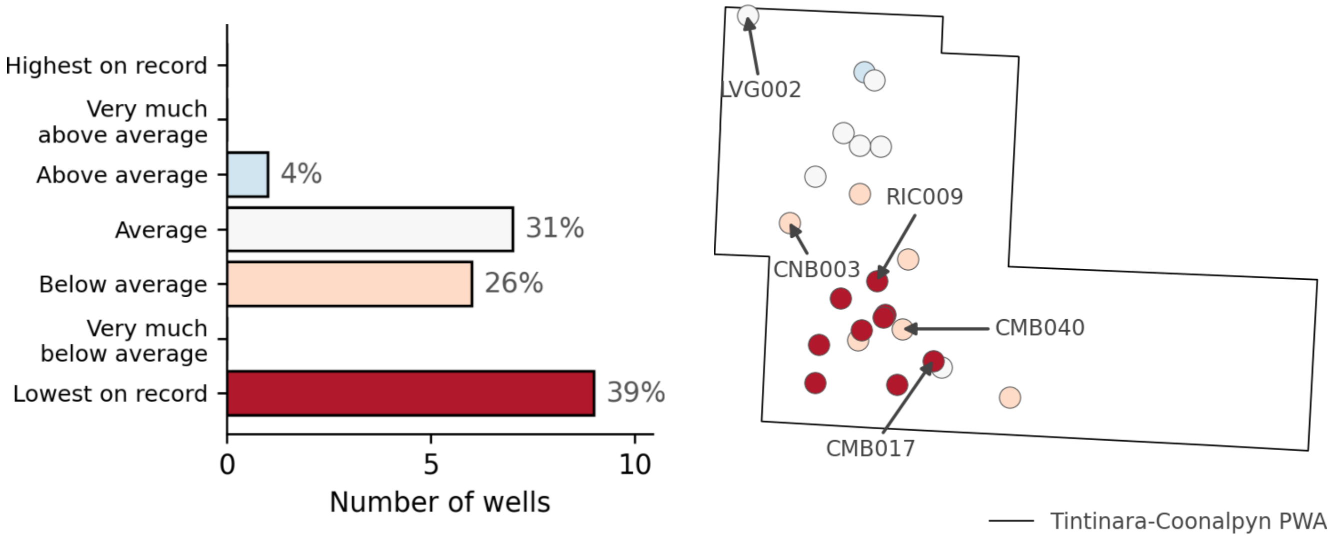

Figure 5.54. 2021 winter-recovered water levels for wells in the confined aquifer in the Tintinara-Coonalpyn PWA

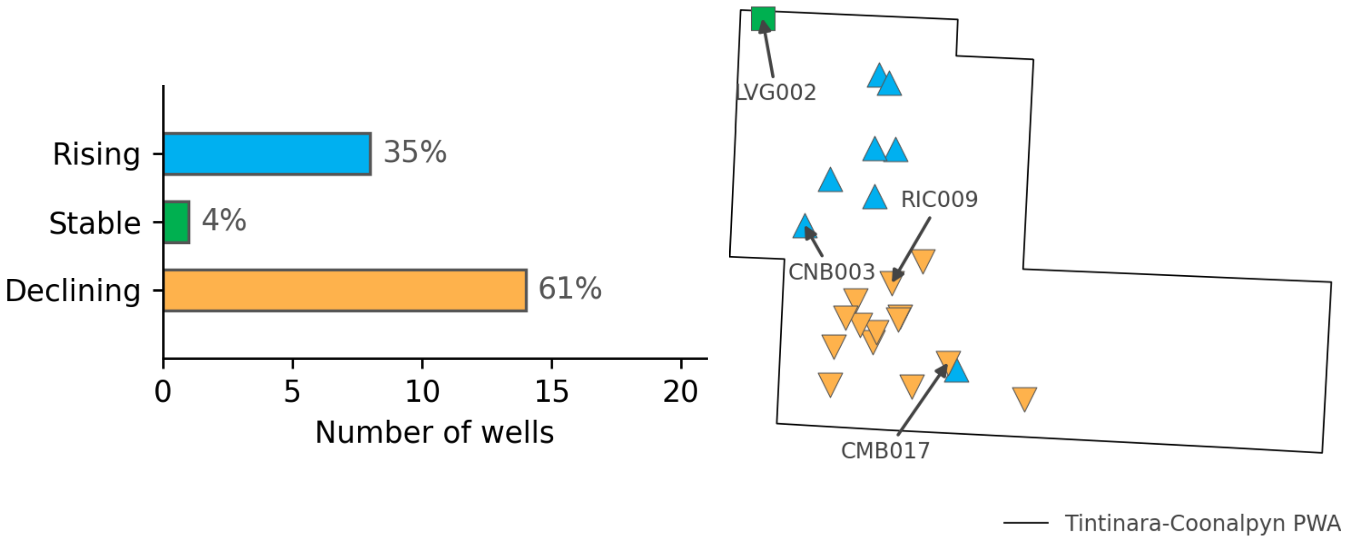

Figure 5.55 2017 to 2021 trend in winter-recovered water levels for wells in the confined aquifer in the Tintinara-Coonalpyn PWA

The majority of representative monitoring wells in the confined aquifer in the Tintinara-Coonalpyn PWA (Figure 5.56) show a trend of declining water levels, occurring around the time of the Millennium Drought (late-1990s through to 2010). Monitoring well LVG002 is located near the northern boundary of the PWA (Figure 5.55) and has seen a recovery in water level since 2010; the water level is currently classified 'Average' (Figure 5.56).

The effects of groundwater pumping on water levels are seen as seasonal fluctuations in water level, and are most pronounced in wells near Tintinara (Figure 1.1) (e.g., RIC009, Figure 5.56).

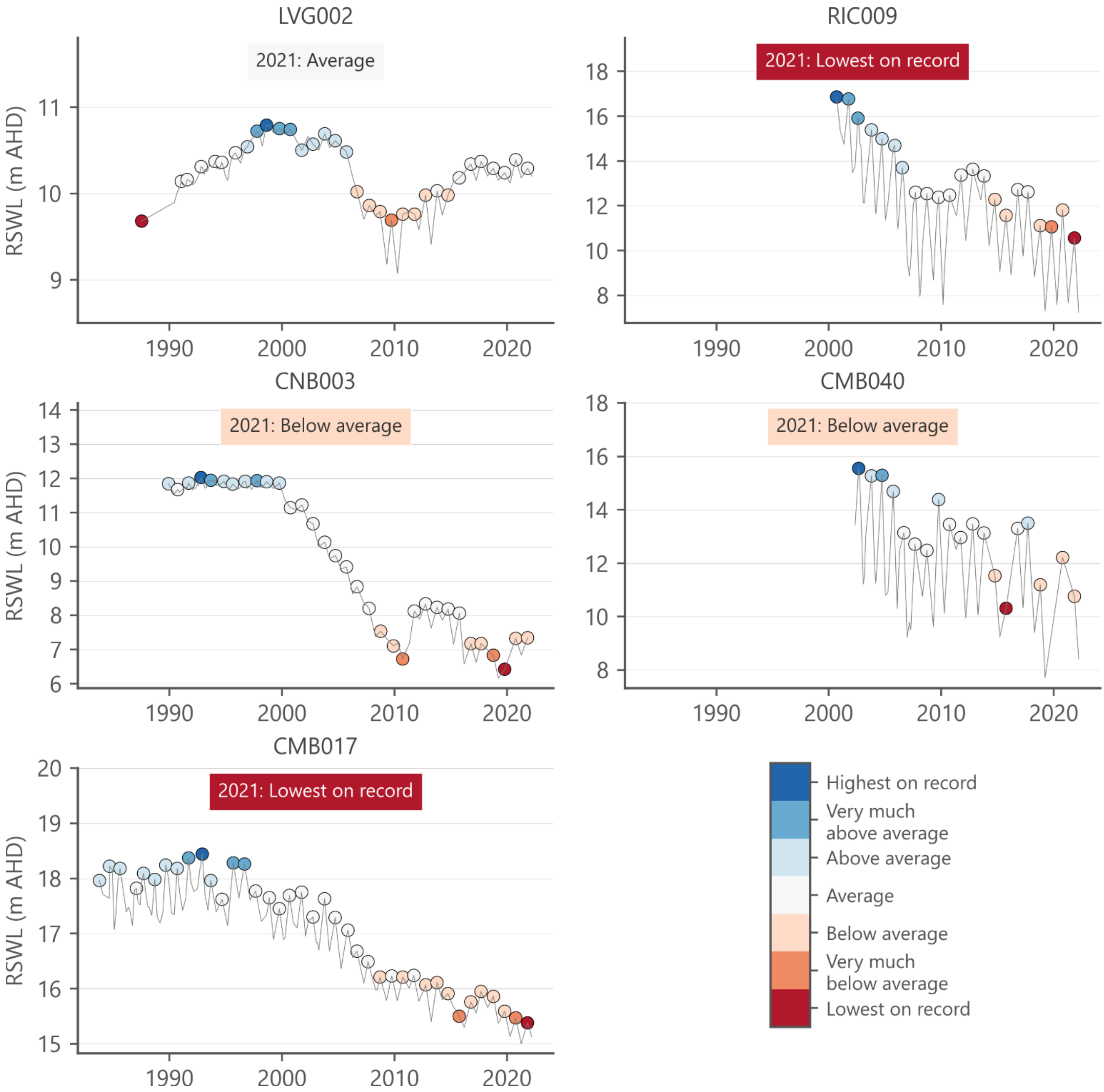

Figure 5.56 Selected hydrographs for wells in the confined aquifer in the Tintinara-Coonalpyn PWA

5.3.5 Tintinara-Coonalpyn and Tatiara PWAs, confined aquifer salinity

In 2021, and from 12 wells in the confined aquifer of the Tintinara-Coonalpyn and Tatiara PWAs, salinity ranges between 988 mg/L and 4,078 mg/L with a median of 1,488 mg/L (Figure 5.57).

In the 10 years to 2021, 9 of 11 wells show stable salinity (±10%) (Section 2.3.2; Figure 5.58). The 10-year salinity trends vary from a decrease of 1.1% per year to an increase of 1.1% per year.

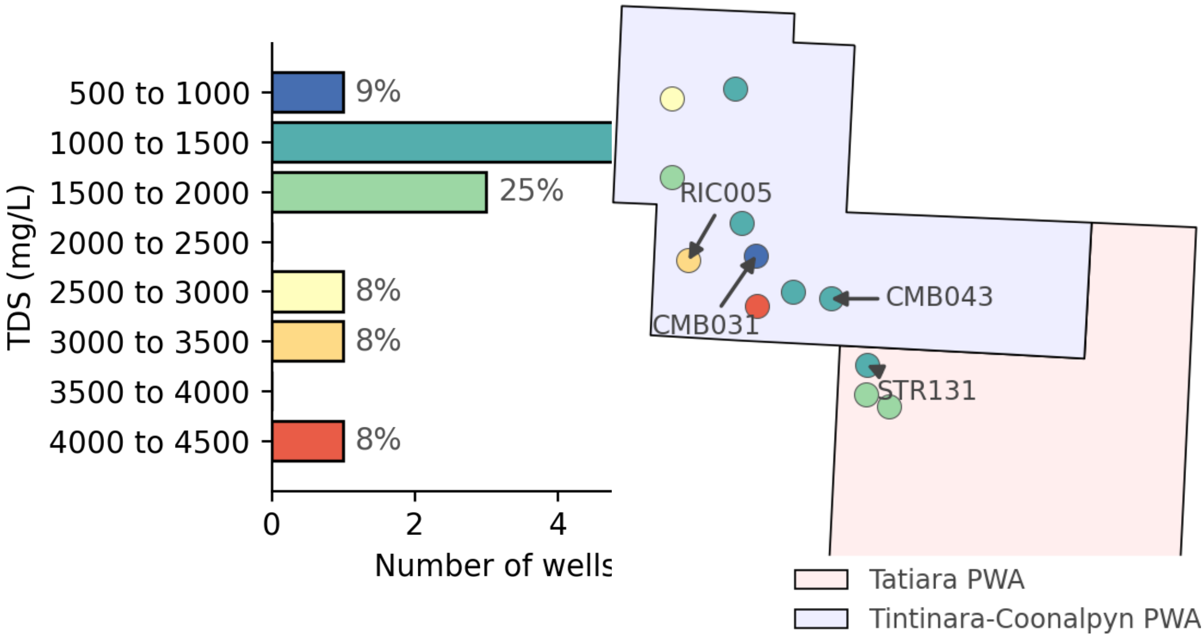

Figure 5.57 2021 salinity observations from wells in the confined aquifer in the Tintinara-Coonalpyn and Tatiara PWAs

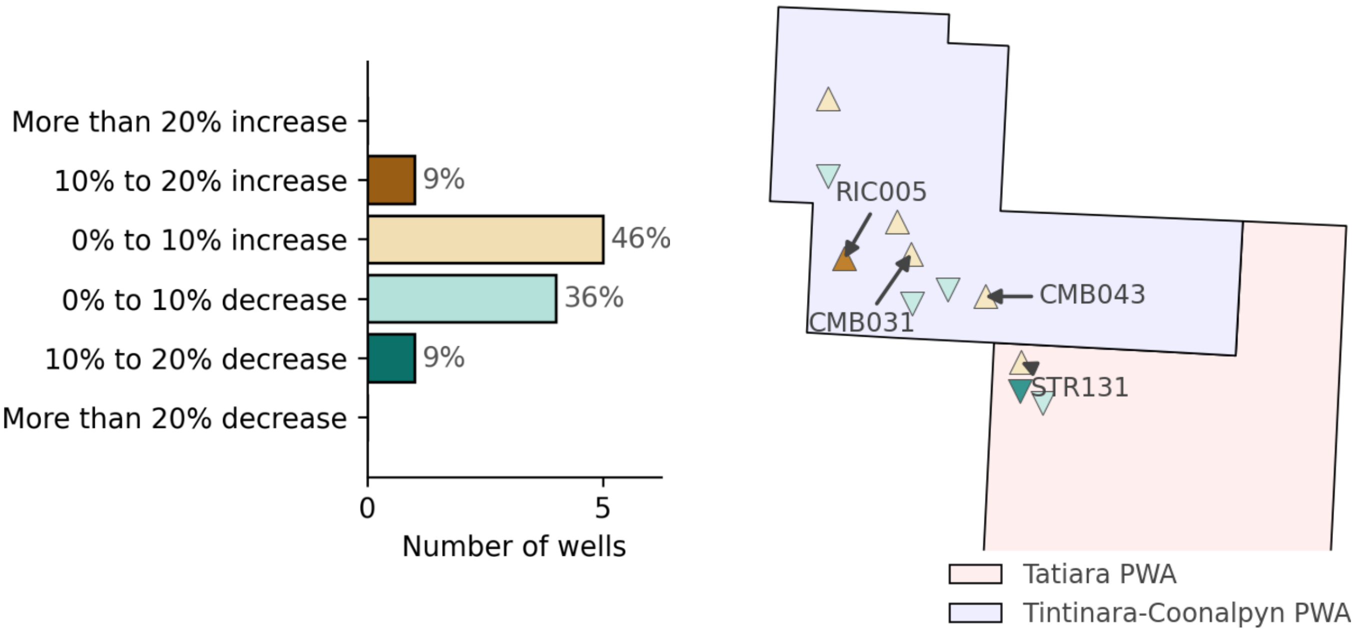

Figure 5.58 Salinity trend in the 10 years to 2021 for wells in the confined aquifer in the Tintinara-Coonalpyn and Tatiara PWAs

Salinity from a selection of confined aquifer monitoring wells in the Tintinara Coonalpyn and Tatiara PWAs illustrate common or important trends (Figure 5.59). Salinity is stable across both PWAs with variations of generally less than 200 mg/L over the past 20 to 30 years.

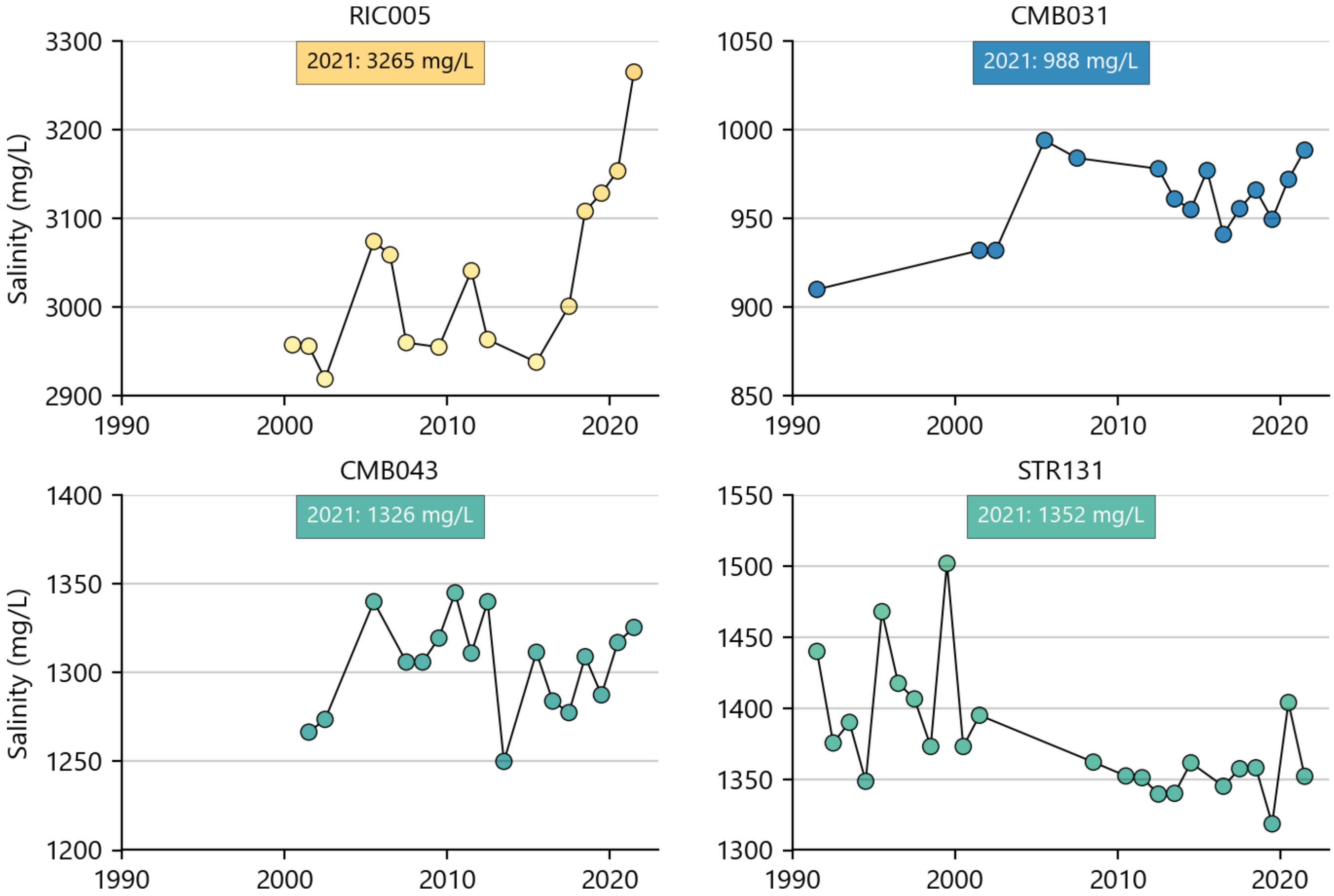

Figure 5.59 Selected salinity graphs for wells in the confined aquifer in the Tintinara Coonalpyn and Tatiara PWAs

6 Water use

Given the lack of reliable surface water flows, groundwater is the source of almost all consumptive water, providing water for town water supply, irrigation, and stock, domestic and industrial uses. Across the Limestone Coast Landscape region, more than 90% of the total groundwater extraction is sourced from unconfined aquifers (Figure 6.1). Extraction from the confined aquifer contributes between 5% and 10% of total licensed water use and a comparatively small volume of surface water is also used in the Morambro Creek area. The majority of water extracted is from the Lower Limestone Coast PWA (Figure 6.2), which is also the largest region by area (Figure 1.1).

The total volume of water used in the 2020–21 water-use year is 358,690 ML (Figure 6.1). This includes only licensed groundwater extraction as no licensed surface water extraction was possible. Water use by commercial forests is estimated at 240,000 ML (DEW 2022), which is not included in the total water use. Imported water from the River Murray via the Tailem Bend to Keith pipeline is also excluded from total water use.

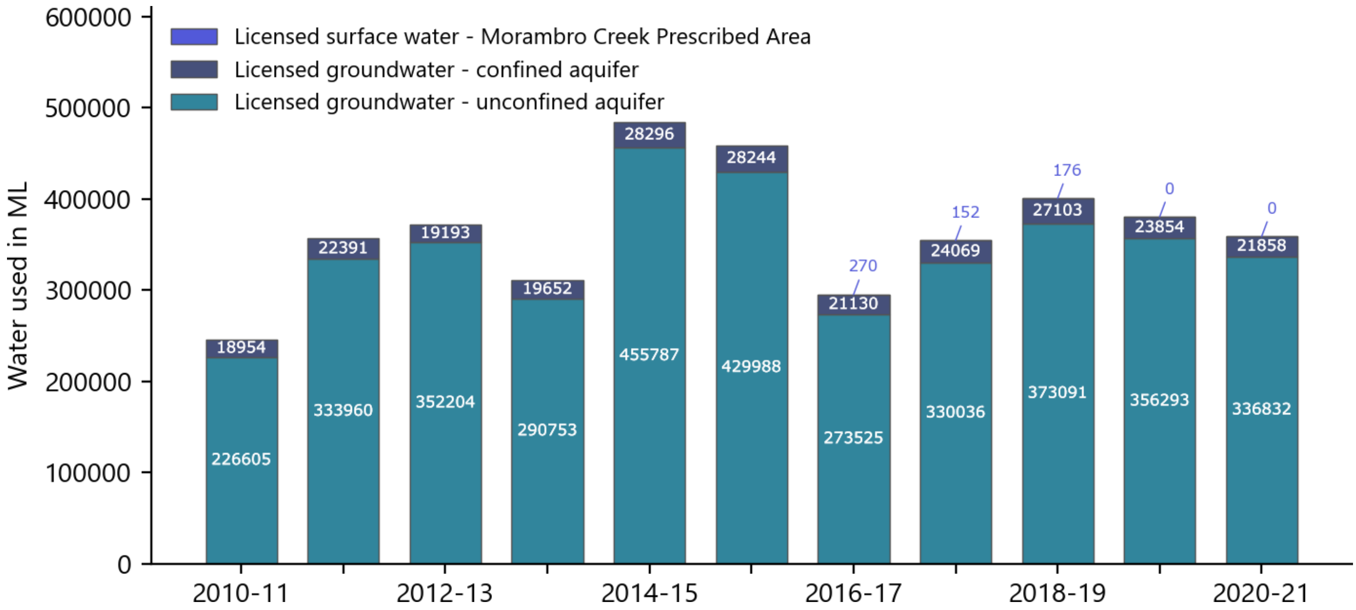

Figure 6.1 Licensed water extraction from 2010–11 to 2020–21 by water resource type

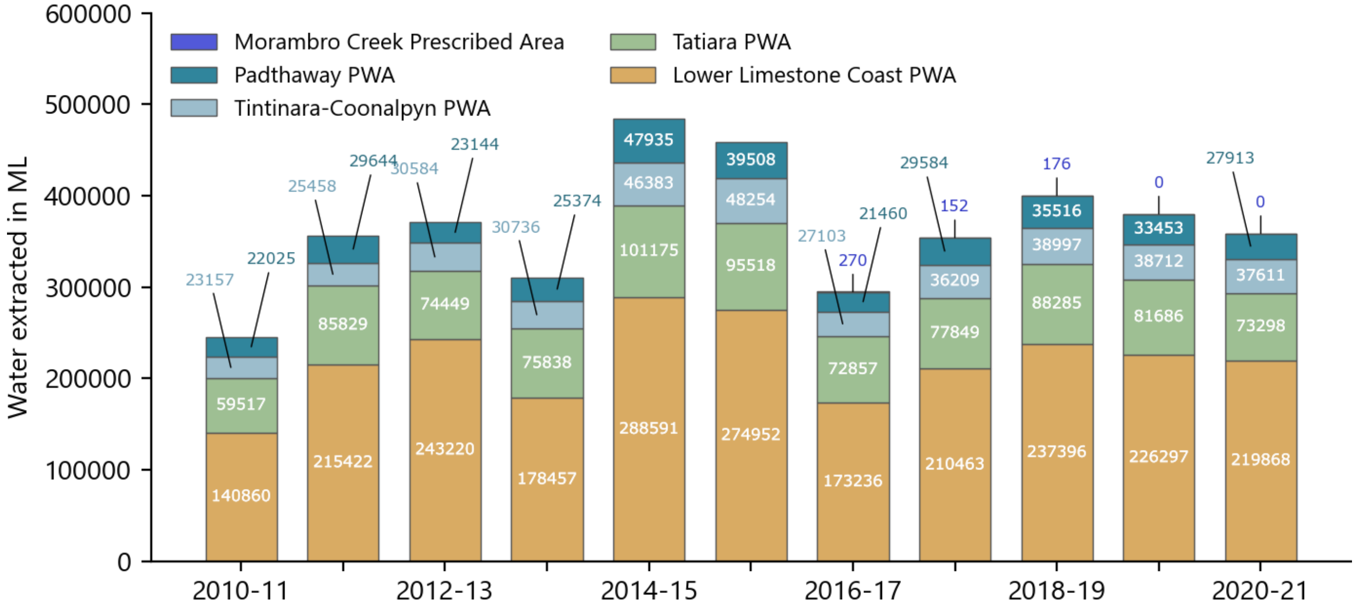

Figure 6.2 Licensed water extraction from 2010–11 to 2020–21 by prescribed area

6.1 Surface water use

The Morambro Creek and Nyroca Channel Prescribed Water Courses (PWCs) and Morambro Creek Prescribed Surface Water Area (PSWA) were prescribed in response to an increase in demand for water for aquifer recharge schemes to address the increasing salinity of the adjacent groundwater resource in the Padthaway PWA. The majority of existing users divert water from the Morambro Creek or the Nyroca Channel. Others divert water via dams or drainage wells. The diverted water is used for aquifer recharge, stock, domestic, irrigation and recreation purposes. There is no commercial, industrial or town take of water in the PWC or PSWA.

Low reliability of streamflow in Morambro Creek has meant there has been no systematic development of the surface water resource. Licensees are limited to a rate of take once specific flow thresholds are reached. Currently, there are 4 licences to take or divert water within the prescribed area.

Streamflow did not occur in 2020–21 and as a result, no surface water extraction from the creek was possible.

6.2 Groundwater use

Most groundwater extraction is from the unconfined aquifers of the Lower Limestone Coast and Tatiara PWAs (Figure 6.3), although the Padthaway PWA has high intensity of use (Figure 1.1). The primary use from the unconfined aquifer is irrigation. Extraction from the confined aquifer occurs mainly across the Lower Limestone Coast and Tintinara-Coonalpyn PWAs (Figure 6.4).

In general, volumes of extraction from unconfined aquifers show an inverse correlation with annual rainfall – relatively low volumes are extracted in years of above-average rainfall. A similar, albeit weaker, inverse correlation generally exists for extractions from the confined aquifers.

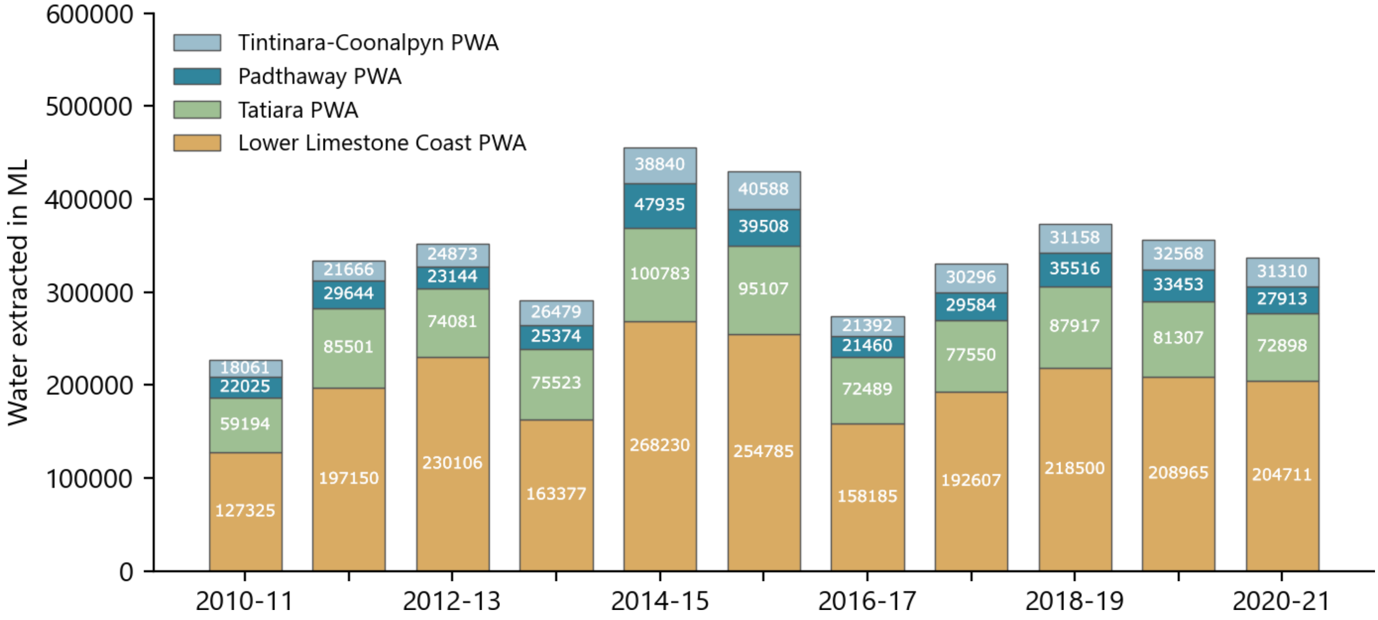

Figure 6.3 Licensed water extraction from the unconfined aquifer between 2010–11 and 2020–21

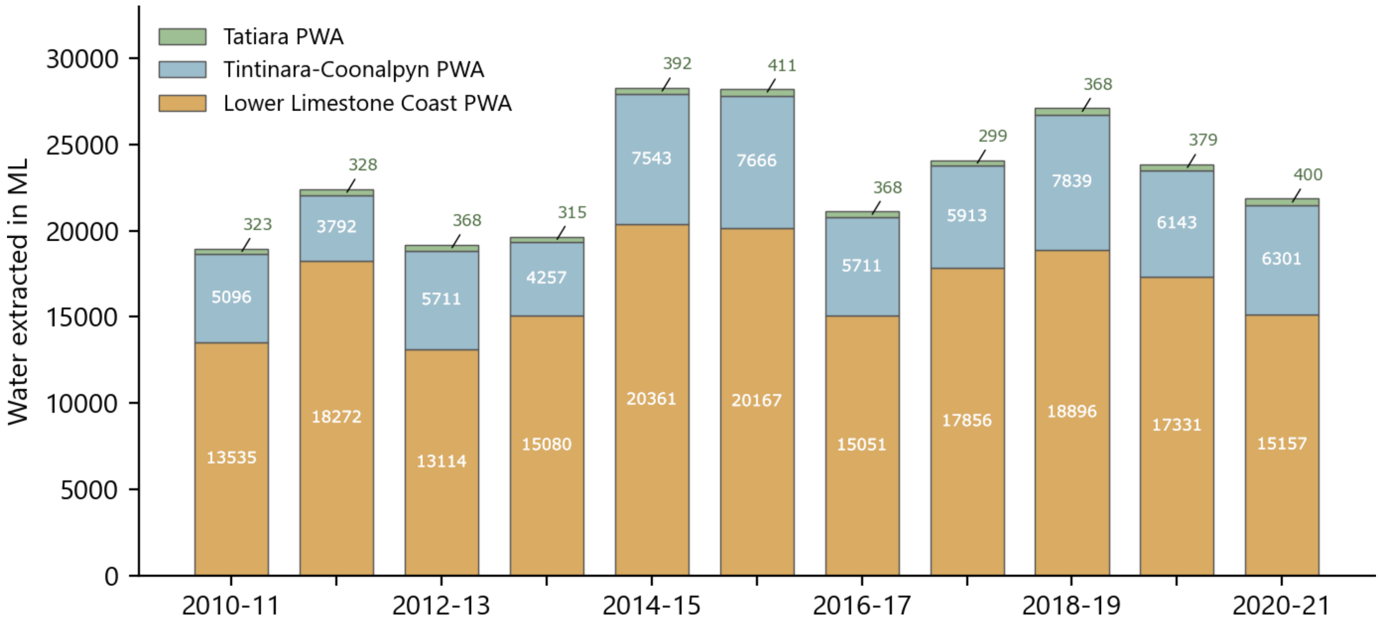

Figure 6.4 Licensed water extraction from the confined aquifer between 2010–11 and 2020–21

6.2.1 Lower Limestone Coast PWA

In 2020–21, the total volume of licensed groundwater extractions from the unconfined aquifer is 204,711 ML. This is a decrease of 2% compared to 2019–20. Relatively low volumes were extracted in 2016–17, 2013–14, and 2010–11, which were all years of above-average rainfall at the Mount Gambier rainfall station (BoM station 26021; Figure 3.2). Licensed groundwater use from plantation forests is omitted from Figure 6.4.

Licensed extractions from the confined aquifer total 15,157 ML in 2020–21, which is a 13% decrease from 2019–20.

6.2.2 Padthaway PWA

In 2020–21, licensed groundwater extractions from the unconfined aquifer are 27,913 ML, which is a decrease of 17% from 2019–20. The lowest volumes were extracted in 2016–17 and 2010–11, which were both years with markedly above-average rainfall (Figure 3.6).

There were no licensed extractions from the confined aquifer in 2020–21 in the Padthaway PWA.

6.2.3 Tatiara PWA

In 2020–21, licensed groundwater extractions from the unconfined aquifer are 72,898 ML, which is a decrease of 10% from 2019–20. The lowest volumes extracted over the past 9 years have been in 2016–17, 2013–14, and 2010–11, which were all years of above-average rainfall (Figure 3.8).

There is an increase in extraction from the confined aquifer of 6% in 2020–21 (400 ML compared to 379 ML in the previous year).

6.2.4 Tintinara-Coonalpyn PWA

In 2020–21, licensed groundwater extractions from the unconfined aquifer are 31,310 ML, which is a decrease of 4% compared to 2019–20.

In 2020–21, licensed extractions from the confined aquifer are 6,301 ML, which is an increase of 3% from 2019–20.

6.3 Farm dams

Farm dam development in the PSWA has the potential to significantly reduce the low-flow component of streamflow of the Morambro Creek and Nyroca Channel prescribed watercourses and the Marcollat watercourse downstream. There are approximately 290 farm dams in the PSWA, and some of these divert water from the PWC and PSWA for stock and domestic purposes. Any recreational use is primarily for amenity dams. Total farm dam storage is estimated from an aerial survey in 2013 to be 250 ML. Across the Morambro PSWA, smaller dams (capacity less than 5 ML) account for the majority of the number of dams (99%) and represent 62% of the total storage capacity of dams. Larger dams (5 ML or greater capacity) make up 1% of the total dam count but contribute 38% of the total storage capacity (Figure 6.5).

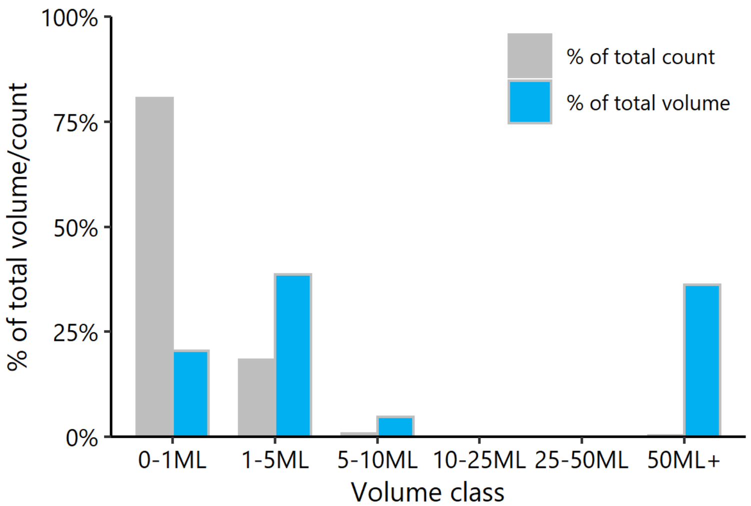

Figure 6.5 Count and volume of farm dam classes in the Morambro PSWA

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