Far North Prescribed Wells Area 2019–20 water resources assessment

Department for Environment and Water
October, 2021

DEW Technical Note 2021/16

Government of South Australia
Department for Environment and Water

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Contents

1 Summary

Far North PWA	GAB (J-K) aquifer

LEGEND

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

Rainfall

- Rainfall across the region was below-average in 2019–20.
- Rainfall at Marree in 2019–20 was 63.5 mm, 64% less than the long-term average of 176 mm/y, while rainfall at Marla was 45.4 mm, 78% below-average.
- Rainfall occurrence and intensity in the arid lands is episodic. Sometimes the region may go without significant rainfall for years, whilst intense rainfall is highly variable and can deliver annual amounts in a single event.
- The Great Artesian Basin (GAB) J-K aquifer is not directly impacted by rainfall trends. However, the demand for stock water in the pastoral industry is affected by stocking rates and the availability of feed, which is in turn affected by trends in rainfall (Fu et al., 2020).

Groundwater

- Water levels in the majority of GAB (J-K) aquifer monitoring wells (72%) in 2020 are at 'average' to 'highest-on-record' levels
- Seventeen percent of monitoring wells, mainly located in the western part of the basin, recorded 'highest-on-record' water levels. 19% of monitoring wells recorded 'lowest on record' water levels – these wells are predominantly located in the east and north-east of the PWA
- Five-year trends in water level show that the majority of wells (78%) have rising or stable water levels
- In 2020, results from 50 wells in the GAB J K aquifer show groundwater salinities vary from 515 to 5262 mg/L, with a median of 1838 mg/L
- In the ten years to 2020, the majority of wells showed a decreasing trend in groundwater salinity (86%) with a median rate of 0.43% decrease per year.

Water use

- The Great Artesian Basin provides 75% of groundwater supplies in the Far North PWA
- Groundwater is predominantly extracted for mining, petroleum, stock and domestic purposes. Groundwater extraction for mining, petroleum and town water supply purposes is generally metered
- Water use for mining and petroleum purposes in 2019–20 was 9% greater than the previous water use year and 49% greater than the twenty-year average.

1.1 Purpose

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

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

This document is the Technical Note for the Far North Prescribed Wells Area (PWA) for 2019–20 and collates rainfall and water use data between July 2019 and September 2020, and groundwater level and salinity data collected between July 2019 and December 2020.

1.2 Regional context

The Far North PWA is located in the South Australian Arid Lands (SAAL) Landscape Region and is bounded in the north and east by the state borders with New South Wales, Queensland and the Northern Territory. The Far North PWA (Figure 1.1) is an administrative region within which groundwater has been prescribed under the *Landscape South Australia Act 2019*. Further, groundwater allocation and sustainable management of groundwater resources within the Far North PWA is administered under the Far North Water Allocation Plan (WAP), which was adopted in February 2021. Groundwater in the Far North PWA is vital for sustaining the mining, petroleum, pastoral and tourism industries and the provision of community water supplies in the SAAL Landscape Region.

Groundwater springs are important ecological features of the arid zone providing permanent habitats for aquatic flora and fauna that need standing water, and a reliable source of water for visiting fauna. Springs that are fed either fully or partially by Great Artesian Basin (GAB) aquifers rely on artesian pressure for the provision of their water needs. Therefore, it is essential that GAB pressures are maintained at levels that provide continuous groundwater discharge at rates sufficient to maintain the ecological value of the springs, whilst also allowing sustainable rates of extraction for consumptive purposes. The WAP employs the use of buffer zones around these springs (Zone A – 5 km from a spring, and Zone B – 5 to 50 km from a spring, Figure 1.1) within which specific principles outlining the acceptable change in water pressure applies to the taking of water, and these are outlined in Sections 6 and 7 of the WAP (SAAL Landscape Board, 2021). Groundwater in the Far North PWA is sourced predominately sourced from the Cadna-owie Formation and Algebuckina Sandstone (and lateral equivalents), which form a single hydrogeological unit known as the Jurassic-Cretaceous (J-K) aquifer. The J-K aquifer contains the largest and regionally most important groundwater resource within the Far North PWA. Other groundwater resources in the PWA include the:

- shallow Quaternary and Tertiary sedimentary aquifers, including the Kati Thanda - Lake Eyre Basin
- Palaeozoic sedimentary aquifers, including sandstones of the Winton and Mackunda Formations as well as minor sandstones in the Rolling Downs Group, such as the Coorikiana and Bellinger Sandstone
- underlying Permo-Carboniferous to Early-Triassic sediments of the Cooper, Arckaringa and Pedirka basins
- basement crystalline fractured rock aquifers.

These aquifer units are further described in Section 4. Detailed descriptions can be found in the references provided in Section 2.

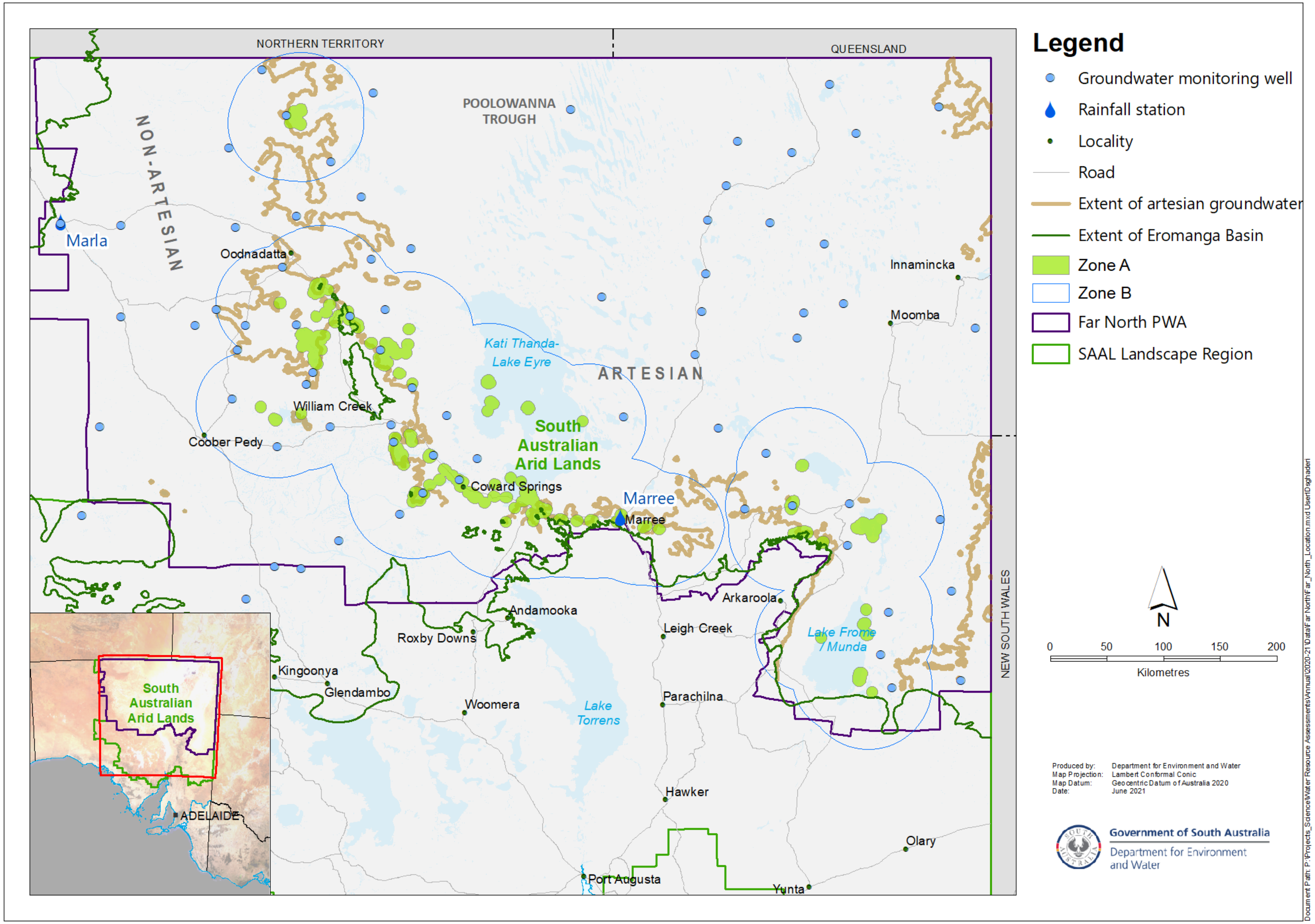

Figure 1.1 Location of Far North PWA

2 Methods and data

This section describes the source of rainfall, surface water, groundwater, and water use data presented in this assessment, and also describes the methods used to analyse and present these data.

2.1 Rainfall

Daily rainfall observations have been used from selected Bureau of Meteorology (BoM) stations in order to calculate monthly and annual totals. Data have been obtained from the SILO Patched Point Dataset[1] service provided by the Queensland Government, which provides interpolated values to fill gaps in observations (Figure 3.1 and Figure 3.2).

2.2 Groundwater

2.2.1 Water level

Water level[2] data were obtained from wells in the Far North PWA monitoring network from manual measurements taken every six months. The water level in non-artesian wells was measured by dipping tape, while the pressure level in artesian wells is measured through a shut-in pressure test. All water level data were verified and anomalous data excluded. The mean water level for each calendar year, for each well, was calculated and used for further analysis.

For wells with at least three years' data, the mean annual water level was ranked and described according to their decile range[3] from lowest to highest on record (Table 2.1). For the most recent year, the number of wells in each decile range was then summarised for each aquifer (e.g. Figure 4.1). Hydrographs are shown for a selection of wells to illustrate common or important trends (e.g. Figure 4.3).

Five-year trends are calculated using mean annual water levels for those wells which have at least five measurements (i.e. at least one measurement a year). The trend line was calculated by linear regression and the well is given a status of 'declining', 'rising', or 'stable', depending on whether the slope of this trend line is below, above or within a given tolerance threshold. This threshold allows for the demarcation of wells where water levels are changing at very low rates and the water level can therefore be considered stable. The threshold also accommodates for very small measurement errors. The number of rising, declining and stable wells are then summarised for each aquifer (e.g. Figure 4.2).

The artesian portion of the GAB is given a tolerance threshold based on the most recent water temperature for the well, as higher temperatures (correlated to higher pressure levels) can lead to higher measurement errors. A tolerance threshold of 20 cm/y is applied for artesian wells with water temperatures greater than 40 degrees Celsius; other artesian wells have a tolerance threshold of 10 cm/y applied, and non-artesian wells have a tolerance threshold of 2 cm/y applied.

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

[2] "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).

[3]. 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.

Table 2.1. Percentile/decile descriptions*

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

* Deciles and descriptions as defined by the Bureau of Meteorology[4]

2.2.2 Salinity

Water samples from flowing artesian wells are collected biannually from monitoring wells located across the Far North PWA. These samples are tested for electrical conductivity (EC) from which the salinity is calculated as total dissolved solids (TDS) and is measured in mg/L. Where more than one water sample has been collected in the course of a year, the annual mean salinity is used for analysis (e.g. Figure 4.4).

Salinity trends are calculated over a period of 10 years where there are at least seven years of salinity data. The trend line is calculated by linear regression and the percentage change in salinity is calculated using 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. The salinity measurements are based on the measurement of the electrical conductivity of a water sample and are often subject to small instrument errors (e.g. Figure 4.5).

Salinity graphs are shown for a selection of wells to illustrate common or important trends (e.g. Figure 4.6).

2.3 Water use

Water use information (Section 5) is based on metered extraction volumes where possible (i.e. for mining and petroleum purposes). Rates of use reported for mining[5] and petroleum[6] purposes are for the water-use year 1 July 2019 through 30 June 2020. Where meters are not installed (mainly domestic use and stock water), allocated volumes are reported instead.

[4] Bureau of Meteorology Annual climate statement at http://www.bom.gov.au/climate/current/annual/aus/

[5] Mines and quarries annual reports at https://energymining.sa.gov.au/minerals/mining/mines_and_quarries

[6] Department for Energy and Mining Petroleum exploration and production system - South Australia at https://peps.sa.gov.au/

2.4 Further information

Groundwater data can be viewed and downloaded using the *Groundwater Data* page 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 of the Far North PWA are:

- Summary reports on the groundwater resources of the Far North PWA and annual groundwater level and salinity status reports (Water Resource Assessments page on WaterConnect9)
- The Water Allocation Plan for the Far North PWA (SAAL Landscape Board, 2021)
- Far North PWA Groundwater Level and Salinity Status Report (DFW 2011)
- Hydrogeological Framework of the Western Great Artesian Basin (Keppel et al. 2013)
- Groundwater recharge, hydrodynamics and hydrochemistry of the Western GAB (Love et al. 2013)
- Groundwater-dependent ecosystems (Gotch, 2013).

[7] https://www.waterconnect.sa.gov.au/Systems/GD/Pages/default.aspx

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

[9] https://www.waterconnect.sa.gov.au/Systems/GSR/Pages/Default.aspx

3 Rainfall

The local rainfall within the Far North PWA has very little influence on groundwater pressure levels as the J-K aquifer is confined. Rainfall occurrence and intensity is episodic, sometimes with marginal rainfall for years, while intense rainfall can deliver average annual amounts in a single event. Rainfall is generally less than 250 mm/y. However, rainfall in the arid areas of the state is highly variable and consequently, averages can be misleading. Average annual evaporation is extremely high, ranging from 2400 to over 3700 mm/y, which substantially exceeds average annual rainfall and results in the rapid evaporation of surface water runoff.

Long-term annual rainfall (1970-2020) in the Far North PWA ranges from 164 mm/y at Coober Pedy in the south-west of the area to 210 mm/y at Marla in the north-west. During 2019–20, rainfall was lower than the long-term average with rainfall ranging from 45 mm/y at Marla to 163 mm/y at Coober Pedy.

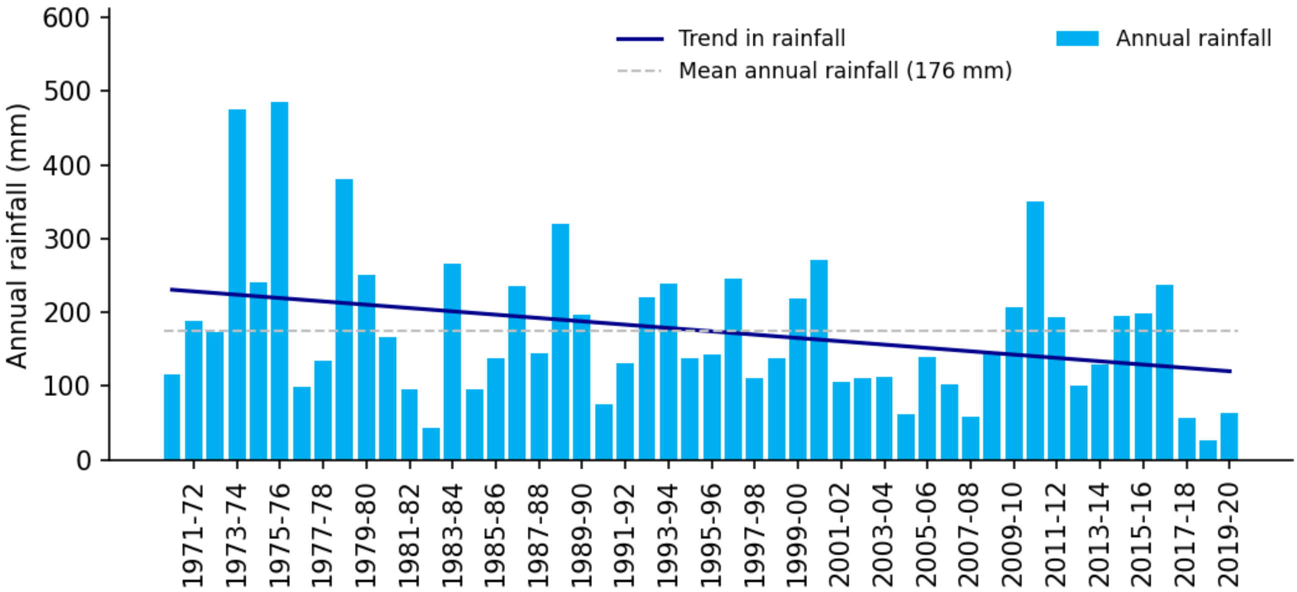

Figure 3.1 Annual rainfall from 1970–71 to 2019–20 at the Marree rainfall station (17031)

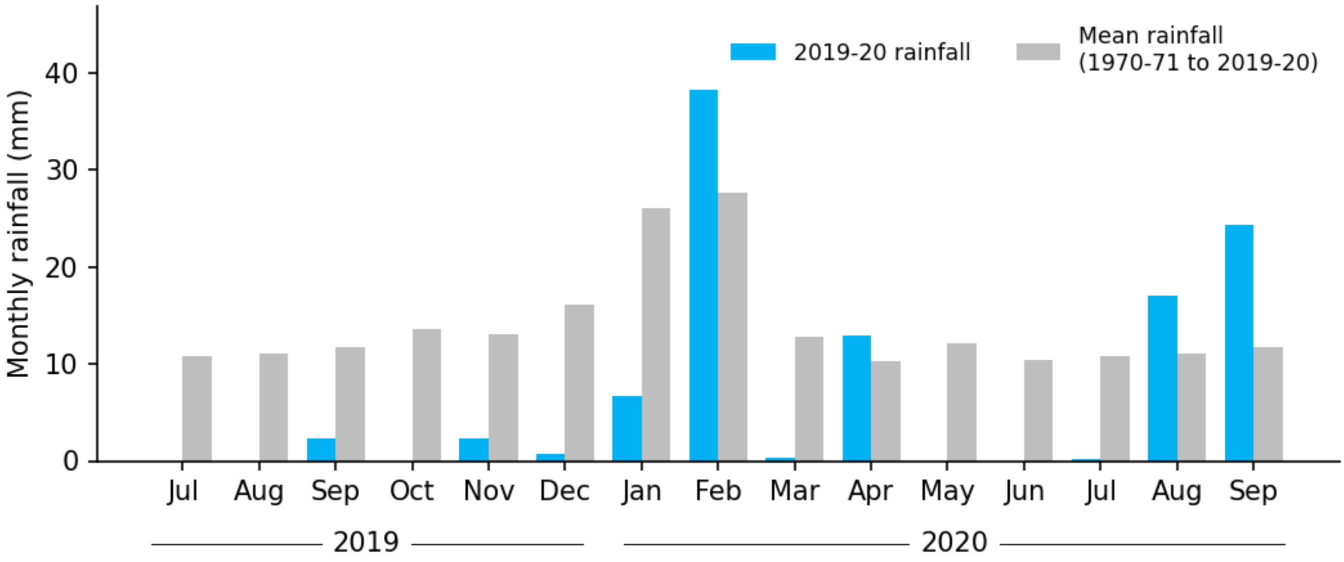

Figure 3.2 Monthly rainfall between July 2019 and September 2020, compared to the long-term monthly average at the Marree rainfall station (17031)

- The Marree rainfall station (BoM station 17031) (Figure 1.1) and is typical of historical rainfall in the southern part of the PWA. In 2019–20, annual rainfall was 63.5 mm, noticeably less than the long-term average of 176 mm/y (1970–2020) (Figure 3.1).
- Annual rainfall over the long-term (1970–2020) shows a declining trend (Figure 3.1).
- Above-average rainfall was observed at Marree in February, April, August and September 2020 (Figure 3.2).

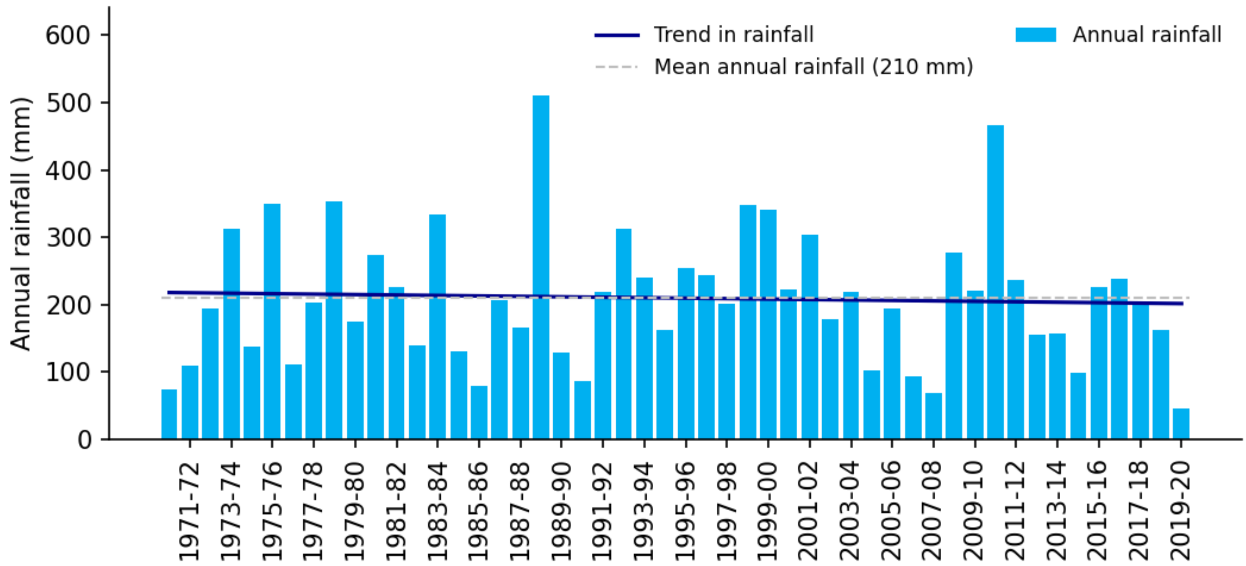

Figure 3.3 Annual rainfall from 1970–71 to 2019–20 at the Marla rainfall station (16085)

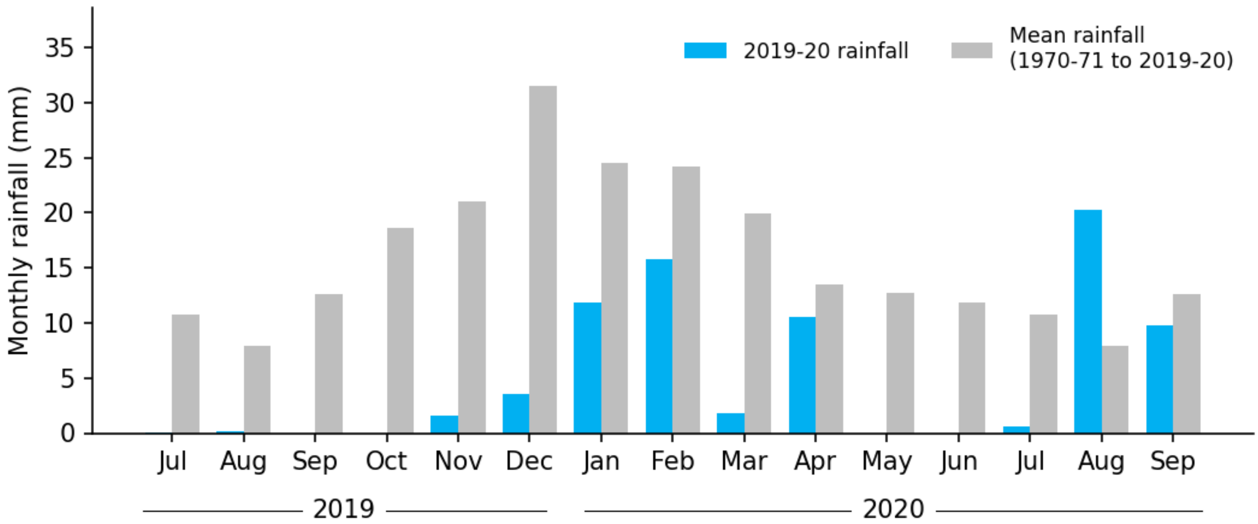

Figure 3.4 Monthly rainfall between July 2019 and September 2020 at the Marla rainfall station (16085)

- The Marla rainfall station (BoM station 16085) provides a representative record of rainfall occurring in the north-west of the PWA, where the J-K aquifer is sub-artesian. The annual rainfall total for 2019–20 was 45.4 mm, which is 165 mm less than the long-term average of 210 mm/y (1970–2020) (Figure 3.3).
- Marla station has observed a stable rainfall trend over the long-term record (1970–2020).
- Dry conditions were recorded in 2019–20 at Marla station when compared to the long-term average (Figure 3.4).

4 Groundwater

4.1 Hydrogeology

The Great Artesian Basin (GAB) is a Jurassic to Cretaceous-aged super-basin containing non-marine and marine sediments that covers approximately one-fifth of the Australian continent (Krieg et al, 1995). The GAB predominantly comprises the Eromanga, Surat and Carpentaria Basins. In South Australia, the GAB is composed largely of Eromanga Basin sediments that vary in thickness from less than 100 m on the margins of the basin to over 3000 m in the north-east of the State within the basin depocentres.

Within the GAB, the Cadna-owie Formation, Algebuckina Sandstone and lateral equivalents form the major water-bearing aquifer system (hereafter referred to as the J-K aquifer). Depth to the J-K aquifer is as much as 2400 m in the State’s north-east but rapidly decreases westwards with the aquifer cropping out along the western margin (Figure 1.1).

Groundwater in the Far North PWA is predominately sourced from the J-K aquifer, whose thickness ranges from less than 50 m around the basin’s western margin to greater than 500 m near the Poolowanna Trough (Figure 1.1). For this reason, all groundwater data presented in this report relates to the J-K aquifer, unless otherwise stated. The majority of wells completed in the J-K aquifer within the Far North PWA are artesian wells.

Recharge to the J-K aquifer in South Australia primarily occurs through lateral in-flow from Queensland, New South Wales and the Northern Territory. At the western margin of the J-K aquifer, some recharge occurs through flooding of ephemeral rivers in South Australia and the Northern Territory, although rates of recharge were likely greater in the past under wetter climatic conditions.

4.2 GAB J-K aquifer - water level

In 2020, the majority of monitoring wells (72%) of J-K aquifer monitoring wells show average or higher levels when compared to their respective historical record. A total of 10 wells show their lowest level on record and these wells are primarily located to the northeast of the PWA (Figure 4.1), while some wells located in the western part of the basin currently show their highest levels on record.

Five-year trends in water levels are variable, with many wells showing stable levels (55%), while an equal number of remaining wells showing rising (23%) and declining (22%) trends. Rates range from a decline of 3.97 m/y to a rise of 0.98 m/y (the median change is 0.02 m/y) (Figure 4.2).

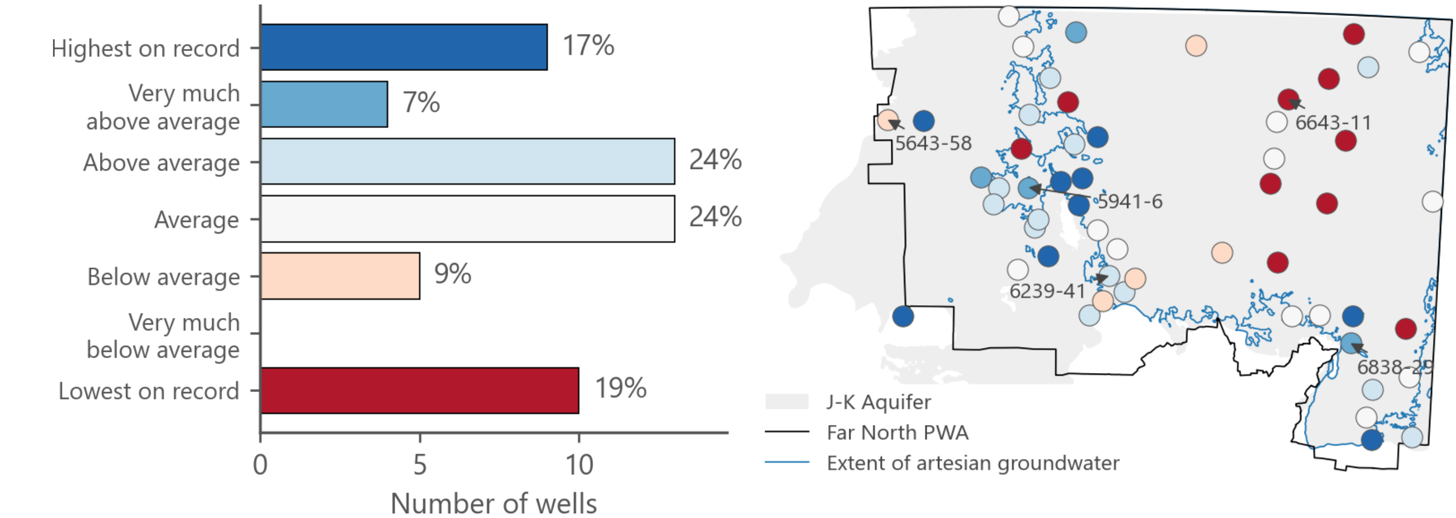

Figure 4.1 2020 recovered water levels for wells in the GAB J-K aquifer

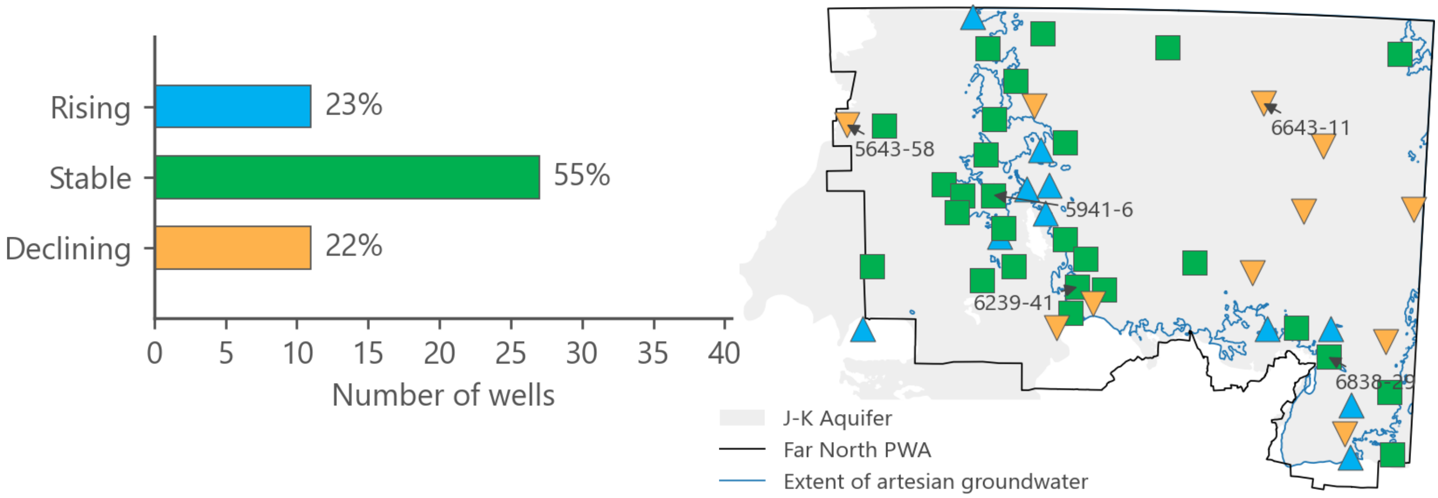

Figure 4.2 2016–20 trend in recovered water levels for wells in the GAB J-K aquifer

Figure 4.3 shows representative hydrographs from a selection of J-K monitoring wells. Monitoring well 5643-58 is located at Marla where the aquifer is confined but not artesian. The pressure level experienced a sudden rise in 1989, which could be due to an extreme rainfall event in 1988–89 (Figure 3.3). Pressure levels remained relatively stable from 2000–19 with a slight declining trend of 0.04 m/y over the past five years. 6239-41 (Strangways Bore 2) is located to the southeast of William Creek and shows a gradual rise since 1996 which may be due to decommissioning of the original flowing well (6239-1, Strangeways Bore 1) at this location in 1993.

Bore 6838-29 (Woolatchi Bore) in the south-eastern region, and 5941-6 (Fergy's Bore) south of Oodnadatta show rising trends in the 1990s-early 2000, possibly associated with artesian well rehabilitation work that occurred at these sites in 1994 and the late 1980s, respectively.

Bore 6643-11 is located at Goyder's Lagoon to the north of the PWA. It shows a declining trend since the late 1980s. Although the pressure level observed in 2020 was the lowest on record, historical data from an adjacent older well (6643-1, not shown here) suggest that the water level was at a considerably lower level in 1940 (i.e. sub-artesian) likely due to uncontrolled flowing of the well.

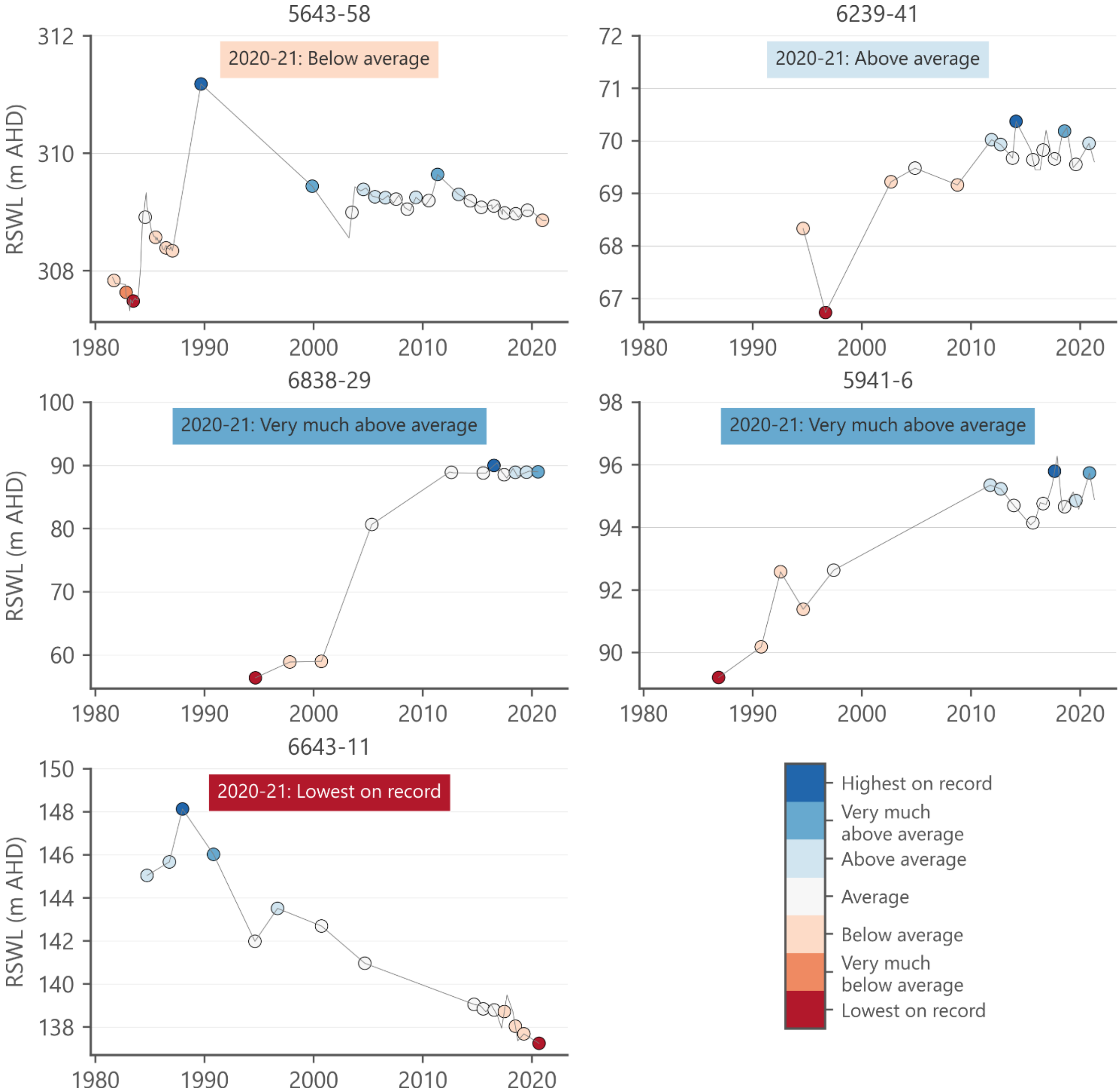

Figure 4.3 Selected GAB J-K aquifer hydrographs

4.3 GAB J-K aquifer - salinity

In 2020, results from 50 wells in the GAB J-K aquifer show groundwater salinities varying from 515 to 5262 mg/L, with a median of 1838 mg/L. The lower salinities are generally in the eastern part of the PWA (Figure 4.4).

In the ten years to 2020, the majority of wells show a decrease in groundwater salinity (86%). The salinity trends over the ten-year period varies from a decrease of 1.11% per year to an increase of 0.95% per year, with a median rate of 0.43% decrease per year (Figure 4.5).

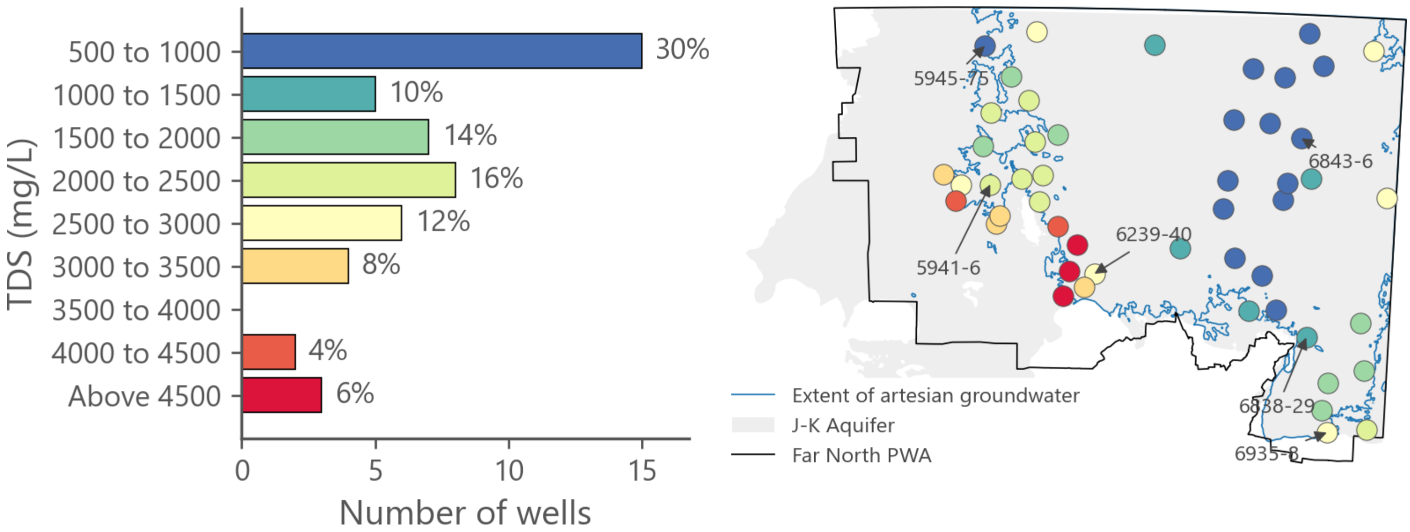

Figure 4.4 2020 salinity observations from wells in the GAB J-K aquifer

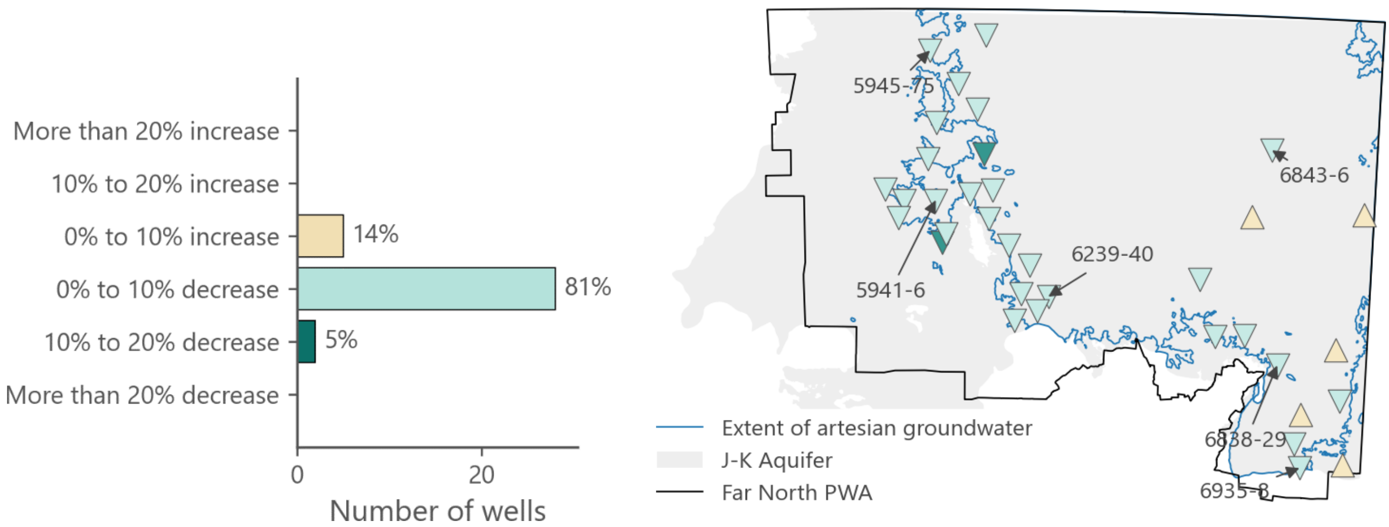

Figure 4.5 Salinity trend in the ten years to 2020 for wells in the GAB J-K aquifer

Figure 4.6 shows representative salinity graphs from a selection of J-K monitoring wells which are only located in the artesian part of the aquifer. Overall, the salinity of the GAB aquifer has remained relatively stable since salinity sampling commenced in the early 1900s.

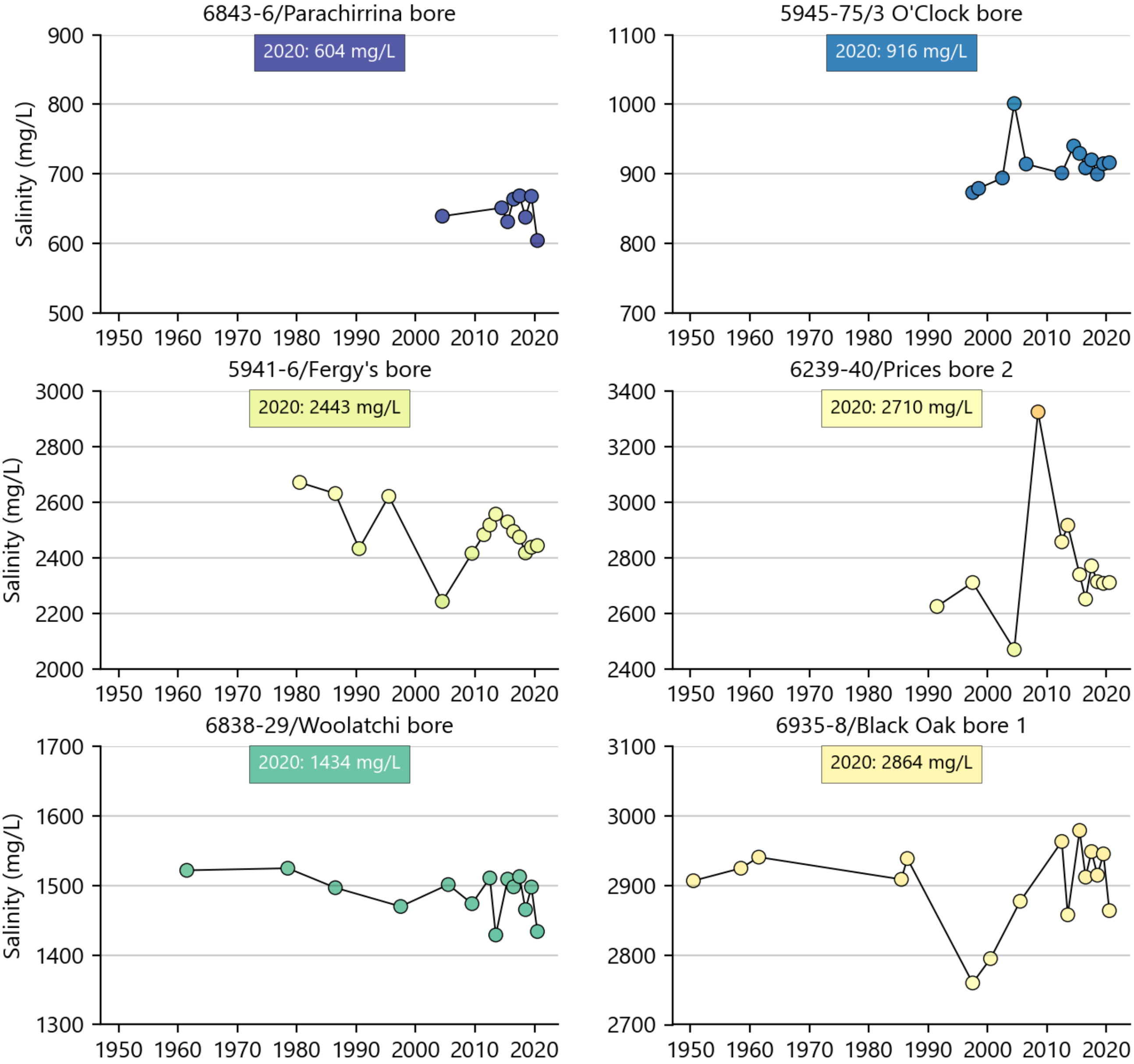

Figure 4.6 Selected GAB J-K aquifer salinity graphs

5 Water use

The Great Artesian Basin provides most (~75%) of the groundwater supplies in the Far North PWA, although there is also significant groundwater extraction from other aquifers including the underlying Arckaringa Basin and the overlying Kati Thanda-Lake Eyre Basins.

Within the Far North PWA, groundwater is predominantly extracted for mining, petroleum and stock and domestic purposes. Currently, groundwater extractions are generally metered only for mining, petroleum and town water supply purposes. Groundwater extractions for mining and petroleum purposes totalled 34 084 ML for 2019–20 (Figure 5.1), an increase in extraction of 2876 ML from the preceding water-use year and 11 338 ML higher than the twenty-year average annual volume of groundwater extraction (22 746 ML). All groundwater extractions for mining and petroleum purposes are within current licenced allocation volumes.

Allocated volumes across the Far North PWA in 2019–20 for purposes other than mining and petroleum are:

- 10 719 ML for stock and domestic purposes.
- 630 ML for town water supply purposes.
- 3083 ML for amenities and camp water purposes.
- 2754 ML for other purposes.

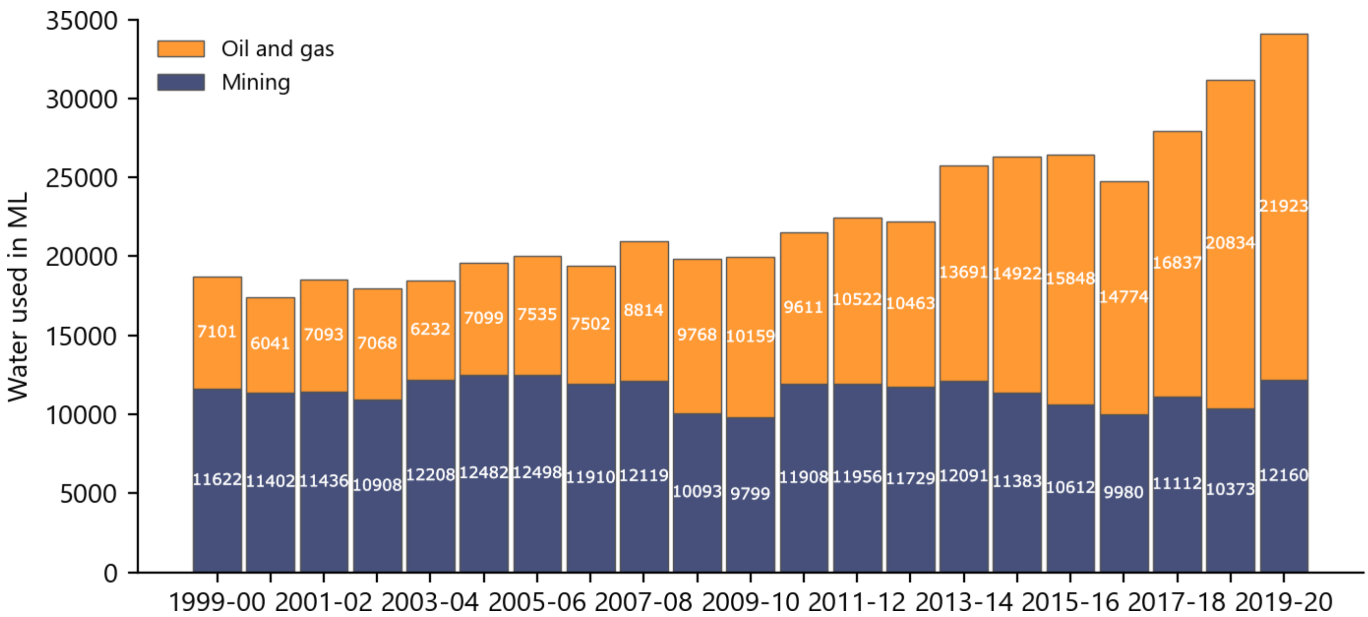

Figure 5.1 Water extraction for mining and petroleum from 2000–01 to 2019–20 in the Far North PWA

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