McLaren Vale Prescribed Wells Area 2018-19 water resources assessment

Department for Environment and Water
December, 2020

DEW Technical report 2020/28

Government of South Australia
Department for Environment and Water

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Contents

1 Summary

Rainfall

- Rainfall at Willunga measured 597 mm in 2018-19, which was marginally less than the long-term average of 605 mm (1979-80 to 2018-19).
- Rainfall at Mount Bold Reservoir measured 613 mm, which was significantly less than the long-term average of 804 mm (1979-80 to 2018-19).
- Rainfall is typically higher along the ranges, decreasing towards the coast.
- Higher than average rainfall totals were recorded in August 2018, November 2018, December 2018, May 2019 and June 2019.
- Long-term data indicate relatively stable rainfall trends.

Groundwater

- Water levels declined within the Port Willunga Formation in the north-east of the basin where the aquifer is unconfined, with most wells (77%) recording lowest levels on record in 2019. The low water levels recorded in 2019 are likely due to an extended pumping season following generally below-average rainfall during 2018-19.
- In 2019, 38% of the monitoring wells in the Maslin Sand aquifer and 41% of monitoring wells in fractured rock aquifers recorded their lowest levels on record, with the median well recording 'below average' levels compared to historic data.
- There is insufficient salinity data to assess short-term trends. Since 2017, the number of salinity observations has increased and once a longer data set is available it will be used for the assessment of short-term trends.

Water use

- Water use in 2018-19 was 20% higher than the long-term average and the highest on record, with a total of 5,096 ML extracted.
- Although water use in 2018-19 was the highest on record, it was 22% lower than the adopted sustainable yield.
- Most of the water extraction (63%) was sourced from the Port Willunga Formation.

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) build on the fact sheets to provide more comprehensive information 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 all resources across all regions in a quick-reference format.

This document is the Technical Note for the McLaren Vale Prescribed Wells Area (PWA) for 2018-19 and addresses rainfall and water use data collected between July 2018 and September 2019 and groundwater data collected up until December 2019.

1.2 Regional context

The McLaren Vale Prescribed Wells Area (PWA) is located approximately 35 km south of Adelaide within the Hills and Fleurieu Landscape Region (Figure 1.1). The McLaren Vale PWA is a regional-scale resource for which groundwater has been prescribed under South Australia's Landscape SA Act 2019 and a water allocation plan, adopted in 2000, provides for sustainable management of the water resources. Groundwater occurs in three major aquifers: two sedimentary aquifers (Port Willunga Formation and Maslin Sands) and the fractured rock aquifers.

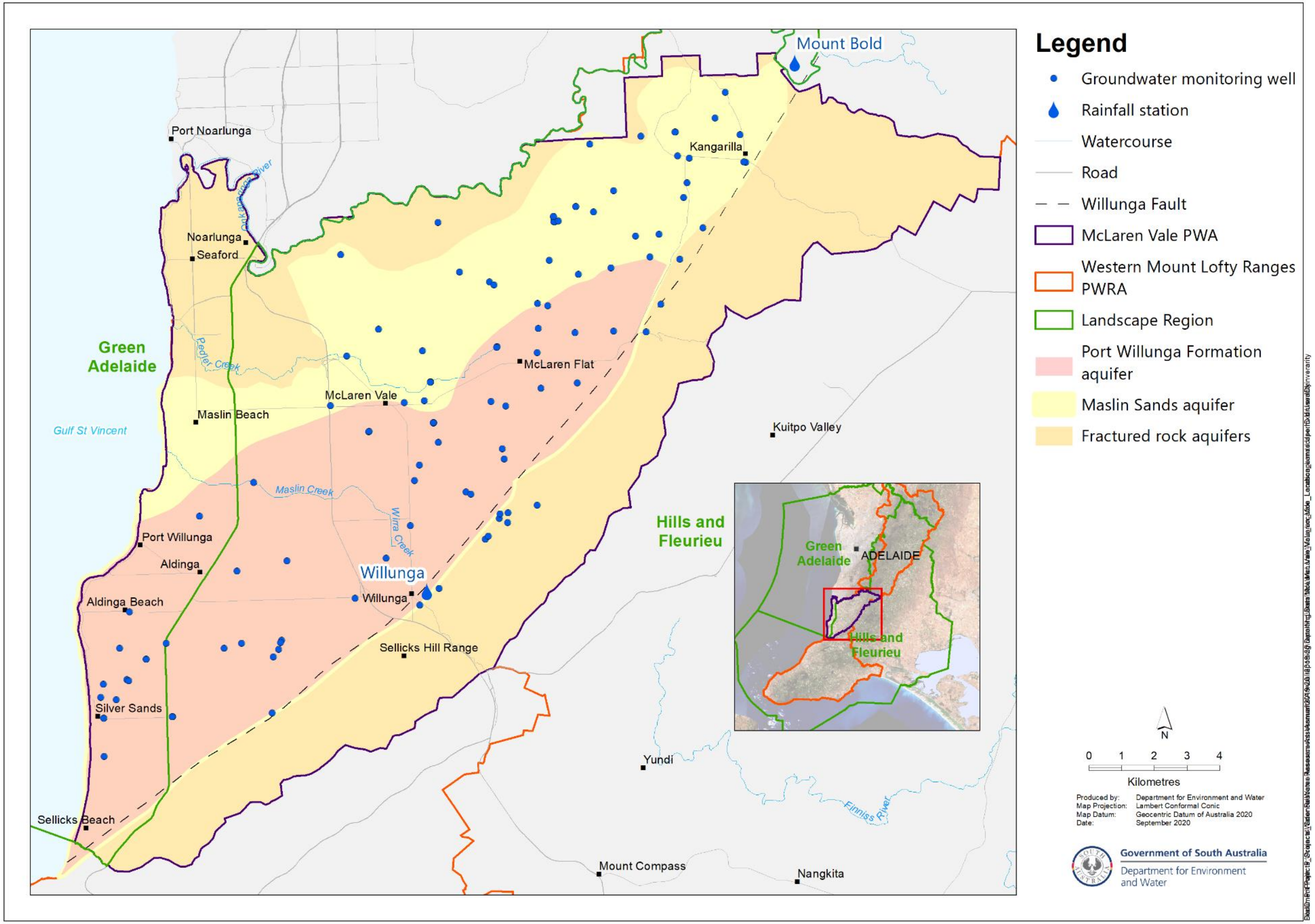

Figure 1.1 Location of McLaren Vale PWA

2 Methods and data

This section describes the source of rainfall, surface water, groundwater and water use data presented in this report, and describes the methods used to analyse and present this 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. The data have been obtained from the SILO Patched Point Dataset service provided by the Queensland Government, which provides interpolated values to fill gaps in observations (Figure 3.1 and Figure 3.2).

Rainfall maps were compiled using gridded datasets obtained from the BoM (Figure 3.3). The long-term average annual rainfall map (1986-2015) was obtained from Climate Data Online. The map of total rainfall in 2018-19 was compiled from monthly rainfall grids obtained for the months July 2018 to June 2019 from the Australian Landscape Water Balance website.

2.2 Groundwater

2.2.1 Water level

Water level[1] data were obtained from wells in the McLaren Vale PWA monitoring network from both manual and continuous logger observations. All available water level data were verified and the maximum annual water level for each well was identified for further analysis. The maximum annual water level represents the unstressed or recovered water level following seasonal irrigation pumping and other uses. The amount of pumping can vary from year to year and the proximity of pumping wells to observation wells may affect the reliability of trends and historical comparisons. Therefore, the recovered water level provides a reliable indicator of the status of the groundwater resource. The period of recovery each year was reviewed for each well. In general, the aquifers in the McLaren Vale PWA return to a maximum recovered level between September and November.

For wells with suitable long-term records, the annual recovered water level was ranked and described according to their decile range[2] from lowest to highest on record (Table 2.1). The definition of a suitable long-term record varies depending on the history of monitoring activities in different areas; for the McLaren Vale PWA, any well with 10 years or more of recovered water level data is included. For the most recent year, the number of wells in each decile range was then summarized for each aquifer (for example see Figure 4.1). Hydrographs are shown for a selection of wells to illustrate common or important trends (for example see Figure 4.3).

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

[1] "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).

[2]. 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 10^{th} percentile.

very small measurement errors. The number of rising, declining and stable wells are then summarized for each aquifer (for example see Figure 4.2).

Moderately-sized, sedimentary, confined and unconfined aquifers such as the Port Willunga Formation and Maslin Sands are given tolerance thresholds of 2 cm/y, while fractured rock aquifers with lower storages are given a tolerance threshold of 1 cm/y.

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 BoM[3]

2.2.2 Salinity

Salinity data were obtained from a network of irrigation wells. Since 2017, irrigators have submitted groundwater samples that DEW has tested for salinity. The results have improved the understanding of temporal and spatial salinity trends. 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 (for example see Figure 4.4).

As of early 2020, there are insufficient salinity data to undertake an analysis of short-term salinity trends.

2.3 Water use

Meter readings are used to calculate licensed extraction volumes for all groundwater sources in the McLaren Vale PWA.

[3] Bureau of Meteorology Annual climate statement 2019

2.4 Further information

Groundwater data can be viewed and downloaded using the *Groundwater Data* page under the Data Systems tab on WaterConnect. For additional information related to groundwater monitoring well nomenclature, please refer to the Well Details page on WaterConnect.

Other important sources of information on water resources on the McLaren Vale PWA are:

- Summary reports on the groundwater resources of the McLaren Vale PWA and annual groundwater level and salinity status reports (*Water Resource Assessments* page on WaterConnect);
- The Water Allocation Plan for the McLaren Vale PWA (AMLR NRM Board, 2007);
- Review of salinity trends in the McLaren Vale PWA (Herczeg and Leaney, 2002; Villeneuve and Harrington, 2012);
- Review of groundwater recharge processes in the McLaren Vale PWA (Batlle-Aguilar and Cook, 2012; Harrington, 2002; Herczeg and Leaney, 2002; Irvine et al., 2017); and
- Review of saltwater intrusion in the McLaren Vale PWA (Morgan et al., 2013; Post and Banks, 2015; Post et al., 2018; Short et al., 2014); and
- For a detailed description of the hydrogeology of the Willunga Basin, refer to Smith et al. (2015).

3 Rainfall

The McLaren Vale PWA is characterised by a Mediterranean climate with warm to hot, dry summers and cool to cold, wet winters. Long-term annual rainfall (1986-2015) varies from up to 900 mm along the ranges in the north-east of the PWA to 500 mm near the coast. During 2018-19, rainfall was appreciably lower than the long-term average with rainfall varying from 750 mm along the northeast of the ranges to less than 450 mm near the coast.

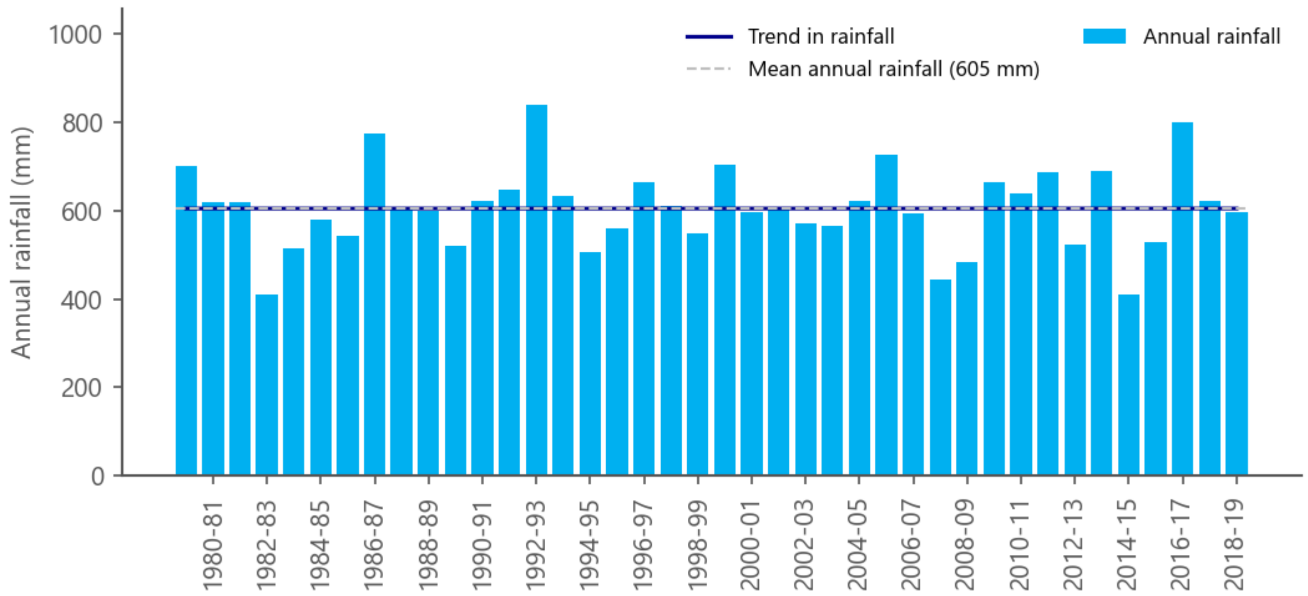

Figure 3.1 Annual rainfall from 1979-80 to 2018-19 at the Willunga rainfall station (23753)

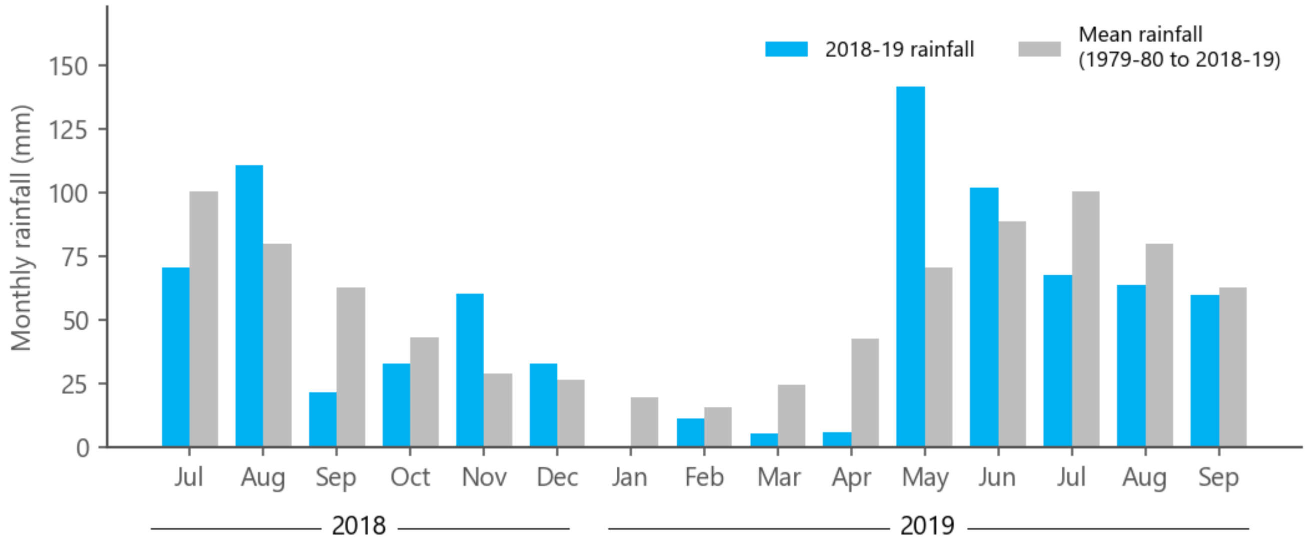

Figure 3.2 Monthly rainfall between July 2018 and September 2019, compared to the long-term monthly average at the Willunga rainfall station (23753)

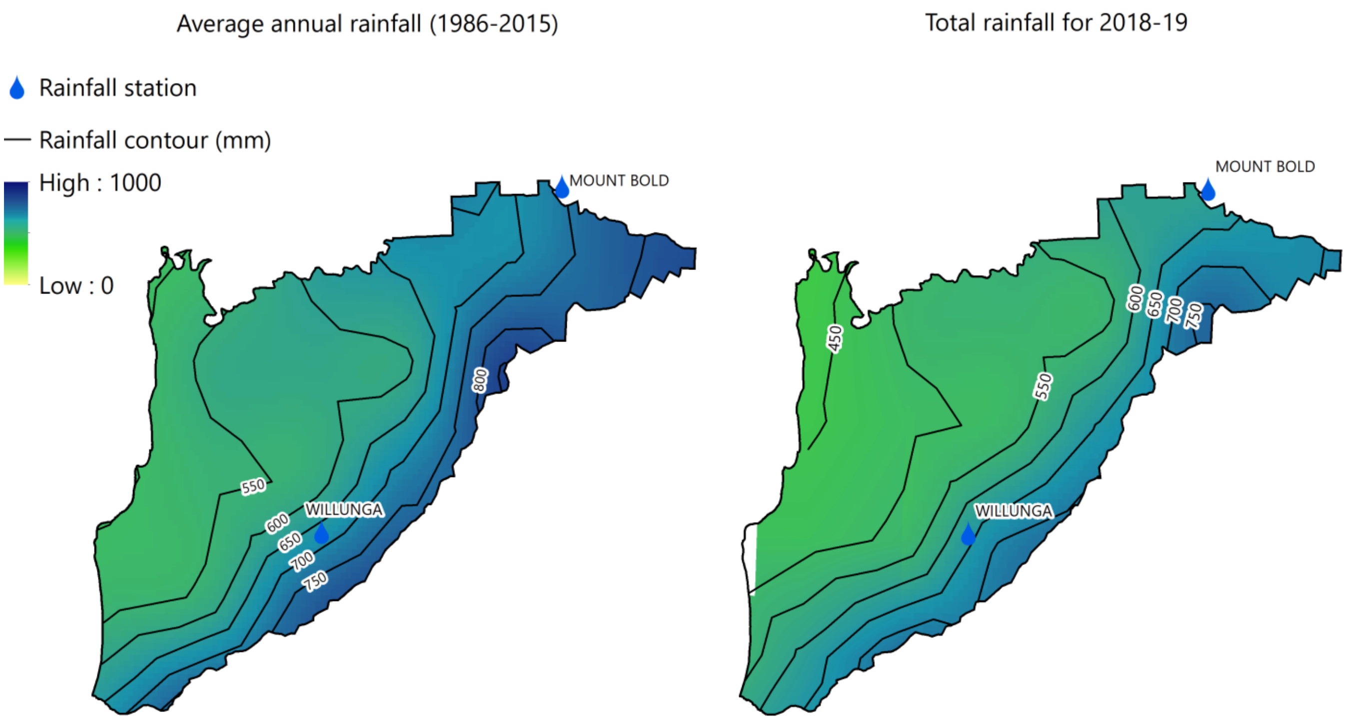

Figure 3.3 Rainfall in the McLaren Vale PWA for 2018-19 compared to the long-term average annual rainfall (1986-2015)

- The Willunga rainfall station (BoM station 023753) is located near the base of the ranges towards the south of the PWA (Figure 3.3)[4] and demonstrates historical rainfall conditions in the McLaren Vale PWA. In 2018-19, annual rainfall was 597 mm, marginally less than the long-term (1979-80 to 2018-19) average of 605 mm (Figure 3.1).
- The long-term rainfall trend over this period has been stable. However, there have been notable periods of above-average rainfall (e.g. 1992-93 and 2016-17) and below-average rainfall (e.g., 1982-86, 2007-09 and 2014-16).
- In 2018-19, a drier than average early spring (2018), summer (2018-19) and winter (2019) were observed at Willunga. Higher than average rainfall totals were recorded in late winter (2018), late spring-early summer (2018) and late autumn-early winter (2019) (Figure 3.2).

[4] Some differences may be noticeable between the spatial rainfall maps and the annual rainfall from individual stations. This is due to the use of different data sources and time periods and further detail is provided in Section 2.1.

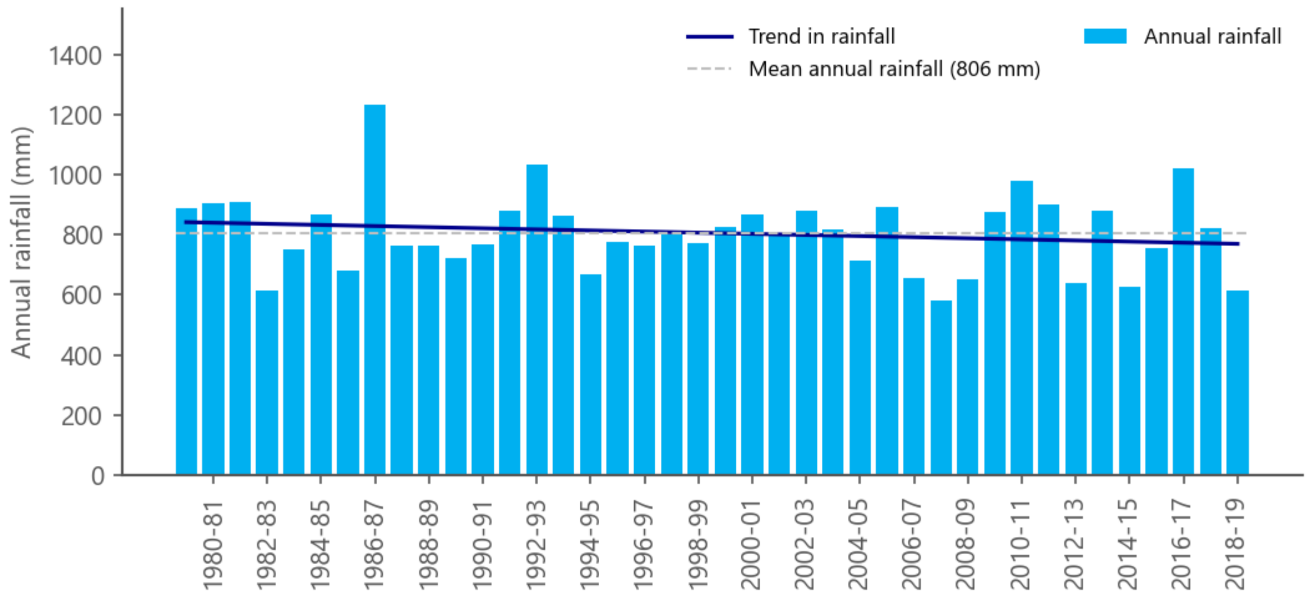

Figure 3.4 Annual rainfall from 1979-80 to 2018-19 at the Mount Bold Reservoir rainfall station (23734)

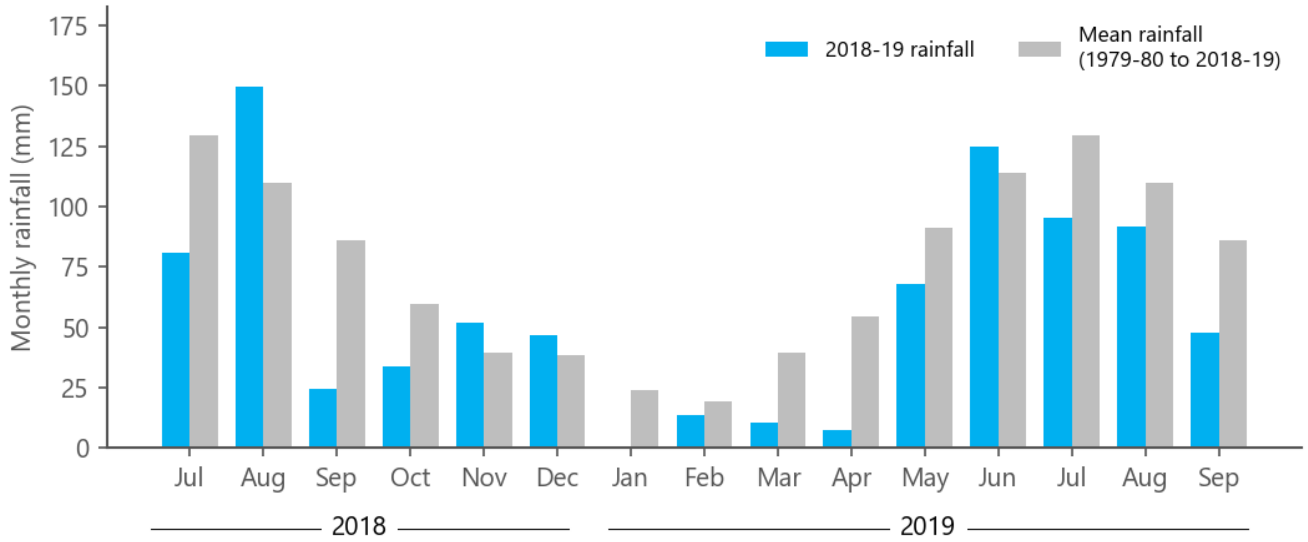

Figure 3.5 Monthly rainfall between July 2018 and September 2019 at the Mount Bold Reservoir rainfall station (23734)

- The Mount Bold Reservoir rainfall station (BoM station 023734) is situated immediately north of the McLaren Vale PWA and provides a representative record of rainfall occurring in the north-east of the PWA. The annual rainfall total for 2018-19 was 613 mm, slightly higher than recorded at Willunga (Figure 3.4). However, this was 191 mm less than the long-term average rainfall for Mount Bold Reservoir between 1979-80 and 2018-19.
- Mount Bold Reservoir (BoM 023734) has observed a marginally declining rainfall trend (-2 mm/y) over the long-term record (1979-80 to 2018-19).
- Apart from above-average rainfall in late winter (2018), late spring-early summer (2018) and early winter (2019), drier than average conditions were recorded in 2018-19 at Mount Bold Reservoir compared to the long-term average (Figure 3.5).

4 Groundwater

4.1 Hydrogeology

The McLaren Vale PWA encompasses sedimentary aquifers of Quaternary and Tertiary age within the Willunga Basin and a fractured rock aquifer which forms the hills in the north of the PWA and east of the Willunga Fault (Figure 1.1). The Willunga Basin is a structurally controlled trough bounded in the south-east by the Willunga Fault and to the north by basement outcrop. The depth of the basin increases toward the southeast and reaches a maximum depth of approximately 250 m near the Willunga Fault. Groundwater occurs in four major aquifers:

- Quaternary.
- Port Willunga Formation (including the Pirramimma Sandstone).
- Maslin Sands.
- Fractured rock.

4.1.1 Quaternary

Sands and interbedded clays form shallow unconfined aquifers which are generally low yielding and provide mostly stock and domestic supplies, with limited extraction for irrigation. Recharge is predominantly derived from local rainfall and runoff through drainage features. In the north-east of the Willunga Basin, the Quaternary Pirramimma Sandstone lies unconformably alongside the Port Willunga Formation. For the purpose of the water allocation plan and this report, the Pirramimma Sandstone is currently considered to be part of Port Willunga Formation with regard to groundwater extraction and resource status.

4.1.2 Port Willunga Formation

The Port Willunga Formation is the main water supply aquifer in the Willunga Basin. It consists of sand and limestone, which are confined by Quaternary sediments in the south and south-western parts of the McLaren Vale PWA. Elsewhere, to the north near McLaren Vale and McLaren Flat, the Port Willunga Formation is unconfined. Well yields are generally between 2 L/s and 16 L/s. Recharge to the Port Willunga Formation primarily occurs where the aquifer is unconfined or outcrops in the north-east of the basin and groundwater flow occurs in a south-westerly direction towards the coast. Groundwater residence times range up to 2,000 years. Marls, mudstone, silts, clay and marly limestone of the Blanche Point Formation aquitard separate the Port Willunga Formation from the underlying Maslin Sands.

4.1.3 Maslin Sands

The Maslin Sands comprises the North Maslin Sands and South Maslin Sands geological units and directly overlies basement rocks. The North Maslin Sands comprises upward-fining cross-bedded quartz sands with poorly sorted gravel deposited in a braided river environment (Smith et al., 2015). The South Maslin Sands comprises fine to coarse carbonaceous and pyritic sand, clay and glauconitic marginal marine deposits (Smith et al., 2015). The Maslin Sands is recharged by rainfall in the north-east of the McLaren Vale PWA where the aquifer outcrops near Kangarilla and Mount Bold. Groundwater flow is towards the south-west with groundwater residence times ranging from 5,000 to more than 20,000 years. Elsewhere, the aquifer is confined and separated from the overlying Port Willunga Formation by the Blanche Point Formation, an aquitard consisting of low-permeability marine mudstone and limestone.

4.1.4 Fractured rock aquifer

Fractured rock aquifers occur in basement rocks (slate, quartzite, shale and limestone) which underlie the sedimentary aquifers within the Willunga Basin and form the ranges to the east of Willunga Fault and along the Onkaparinga Gorge. Infiltration of rainfall provides recharge to the fractured rock aquifers in these areas and groundwater flow generally follows the topography from high elevations around the basin margin towards the centre of the basin. Beneath the sedimentary formations, groundwater flow in the fractured rock aquifer bears south-west towards the coast.

4.2 Port Willunga Formation Aquifer - water level

Following the 2018-19 irrigation season, the majority (77%) of Port Willunga Formation (PWF) aquifer monitoring wells recorded the lowest water level on record. These wells are in the central and northern portion of the aquifer where the PWF aquifer is unconfined and irrigation extraction is concentrated. Most monitoring wells with a declining trend monitor the unconfined Pirramimma Sandstone and are clustered to the east of McLaren Vale (Figure 4.1).

The changes in water levels over the last 30 years in wells with suitable long-term records show a decline ranging from 2.39 m to 7.59 m (the median change is a decline of 4.44 m).

Five-year trends in water levels are declining in the majority of wells (72%), with rates ranging from a decline of 0.19 m/y to a rise of 0.13 m/y (the median change is declining at 0.15 m/y) (Figure 4.2).

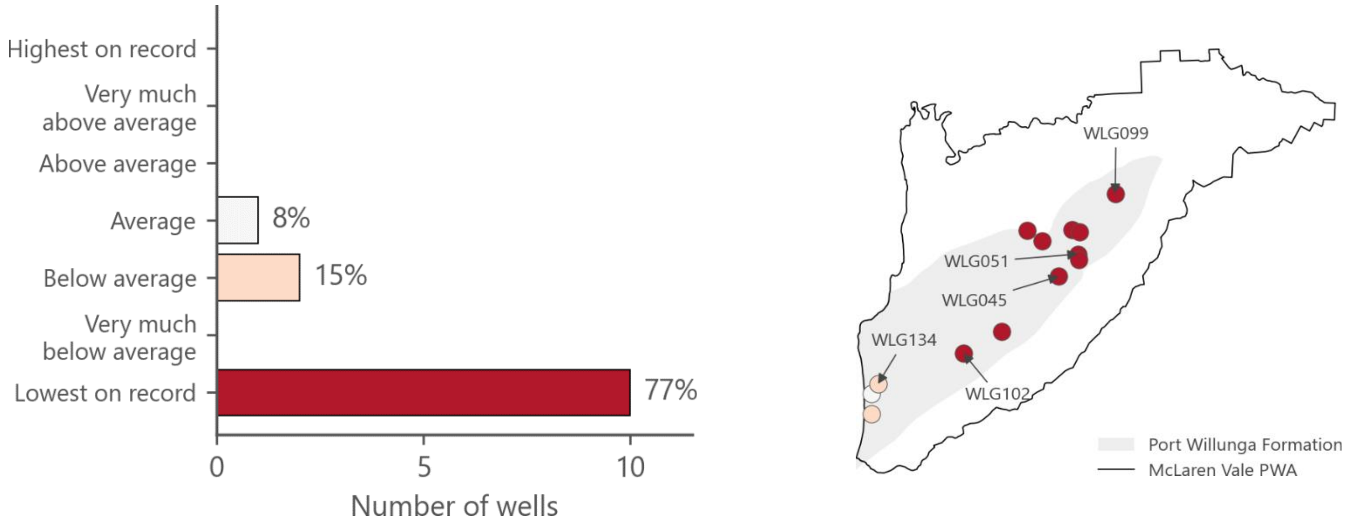

Figure 4.1 2019 recovered water levels for wells in the Port Willunga Formation aquifer

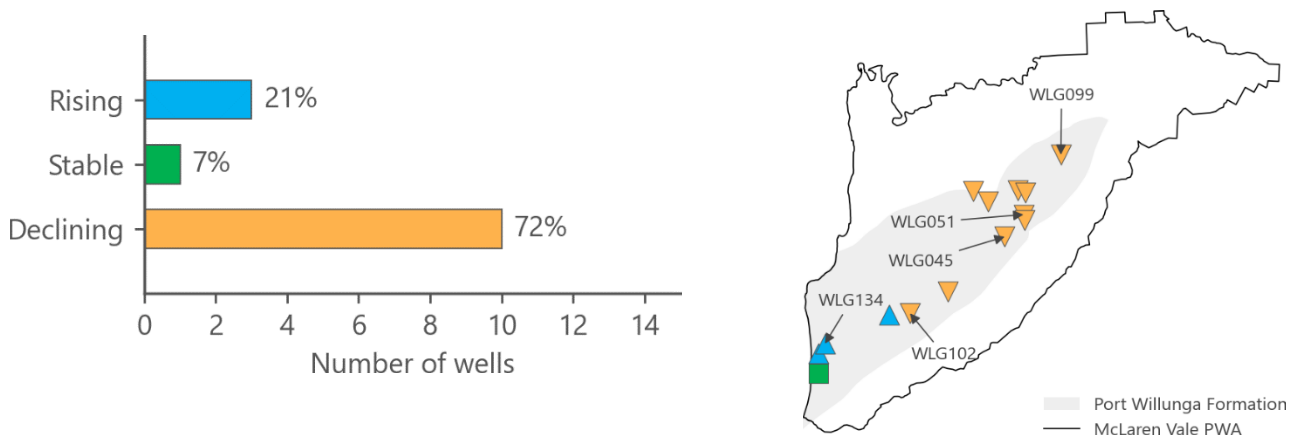

Figure 4.2 2015-2019 trend in recovered water levels for wells in the Port Willunga Formation aquifer

Figure 4.3 shows representative hydrographs from a selection of PWF monitoring wells. Four of the five representative monitoring wells (WLG045, WLG051, WLG099 and WLG102) recorded their lowest water level on record in 2019 which is likely due to an extended pumping season following generally below-average rainfall during 2018-19. Typically, water level in the PWF has been stable in the south-west of the aquifer over the long-term where it is confined, with only minor seasonal fluctuations owing to low water use from the PWF in this area (e.g., WLG134). Towards the southern portion of the basin, the PWF has recorded a decline in recovered water levels of approximately two metres over the past 20 year (e.g. WLG102). In the central portion of the basin, water levels have declined by more than five metres over the long-term record (e.g. WLG051). Further north, declining groundwater levels are more pronounced (up to ten metres) where irrigation extraction volumes are high compared to water use in the south-west of the PWF (e.g. WLG045 and WLG099).

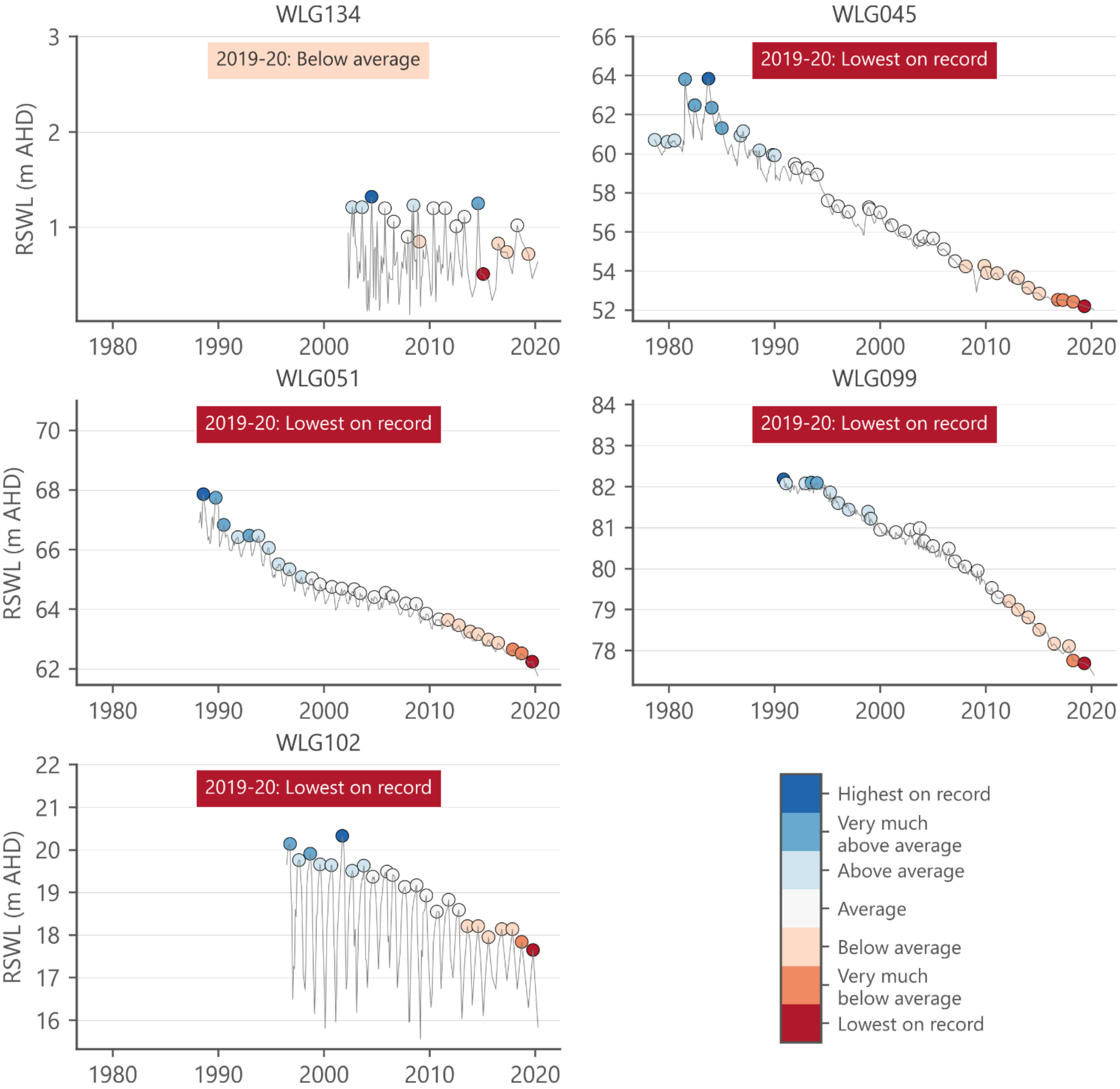

Figure 4.3 Selected Port Willunga Formation aquifer hydrographs

4.3 Port Willunga Formation Aquifer - salinity

Since 2017, irrigators in the McLaren Vale PWA have submitted groundwater samples that DEW have tested for salinity concentration. In 2019, salinity results from 118 irrigation wells in the PWF aquifer ranged between 251 mg/L and 3448 mg/L with a median of 1093 mg/L (Figure 4.4). Typically, salinities are lower (<1,000 mg/L) in the centre of the basin, with the lowest salinities in the vicinity of the McLaren Vale township, extending north-east towards McLaren Flat and south beyond McMurtrie Road. Salinity in the PWF increases to approximately 2,000 mg/L towards the coast and to the north-east.

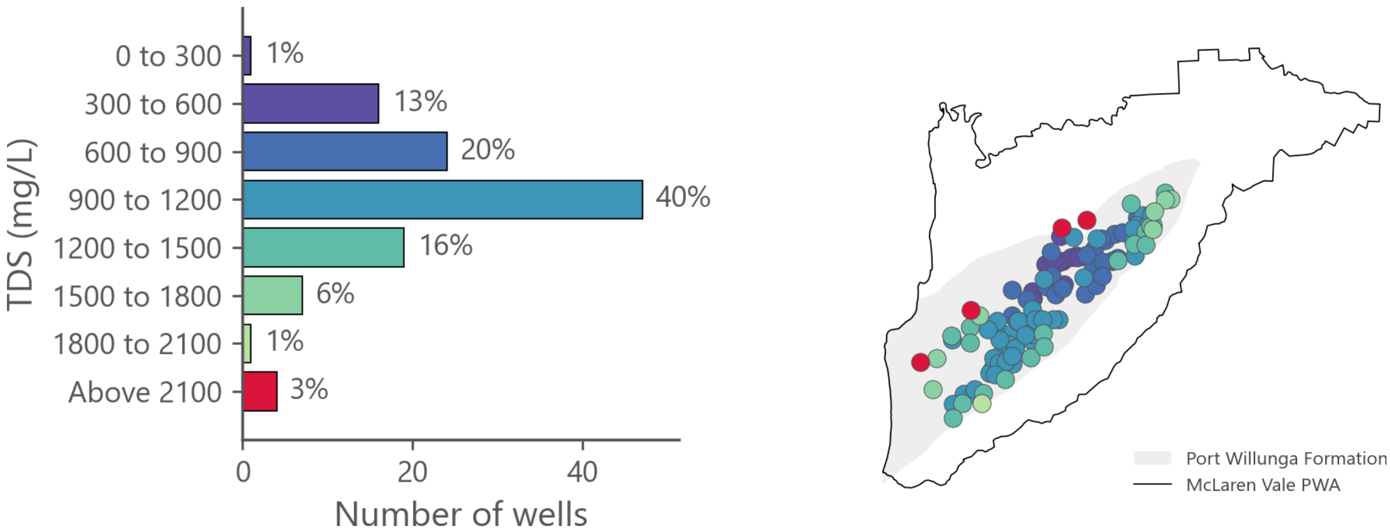

Figure 4.4 2019 salinity observations from wells in the Port Willunga Formation aquifer

4.4 Maslin Sands aquifer - water level

Following the 2018-19 irrigation season, the water levels observed in six (38%) of the Maslin Sands aquifer monitoring wells were lowest on record. These wells are spread across the aquifer boundary from the north-east near Kangarilla where the aquifer is unconfined, to near the coast where the aquifer is confined by the Blanche Point Formation. Five monitoring wells (31%) recorded average recovered water levels and have a similar spatial distribution to those wells which recorded their lowest water level on record (Figure 4.5).

The change in water level over the last 30 years in wells with suitable long-term records ranged from a decline of 5.26 m to a rise of 2.39 m (the median change is a decline of 0.69 m). The majority of wells (75%) recorded a decline in water level over this time period.

Five year trends in water levels are declining for 50% of wells, with rates ranging from a decline of 0.29 m/y to a rise of 0.45 m/y (the median change is a decline at 0.02 m/y) (Figure 4.6).

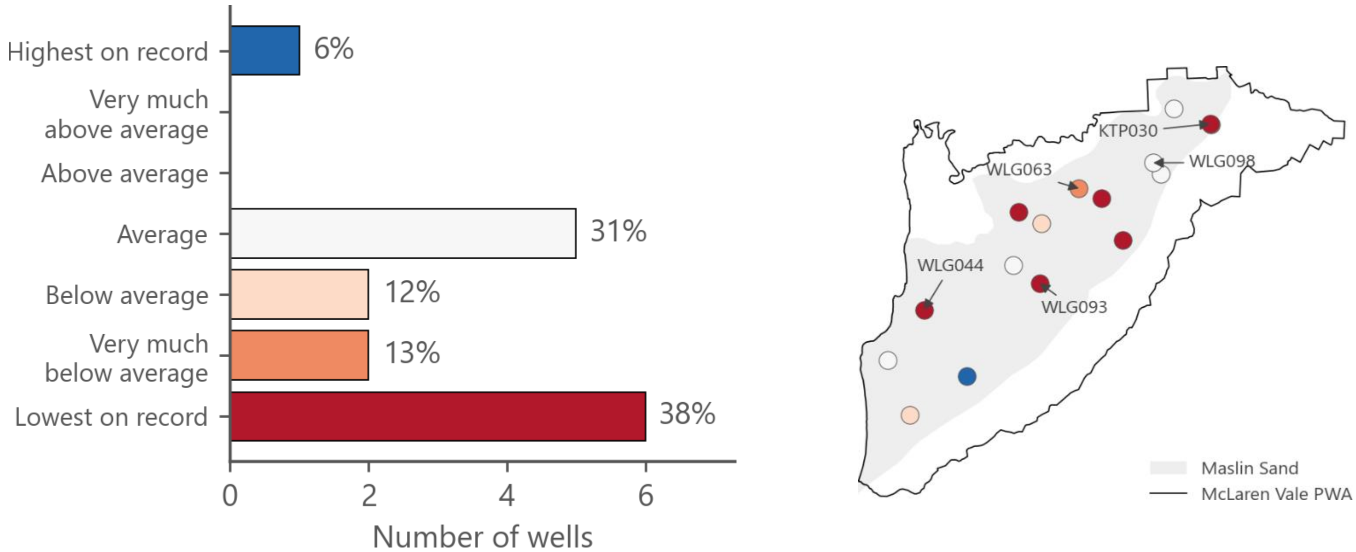

Figure 4.5 2019 recovered water levels for wells in the Maslin Sands aquifer

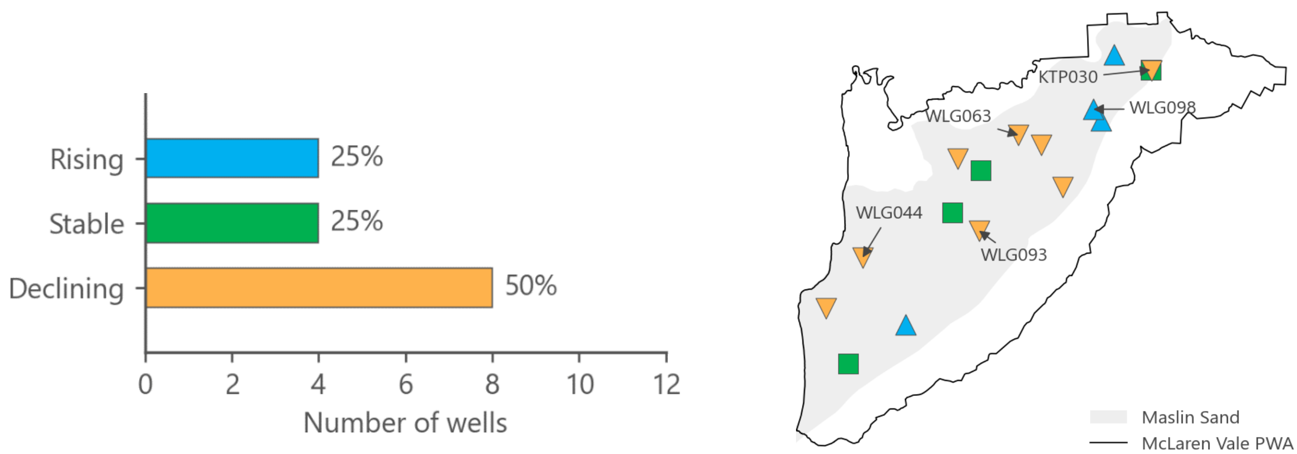

Figure 4.6 2015-2019 trend in recovered water levels for wells in the Maslin Sands aquifer

Figure 4.7 shows representative hydrographs from a selection of monitoring wells. Three of the five monitoring wells (WLG044, WLG093 and KTP030) recorded their lowest water level on record in 2019, while WLG063 was very much below average. This may be due to an extended duration of pumping season following generally below-average rainfall during 2018-19 which resulted in extraction from the aquifer at its highest level on record. Generally, the declining trend in recovered water level has steadied following water level declines of one to four metres over the historical record until 2000 in the central region of the aquifer (WLG063 and WLG093) and until 2010 in the coastal (WLG044) and north eastern (KTP030) regions. In the far north-eastern section of the aquifer, a water level rise has occurred over the past 10 years (WLG098).

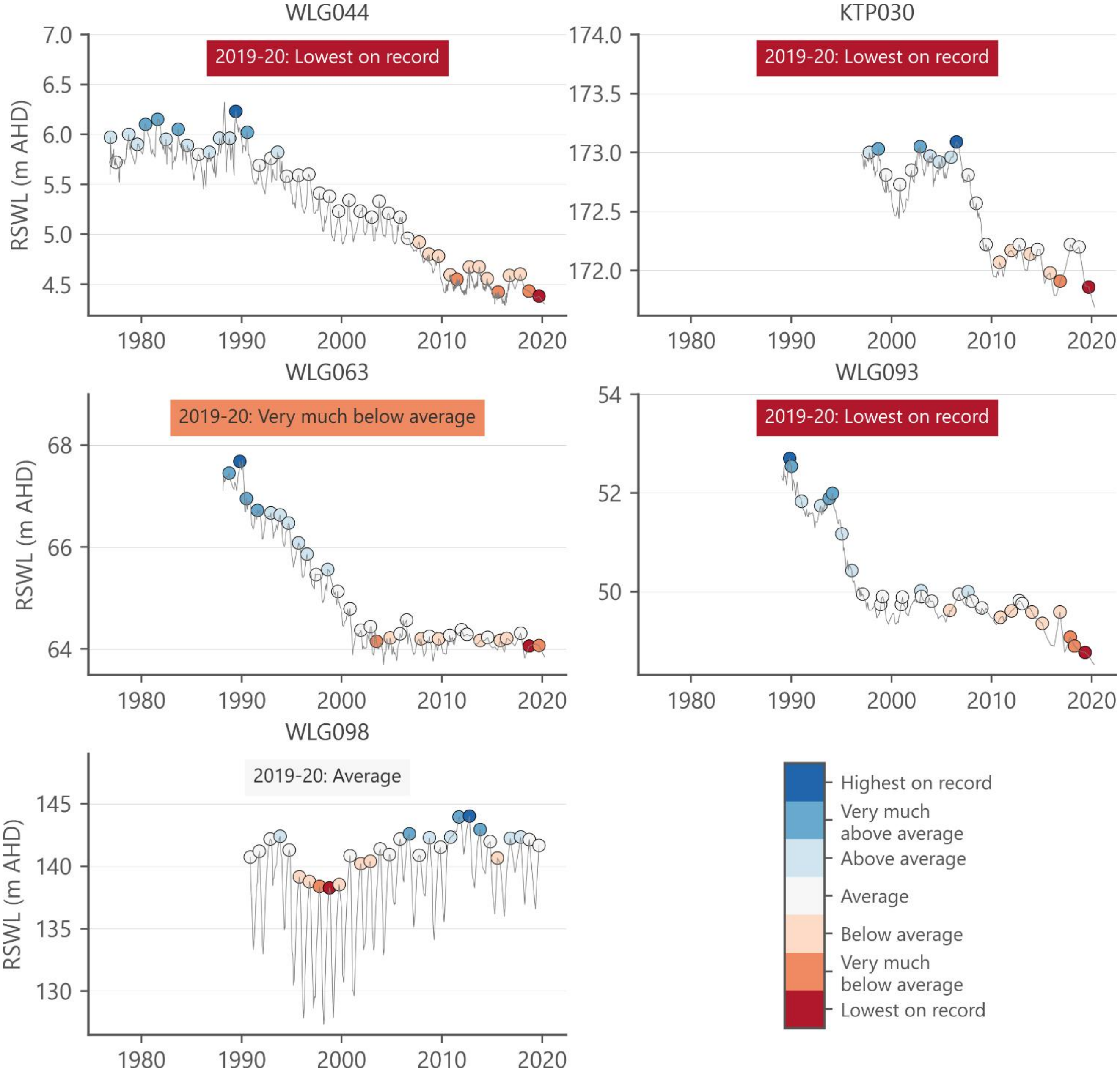

Figure 4.7 Selected Maslin Sands aquifer hydrographs

4.5 Maslin Sands aquifer - salinity

Since 2017, irrigators in the McLaren Vale PWA have submitted groundwater samples that DEW have tested for salinity concentration. In 2019, salinity results from 51 irrigation wells in the Maslin Sands aquifer ranged between 485 mg/L and 1993 mg/L with a median of 921 mg/L (Figure 4.8). Most salinity observations in the Maslin Sands aquifer are from an area between Kangarilla and north of McLaren Vale and north of the Willunga golf course. These areas align with key groundwater extraction areas from the aquifer. Typically, salinities are lower (<1,000 mg/L) in the north of the basin where the aquifer outcrops and receives direct rainfall recharge. Salinity increases down-gradient towards the coast and along the south-west margin.

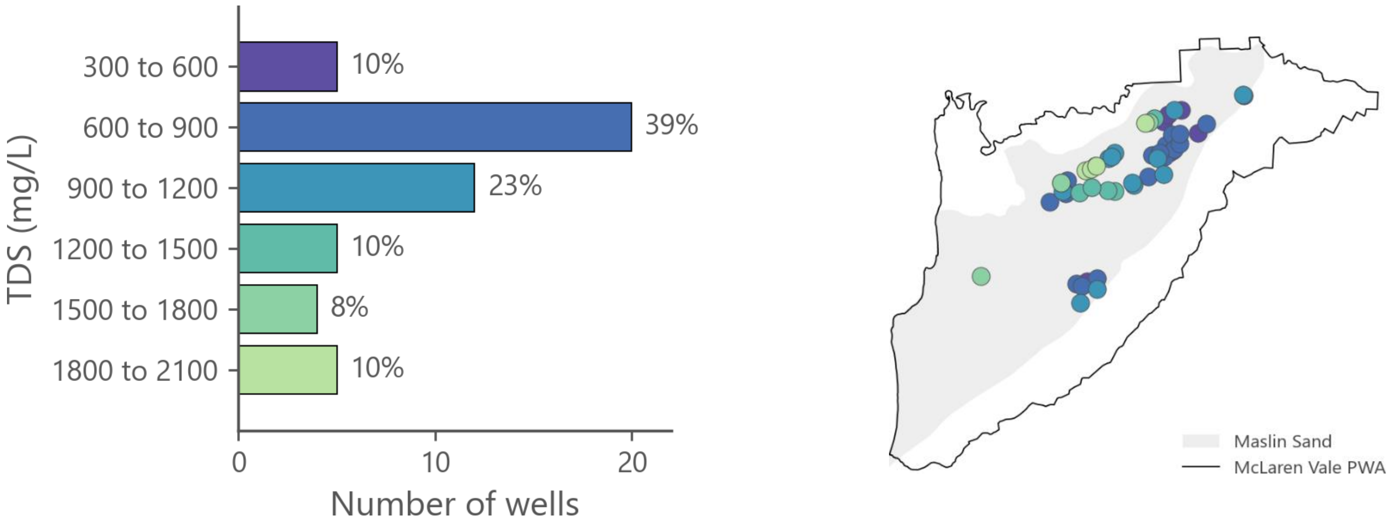

Figure 4.8 2019 salinity observations in the Maslin Sands aquifer

4.6 Fractured rock aquifers - water level

The wells monitoring the fractured rock aquifers are located along the ranges east of Willunga Fault and along Onkaparinga Gorge (Figure 4.9). In 2019, the majority (67%) of these wells recorded recovered water levels between below average to lowest on record.

The change in water level over the last 20 years in wells with suitable long-term records ranged from a decline of 5.97 m to a rise of 3.70 m (the median change is a decline of 0.05 m). More than half of these wells (55%) recorded a decline in water level over this time period.

Five-year trends in water levels are declining in 61% of wells, with rates ranging from a decline of 0.24 m/y to a rise of 1.73 m/y (the median change is a decline at 0.03 m/y) (Figure 4.10).

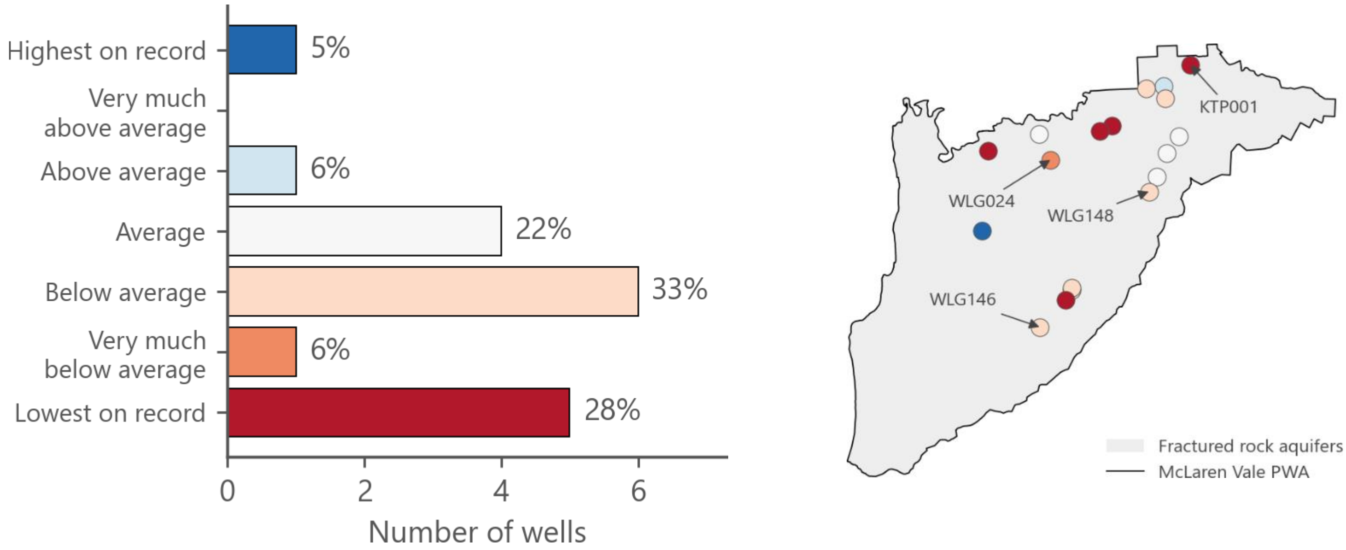

Figure 4.9 2019 recovered water levels for fractured rock aquifers

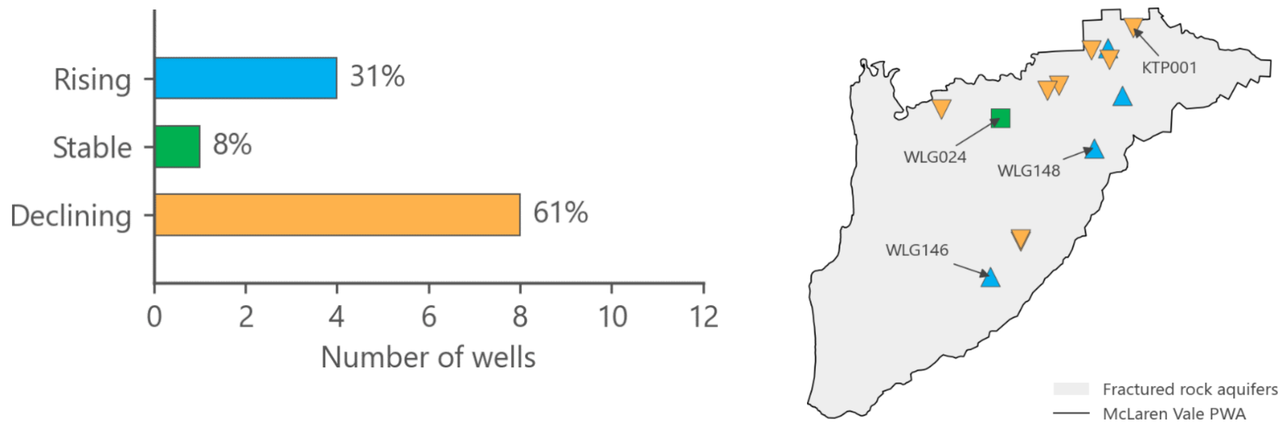

Figure 4.10 2015-2019 trend in recovered water levels for wells in fractured rock aquifers

Figure 4.11 shows representative hydrographs from a selection of monitoring wells. All four show below-average to lowest-on-record recovered water levels in 2019 which is likely due to below-average rainfall during 2018-19, particularly in the north of the PWA. Groundwater level trends in the fractured rock aquifer are generally very responsive to rainfall patterns, especially where basement rock outcrops and receives direct rainfall recharge.

East of Willunga, water levels in the aquifer have been relatively stable over the long-term record and over the past five years water levels recovered from the lowest on record in 2015 though recent years have shown a decline in levels due to low rainfall (WLG146). Historically, there have been large water level declines of up to 30 m east of McLaren Flat but water levels have stabilised in recent years (WLG148). Further north, near Kangarilla, water levels in the aquifer have declined by up to five metres over the long-term record (WLG024 and KTP001).

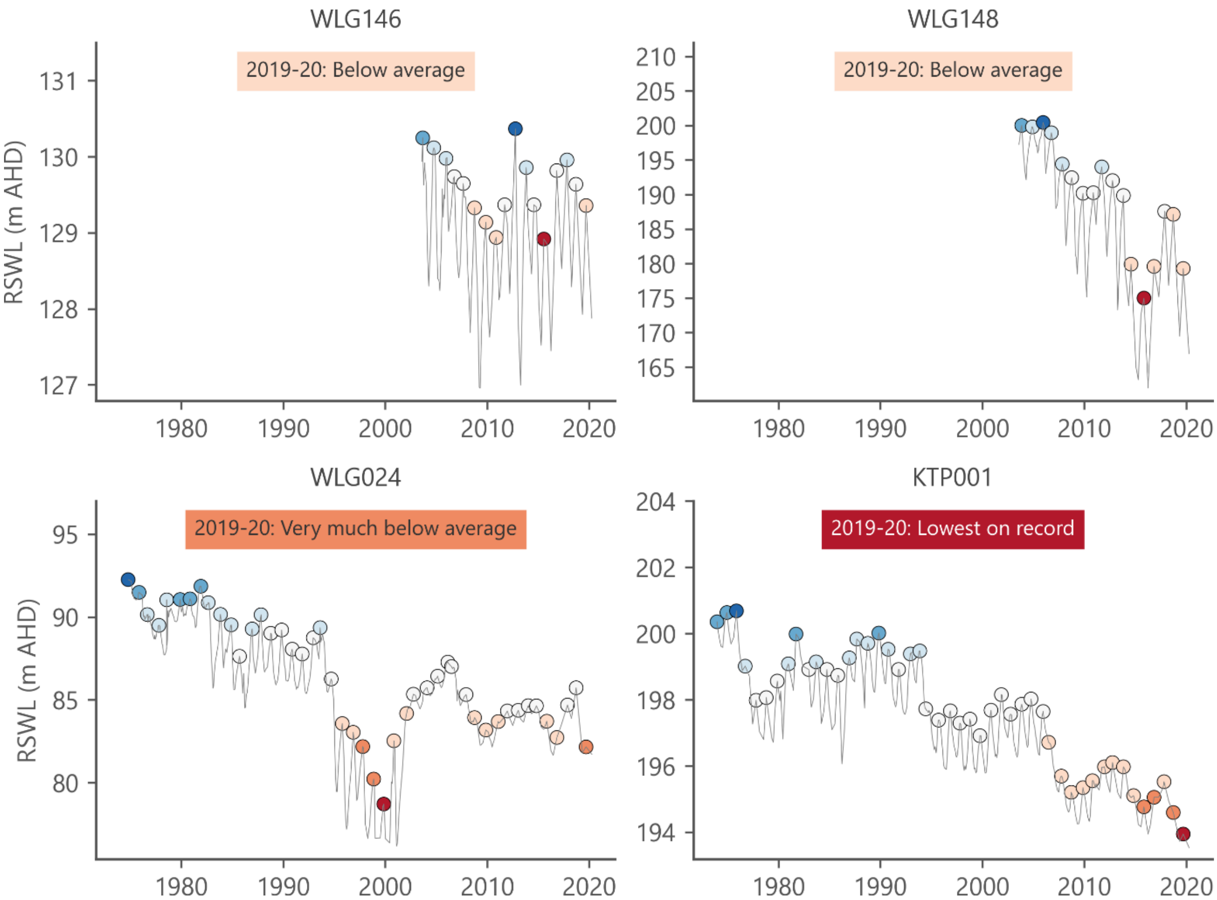

Figure 4.11 Selected hydrographs for wells in fractured rock aquifers

4.7 Fractured rock aquifers - salinity

Groundwater salinity in fractured rock aquifers can be highly variable due to the complex system of preferential flow paths affecting recharge and movement through the aquifer.

Since 2017, irrigators in the McLaren Vale PWA have submitted groundwater samples that DEW has tested for salinity concentration. In 2019, salinity results from 45 irrigation wells in the fractured rock aquifers ranged between 696 mg/L and 3259 mg/L with a median of 1398 mg/L. Lower salinities (<1,200 mg/L) were recorded along the ranges east of McLaren Vale and north of Kangarilla, although the aquifer salinity in these areas was variable with some recorded salinities above 2,000 mg/L. (Figure 4.12).

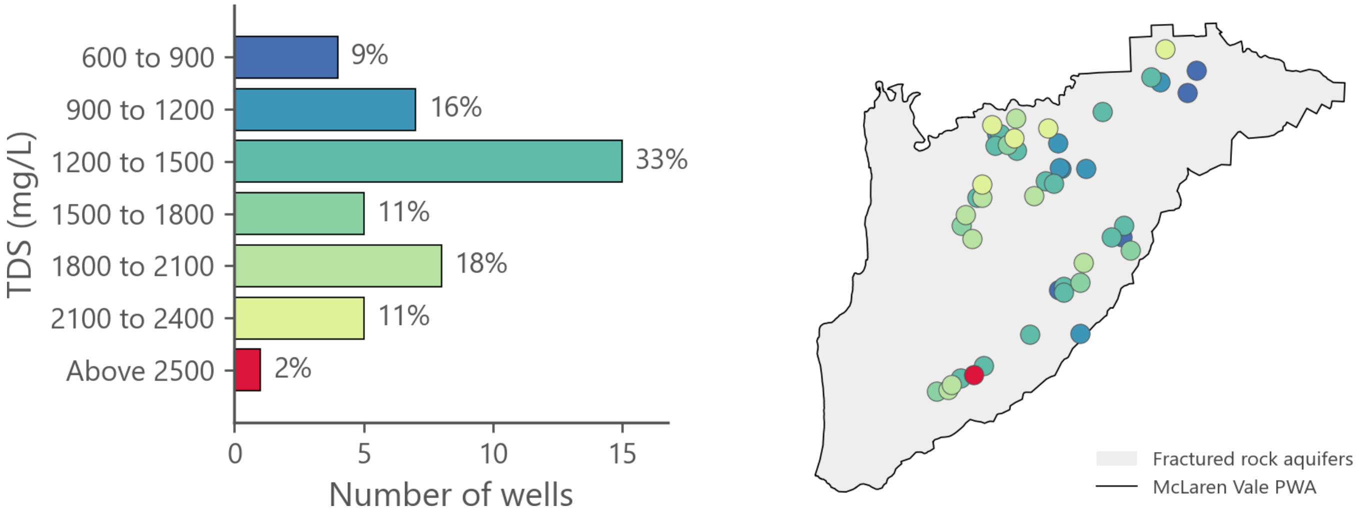

Figure 4.12 2019 salinity observations in fractured rock aquifers

5 Water use

Metered groundwater extraction in the McLaren Vale PWA totalled 5096 ML for 2018-19 (Figure 5.1), an increase in extraction of 645 ML from the preceding water-use year and 20% higher than the average annual long-term volume of groundwater extraction (4090 ML). In 2018-19:

- 955 ML (19% of the total extraction) was sourced from the fractured rock aquifer, which was approximately 15% higher than the average annual extraction from the fractured rock aquifer over the long-term average.
- 955 ML (19% of the total extraction) was sourced from the Maslin Sands aquifer, which was approximately 28% higher than the average annual extraction over the long-term average.
- 3183 ML (62% of the total extraction) was sourced from the Port Willunga Formation aquifer, which was approximately 19% higher than the average annual extraction over the long-term average (Figure 5.2).

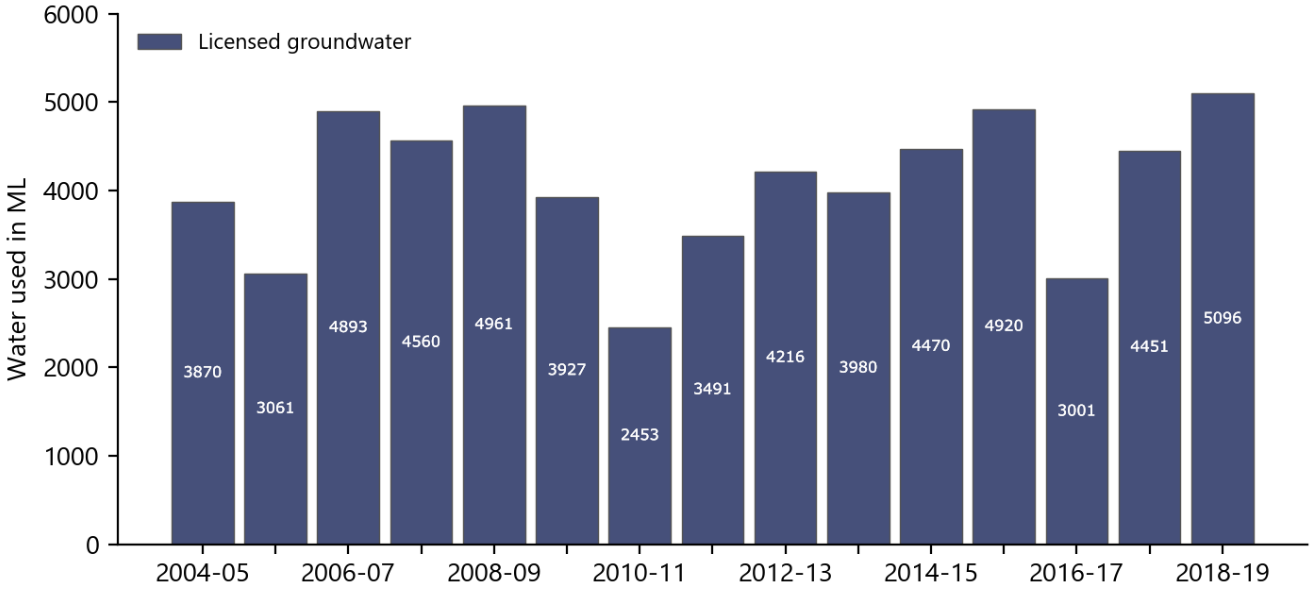

Figure 5.1 **Water extraction for 2004–05 to 2018–19 for the McLaren Vale PWA**

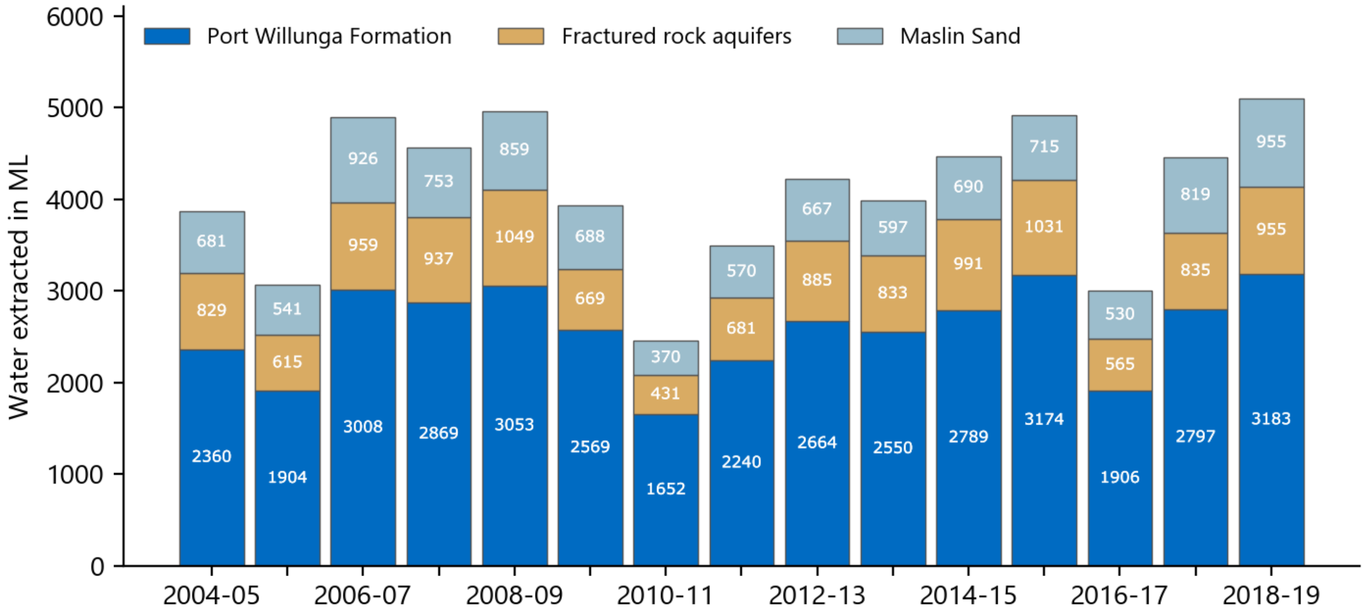

Figure 5.2 Metered groundwater extraction in aquifers of the McLaren Vale PWA

Two managed aquifer recharge (MAR) schemes operate in the McLaren Vale PWA. Reclaimed water provides an alternate source of water for irrigation and relieves pressure on the groundwater system. The two schemes on Plains Road at Aldinga and Hart Road at Aldinga Beach have design capacity to inject up to 550 ML/y into the Port Willunga Formation.

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