Prescribed areas of the Eastern Mount Lofty Ranges
2018-19 water resources assessment

Department for Environment and Water
November, 2020

DEW Technical report 2020/25
Contents

1 Summary
   1.1 Purpose
   1.2 Regional context

2 Methods and data
   2.1 Rainfall
   2.2 Surface water
      2.2.1 Annual streamflow
      2.2.2 Monthly streamflow
      2.2.3 Daily streamflow
      2.2.4 Salinity
   2.3 Groundwater
      2.3.1 Water level
      2.3.2 Salinity
   2.4 Water use
   2.5 Further information

3 Rainfall

4 Surface water
   4.1 Streamflow
      4.1.1 Bremer River (A4260533)
      4.1.2 Finniss River (A4260504)
   4.2 Salinity

5 Groundwater
   5.1 Hydrogeology
      5.1.1 Fractured rock aquifers
      5.1.2 Permian Sand aquifer
      5.1.3 Murray Group Limestone aquifer
   5.2 Fractured rock aquifers - water level
   5.3 Fractured rock aquifers - salinity
   5.4 Permian Sand aquifer
      5.4.1 Finniss Permian 1 UWMZ - water level
      5.4.2 Tookayerta Permian UWMZ - water level
      5.4.3 Finniss Permian 1 and Tookayerta UWMZs - salinity
   5.5 Murray Group Limestone aquifer
      5.5.1 Currency Limestone UWMZ - water level
      5.5.2 Currency Limestone management zone - salinity
      5.5.3 Angas Bremer PWA - water level
      5.5.4 Angas Bremer PWA - salinity

6 Water use
   6.1 Surface water use
   6.2 Groundwater use
6.2.1 Groundwater use in the Angas Bremer PWA

6.3 Farm dams

7 References
## 1 Summary

### Rainfall
- Rainfall across the region was lower than average in 2018–19. Rainfall at Mount Barker in 2018–19 was 630 mm, 13% below average, while rainfall at Langhorne Creek was 304 mm, 20% below average.
- Rainfall is typically higher in highland areas and decreases eastwards over the Murray Plains due to the ‘rain shadow’ effect.

### Surface water
- In 2018–19, lower-than-average streamflow was recorded in all four of the representative gauging stations (Angas River, Bremer River, Currency Creek and Finniss River), with three of them recording ‘very much below average’ streamflow.
- Long-term data trends at the representative gauges show a decline in streamflow.
- The highest salinity in the Bremer River in 2018–19 was 2077 mg/L and 1314 mg/L in the Finniss River. These values remain within the historical ranges experienced at each site.

### Groundwater
- Water levels in the three aquifer systems (fractured rock, Permian Sand, and Murray Group Limestone) were generally at average levels, with wells in the Murray Group Limestone within the Angas Bremer PWA generally at above average levels.
- Of the 142 monitoring wells, 59 (42%) had average recovered water levels in 2018–19 when compared to historic levels. 6 wells were lowest on record (in fractured rock aquifers and the Permian Sand aquifer) and 4 were highest on record.
- The majority of irrigation wells with salinity data show stable salinities over the period of 2015 to 2019 (more than 60% of wells in each aquifer). Permian Sand aquifer wells show the most variability in salinity trends.

### Water use
- Consumptive water use includes a variety of licensed purposes (irrigation, industrial, intensive animal production, environmental and recreational uses) and non-licensed uses such as stock and domestic and plantation forestry. Water is sourced through pumping and diversions from watercourses and aquifers and interception and storage by farm dams.
- Estimated water consumption in 2018–19 was 32910 ML. This includes metered groundwater extraction: 10952 ML, licensed surface water dams: 4137 ML, licensed watercourse extractions: 5900 ML, non-licensed surface water demand: 3483 ML, forestry: 3191 ML and Lower Angas Bremer flood allocation: 5247 ML.
- Water use was higher due to increased irrigation demand resulting from lower than average summer rainfall.
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 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**: (these documents) build on the fact sheets to provide more comprehensive information for each resource area, helping to identify in further detail the resource condition;
- **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 Eastern Mount Lofty Ranges (EMLR) Prescribed Water Resources Area (PWRA) (which includes the Angas Bremer Prescribed Wells Area (PWA)) for 2018-19 and addresses rainfall, surface water and water use data collected between July 2018 and September 2019, and groundwater data collected up until December 2019.

1.2 Regional context

The EMLR PWRA is located approximately 50 km to the east of Adelaide and occupies an area of 2845 km² (Figure 1.1). The area incorporates the eastern slopes of the Mount Lofty Ranges which lies within Hills and Fleurieu Landscape Region and the Murray Plains which lie within the Murraylands and Riverland Landscape Region. It is a regional-scale resource for which groundwater and surface water are prescribed under South Australia’s Landscape SA Act 2019. A water allocation plan adopted in 2013 provides rules for the management of the water resources.

The PWRA is located within the Murray-Darling Basin and can be divided into two topographically distinct regions. The west of the PWRA is characterised by steep hills and valleys, while the eastern side comprises flat plains and localised rises stretching out towards the River Murray.

The PWRA extends from the Milendella Creek catchment in the north to Currency Creek catchment in the south and contains sixteen surface water catchments. Eleven of the catchments have watercourses that drain from the eastern slopes of the Mount Lofty Ranges to the River Murray and Lake Alexandrina, with the Bremer, Angas and Finniss Rivers being the larger watercourses. There are also a number of catchments that have streams that rise in the ranges but do not persist and contribute little water into the River Murray.

A number of different aquifers containing underground water occur within the PWRA. These include both fractured rock aquifers in the Mount Lofty Ranges (Adelaidean and Kanmantoo Group rocks) where water is stored and moves through joints and fractures in rock, as well as sedimentary aquifers in Permian Sand deposits located in some valleys around Mount Compass and Ashbourne (Figure 1.1).

Groundwater is also utilised from the Murray Group Limestone aquifer in the eastern part of the PWRA within the Currency Creek Limestone underground water management zone and also within the Angas-Bremer PWA located around Langhorne Creek and Milang (Figure 1.1).
Prescribed areas of the Eastern Mount Lofty Ranges 2018-19 water resources assessment

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

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

2.1 Rainfall

Daily rainfall observations were used from selected Bureau of Meteorology (BoM) stations in order to calculate monthly and annual totals. The data were obtained from the SILO Patched Point Dataset service provided by the Queensland Government, which provides interpolated values to fill gaps in observations (Figure 3.1 to Figure 3.4). Rainfall maps were compiled using gridded datasets obtained from the BoM (Figure 3.5). The long-term annual rainfall map (1986-2015 average) was obtained from Climate Data Online. The map of total rainfall in 2018–19 was compiled from monthly rainfall grids obtained for the months between July 2018 and June 2019 from the Australian Landscape Water Balance website.

2.2 Surface water

2.2.1 Annual streamflow

The status of each of the gauging stations is determined by expressing the annual streamflow for the applicable year as a percentile\(^1\) of the total period of data availability. The period of data availability for the Bremer and Finniss River streamflow gauging stations is 1976–77 to 2018–19. Streamflow data were then given a description based on their percentile and decile\(^1\) (Table 2.1).

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

* Deciles and descriptions as defined by the BoM\(^2\)

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

---

\(^1\) 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 10\(^{th}\) percentile.

\(^2\) Bureau of Meteorology Annual climate statement 2019
2.2.2 Monthly streamflow

Monthly streamflow for the applicable year is assessed alongside the long-term monthly streamflow (Figure 4.3A and Figure 4.5A) for the period 1976–77 to 2018–19 and long-term monthly statistics including (a) high flows (25\textsuperscript{th} percentile), (b) median flows (50\textsuperscript{th} percentile) and low flows (75\textsuperscript{th} percentile).

2.2.3 Daily streamflow

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

2.2.4 Salinity

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

![Box and whisker plot]

Figure 2.1. Box and whisker plot

2.3 Groundwater

2.3.1 Water level

Water level\textsuperscript{3} data were obtained from wells in the monitoring network by both manual and continuous logger observations. All available water level data are verified and reduced to an annual maximum water level for each well for further analysis. The annual maximum level is used as this represents the unstressed or recovered water level following pumping each year for irrigation and other uses. The amount of pumping can vary from year to year and the proximity of pumping wells to monitoring wells may affect the reliability of trends and historical comparisons. Therefore the recovered level is used as it is a more reliable indicator of the status of the groundwater resource. The period of recovery each year was reviewed for each well; in general the aquifers in the EMLR PWRA return to a recovered maximum level between June and December.

For those wells with suitable long-term records, the annual recovered water levels were then ranked from lowest to highest and given a description in the same way as annual streamflow, according to their decile range (see above, Table 2.1). The definition of a suitable long-term record varies depending on the history of monitoring activities in different areas; for the EMLR PWRA, any well with 10 years or more of recovered water level data is included. The number of wells in each description class for the most recent year is then summarised for each aquifer (for example

\textsuperscript{3} “Water level” in this report refers to both the watertable elevation, as measured in wells completed in unconfined aquifers, and the potentiometric water level elevation, as measured in wells completed in confined aquifers where the water level or pressure in the monitoring well rises above the top of the aquifer. These are collectively referred to as the “reduced standing water level” (RSWL).
Five-year trends 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 for very small measurement errors. The number of rising, declining and stable wells are then summarised for each aquifer (for example see Figure 5.2).

Sedimentary confined and unconfined aquifers such as the Murray Group Limestone and Permian Sand aquifers in this report are given tolerance thresholds of 2 cm/y, while fractured rock aquifers with lower storages are given a tolerance threshold of 1 cm/y.

Twenty-year changes in water level were calculated as the difference between the average water level in a three-year period twenty years ago (i.e. 1998–2000) and the average water level in 2019.

### 2.3.2 Salinity

Water samples from pumping irrigation wells are provided to DEW by licence holders in the EMLR PWRA and Angas Bremer PWAs. These samples are tested for electrical conductivity (EC) and the salinity (total dissolved solids measured in mg/L, abbreviated as TDS) is calculated. Where more than one water sample has been collected in the course of a year, the annual mean salinity is used for analysis. An example of the results is shown in Figure 5.4.

Five-year salinity trends are calculated where there are at least five 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) \times 5}}{\text{Value of trend line at start of period (mg/L)}} \times 100
\]

If the percentage change is greater than 10% then the well is given a status of ‘increasing’ or ‘decreasing’ depending on how the salinity is changing, while if the absolute percentage change is less than 10% it is given a status of ‘stable’. The latter is intended to reflect the fact that salinity measurements based on the measurement of the electrical conductivity of a water sample are often subject to small instrument errors. The number of increasing, decreasing and stable wells are then summarized in for each resource (e.g. Figure 5.5).

### 2.4 Water use

Meter readings are used to estimate licensed extraction volumes for both surface water and groundwater sources. Where meter readings are not available, licensed or allocated volumes are used for surface water sources (Figure 6.1 to Figure 6.3). Non-licensed water use (stock and domestic) from farm dams is not metered and is estimated at 30% of dam capacity (AMLR NRM Board, 2019). Further information on the number, type and distribution of farm dams in the PWRA is provided in Section 6.3. Dam capacity estimates are undertaken using different methods with data derived from aerial surveys one of the primary sources.
2.5  Further information

Both surface water and groundwater data can be viewed and downloaded using the *Surface Water Data* and *Groundwater Data* pages under the Data Systems tab on WaterConnect. 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 EMLR PWRA are:

- Summary reports on the surface water and groundwater resources of the EMLR PWRA (DEWNR, 2014) and groundwater resources of the Angas Bremer PWA (DEWNR, 2012) and annual surface water status reports such as DEW, 2019a and groundwater level and salinity status reports such as DEW, 2019b,c,d.


- Penney et al. (2019) detail the surface water modelling to support South Australia’s requirements under the Basin Plan in the Eastern Mount Lofty Ranges Water Resources Plan area.


- Zulfic and Barnett (2004) provide a detailed background of hydrogeological data and sustainable yield estimates for the groundwater resources of the EMLR PWRA.
3 Rainfall

The eastern slopes of the Mount Lofty Ranges descend to the broad Murray Plains and eventually to the River Murray and the lower lakes of Lake Alexandrina and Lake Albert. The variation in topography found within the EMLR PWRA and the adjacent Western Mount Lofty Ranges PWRA produces a ‘rain shadow effect’ that is the main reason for the contrast in rainfall within the area. The Mount Lofty Ranges cause westerly winds to rise and cool; if these winds have a high enough moisture content, this results in condensation and precipitation along the mountain ranges, predominantly on the western side. The winds continue down the eastern slopes and onto the plains but with much lower moisture concentrations, resulting in comparatively less rainfall on the Murray Plains.

Figure 3.1. Annual rainfall for 1976–77 to 2018–19 at the Mount Barker rainfall station (23733)

Figure 3.2. Monthly rainfall between July 2018 and September 2019, Mount Barker rainfall station (23733)
Following the hills from south-west to north-west in the EMLR PWRA, rainfall ranges from approximately 500 to 1000 mm between the Harrogate rainfall station (number 23722) and the Mount Compass rainfall station (number 23735). In contrast, the Murray Plains rainfall ranges from less than 300 mm to 500 mm from the north-east to the south-east of the PWRA.

Figure 3.3. Annual rainfall for 1976–77 to 2018–19 at the Langhorne Creek rainfall station (24515)

Figure 3.4. Monthly rainfall between July 2018 and September 2019, Langhorne Creek rainfall station (24515)
Figure 3.5. Rainfall in the EMLR PWRA for 2018–19 compared to the standard 30-year climatological average (1986-2015)

- Mount Barker rainfall station (BoM station 23318) represents the higher rainfall areas of the Mount Lofty Ranges. The annual total recorded for 2018–19 was 630 mm. This was 96 mm lower than the average annual rainfall of 726 mm (1976–77 to 2018–19).

- Langhorne Creek rainfall station (BoM station 23318) represents the lower rainfall areas of the plains. The annual total recorded for 2018–19 was 304 mm. This was 74 mm lower than the average annual rainfall of 378 mm (1976–77 to 2018–19).

- Drier-than-average conditions were recorded in July, September and October 2018, as well as January to April and June 2019 at both Mount Barker and Langhorne Creek rainfall stations. Only in May 2019 was rainfall greater than the monthly average.

- Rainfall in 2018–19 was significantly lower in all parts of the PWRA compared to the long-term average annual rainfall patterns. The long-term-average annual rainfall shows the higher rainfall band (800–850 mm) being present near Mount Barker, whereas these rainfall bands were not present in the PWRA in 2018–19.

---

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.
4 Surface water

4.1 Streamflow

The main watercourses in the EMLR PWRA include the lower-yielding Bremer and Angas Rivers and the higher-yielding Finiss River and Currency Creek. These watercourses, along with numerous streams from a number of other smaller catchments within the PWRA, drain from the eastern side of the Mount Lofty Ranges and discharge into the River Murray and Lake Alexandrina. Trends in streamflow and salinity are primarily rainfall driven, i.e. lower than average winter rainfall will result in reduced annual streamflow volumes. Conversely, higher rainfall will result in increased surface water availability. Prolonged drier-than-average rainfall years combined with hotter and drier conditions associated with changing climate is expected to have direct implications to management of water resources in the EMLR PWRA. The spatial variability in hydrological behaviour of the surface water catchments within the EMLR makes it challenging when assigning a single representative streamflow gauging station for the PWRA. Therefore multiple streamflow gauging stations were used for the analysis (Figure 1.1). The following stations were chosen to be representative of the wetter parts (higher rainfall and streamflow):

- Finiss River (A4260533)
- Currency Creek (A4260530)

And the drier parts (lower rainfall and streamflow) of the EMLR PWRA:

- Angas River (A4260503)
- Bremer River (A4260533)

In 2018–19, lower-than-average streamflow was recorded in all four of the representative gauging stations (Figure 4.1), with three of these recording ‘very much below average’ streamflow. The common streamflow data availability period is 1976–77 to 2018–19. Further detail on analysis methodologies used can be found in Section 2.
4.1.1 Bremer River (A4260533)

One of the principal long-term streamflow gauging stations for the drier parts of the PWRA is on the Bremer River and covers a catchment area of 492 km$^2$. This site is located where the Bremer River flows from the Eastern Mount Lofty Ranges onto the Bremer Plains. The Bremer River then flows past the township of Langhorne Creek and into Lake Alexandrina.

Figure 4.2. Annual deviation from mean streamflow on the Bremer River (1976-77 to 2018–19)

Figure 4.3. (A) Long-term monthly statistics and 2018–19 monthly streamflow on the Bremer River; (B) Long-term average monthly streamflow and 2018–19 daily streamflow on the Bremer River
The deviation of each individual year’s streamflow from the long-term average is shown in Figure 4.2. The annual streamflow in the Bremer River was 3124 ML for 2018–19, which was 13646 ML (81%) below the average annual streamflow of 16 770 ML (1976–77 to 2018–19).

The annual total is ranked as ‘below average’ assessed for the period 1976–77 to 2018–19. Annual streamflow in the Bremer River indicates a long-term declining trend, with 3 of the last 5 years below the average annual streamflow (Figure 4.2).

Figure 4.3A shows the monthly streamflow for 2018–19 (grey bars) relative to the long-term monthly streamflow (1976–77 to 2018–19) for (a) low flows (25th percentile), (b) median flows (50th percentile) and high flows (75th percentile). All months were drier than average in 2018–19 and were below the 50th percentile (or median) monthly streamflow. No streamflow was recorded between January and March 2019. Typically, the majority of the streamflow occurs between July and October on the Bremer River and accounts for over 90% of the total annual flow in any given year.

Figure 4.3B presents the long-term average monthly streamflow (1976–77 to 2018–19) and the daily flows for 2018–19. Maximum daily flows were recorded in August 2018 and there were 108 zero flow days experienced in 2018–19 due to the ephemerality of the system. In the period from July to September 2019, flows remained below the long-term average monthly streamflow.
4.1.2 Finniss River (A4260504)

One of the principal long-term streamflow gauging stations for the wetter parts of the PWRA is on the Finniss River and the station has an upstream catchment area of 193 km². The Finniss is the highest yielding catchment in the PWRA, and flows from the Eastern Mount Lofty Ranges and eventually into Lake Alexandrina. The station measures flow only from one of the main sub-catchments (Meadows Creek) and not the flow from the entire Finniss catchment.

Figure 4.4. Annual deviation from mean streamflow on the Finniss River (1976-77 to 2018–19)

Figure 4.5. (A) Long term monthly statistics and 2018–19 monthly streamflow on the Finniss River; (B) Long term average monthly streamflow and 2018–19 daily streamflow on the Finniss River
The deviation of each individual year’s streamflow from the long-term average is shown in Figure 4.4. The annual streamflow in the Finnis River was 5763 ML in 2018–19, which was 16755 ML below the average annual streamflow of 22 518 ML (1976–77 to 2018–19).

The annual total is ranked as ‘very much below average’ assessed for the period 1976–77 to 2018–19. Annual streamflow in the Finnis River indicates a long-term declining trend with 3 of the last 5 years below the average annual streamflow (Figure 4.4).

Figure 4.5A shows the monthly streamflow for 2018–19 (grey bars) relative to the long-term monthly streamflow (1976–77 to 2018–19) for (a) low flows (25th percentile), (b) median flows (50th percentile) and high flows (75th percentile). All months were drier than average in 2018–19 and were below the 50th percentile (or median) monthly streamflow. Streamflow occurred from throughout the year but most was concentrated between July to December 2018 and again between April and June 2019. Typically, the majority of the flows occur between July and October on the Bremer River and account for almost 90% of the total annual flow in any given year.

Figure 4.5B presents the long-term monthly average streamflow (1976–77 to 2018–19) and the daily flows for 2018–19. Maximum daily flows were recorded in August 2018 and there were no zero-flow days experienced in 2018–19. In the period from July to September 2019, flows remained below the long-term average monthly streamflow.
4.2 Salinity

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

Salinity is recorded routinely in many locations across the PWRA. Two sites are used as representative stations, one in the Bremer River catchment (A4260533) with data available from 1995. The second station is located on the Finniss River (A4261075) with data available from 2004. Figure 4.6 and Figure 4.7 show the long-term monthly salinity statistics for the period of data availability and median monthly values for 2018–19 (red dots) at the two streamflow gauging stations.

![Figure 4.6. Long-term and 2018–19 monthly salinity at the Bremer River streamflow gauging station (A4260533)](image-url)
Figure 4.7. Long-term and 2018–19 monthly salinity at the Finniss River streamflow gauging station (A4261075)

The median long-term salinity observed on the Bremer River is 1600 mg/L and 800 mg/L for the Finniss River. The long-term monthly data for both the Bremer and Finniss Rivers indicate a high variability in salinity, which is indicated by the greater range between the minimum and maximum values. The median monthly salinity values for 2018–19 can also be seen in Figure 4.6 and Figure 4.7 (red dots).

The highest salinity recorded in the Bremer and Finniss Rivers in 2018–19 was 2077 mg/L and 1314 mg/L respectively. No salinity data has been recorded between February and April 2019 due to insufficient streamflow recorded at both sites. The remainder of the months experienced salinity levels within the historical ranges recorded each month.
5 Groundwater

5.1 Hydrogeology

The EMLR PWRA is topographically separated into highlands of the eastern Mount Lofty Ranges and plains leading down to the Murray River. The highlands region is underlain by Neoproterozoic and Palaeozoic rocks of the Adelaide Geosyncline, and the plains region is underlain by younger sedimentary rocks of the Murray Basin. Thinner Quaternary deposits occur in valleys in the highlands and widely across the eastern part of the PWRA. Basement rocks in the highlands areas form fractured rock aquifers, where groundwater is stored and moves through joints and fractures, while sedimentary rocks and sediments in both the highlands and plains areas form sedimentary aquifers such as the Permian Sand aquifer and the Murray Group Limestone aquifer. In sedimentary aquifers, groundwater is stored in and flows through the pore spaces within the sediments. Recharge to all aquifers of the EMLR PWRA generally occurs directly from rainfall percolating to the water table through the soil profile or indirectly through lateral flow from adjacent aquifers. Shallow Quaternary aquifers are generally low yielding and contain poorer quality water with limited use, so they are not discussed in this report.

5.1.1 Fractured rock aquifers

The fractured rock aquifers of the EMLR PWRA occur in four geological units; the Barossa Complex, Adelaidean rocks, the Normanville Group and the Kanmantoo Group. Generally, Adelaidean rocks along the higher elevation, western part of the PWRA, are more favourable in terms of recharge, salinity and yields, while the Barossa Complex and Kanmantoo Group provide groundwater of poorer quality and low yields. Groundwater flow within fractured rock aquifers generally follows the topography and moves from higher elevations toward lower elevations, where it eventually flows through sedimentary aquifers in the valleys and enters rivers and streams. The regional flow direction in the fractured rock aquifers is from north–west to south–east.

5.1.2 Permian Sand aquifer

The Permian Sand aquifer occurs in several large U-shaped valleys that were carved by large continental ice sheets about 280 million years ago. It occurs in the Cape Jervis Formation and comprises glacial deposits of unconsolidated sands, silts and clays with occasional gravel beds. The Permian Sand aquifer forms part of the eastern slopes of the highlands region and underlies the Murray Basin sediments of the plains region. The Permian Sand aquifer can be highly permeable which results in high yields and low salinities. However, productivity of this aquifer varies due to a high clay content in some areas, and at these locations, the aquifer is instead low yielding and high in salinity. The Permian Sand aquifer is widely developed for irrigation and town water supply. This report focuses on the Permian Sand aquifer in the Finniss Permian 1 and Tookayerta Permian underground water management zones (UWMZs), which are defined in the EMLR PWRA water allocation plan (Figure 1.1).

5.1.3 Murray Group Limestone aquifer

The Murray Group Limestone occurs in the Murray Basin and predominantly consists of shallow marine fossiliferous limestone that was deposited about 50 million years ago. The aquifer is up to 100 m thick and overlies the Kanmantoo Group and the Permian Sand aquifer in some areas. It is confined by the overlying Quaternary clay sediments to the south-west of Murray Bridge, however, it is unconfined to the north. It has low salinity groundwater in the southern area of the plains region where it is the main source of groundwater for irrigation. This is the result of freshwater recharge to the aquifer thought to have occurred several thousand years ago during a period that experienced much higher rainfall. However, today there is little evidence of natural freshwater recharge to this aquifer. Increased extraction from this aquifer during the Millennium drought led to rising salinities in the aquifer. Since then, decreased pumping has stabilised salinity levels and managed aquifer recharge (MAR) operations in the Langhorne Creek area have raised pressure levels and freshened the aquifer. This report focuses on the Murray Group Limestone aquifer in Prescribed areas of the Eastern Mount Lofty Ranges 2018-19 water resources assessment
the Currency Limestone underground water management zone, which is defined in the EMLR PWRA water allocation plan and the Angas-Bremer Prescribed Wells (Figure 1.1).

### 5.2 Fractured rock aquifers - water level

Following the 2018–19 irrigation season, the majority (52%) of fractured rock aquifer monitoring wells with long-term records showed average recovered water levels (Figure 5.1). These wells are spread across the aquifer with the majority located on the western portion of PWRA where most groundwater extraction occurs. For four monitoring wells the observed water level was their lowest level on record. The change in water level over the last 20 years in 22 wells with suitable long-term records ranged from a decline of 8.52 m to a rise of 1.71 m (median change is a decline of 0.50 m).

Five-year trends in water levels show rising trends for 48% of wells ranging from 0.03 m/y to 0.96 m/y with a median of 0.23 m/y (Figure 5.2). Similarly, 52% of wells show declining trends at rates of 0.02 m/y to 0.98 m/y with a median of 0.26 m/y.

![Figure 5.1. 2019 recovered water levels for wells in the fractured rock aquifers](image1)

![Figure 5.2. 2015-2019 trend in recovered water levels for wells in the fractured rock aquifers](image2)
Groundwater levels show seasonal fluctuations and a relatively stable trend from 1990 to 2014. However, groundwater levels in half of the monitoring wells have been declining over the past five years and some are now at their lowest level on record (Figure 5.3). An example of a well with lowest on record water level is the monitoring well NGK006, located near Mount Compass, which is completed in granite underlying the Permian Sand aquifer.

Monitoring well MCF011 is located in Mount Barker. Seasonal variations in groundwater levels have reduced since 2002, which is likely due to a decrease in irrigation caused by the urban expansion of Mount Barker. Despite below average levels in 2019, water levels have remained generally stable over the past 30 years.

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

MCF014 is located between Meadows and Macclesfield. Groundwater levels were declining prior to 2010 but have recovered since then and reached their highest level on record following record rainfall in 2016. Groundwater levels have since declined to average long-term levels following reduced rainfall.

Figure 5.3. Selected fractured rock aquifer hydrographs
5.3 Fractured rock aquifers - salinity

Groundwater salinity is highly variable in the fractured rock aquifers and is influenced by the type of rock in which fractures occur. Since 2015, irrigators in the EMLR PWRA have submitted groundwater samples that DEW has tested for salinity. In 2019, results from 315 irrigation wells in the fractured rock aquifers ranged between 167 mg/L and 5675 mg/L with a median of 1351 mg/L (Figure 5.4).

In the five years to 2019, the majority of wells with available data showed stable (73%) or decreasing (12%) trends in salinity (Figure 5.5). The remaining wells (15%) showed an increasing trend in groundwater salinity, with rates of increase ranging from 9 mg/L/y to 138 mg/L/y.

![Figure 5.4](image)

**Figure 5.4.** 2019 salinity observations from wells in the fractured rock aquifers

![Figure 5.5](image)

**Figure 5.5.** 2015-2019 trend in groundwater salinities for wells in the fractured rock aquifers
5.4 Permian Sand aquifer

5.4.1 Finniss Permian 1 UWMZ - water level

Following the 2018–19 irrigation season, recovered water levels observed in the majority (80%) of Permian Sand monitoring wells in the Finniss Permian 1 UWMZ were average when compared to their historic records (Figure 5.6). Only two wells near Ashbourne showed below-average levels. The change in water level over the last 20 years in 15 wells with suitable long-term records ranged from a decline of 1.29 m to a rise of 0.22 m (median change is a decline of 0.57 m). The majority of wells (87%) recorded declining water levels over this time period.

Five-year trends in water levels show declining trends for 63% of wells, ranging from 0.03 m/y to 0.41 m/y with a median of 0.23 m/y (Figure 5.7).

Figure 5.6. 2019 recovered water levels for wells in the Finniss Permian 1 UWMZ

Figure 5.7. 2015-2019 trend in recovered water levels for wells in the Finniss Permian 1 UWMZ
Monitoring wells KND002, KND010 and KND013 are located in the northern parts of the Finniss Permian 1 UWMZ, at Ashbourne and to the south of Ashbourne, where the majority of groundwater extraction occurs. Groundwater levels are more elevated in these areas and show seasonal fluctuations (Figure 5.8). Groundwater levels in these wells experienced their lowest levels on record during the Millennium drought from 2004 to 2009. Despite fluctuations, groundwater levels were relatively stable throughout the record and current levels are ranked average when compared to the entire record.

Monitoring wells KND021 and NGK071 are located on the lower parts of the Finniss River catchment where groundwater monitoring started in 2005. Groundwater levels for both these wells are stable with minor seasonal fluctuations. In 2019, groundwater levels for both these wells are ranked average when compared to the entire record.

Figure 5.8. Selected hydrographs for the Permian Sand aquifer in the Finniss Permian 1 UWMZ
5.4.2 Tookayerta Permian UWMZ - water level

Following the 2018–19 irrigation season, recovered water levels observed in about half (45%) of Permian Sand monitoring wells in the Tookayerta Permian UWMZ were below average when compared to their historic records (Figure 5.9). These wells are mainly located on the western part of the area, near Mount Compass, higher in the catchment, where groundwater is extensively used for irrigation, town water supply and industrial purposes. In two wells, recovered water levels were observed which were the lowest on record. Conversely, five wells showed recovered water levels very much above average. The change in water level over the last 20 years, in fourteen wells with suitable long-term records reflects this variability, with long-term changes ranging from a decline of 3.45 m to a rise of 4.54 m (median change is a decline of 1.00 m).

Five-year trends in water levels are showing rising trends for 45% of wells, ranging from 0.02 m/y to 0.73 m/y with a median of 0.11 m/y (Figure 5.10). Of the remaining wells, three (13%) recorded stable trends and twelve (44%) recorded declining trends from 0.02 m/y to 0.67 m/y with a median of 0.14 m/y.

Figure 5.9. 2019 recovered water levels for wells in the Permian Sand aquifer, within the Tookayerta Permian UWMZ

Figure 5.10. 2015-2019 trend in recovered water levels for wells in the Permian Sand aquifer, within the Tookayerta Permian UWMZ
Monitoring wells NGK011, NGK004 and NKG014 are located in the vicinity of Mount Compass, in the western and upper part of the Tookayerta Creek catchment. All three wells show a gradual declining trend since monitoring started (Figure 5.11). NGK011 and NGK004 show seasonal fluctuation, while NGK014, located around 5 km east of Mount Compass, shows no seasonal changes. The total decline for these wells ranges between 1.0 m and 2.5 m since 2000. Current levels are ranked below average compared to their monitoring record.

Monitoring well NGK037 is located 4 km southeast of Mount Compass and shows relatively stable groundwater levels since monitoring started in 2003. Monitoring well NGK019 is located in the south-eastern part of the management zone, where metered groundwater extraction is minimal. Groundwater levels show a declining trend since monitoring started in the late 1990s up until the end of the Millennium drought in 2009. Since then, groundwater levels have been gradually rising and in 2019 were ranked very much above average compared to historic data.

**Figure 5.11. Selected hydrographs for the Permian Sand aquifer, Tookayerta Permian UWMZ**
5.4.3 Finniss Permian 1 and Tookayerta UWMZs – salinity

The salinity of wells completed in the Permian Sand aquifer within the Finniss Permian 1 and Tookayerta Permian management zones is very fresh, with most wells used for irrigation being below 750 mg/L. Since 2015, irrigators in the EMLR PWRA have submitted groundwater samples that DEW has tested for salinity concentration. In 2019, salinity results from 112 irrigation wells in the Permian Sand aquifer ranged between 68 mg/L and 3195 mg/L with a median of 250 mg/L (Figure 5.12).

In the five years to 2019, the majority of monitoring wells with available data showed stable salinity trends (56% of wells), with a minority showing decreasing trends (21% of wells; Figure 5.13). The remaining wells with salinity data (23%) showed an increasing trend in groundwater salinity.

![Figure 5.12. 2019 salinity observations in the Permian Sand aquifer](image)

![Figure 5.13. 2015-2019 trend in groundwater salinities for wells in the Permian Sand aquifer](image)
5.5 Murray Group Limestone aquifer

5.5.1 Currency Limestone UWMZ - water level

Following the 2018–19 irrigation season, the recovered water level in all monitoring wells returned to average or above-average levels compared to their historic record, with one well recovering to the highest levels on record (Figure 5.14). The change in water level over the last 20 years in those wells with suitable long-term records range from a decline of 2.26 m to a rise of 1.04 m, although the median change is a rise of 0.07 m.

Five-year trends in water levels show rising trends for all 12 wells with available data, ranging from 0.07 m/y to 0.27 m/y (median 0.16 m/y; Figure 5.15).

![Figure 5.14. 2019 recovered water levels for wells in the Murray Group Limestone aquifer](image)

![Figure 5.15. 2015-2019 trend in recovered water levels for wells in the Murray Group Limestone aquifer](image)
Murray Group Limestone monitoring wells in the Currency Limestone UWMZ are generally following similar trends, with all wells showing consistent declines from the mid-2000s to 2010, potentially due to increased groundwater extraction as a result of below-average rainfall (Figure 5.16). Since 2010, groundwater levels have been gradually rising to pre-drought levels with some monitoring wells showing their highest levels on record (e.g. NGK044). However, the length of the monitoring record is short, mainly beginning in 2004, when groundwater levels were declining and possibly at a minimum. Some wells with longer records suggest that groundwater levels have been higher in the past e.g. NGK008.

Figure 5.16. Selected hydrographs for wells in the Murray Group Limestone aquifer
5.5.2 Currency Limestone management zone - salinity

Within the Currency Limestone UWMZ, the salinity of the Murray Group Limestone aquifer can be affected by downward leakage from overlying brackish Quaternary aquifer. This leakage can occur when the groundwater elevation of the Quaternary aquifer is greater than that of the Murray Group Limestone aquifer, which may occur if extraction from the latter is high. As a result, salinity trends are monitored in the Currency Limestone UWMZ using water samples which have been submitted by irrigators to DEW since 2015. In 2019, salinity results from 20 irrigation wells ranged between 633 and 3303 mg/L (median 1309 mg/L; Figure 5.17).

In the five years to 2019, five wells with available data recorded stable groundwater salinity trends (Figure 5.18).

![Figure 5.17. 2019 salinity observations from Murray Group Limestone aquifer wells in the Currency Limestone UWMZ](image)

![Figure 5.18. 2015-2019 trend in groundwater salinities for Murray Group Limestone wells in the Currency Limestone UWMZ](image)
5.5.3 Angas Bremer PWA - water level

Following the 2018–19 irrigation season, the recovered water level in all monitoring wells returned to average or above-average levels compared to their historic levels (Figure 5.19). The change in water level over the last 20 years in Murray Group Limestone aquifer wells with suitable long-term records ranged from a decline of 0.13 m to a rise of 2.44 m (the median change is a rise of 0.49 m).

Five-year trends in water levels show rising and stable trends for 74% of wells; 26% of wells are declining (Figure 5.20). Rates of rising water levels range from 0.03 m/y to 0.29 m/y (median 0.15 m/y), while rates of decline range from 0.02 m/y to 0.17 m/y (median 0.05 m/y).

![Figure 5.19. 2019 recovered water levels for the Murray Group Limestone aquifer of Angas Bremer PWA](image)

![Figure 5.20. 2015-2019 trend in recovered water levels for wells in the Murray Group Limestone aquifer of Angas Bremer PWA](image)
The groundwater levels observed in the Murray Group Limestone aquifer are strongly influenced by groundwater extractions from this aquifer, with seasonal fluctuations occurring to varying degrees. Hydrographs for selected monitoring wells are shown in Figure 5.21. These are located adjacent to the Angas River (BRM007, BRM034) and the Bremer River (FRL004, FRL062, FRL064) where the majority of groundwater extraction occurs. Trends from throughout the area show decreasing or stable trends prior to the significant reduction in groundwater extraction in the early 1990s.

The reduction in groundwater extraction was in response to the increased availability of River Murray water sourced from Lake Alexandrina. The reduction in groundwater extractions resulted in a substantial recovery in groundwater levels, which continued until the 2006 drought when extractions increased due to the decreasing availability of River Murray water from Lake Alexandrina, due to access and salinity problems. Drawdowns in the confined limestone aquifer reached a peak during 2009 and 2010 after which new pipelines from the River Murray and significant volumes of managed aquifer recharge have produced a recovery in water levels which continues in 2019.

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

Since 2015, irrigators in the Angas Bremer PWA have submitted groundwater samples that DEW has tested for salinity concentration. In 2019, salinity results from 55 irrigation wells ranged between 289 and 5611 mg/L (median 1821 mg/L; Figure 5.22). It should be noted that groundwater salinity in many irrigation wells may vary considerably from year to year depending on the volume of fresher River Murray water which is being injected into the aquifer as part of managed aquifer recharge (MAR) operations, and the timing of these injection periods.

Five-year trends in salinity show stable salinities in 78% of wells with available data, and decreasing salinities in 22% of wells (Figure 5.23). Decreases in groundwater salinities are likely due to MAR operations.

Figure 5.22. 2019 salinity observations in Murray Group Limestone aquifer wells in the Angas Bremer PWA

Figure 5.23. 2015-2019 trend in groundwater salinities Murray Group Limestone aquifer wells in the Angas Bremer PWA
6 Water use

Demand for water in the EMLR can be broadly divided into consumptive use, other public benefits (Indigenous and cultural values, recreation, fisheries, tourism, navigation and amenity values) and environmental requirements. The main consumptive uses in the EMLR PWRA are non-licensed (stock and domestic uses), forestry and licensed purposes (e.g. irrigation, industrial use and intensive animal production). Metering of groundwater extractions across the EMLR PWRA started in 2015-16. Water use over the past four years when groundwater extractions were metered is shown in Figure 6.1. Surface water use in the EMLR PWRA is not comprehensively metered, therefore in this report licence allocations are used to provide an indication of the volumes of water being used.

![Figure 6.1. Water used from 2015–16 to 2018–19 for the EMLR PWRA, including the Angas Bremer PWA](image)

![Figure 6.2. Metered groundwater extraction in aquifers of the EMLR PWRA](image)
The total volume of water used in 2018–19 was 32 910 ML (Figure 6.1). This includes only:

- Metered groundwater extraction across both the EMLR PWRA and Angas-Bremer PWA, excluding managed aquifer recharge injection volumes (Figure 6.2); and
- Surface water volumes discussed below in Section 6.1.

### 6.1 Surface water use

In 2018–19, the total water allocation for the EMLR PWRA was estimated to be 21 959 ML (compared to 21 943 ML in 2017–18). This consists of:

- 5247 ML for the Lower Angas Bremer flood allocation (excluding the volume allocated for delivery of flood diversions);
- 4137 ML from licensed surface water sources (dams);
- 5900 ML from licensed watercourse sources (excluding flood diversions);
- 3191 ML from plantation forestry. This is based on analysis in the water allocation plan (SAMDB NRM Board, 2013);
- 3483 ML water demand for stock and domestic, which is not required to be licensed. This is approximated at 30% of dam capacity and is based on analysis in the water allocation plan (SAMDB NRM Board, 2013).

These values are shown in Figure 6.1.

### 6.2 Groundwater use

Groundwater is extracted from the aquifers of the EMLR PWRA for a range of purposes, such as irrigation of crops, town water supply, stock and domestic use. Water taken for irrigation and town water supply is metered and is managed through a water licensing system. Water taken for stock and domestic purposes is exempt from this requirement.

In 2018–19, a total volume of 10 952 ML has been extracted from all groundwater resources across the area (Figure 6.2). Of this total:

- 43% was extracted from fractured rock aquifer UWMZs;
- 31% from the Permian Sand aquifer in the Tookayerta and Finnis Permian 1 UWMZs;
- 26% was from the Murray Group Limestone (14% from Angas Bremer PWA, and 12% from the Currency Limestone UWMZ in the EMLR PWRA).

Available metered data suggest a similar spatial distribution of extraction across management zones in previous years.

#### 6.2.1 Groundwater use in the Angas Bremer PWA

Metered groundwater extractions for licensed purposes (excluding stock and domestic use) in the Angas Bremer PWA totalled 1530 ML in the 2019 water-use year (Figure 6.3), which represents an 89% increase from the previous water-use year.

The increase in extraction from 2005 to 2010 was due to River Murray Prescribed Watercourse allocations sourced from Lake Alexandrina being unsuitable because of high salinity and access difficulties due to the receding shoreline.
As a consequence, demand for groundwater increased significantly. The recent decrease in groundwater extractions reflects the recovery in the condition of the lake and increased access to River Murray water allocations via pipelines.

Managed aquifer recharge occurs along the Angas River, Bremer River and Mosquito Creek. The amount of surface water injected into the confined limestone aquifer from these sources varies significantly, depending on the availability of stream flow with salinities less than 1500 mg/L. The construction of two pipelines from the River Murray during the millennium drought has increased the reliability and the volumes of water available for managed aquifer recharge.

In 2019, the total volume of injected water was considerably lower than previous years due to less surplus river water being available for injection. Over the 2016-18 period, injection volumes were greater than extraction which may have reduced the impact of higher groundwater extraction in 2019 on groundwater levels (Figure 5.21).

![Figure 6.3. Metered groundwater extraction and injection in the Murray Group Limestone aquifer in the Angas Bremer PWA](image)

### 6.3 Farm dams

Based on the information contained in the EMLR WAP, there are approximately 7000 farm dams in the prescribed area with an estimated total storage capacity of about 18285 ML. The Angas River catchment contains 15% of the farm dams (which equates to 18% of the storage capacity). The Bremer River has 27% of the farm dams and storage capacity. The Currency Creek catchment contains 8% of the dams and storage capacity and the Finniss River catchment has 30% of the total farm dams and storage capacity.

Non-licensed dams make up the majority of dam numbers in the PWRA, with 86% of them being non-licensed dams less than 5 ML in capacity. However, they only make up about 32% of the total dam capacity. Non-licensed dams of 5 ML or more account for 31% of the total dam capacity, and licensed dams represent 37% of this total capacity.

Detailed analysis of the farm dams in the Bremer River catchment (Figure 6.4 inset) shows that there are 2294 farm dams (139 of these are licensed) with a total storage capacity of 5473 ML. Across the Bremer catchment, smaller dams (capacity less than 5 ML) account for the majority of the number of dams (91%), but represent only 42% of the total storage capacity of dams. Larger dams (5 ML or greater capacity) make up only 9% of the total dam count but contribute to 58% of the total storage capacity. The average farm dam density of the EMLR PWRA as a whole and the Bremer catchment is 9 ML/km². The higher dam concentrations are typically found in the headwater catchments and high rainfall areas (Figure 6.4).
Figure 6.4. Farm dam density in the EMLR PWRA (Inset: farm dam volume and count in the Bremer River catchment)

Prescribed areas of the Eastern Mount Lofty Ranges 2018-19 water resources assessment
7 References


