Technical note supporting the 2018 River Murray: water (Quantity and quality) Trend and Condition Report Card

DEW Technical note 2018/11

Government of South Australia
Department for Environment and Water

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Summary

The River Murray is the largest river system in Australia. Rising in the east of the country, it flows into South Australia at the border with New South Wales and Victoria. The River Murray is an important river for South Australia for a number of reasons. It is the main source of water for many towns including Adelaide, as well as the main source of irrigation water for much of the South Australian Murray-Darling Basin region. It is also one of the state's most important ecological systems supporting a variety of ecosystems from the River itself, floodplains, wetlands and lagoons, many of which are of national and international significance.

The quantity and quality of water was assessed over a 40 year window to align with the River Murray Status Reports that are produced annually based on data availability at the SA border. The high flow of the 2016/17 year was within the top 25% of flow years across the 40 year window, and combined with zero breaches of Basin Plan salinity targets (as the indicator of water quality) limits in 2016/17, meant that the condition of the quantity and quality of water was classed as **very good**.

The assessment of trend showed some differences between the quantity and the quality of water. The quantity of water, measured as the volume of water flowing to South Australia in the river, was classed as **stable**. Without the 2016/17 high flow year and the provision of environmental flows the trend would have been classed as getting worse. The water quality (salinity) trend was classed as **getting better**. Given the link between salinity and flow (i.e. increased flow for dilution would be expected to decease salinity for a given salt load), this getting better trend suggests that the various management actions undertaken to control salinity in the River Murray, such as salt interception schemes, are contributing to improving water quality conditions .

1 Introduction

The *Natural Resources Management Act 2004* has a requirement ''to keep the state and condition of the natural resources of the State under review.' In order to consolidate the data collected around the state into a simple, and easy to interpret information source, the Department for Environment and Water (DEW) produces report cards for the state's natural resources. Previous rounds of report cards have reported against the targets in the South Australian Natural Resource Management Plan (Government of South Australia, 2012). However, for the subsequent rounds of reporting, the report cards will not only seek to report on the state of the natural resources of South Australia, but will also form the main source of data for the State of the Environment Report.

The State of the Environment Report (SOER) is a legislated requirement under the *Environment Protection Act 1993*. The SOER has several key assessments that need to be undertaken including:

- Include an assessment of the condition of the major environmental resources of South Australia 112(3(a))
- Include a specific assessment of the State of the River Murray, especially taking into account the Objectives for a Healthy River Murray under the *River Murray Act 2003* 112(3(ab))
- Identify significant trends in environmental quality based on an analysis of indicators of environmental quality 112(3(b))

The River Murray has previously been part of the report carding process as it is a focal point of the state's natural resources. See the 2014 River Murray report cards here. However, the way that the river health has been assessed has continuously been adapted to reflect both the needs of the reporting as well as the data and information available. For the 2018 report cards, the River Murray report cards will be adapted to reflect the requirements of the SOER.

The *Environment Protection Act 1993* specifically refers to the *River Murray Act 2003* for the assessment of the health of the River Murray. Under the River Murray Act there is a series of objectives known as the Objectives for a Healthy River Murray (*River Murray Act 2003* 7(1–5)). These objectives cover a range of issues including:

- River health
- Environmental flows
- Water quality
- Human dimensions.

The suite of River Murray report cards for 2017 was developed with specific line of sight to the objectives for a healthy River Murray to facilitate both adequate reporting on the condition of the State's natural resources as well as the requirements of the SOER.

The seven report cards for the River Murray are:

- River Murray: floodplain trees (Tree condition index) Trend and Condition Report Card
- River Murray: Coorong and Lower Lakes vegetation (Vegetation target success) Trend and Condition Report Card
- River Murray: high value wetlands (Achievement of ecological targets) Trend and Condition Report Card
- River Murray: Murray Mouth (Days open) Trend and Condition Report Card
- River Murray: fish passage (Permanently wet area accessible) Trend and Condition Report Card

- River Murray: flow regime (Achievement of environmental water requirements) Trend and Condition Report Card
- River Murray: water (quantity and quality) Trend and Condition Report Card

This report provides the background information, methodology and results that will underpin the 2017 River Murray Water Quantity and Quality Report Card. This report card reports on the trend and condition of the quantity and quality of the water in the River Murray. It is important to note that there are already multiple methods and reports on the water in the River Murray. Key data sources for this reporting include the WaterConnect website and associated reports (here) and the River Murray Prescribed Watercourse Status Reports (here).

The River Murray is one of South Australia's most important natural resources. It provides water for the majority of people in the state as well as water for a large proportion of the state's agriculture and industry. The River Murray also supports diverse ecosystems as well as social and cultural values. All of these are dependent on good water quantity and quality. Flows into South Australia are influenced by a number of factors. Over decades, regulation of the River Murray, combined with river operations arrangements to support irrigation and navigation, have reduced the volume of water flowing to South Australia and altered the patterns of flow in the river as well as the connections between the river and its wetlands and floodplains. On a yearly basis, limited storage capacity, means that the status of surface water resources in the South Australian River Murray are still highly dependent on rainfall across the Murray-Darling Basin, with trends in streamflow primarily climate driven, i.e. below-average rainfall results in a reduction in annual streamflow volumes. Finally, on a seasonal basis, below-average summer rainfall and above average temperatures can also result in increasing irrigation extractions, and these two elements can reduce the amount of streamflow.

One of the major threats to water quality is increased salinity that affects the River Murray's economic, social, cultural and environmental values. Historically, river regulation and increased water extraction in conjunction with the clearance of native vegetation and the development of agriculture across the Murray-Darling Basin led to increases in salt near the soil surface and entering the river. As the River Murray is the lowest point in the landscape, it is the focus of saline groundwater discharge from regional aquifers which significantly influences salinity levels in the river. Streamflow levels then influence salinity levels in the river with lower flows being associated with increases in salinity. In general, high stream flows dilute salinity within the channel unless there is overbank flooding which can, if not carefully managed, lead to large quantities of salt moving from the floodplain to the river.

There are other water quality issues that can affect the River Murray's economic, social, cultural and environmental issues. Blue-green algal blooms can form in the river or associated wetlands which can limit water use or access and increase water treatment costs. Blackwater events may also occur when large amounts of organic matter are dissolved and transported downstream. These events can be associated with fish-deaths and also increased water treatment costs. Finally, during the millennium drought, a number of important wetlands were affected by acidification which renders the water unfit for any human use and has adverse consequences for the environment.

This report card uses the calculated flow to the South Australian River Murray as the measure of quantity. It is acknowledged that there are additional inputs of water to the South Australian River Murray, however, these are considered to be minimal compared to the flow coming across the border. The quality aspect of the assessment refers to the salinity of the water within the River Murray measured at two locations (Murray Bridge and Morgan).

2 Methods

2.1 Condition assessment

The condition of water quantity was defined as the River Murray flow to South Australia. Flow to South Australia is calculated based on both the River Murray downstream of Rufus River (Gauge: A4260200) and the Mullaroo Creek (Gauge: A4140211) stations; the calculated flow is reported as the virtual site Flow to South Australia (Gauge: A4261001). Long-term gauging stations at Morgan (Gauge: A4260554) and Murray Bridge (Gauge: A4261003/A4261126) provide a good indication of salinity (measured as Electrical Conductivity or EC) for sections of the River Murray between the SA state border and the Lower Lakes. Information on these gauges can be found on the WaterConnect website (here) Locations of gauges used for the assessment are provided in Figure 1.

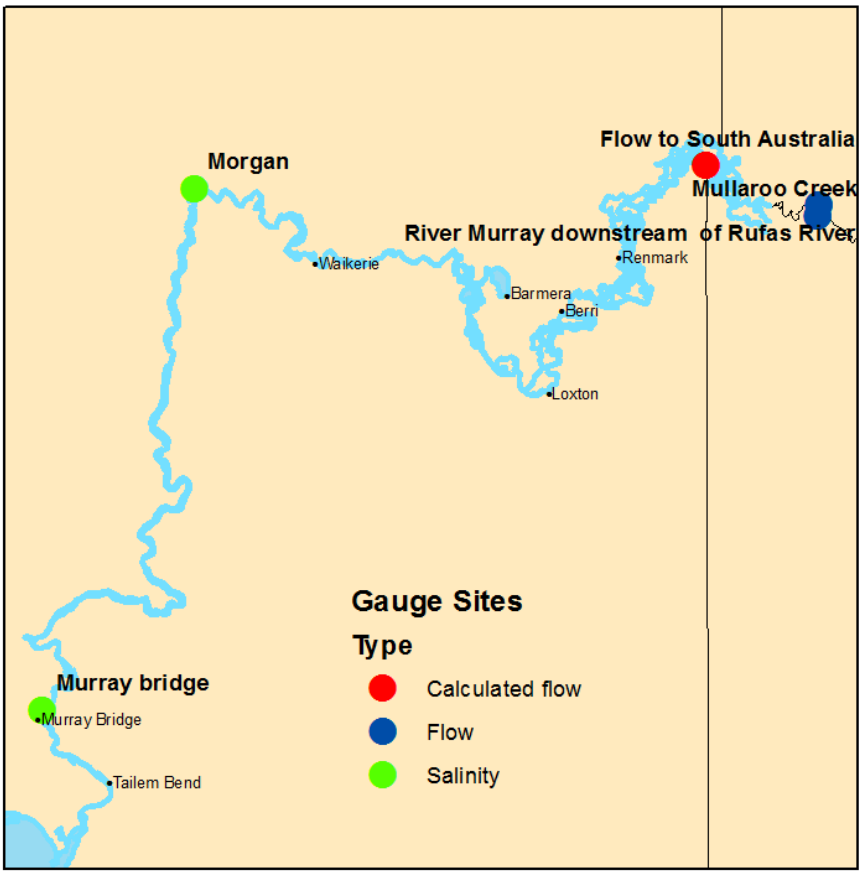

Figure 1: Map of the locations of the gauging stations used for the assessment of South Australian River Murray quantity and quality.

The condition assessment was undertaken based on the method developed for the Status Reports produced by the SA Department for Environment and Water on an annual basis for the prescribed water resources of the State. For flow, the condition is assigned based on the percentile of flow for the year against the previous 40 years according to Table 1. Salinity is assessed against targets in the Basin Plan (Section 9.14) (less than 800 EC (µs/cm) at Morgan and less than 830 EC (µs/cm) at Murray Bridge) for the 2016/17 year.

Table 1: Condition classes used to assign condition to the flow of the River Murray into South Australia, based on the Surface Water Status Reports.

Condition class	Annual flow percentile (last 40 years)	Salinity targets met (per cent of time)
Poor	0-25	Less than 90
Fair	26-50	90-94
Good	51-75	95-97
Very good	76-100	98-100

2.2 Trend assessment

The time series flow and salinity data was analysed using a Bayesian modelling approach. This modelling approach was used as it provides more information surrounding the results and allows for a more detailed assessment of trend results based on variability inherent in the data, i.e. it not only provides the current trend but provides confidence intervals allowing for an objective and transparent assessment of trend. Trend analysis was undertaken using a negative binomial model looking at the annual time series of flow data. A negative binomial model was chosen for the flow data due to the dispersed nature of the data, the skew of the data and to ensure that the model did not estimate negative flows. The salinity data was analysed using a Gaussian model. Separate models were developed for flow, salinity at Morgan and salinity at Murray Bridge. Analysis was undertaken in R Studio (version 1.1.383, running R version 3.4.2, R Core Team, 2013) using Bayesian Generalized Linear Models (using the stan-glm function in the rstanarm package, Stan Development Team 2016).

The following values were estimated from the posterior distribution resulting from the Bayesian analysis:

- Slope (trend)
- Change between 1978 and 2017 (magnitude of any change)

Generic definitions for trend are provided in Table 2, including the specific values used here as thresholds to define the classes.

Table 2: Definition of trend classes used for the assessment of trend for the water quantity and quality of the South Australian River Murray (1978-2017).

Trend	Description	Threshold
Getting better	Over a scale relevant to tracking change in the indicator it is improving in status with good confidence	Greater than 90% likelihood that target achievement trends are positive
Stable	Over a scale relevant to tracking change in the indicator it is neither improving or declining in status	Less than 90% likelihood that target achievement trends are positive or negative
Getting worse	Over a scale relevant to tracking change in the indicator it is declining in status with good confidence	Greater than 90% likelihood that target achievement trends are negative
Unknown	Data are not available, or are not available at relevant temporal scales, to determine any trend in the status of this resource	Not applicable
Not applicable	This indicator of the natural resource does not lend itself to being classified into one of the above trend classes	Not applicable

2.3 Reliability

The reliability of the data was scored using the scoring system developed for the 2017 Report Cards. This scoring system uses four scores to assess different aspects of the data used to underpin the report card. Scores for all four are then averaged to determine the final score. The four scores categories are:

- Information currency
- Information applicability
- Spatial representation
- Information accuracy

Scoring was undertaken according to Table 3.

Table 3: Scoring system for the reliability of the information used to underpin the analysis for the River Murray Water Quantity and Quality Report Card.

Score given	Information currency	Information applicability	Spatial representation	Information accuracy
1	Information >10 years old	Data are based on expert opinion of the measure	From an area that represents less than 5% the spatial distribution of the asset within the region/State or spatial representation unknown	Better than could be expected by chance
2	Information up to 10 years old	All data based on indirect indicators of the measure	From an area that represents less than 25% the spatial distribution of the asset within the region/State	> 60% better than could be expected by chance
3	Information up to 7 years old	Most data based on indirect indicators of the measure	From an area that represents less than half the spatial distribution of the asset within the region/State	> 70 % better than could be expected by chance
4	Information up to 5 years old	Most data based on direct indicators of the measure	From across the whole region/State (or whole distribution of asset within the region/State) using a sampling design that is not stratified	> 80 % better than could be expected by chance
5	Information up to 3 years old	All data based on direct indicators of the measure	From across the whole region/State (or whole distribution of asset within the region/State) using a stratified sampling design	> 90 % better than could be expected by chance

3 Results

3.1 Condition

The condition assessment showed that the South Australian River Murray is in very good condition for the 2016/17 year. The total flow to South Australia was 9238 GL in 2016/17, which is in the 76% percentile of flows to South Australia over the last 40 years (Figure 2).

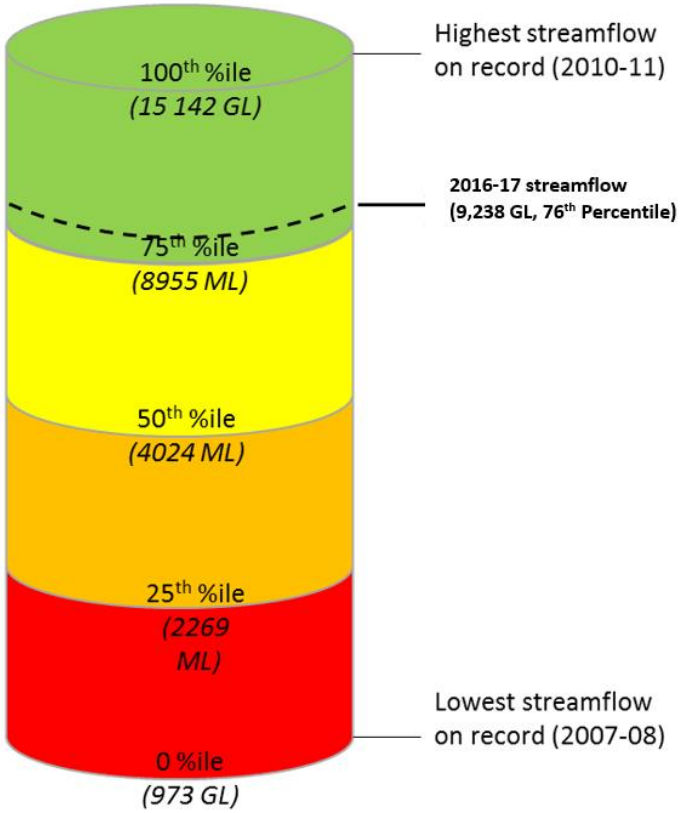

Figure 2: Condition classes used for the assignment of condition showing the 2016/17 year. Percentiles calculated based on the flow to South Australia over the last 40 years.

The condition assessment of the water quality (salinity) results showed that at no point in the 2016/17 were the salinity limits breached for either Murray Bridge or Morgan (Figure 3). Based on this the condition of water quality in the South Australian River Murray was classed as very good.

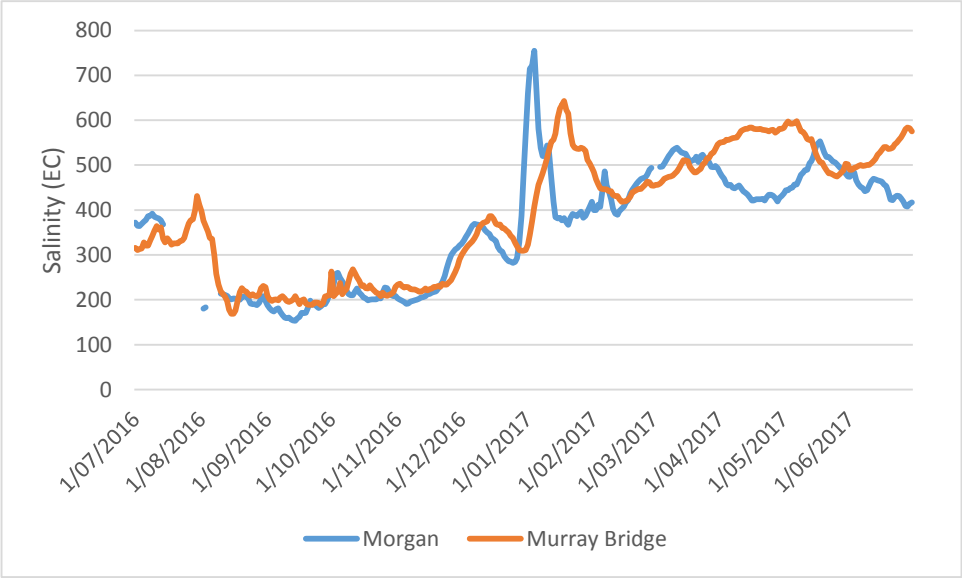

Figure 3: Average daily salinity (EC) levels measured at Morgan and Murray Bridge for the 2016/17 year

3.2 Trend

The trend assessment showed that the flows to South Australia are stable over the last 40 years (Table 4). This result is influenced by two main factors, the environmental water that has been delivered to South Australia over the last decade and the two large flow years (2010/11 and 2016/17) that have occurred since the end of the Millennium Drought (2001-2009) (Figure 4). These two factors have a high degree of influence on the estimation of trend using the Bayesian modelling approach (Figure 5). The modelling approach was run with these two factors removed independently and in both cases the result changed to show that the flows to South Australia were getting worse i.e. the proportion of negative slopes exceeded 0.9.

Table 4: Summary of Bayesian Belief Model for flow to South Australia outputs based on 4000 model runs.

Proportion of negative Slopes	Proportion of positive slopes	Mean slope	Trend
0.86075	0.13925	-0.01083	Stable

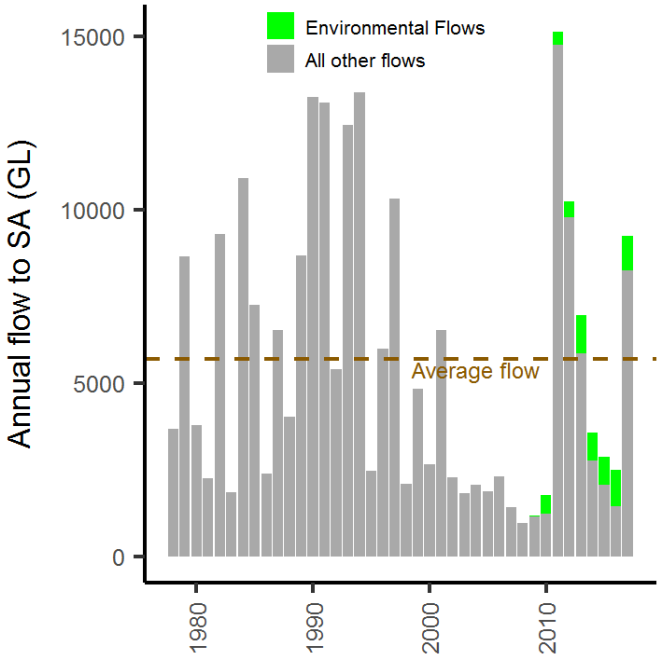

Figure 4: Annual flows to South Australia over the last 40 years highlighting the environmental water as part of the flows in the last decade.

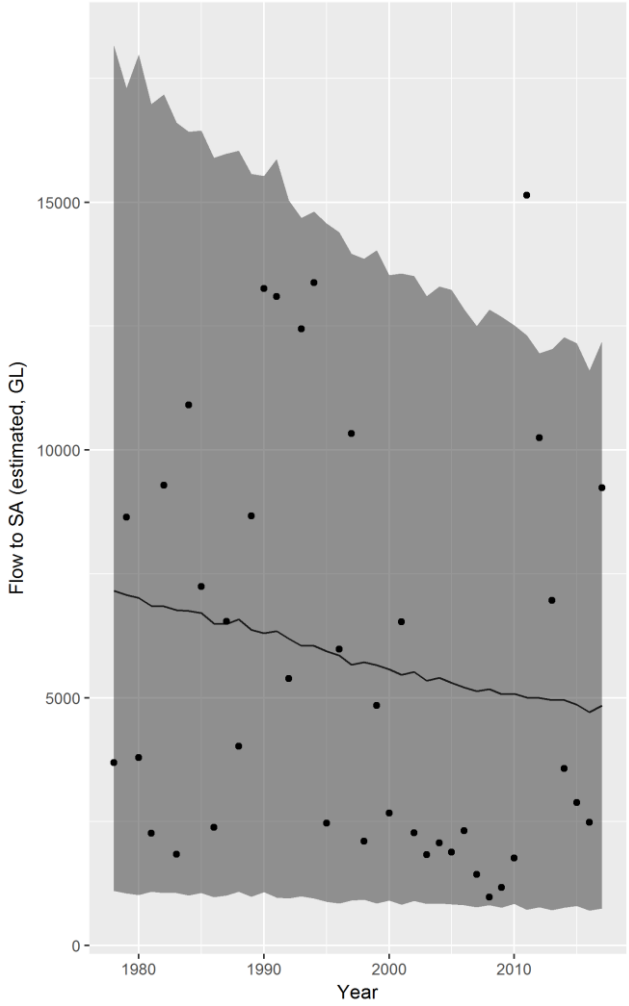

Figure 5: Modelled flow to South Australia from the Bayesian modelling approach. Shaded areas show the 90% credible intervals for the modelling results illustrating the variability in the data.

The salinity trend analysis showed that the salinity of the River Murray in South Australia is getting better, i.e. getting fresher (Table 5, Figure 5). This result is expected to be largely attributed to efforts to manage salinity such as the salt interception schemes, as well as additional flows are contributing to improving water quality (salinity) conditions in the SA River Murray.

Table 5: Summary of Bayesian Belief Model for the salinity of the South Australian River Murray outputs based on 4000 model runs

Location	Proportion of negative slopes	Proportion of positive slopes	Mean slope	Trend
Morgan	1	0	-0.039	Getting better
Murray Bridge	1	0	-0.029	Getting better

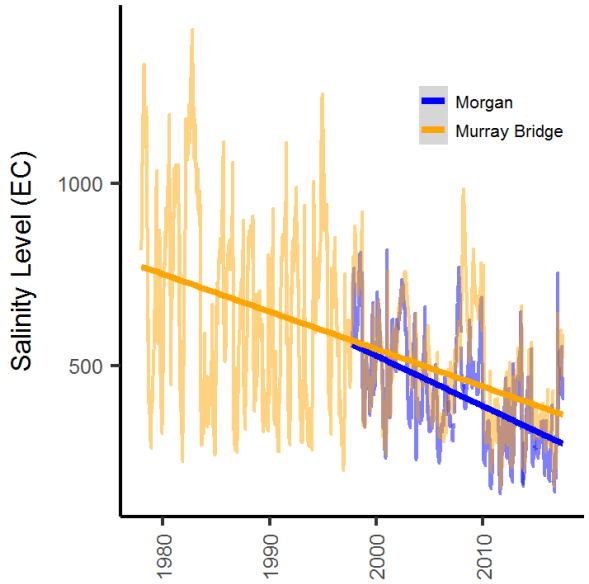

Figure 5: Salinity trends for the two sites modelled.

3.3 Reliability

Overall, the reliability of the data was scored as a five out of a possible five. This means that there is high confidence in the reliability of the data and the conclusions drawn from it. The scores for each of the four guides along with justification is provided in Table 6.

Table 6: Results of the reliability assessment of the CLLMM Vegetation data

Guide	Score	Justification
Currency	5	Data available up to date
Applicability	5	The data used is a direct measure of the indicators
Spatial representation	3	The data used for this report is from selected monitoring sites across the South Australian River Murray
Accuracy	5	The data is considered to be as accurate as possible

4 Discussion

4.1 Condition

The assessment of the condition of the quantity of water coming to South Australian River Murray as very good is a reflection of the 2016/17 flow year only, identified in the top 25% of years over the last 40 years of recorded flow data. This is a reflection of the higher than average rainfall through the Murray-Darling Basin in 2016/17. Of the 9238 GL of water that flowed into the South Australian River Murray, 996 GL was recovered environmental water. Without the addition of this environmental water (i.e. additional to the higher unregulated flow), the condition would have been below the 75th percentile.

The condition of the water quality (salinity) within the channel of the South Australian River Murray was also classed as very good. This reflects that at no point over the 2016/17 year were the salinity limits breached.

4.2 Trend

The trend in the quantity of water flowing to the South Australian River Murray was classed as stable over the last 40 years. This selection of a 40 year window certainly had an impact on the results. Choosing a different window would have resulted in different results, i.e. if the periods since the end of the drought only was considered the flow would have been expected to have been classed as getting better, or if the period since settlement the results would have been expected to have been to be classed as getting worse.. Since the end of the millennium drought (2010), there has been two big flow years (2010/11 and 2016/17), including the largest flow in the 40 year window. Without these flows and the additional environmental flows received in the last decade, the trend would have been classed as getting worse.

The water quality (salinity) trend at both Morgan and Murray Bridge was classed as getting better. The results for this were strong with 100% of the model runs showing a declining level of salinity over the 40 year window.

5 References

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