Hills and Fleurieu Landscape Region PWRA ecological condition assessment 2022

Department for Environment and Water

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Foreword

The Department for Environment and Water (DEW) is responsible for the management of the State's natural resources, ranging from policy leadership to on-ground delivery in consultation with government, industry and communities.

High-quality science and effective monitoring provides the foundation for the successful management of our environment and natural resources. This is achieved through undertaking appropriate research, investigations, assessments, monitoring and evaluation.

DEW's strong partnerships with educational and research institutions, industries, government agencies, Landscape Boards and the community ensures that there is continual capacity building across the sector, and that the best skills and expertise are used to inform decision making.

Ben Bruce
CHIEF EXECUTIVE
DEPARTMENT FOR ENVIRONMENT AND WATER

Acknowledgements

The Department for Environment and Water (DEW) acknowledges Aboriginal people as the First Peoples and Nations of the lands and waters we live and work upon and we pay our respects to their Elders past and present. We acknowledge and respect the deep spiritual connection and the relationship that Aboriginal and Torres Strait Islander people have to Country. The work documented in this report was undertaken on the traditional lands of the Peramangk, Kaurna and Ngarrindjeri Nations. DEW acknowledges the care for country that these Nations continue to provide to these lands.

DEW thanks the various groups and bodies that have collected the data that underpins this assessment. In particular the Environmental Protection Authority of South Australia, Aquasave, Australian Water Quality Centre, Freshwater Macroinvertebrates, the South Australian Research and Development Institute (Aquatic Sciences) and the Bioblitz Program for the Angas Bremer and Marne Saunders.

DEW would also like to thank the Murraylands and Riverlands and the Northern and Yorke Landscape Boards and staff for support through this process and access to regional monitoring data.

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Contents

1 Background and Context

Under the *Landscapes South Australia Act 2019* (the Act), a water allocation plan (WAP) must include an assessment of the capacity of the water resource to meet environmental objectives [s. 53(1)(b)(i)]; a statement of the environmental outcomes expected to be delivered on account of the provision of environmental water under the plan [s. 53(1)(b)(iii)]; and must set out principles associated with the determination of water access entitlements and for the taking and use of water so that an equitable balance is achieve between environmental, social and economic needs for the water [s. 53(1)(d)(i)]. The Act also requires a WAP to be reviewed on a comprehensive basis at least once every 10 years (54, 1) that provides an assessment of whether the WAP remains appropriate or requires amendment (54, 2b) among other requirements.

The WAPs of the Eastern Mount Lofty Ranges (EMLR) and Western Mount Lofty Ranges (WMLR) prescribed water resources areas (PWRAs) were first adopted in 2013 and are therefore nearing the 10-year review timeframe. In preparation for this review, Landscapes Hills and Fleurieu requested an assessment of the current condition of the aquatic ecosystems to provide context and background information for stakeholders that relates to the review of the environmental principles of the WAPs.

The purpose of this report was to summarise the results of the trend and condition assessment of the fish and macroinvertebrate communities of the two PWRAs. Where appropriate, the data from the Marne Saunders and Barossa PWRAs have also been included for regional context. These results are accompanied by an assessment of three key ecologically relevant flow metrics recorded at locations across the two PWRAs. This report is not intended as an evaluation of the environmental outcomes outlined in the current WAPs; however, the information presented here will form part of the evidence base for an evaluation of the environmental outcomes of the WAPs at a later date.

This assessment focused on three areas: fish, macroinvertebrates and flow. An assessment of the trend and condition of the fish community was undertaken as the fish community condition is a high priority for many stakeholder groups and provides a good indication of overall ecosystem health. Macroinvertebrate community trend and condition, assessed as macroinvertebrate community condition, is one of the best overall indicators of aquatic ecosystem condition. The assessment of the three key ecologically relevant flow metrics was undertaken to provide context to the ecological assessments.

2 Methods

Across the assessments undertaken, the focus is on the two prescribed areas in the Hills and Fleurieu Landscapes Region. However, to provide additional context at the regional scale, data from the Barossa PWRA (located in the Northern and Yorke Landscape Region) and the Marne Saunders PWRA (located in the Murraylands and Riverlands Landscape Region) are also included for some of the assessments.

2.1 Flow assessment

For the assessment of the flow across the PWRAs, flow data from monitoring stations across the PWRAs were compared to modelled flow data with the impacts of dams (and reservoirs) and water extraction removed.

Flow data from monitoring stations (hence referred to as “actual flow”) were downloaded from the Aquarius database accessed via the Water Data portal. Data from all flow monitoring stations that were active between 1990 and present were downloaded and assessed to ensure there were no excessive gaps in the data and that the period of data collected was at least 10 years. The suitable monitoring sites were compared to the existing surface water models for the PWRAs and, where suitable modelling nodes were identified, modelled no dams/extraction daily flow data was extracted for the period 1974-2006 in line with the investigations used to underpin the WAPs, hereafter referred to as the "modelled flow".

Actual flow data were screened to ensure the flow data were of suitable quality and there was no more than 5% missing data in any given year. If any given year had more than 5% missing flow data, the year was dropped from the assessment.

Flow data were processed using the R language and environment, operated in R Studio (R Studio version 1.2.5042, running R version 4.0.0 R Core Team, 2013). These metrics are:

1) the total flowing period measured as the number of days of the year that the river is flowing;*
2) the number of low flow season (December – May) fresh pulse flow days measured as the number of days over the low flow season that have flow greater than the two times the median of all non-zero flows for the season; and
3) the number of transition 1 flow season (June - July) fresh pulse flow days measured as the number of days over the transition 1 flow season that have flow greater than the two times the median of all non-zero flows for the season.

* The metric has traditionally been reported as number of cease to flow days; however, to provide a more uniform assessment, the metric was inverted such that interpretation of trend was consistent across all three metrics.

The thresholds used to calculate the number of days for the three metrics were calculated based on the actual measured flow data except in cases where the actual flow data were overly impacted by outside factors causing significant increases in flow (generally SA Water inputs). These sites are identified in the results section. The threshold for 'zero flow' was set at 0.05ML/day. Below this level, the measurement of flow becomes unreliable at some gauging stations and is therefore considered a safe cutoff. This is equivalent to half a litre per second or 50,000 litres per day. All the assessments undertaken were done at the site scale only with no attempt to model any regional trends.

Trend assessment

Trend assessment was undertaken on the flow metrics for the actual flow data. Trend assessment was undertaken using R Studio (version 1.2.5042, running R version 4.0.0 R Core Team, 2013) using Bayesian Generalized Linear Mixed Models (using the stan-glmer function in the rstanarm package, Stan Development Team, 2016). The number of days each of the metrics were met per flow year was modelled for each site. Each run of the model produced an estimate of slope. Estimates of slope from the 5000 model iterations were used to characterise the likelihood of trends within the data in line with the Intergovernmental Panel on Climate Change likelihood categories (based on Mastrandrea et al., 2010), Table 1).

Table 1: Trend assessment classes based on the percentage of positive/negative slopes returned from the Bayesian modelling approach.

% positive slope results	% negative slope results	Trend assessment
99-100	0-1	Virtually certain increase
95-99	5-1	Extremely likely increase
90-95	10-5	Very likely increase
66-90	10-33	Likely increase
33-66	33-66	About as likely as not

10-33	66-90	Likely decrease
10-5	90-95	Very likely decrease
5-1	95-99	Extremely likely decrease
0-1	99-100	Virtually certain decrease

Condition assessment

The metrics calculated from the modelled flow data were compared to those for the actual flow recorded over the reporting period. Condition was described based on the difference between the two.

The condition of the number of zero-flow days was split into two different classes based on the perenniality of the site in the baseline scenario (Table 2). If the site was perennial, or near perennial, under the baseline scenario a stricter condition assessment was applied as smaller changes to the flow thorough these sites will result in larger ecological changes. A perennial, or near perennial, site was defined as having 30 or less cease to flow days on average under the baseline flow data based on discussions with local fish and macroinvertebrate exerts. The condition of the two fresh metrics was assessed based on the difference from the baseline as per Table 3 derived from targets in the current WAPs for the region. In some cases, the results show an improvement over the baseline condition. No condition is ascribed to these sites except to say that flow is higher than baseline.

Table 2: Condition classes used for the zero-flow day metric separated by the perenniality of the site under no dams/extraction modelled data.

Flow class	Improved over baseline	Very good	Good	Fair	Poor	Very poor
Perennial or near perennial (>335 days of flow)	Number of flow days greater than baseline	0–5 day decrease in flow days	5–10 day decrease in flow days	10–20 day decrease in flow days	20–30 day decrease in flow days	No longer perennial, <335 flow days per year
Intermittent (<335 flow days)	Number of flow days greater than baseline	Less than 10% decrease in flow days	10-20% decrease in flow days	20-30% decrease in flow days	Greater than 30% decrease in flow days	100% decrease in flow days

Table 3: Flow target condition scoring criteria for the low flow and T1 fresh flow days target

Condition score	Percentage difference
Very good	Less than 15%
Good	15-30%
Fair	30-45%
Poor	Greater than 45%

2.2 Macroinvertebrate assessment

The assessment of macroinvertebrate community condition was undertaken using a newly developed contemporary macroinvertebrate condition model (CMCM) for the region (DEW in prep). The model uses a biological condition gradient method to assign condition based on a series of community attributes based on the original biological condition gradient model framework from Davies and Jackson (2006). The CMCM model provides an overall community score ranging from 1 (very poor) through to 6 (excellent).

Data for assessment were sourced from the multiple monitoring programs currently or recently operating across the Hills and Fleurieu region including the Flows for the Future monitoring program (DEW), the Securing Low Flows monitoring program (Hills and Fleurieu Landscapes Board) and the BioBlitz program (DEW and Hills and Fleurieu Landscape Board). Data for each site were pooled per year rather than keeping habitat and season separate. This provides annual picture of condition across the whole of the site.

Additional data were sourced from the Environmental Protection Authority's Aquatic Ecosystem Reporting (AECRs) program (EPA 2023). These data are presented without modification using the EPA's AECRs condition rating system. Additional information on the AECRs program and the individual site assessments can be found here.

Data are presented for not only the Hills and Fleurieu Region but also for the Marne Saunders and Barossa Prescribed Water Resource Areas for additional regional context.

Trend assessment

Trend data were assessed using the same analysis model described in the flow trend assessment section. Sites that have been visited five or more times were assessed for trend. Sites with fewer visits were not considered suitable for trend assessment. Trend assessment was undertaken for each site individually; however, the data were not considered suitable for undertaking any regional assessments. Trends were classified as per table 1.

Condition assessment

The condition assessment was undertaken by assessing the most recent year of data available for each site, limited to 2019 - 2022. The achievement of the WAP target ('moderate or better macroinvertebrate community condition') was defined as achieving a BCG score of three or greater (or fair condition under the BCG condition rating system).

2.3 Fish assessment

Fish data were sourced from Landscape Board (formerly NRM Board) funded programs across the Hills and Fleurieu, Green Adelaide, Northern and Yorke and Murraylands and Riverland regions. Fish community condition information for the WMLR was sourced directly from appendix 2 of Schmarr et al. (2022) and recruitment information was sourced directly from SARDI uploads to the biological database of South Australia. Fish community condition information and recruitment information for the EMLR and Marne Saunders was sourced from Aquasave.

All fish data used in this report are either currently available or will be available via the biological database of South Australia (available here). All condition scores are calculated based on this raw data, though condition assessments are not captured in the biological database; hence, being sourced from recent publications or direct from samplers.

Condition Assessment

Both SARDI Aquatic Sciences and AquaSave have a condition model that they use on their respective datasets. The condition data presented here are respective to the collector, i.e. SARDI data are presented using the SARDI condition model and the AquaSave data are presented using the Aquasave condition model. There are differences between the condition modelling processes that mean that the results are not directly comparable. However, the trend calculated based on the condition data is comparable as it is assessed using the same method, albeit on different condition data.

The SARDI condition model is a biological condition gradient model that assesses a range of community attributes and combines them into an overall condition score out of six (Schmarr et al. 2022). SARDI and Green Adelaide recently completed a review of their data for the last ten years. These data were used and presented here without modification (Schmarr et al. 2022). Care needs to be taken when interpreting the data as the biological condition gradient (BCG) scores range from 1 (Excellent) to 6 (Very poor) while all other condition assessments provided in this report use higher numbers to indicate better condition.

The AquaSave condition model is based around recruitment (0+ years) and survivor (2+ years) numbers as well as overall community diversity (N. Whiterod, pers. comm. 2020). The assessments undertaken at each site are specific to the site based on previously caught species and condition is scored out of nine. Data were provided by AquaSave along with the model in the form of an Excel spreadsheet. The model was recoded into the R Studio environment and run for the years 2012-2020.

In addition to this, an assessment was undertaken which was designed to provide an insight into the achievement of the WAP fish target (better than marginal recruitment in at least 7 out of 10 years of Mountain/Obscure Galaxias and Southern Pygmy Perch). Given the lack of suitable time series data for much of the region, the assessment was undertaken by looking at the risk that the target will not be achieved for Mountain/Obscure Galaxias based on the recruitment in any given year. The risk level was based around numbers developed in Green et al. 2014 (table 4).

Table 4: Risk ratings used to describe the risk to the achievement of the Mountain/Obscure Galaxias target in the WAPs based on the number of recruits caught at a site.

Risk Level	Number of recruits
No Recruitment	0
Extreme	1-8
Very high	9-30
High	30-60
Moderate	60-116
Low	116-232
Very low	>232

Trend assessment

Trend data were assessed using the same analysis model for the flow and macroinvertebrate metrics. The condition scores were used at sites with four or more visits. However, as with the other trend assessments, there was no attempt to characterise a regional trend. Similarly, trend was also assessed for the number of Mountain/Obscure Galaxias recruits recorded at each site as a compliment to the risk assessment undertaken in the condition section.

3 Results

3.1 Flow assessment

A total of 62 flow gauges were assessed for suitability and 35 gauges were deemed to have sufficient data for assessment and have a suitable surface water model that could generate a no dams/extraction dataset. Of these, 14 were in the EMLR and 21 in the WMLR. Due to the location of flow monitoring stations across the landscape, there is an over-representation of perennial sites in the data. This should be noted in any interpretation of results especially in regard to generalizations across the region.

Flow Trend

The identified trends for the number of flow days were generally found to be stable or decreasing with only 5 sites showing an increase in the number of flow days (Table 5, Figure 1). 19 sites were found to be stable with the remaining 11 sites noted to be decreasing. Of the five sites showing an increase in flowing days, three started monitoring in the mid-2000s during the millennium drought resulting in a suppressed starting position. In general, the mean slope of the models is correlated with the strength of the trend assessment i.e., sites that showed stronger trends generally had steeper mean slopes. The mean slopes across all sites were -0.0047 (range from - 0.2399 to 0.0805); however, this is heavily influenced by a single site (Dawesley Creek upstream Brukunga Mine - A4260658) that had a slope an order of magnitude higher than other sites (-0.2399). With this site removed the average slope was 0.0022 (range from -0.011 – 0.0805) illustrating the impacts of the three sites with positive trends under the influence of the Millennium Drought.

The trends in low-flow season fresh days were more evenly distributed with 11 sites showing an increase in days, 13 remaining stable and 11 showing a decrease (Table 5, Figure 1). Five sites, showing an increasing trend, began monitoring in the mid-2000s suggesting a post drought recovery rather than actual long-term increasing trend. In comparison to the slopes seen in the flow days assessment, the slopes were generally steeper in the low flow season fresh days. The mean slope across all sites was 0.0034 but ranged from -0.2222 to 0.0641. The stronger results for the low flow season fresh days were linked to the reduction in variability of the data. The lack of variability in the data (i.e., sites are more consistent through time) means that years that deviate from this have a strong effect.

The trends in T1 season fresh days were also evenly distributed. Sixteen sites show an increasing trend, four showed a stable trend while 15 showed a decreasing trend (Table 5, Figure 1). The mean slope was 0.0029 across all sites. The slopes ranged from -0.1963 to 0.2091. As with the low-flow season fresh days, the stronger trend results are due to the less variable nature of the data increasing the impact of any changes through time.

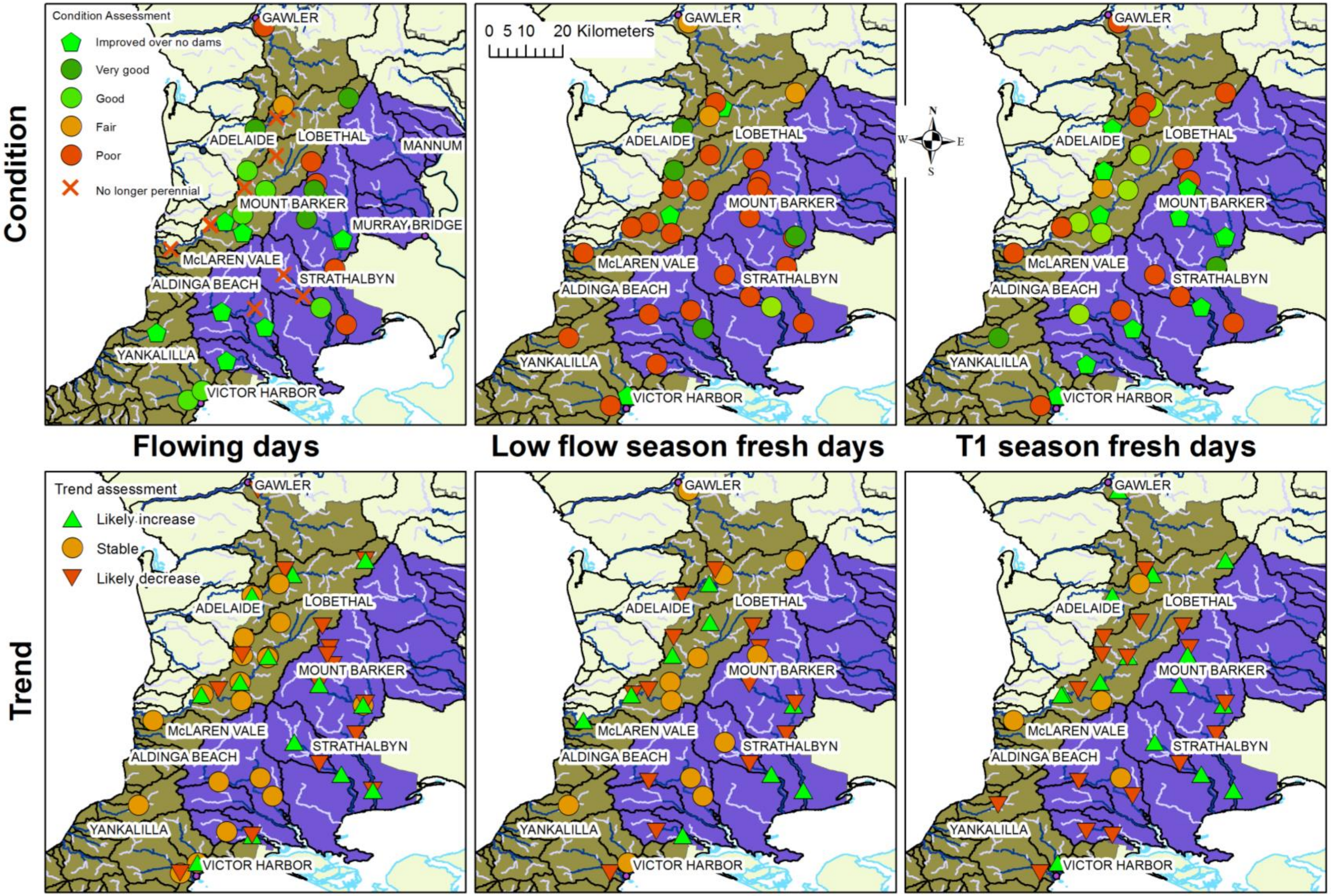

Figure 1: Trend and condition assessment results for the three flow metrics used. Trend assessment generalized to show improving, stable or decreasing.

Table 5: Trend and condition assessment results including mean slope, identified trend and condition rating for the three flow metrics that were assessed for the suitable flow sites in the EMLR and WMLR PWRA. Start and end years vary between sites. Shaded cells represent sites where modelled data was used to generate flow threshold values.

					Flow days			Low flow season fresh days			T1 Season fresh days		
Site	Catchment	Flow class	Start year	End year	Mean Slope	Trend	Condition	Mean Slope	Trend	Condition	Mean Slope	Trend	Condition
A4260503	Angas	Perennial	1990	2020	0.0187	Extremely likely increase	No longer perennial	-0.0043	Stable	Poor	0.0251	Likely increase	Poor
A4260504	Finniss	Perennial	1990	2019	0.0002	Stable	Improved over no dams	-0.0159	Likely decrease	Poor	-0.0297	Extremely likely decrease	Good
A4260530	Currency	Perennial	1991	2019	-0.0019	Stable	Improved over no dams	-0.0404	Very likely decrease	Poor	-0.0438	Very likely decrease	Improved over no dams
A4260533	Bremer	Ephemeral	1990	2010	-0.0233	Very likely decrease	Poor	-0.1301	Extremely likely decrease	Poor	-0.0687	Extremely likely decrease	Very good
A4260557	Bremer	Ephemeral	1990	2019	-0.0108	Very likely decrease	Very good	-0.0171	Likely decrease	Poor	0.0101	Likely increase	Improved over no dams
A4260558	Bremer	Ephemeral	1990	2019	-0.0027	Stable	Good	-0.0013	Stable	Poor	0.0265	Very likely increase	Very good
A4260658	Bremer	Ephemeral	1994	2018	-0.2399	Virtually certain decrease	Poor	-0.2222	Virtually certain decrease	Poor	-0.1963	Virtually certain decrease	Poor
A4260659	Bremer	Ephemeral	1994	2018	-0.0129	Very likely decrease	Very good	0.0104	Stable	Poor	0.0380	Extremely likely increase	Improved over no dams
A4260679	Bremer	Ephemeral	1998	2019	-0.0031	Stable	Improved over no dams	0.0654	Extremely likely increase	Poor	0.0393	Likely increase	Improved over no dams
A4260688	Bremer	Ephemeral	2000	2019	-0.0382	Very likely decrease	Improved over no dams	-0.1555	Extremely likely decrease	Very good	-0.2040	Extremely likely decrease	Improved over no dams
A4261071	Bremer	Ephemeral	2005	2019	-0.0351	Likely decrease	Poor	0.2657	Likely increase	Poor	0.1168	Likely increase	Poor
A4261074	Angas	Ephemeral	2005	2019	0.0805	Virtually certain increase	Good	0.0795	Likely increase	Good	0.2091	Extremely likely increase	Improved over no dams
A4261075	Angas	Perennial	2006	2019	0.0057	Stable	No longer perennial	0.0184	Stable	Poor	-0.0328	Stable	Poor
A4261103	Finniss	Ephemeral	2007	2019	0.0112	Stable	Improved over no dams	-0.0538	Stable	Very good	-0.0678	Very likely decrease	Improved over no dams
A5010503	Inman	Perennial	1996	2019	0.0001	Stable	Good	-0.0167	Likely decrease	Poor	-0.0297	Likely decrease	Poor
A5011027	Hindmarsh	Perennial	2010	2019	0.0049	Stable	Good	-0.0513	Stable	Improved over no dams	0.0736	Likely increase	Improved over no dams

					Flow days			Low flow season fresh days			T1 Season fresh days		
Site	**Catchment**	**Flow class**	**Start year**	**End year**	**Mean Slope**	**Trend**	**Condition**	**Mean Slope**	**Trend**	**Condition**	**Mean Slope**	**Trend**	**Condition**
A5020502	Myponga	Perennial	1990	2019	-0.0016	Stable	Improved over no dams	0.0055	Stable	Poor	-0.0260	Very likely decrease	Very good
A5030500	Onkaparinga	Perennial	1990	2019	0.0071	Stable	No longer perennial	-0.2969	Very likely decrease	Poor	0.2609	Extremely likely increase	Poor
A5030502	Onkaparinga	Perennial	1990	2019	-0.0036	Likely decrease	Improved over no dams	-0.0212	Likely decrease	Poor	-0.0350	Extremely likely decrease	Good
A5030504	Onkaparinga	Perennial	1990	2019	-0.0002	Stable	Good	-0.0033	Stable	Improved over no dams	0.0096	Likely increase	Improved over no dams
A5030506	Onkaparinga	Ephemeral	1990	2012	0.0009	Stable	Improved over no dams	0.0078	Stable	Poor	0.0020	Stable	Good
A5030507	Onkaparinga	Perennial	1995	2019	-0.0020	Stable	No longer perennial	0.0469	Extremely likely increase	Poor	-0.0281	Very likely decrease	Good
A5030508	Onkaparinga	Ephemeral	1990	2009	-0.0268	Likely decrease	Poor	-0.1047	Likely decrease	Poor	-0.1314	Likely decrease	Poor
A5030509	Onkaparinga	Perennial	1995	2019	-0.0022	Stable	No longer perennial	0.0232	Likely increase	Poor	-0.0163	Likely decrease	Fair
A5030526	Onkaparinga	Perennial	1995	2019	-0.0008	Stable	Good	0.0641	Virtually certain increase	Very good	-0.0395	Extremely likely decrease	Improved over no dams
A5030537	Onkaparinga	Ephemeral	1994	2019	-0.0008	Stable	Improved over no dams	0.0479	Very likely increase	Improved over no dams	0.0060	Likely increase	Improved over no dams
A5031001	Onkaparinga	Perennial	2003	2019	0.0002	Stable	Good	0.0124	Stable	Poor	-0.0531	Very likely decrease	Good
A5031004	Onkaparinga	Perennial	2007	2019	0.0413	Likely increase	No longer perennial	0.2276	Extremely likely increase	Poor	0.1912	Very likely increase	Poor
A5031005	Onkaparinga	Perennial	2007	2019	0.0486	Likely increase	No longer perennial	0.2476	Likely increase	Poor	-0.0427	Stable	Poor
A5040500	Torrens	Perennial	1990	2018	0.0348	Extremely likely increase	No longer perennial	0.0058	Stable	Improved over no dams	0.0622	Very likely increase	Good
A5040512	Torrens	Ephemeral	1990	2019	-0.0073	Likely decrease	Very good	0.0130	Stable	Fair	0.0195	Likely increase	Poor
A5040523	Torrens	Perennial	1992	2019	-0.0025	Stable	Very good	0.0645	Extremely likely increase	Very good	0.0216	Likely increase	Improved over no dams
A5040525	Torrens	Ephemeral	1993	2019	-0.0057	Likely decrease	Fair	-0.0225	Likely decrease	Poor	-0.0154	Likely decrease	Poor
A5041003	Torrens	Perennial	2005	2019	0.0101	Stable	No longer perennial	0.0511	Likely increase	Fair	-0.0134	Stable	Poor
A5050503	SPara	Ephemeral	1990	2019	-0.0087	Likely decrease	Poor	0.0206	Stable	Fair	0.0633	Very likely increase	Poor

Flow condition

The condition of the three metrics assessed is shown in Table 5 and Figure 1. There was considerable variability in the results, both in terms of within a single metric as well as across a single site. There were two key reasons for this. Firstly the impacts to the flow regime at each site varied considerably and; secondly, the surface water models are not perfect reflections of the actual flow observed at a site (though generally considered adequate for this assessment). All the results presented here need to be interpreted with this in mind.

The condition of the flow day metric was evenly spilt across flow condition classes with 15 sites considered to be in fair or worse condition (failing the target set in current WAPs) while 20 site were passing. Nine sites were shown to be improved over the baseline data while nine sites, classified as perennial under the baseline data, were classed as no longer perennial and is considered to be a negative outcome.

The results for the low-flow season fresh days show most sites in poor condition (23 sites) with a further three sites considered in fair condition. A single site was in good condition, four sites were classed as very good and four are improved over the modelled data.

The results for the T1 season fresh flow days are considerably more variable that the other two metrics. The condition assessment shows 14 sites in poor or fair condition, six sites in good condition, three in very good and 12 sites show an improvement over modelled data.

There are several sites where the observed data and the baseline average show no overlap. The condition assessment at these sites needs to be interpreted with caution as there is a miss-match between the modelled data and the actual flow. This mismatch does not impact on the assessment of trend for the metric.

3.2 Macroinvertebrate assessment

There was a total of 609 macroinvertebrate samples that were used for the assessment of trend and condition across the region assessed. These data were sources from the BioBlitz Program (267 samples), the Flows for the Future Program (174 samples) and the Securing Low Flows Program (168 samples). These samples were collected from 50 sites from 2016 to 2022.

Once data were pooled there was a total of 226 individual site-year data points from 50 sites. Of these, there was 25 sites that were visited five or more times allowing for assessment of trend.

For context, although not assessed in detail for this assessment, there was 292 samples from by the EPA across the same region over the period 2008 – 2021 from 185 sites.

Trend assessment

The trend was assessed for the BCG score for the macroinvertebrate community condition based on the results of the CMCM. The results of the trend assessment are shown in table 6. It is important to note that the assessment of trend does not automatically indicate a significant change in condition, it only shows a consistent trend in results. This is clear with some of the more stable flow condition sites such as Schmitt Rd or Yacca Rd that show degrees of increasing trends but the slope of these trends is small.

The trend in overall macroinvertebrate community condition show mixed results with most sites showing some form of decreasing condition (12 sites). Seven sites show a stable result and six sites showed increasing trend.

Table 6: Trend results for the macroinvertebrate community condition assessed for the MLR PWRAs.

Site	Percentage of negative slopes	Mean slope	Mean slope 90% confidence interval	Trend	Minimum year	Maximum year
Nunn Rd West	0.0159	0.163572069	0.054 to 0.274	Extremely likely increase	2017	2022
Yacca Rd	0.068	0.068045922	-0.008 to 0.143	Very likely increase	2017	2022
Paris Creek Road	0.1262	0.087740722	-0.047 to 0.224	Likely increase	2016	2022
Bull Ck Trib	0.127	0.194945172	-0.107 to 0.492	Likely increase	2017	2022
Upper Saunders Creek	0.1796	0.129170799	-0.137 to 0.381	Likely increase	2017	2022
Schmitt Road	0.1938	0.03499568	-0.038 to 0.106	Likely increase	2017	2022
Red Gum Rd	0.3562	0.022408788	-0.089 to 0.134	About as likely as not increase	2017	2022
Quarry Road	0.4581	0.004356869	-0.071 to 0.079	About as likely as not increase	2016	2022
Carrick Creek East	0.503	-4.20E-04	-0.177 to 0.177	About as likely as not increase	2017	2022
Meadows	0.528	-0.005671365	-0.165 to 0.153	About as likely as not increase	2016	2022
Rushmore Reserve	0.5983	-0.019507181	-0.163 to 0.124	About as likely as not increase	2016	2021
Cranford Road	0.6218	-0.037926827	-0.269 to 0.196	About as likely as not increase	2017	2021
Upper Rodwell Creek	0.6493	-0.044886507	-0.268 to 0.181	About as likely as not increase	2017	2022
Polworth Drive	0.679	-0.011715516	-0.061 to 0.038	Likely decrease	2017	2022
Paris Creek LFB	0.7688	-0.038079501	-0.128 to 0.056	Likely decrease	2016	2022
Jutland Water Reserve	0.7903	-0.107634693	-0.35 to 0.143	Likely decrease	2017	2021
Vigars Road	0.7957	-0.079594601	-0.259 to 0.098	Likely decrease	2017	2021
Braeside Road	0.8631	-0.06045233	-0.155 to 0.035	Likely decrease	2016	2022
Sunnydale Road	0.9439	-0.040213569	-0.082 to 0.002	Very likely decrease	2016	2022
Wild Dog Creek Rd	0.9612	-0.079268977	-0.148 to -0.008	Extremely likely decrease	2017	2022
Netherford	0.9618	-0.304126325	-0.575 to -0.031	Extremely likely decrease	2017	2021

Strathalbyn	0.9629	-0.110811345	-0.209 to -0.01	Extremely likely decrease	2016	2022
Nunn Rd East	0.964	-0.055756374	-0.106 to -0.006	Extremely likely decrease	2017	2022
Bull Creek	0.9666	-0.091083274	-0.169 to -0.011	Extremely likely decrease	2016	2021
Whites Rd	0.989	-0.109886003	-0.177 to -0.041	Extremely likely decrease	2017	2022

The distribution of the trend results is mixed with no clear spatial pattern observable. The timeframe over which the trend is assessed is short generally starting and ending during a wet period with a very dry series of years in the middle.

Macroinvertebrate community condition

Across the samples assessed, the average condition score was 2.64, which was slightly lower than the average for the most recent year of sampling alone (2.57, Figure 2 and 3 respectively). Scores ranged from 1.39 (Upper Saunders Creek in 2019) through to 3.95 (Nunn Rd West in 2022). The spread of condition scores across all sites (Figure 2), and for the most recent year of sampling (Figure 3), show a relatively normal distribution with no skew relative to the mean. It should be noted that the selection of sites across the region is not random and; therefore, the mean and median values of the dataset may not reflect the general condition across the entire region.

The total condition dataset for the most recent years is presented in appendix 1.

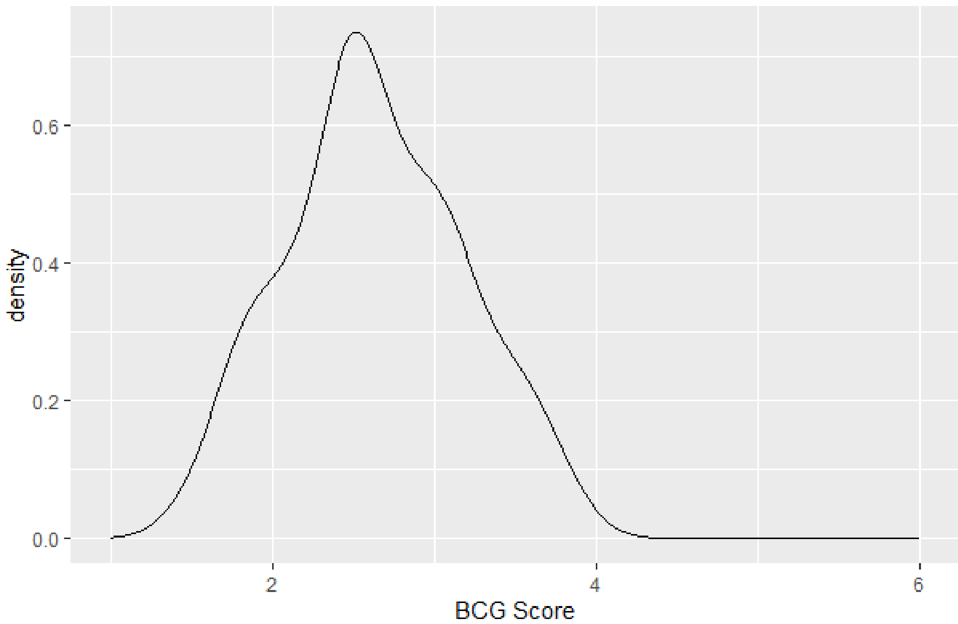

Figure 2: Density plot of the CMCM scores across all years.

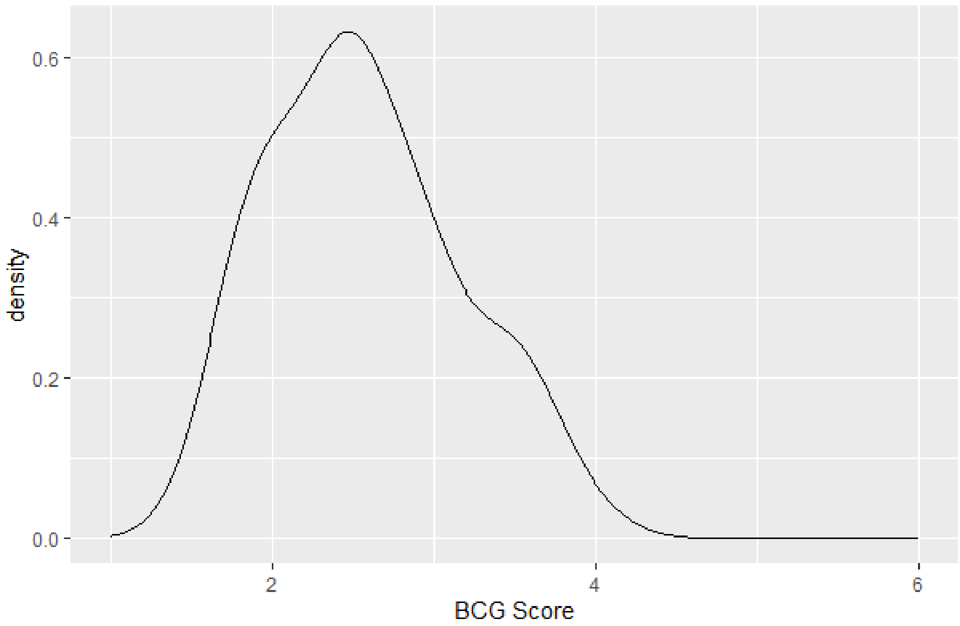

Figure 3: Density plot of the CMCM scores for the most recent year of data collected (mostly 2022 but ranging from 2017).

The condition scores show a general south to north gradient with sites in the south generally showing higher condition that those in the north. The exception to this appears to be the headwaters of the Bremer River which generally show fair condition when compared to the mid reaches or to the Angas River to the south.

When considering the condition through time, sites higher in the headwaters, or those with a more variable flow regime, experience a higher degree of variability in CMCM score (Figure 4). Sites such as Bull Creek Tributary and Upper Saunders Creek show very large variations between years while other sites show minimal variation (e.g., Polworth Drive or Schmitt Rd).

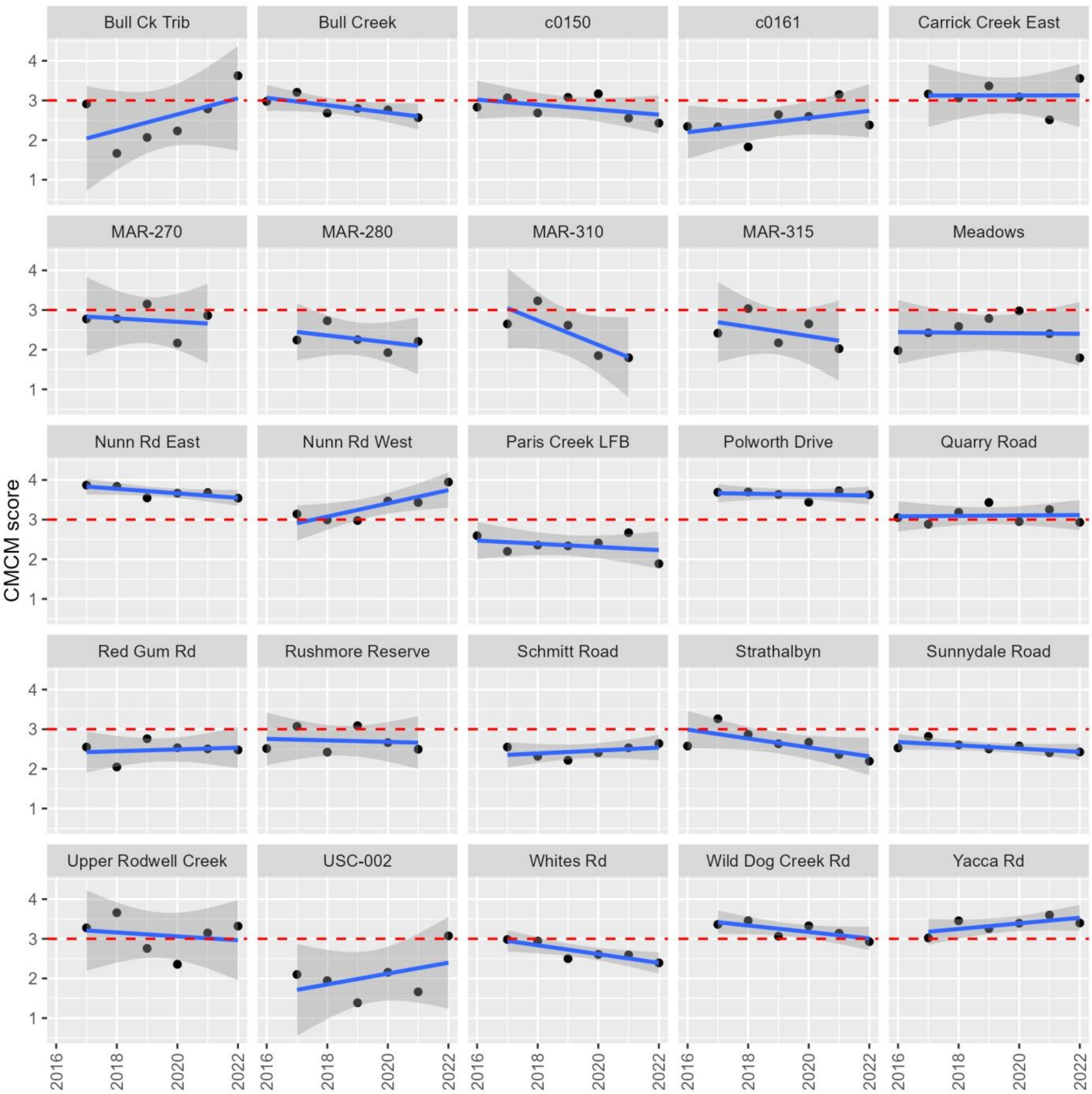

Figure 4: CMCM scores for each site through time. A simple linear regression is represented by the blue line, the shaded area represents the standard error. The red dashed line represents the condition score required to pass the macroinvertebrate condition target.

Considering the WAP target of moderate or better community condition, at the most recent year of sampling, 40 of the 50 sites assessed were not considered to be met, while 10 sites were considered to have passed the target. These sites were well spread across the region ranging from Upper Saunders Creek in the Saunders Catchment down to nearly all sites in the Carrickalinga Catchment and Polworth Drive in the Inman Catchment (Figure 5).

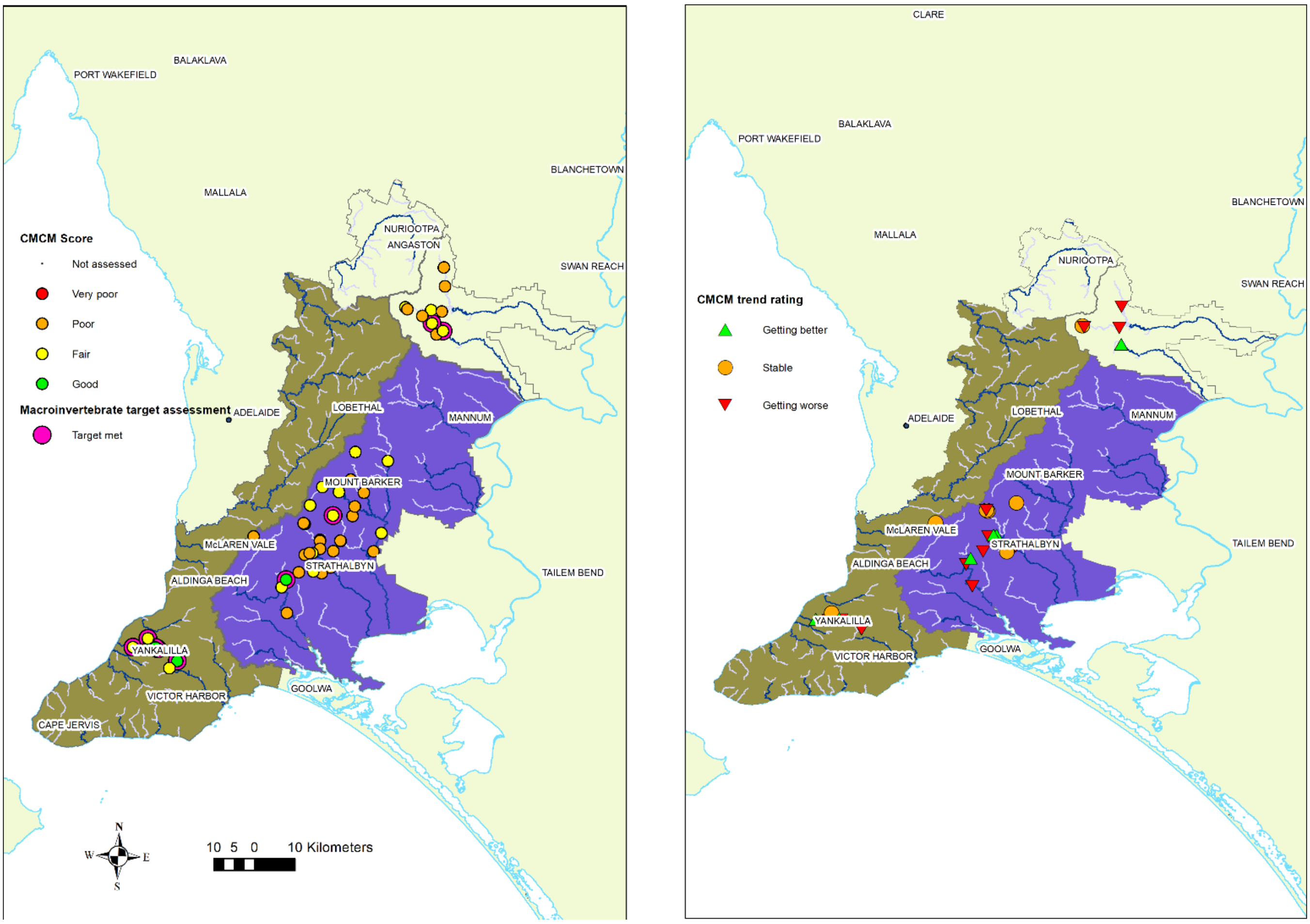

Figure 5: Macroinvertebrate community condition for the most recent sampled year (left) and the trend in community condition across all years of sampling based on the CMCM results (right). Sites where the condition target has been met are haloed in purple.

EPA AECR scores

The EPA AECRs process also uses the Biological Condition Gradient framework; however, it is applied using an expert panel to determine condition scores (Goonan et al. 2018). The AECR scores are presented here without modification based on the reports that can be found online here (EPA 2023). The data presented ranges from 2008 through to 2021 and includes 292 individual condition scores. Most sites were classed as fair (124 sites), followed by poor (76 sites), good (74 sites), very good (10 sites) and very poor (8 sites). The most recent score for each site is shown in Figure 6.

As with the CMCM results, there is a general south – north gradient of condition with sites in the southern areas more likely to be in better condition that those in the north. There is also a collection of good condition sites along the western margin of the WMLR prescribed area although this is generally linked to site selections rather than a notable condition gradient. Sites in better condition are targeted in this area to maintain surveillance of these sites through time.

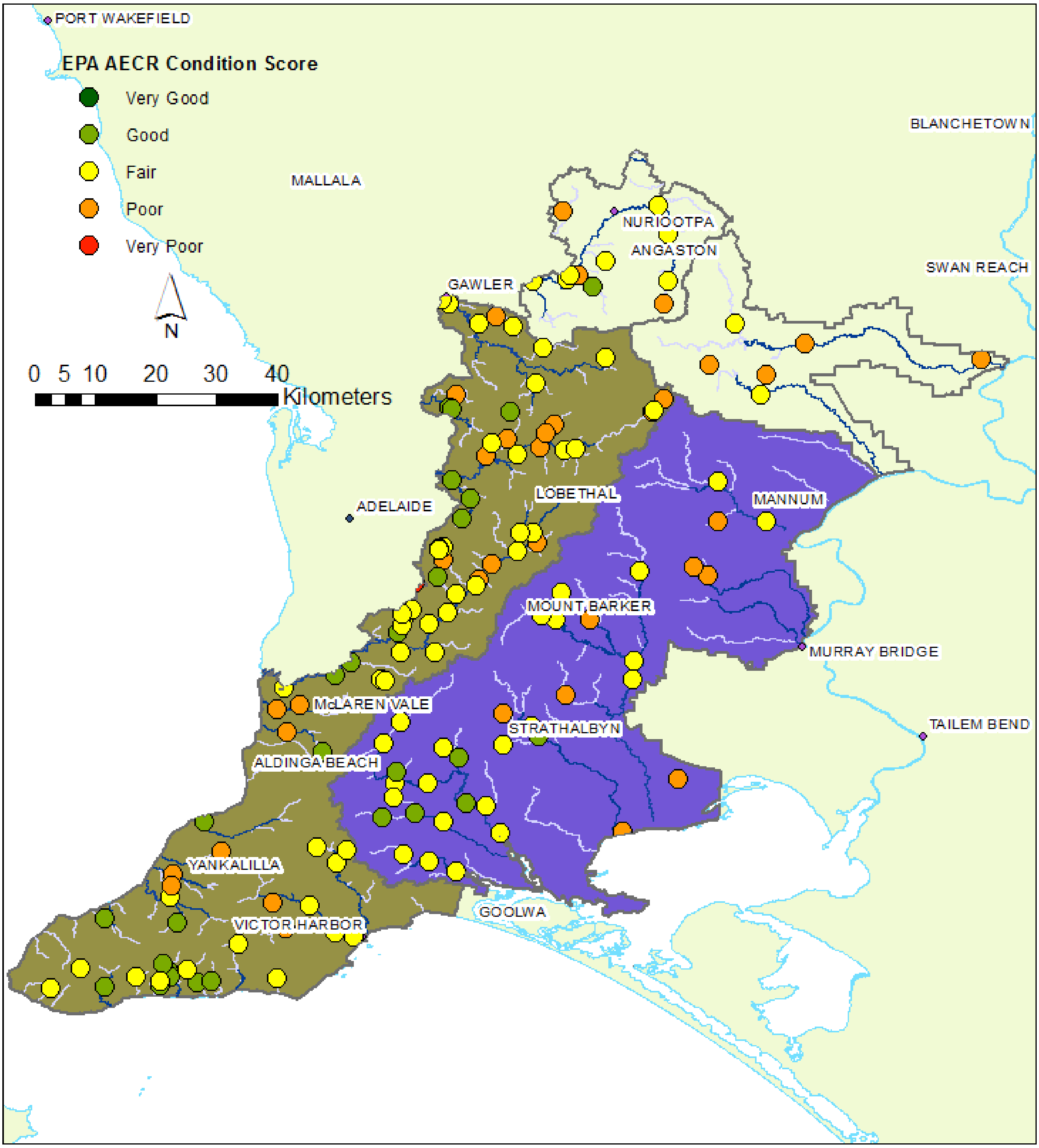

Figure 6: EPA AECR scores across the four prescribed areas of the Mount Lofty Ranges. Data sourced from EPA (2023).

3.3 Fish results

Fish condition WMLR

Unless otherwise referenced, all fish condition data for the WMLR are sourced directly from Appendix 2 of Schmarr et al. (2022).

Across the WMLR, a total of 237 individual sites have been sampled by SARDI under various programs since 2006 (Schmarr et al. 2022). On average there are 36 sites sampled per year; however, the sampling effort has not been consistent across years with 2013 having 120 samples while there are no samples recorded for 2009, 2010 and 2018.

To assess the contemporary condition of the fish community, the most recent sampling event for each site was taken for sites sampled in or after 2019. This provided a subset of 60 sites with a sample between 2019 and 2021. Across these 60 sites, the mean score was 3.36 and a median value of 3.66 (Figure 7). This is compared to the overall mean and median from all samples (3.57 and 3.67 respectively). It should be noted that the selection of sites across the region is not random and; therefore, the mean and median values of the dataset may not reflect the general condition across the entire region.

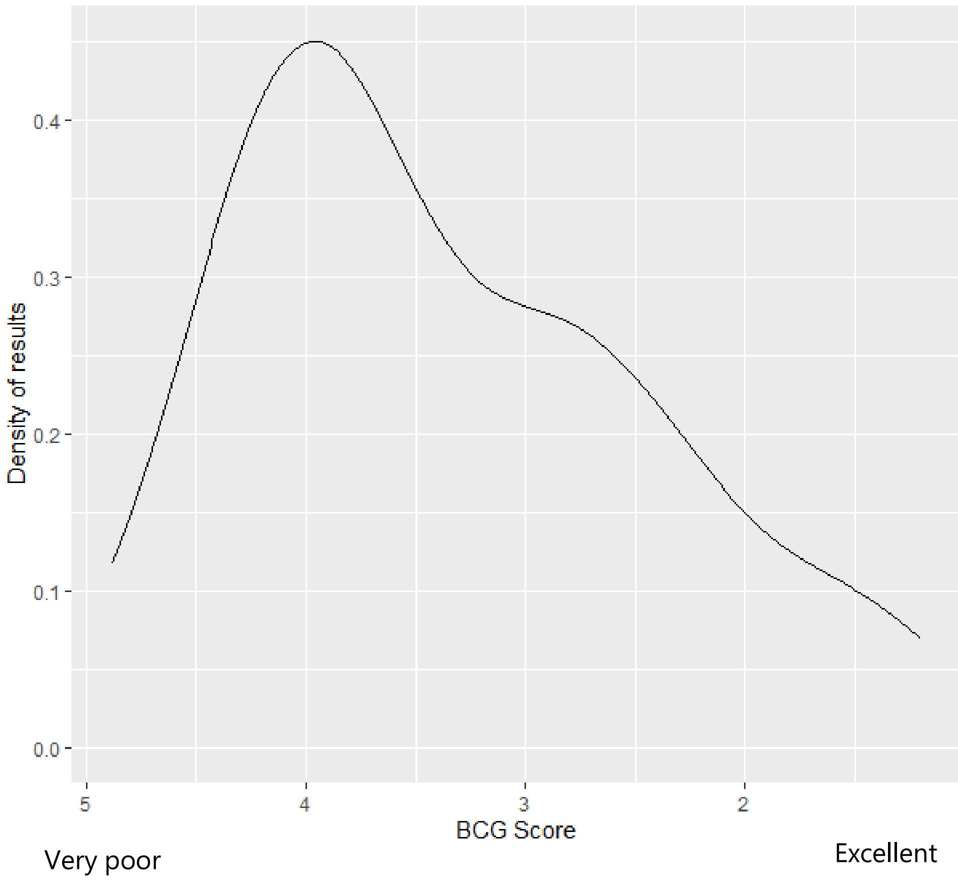

Figure 7: Density plot of the BCG scores for the most recent sampling event for each of the sites sampled between 2019 and 2021 (data from Schmarr et al. 0222). A BCG score of 6 is considered very poor, while a BCG score of 1 is considered excellent.

At the time of conducting the analysis, the most recent year of sampling (2021) had a focus on estuarine habitat so there were only five true aquatic sites sampled. These five sites were all located in the Field River and had BCG Scores ranging from 3 to 3.81. The full condition result dataset is available in Appendix 2 of Schmarr et al. (2022) and shown in Figure 8.

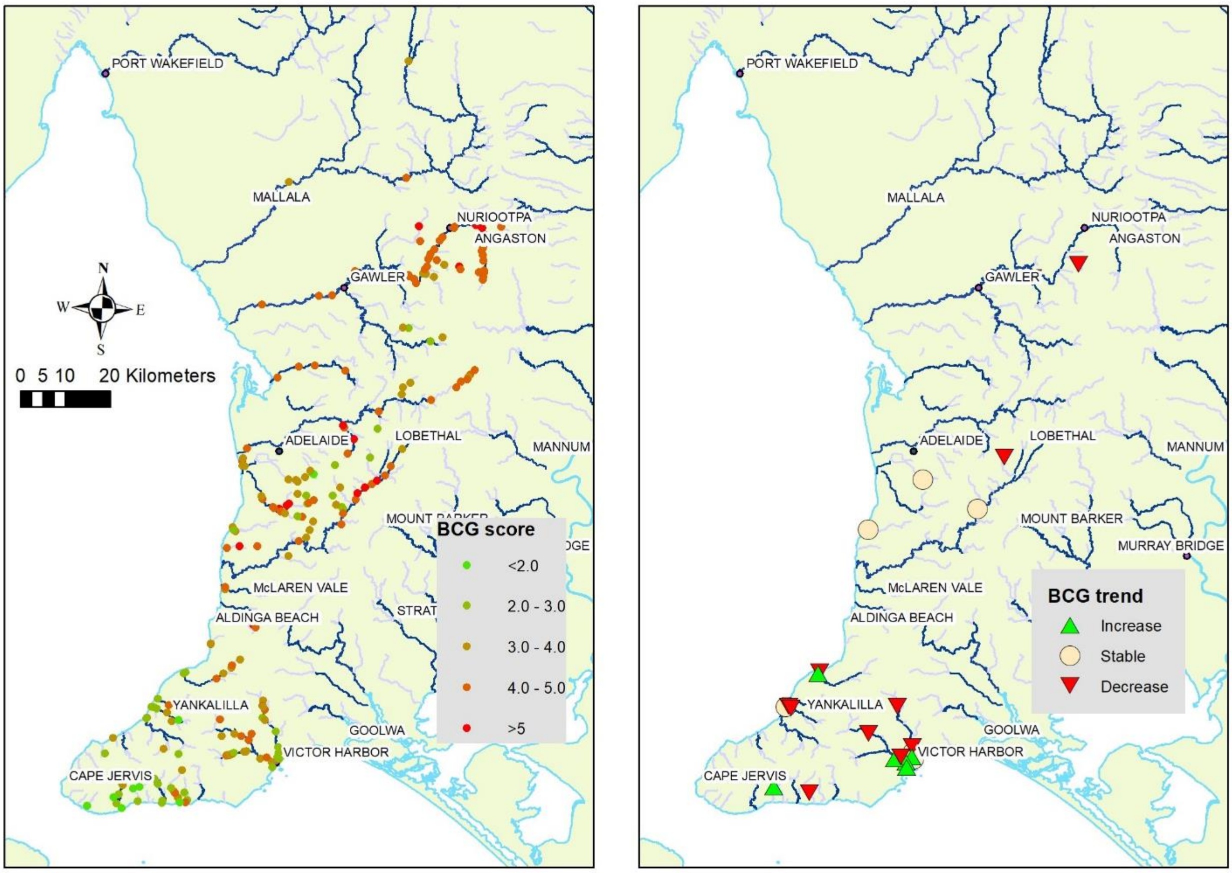

Figure 8: Maps of the fish community condition (most recent sampling event BCG score for each site, left) and trend through time for sites with 5 or more visits (right). Data from Schmarr et al. (2022).

Fish trend WMLR

From the 2006 – 2021 SARDI dataset (Schmarr et al. 2022) there was a total of 23 sites that had been visited 5 or more times. The minimum and maximum years varied across all sites which needs to be considered when interpreting the results. Of the 23 sites that were assessed for trend, 11 sites were considered to have varying degrees of decreasing trend, six were classed as stable and six were classed as having varying degrees of increasing trend (Table 7, Figure 8).

Table 7: Trend and most recent Biological Condition Gradient score for the sites that were assessed for fish community trend in the WMLR. Underpinning data from Schmarr et al. (2022).

Catchment	Site	Minimum year	Maximum year	Prop of positive Slopes	Mean slope	Trend	Most recent BCG score
Inman	Armstrong Rd Bridge	2015	2017	0.89	0.13	Likely increase	3.78
Boat Harbour	Boat Harbour Gauge	2013	2019	0.88	0.10	Likely increase	1.9
Bungala	Bungala Caravan Park Bridge	2015	2017	0.54	0.01	stable	2.93
Bungala	Bungala South Rd	2011	2017	0.25	-0.03	Likely decrease	2.67
Callawonga	Callawonga Gauge	2013	2019	0.14	-0.03	Likely decrease	4.47
Hindmarsh	Cootamundra Reserve	2011	2017	0.65	0.01	stable	2.76
Patawalonga	DS Brownhill Caravan Park	2011	2020	0.63	0.02	stable	4.25
Inman	Glacier Rock	2011	2019	0.27	-0.03	Likely decrease	3.95

Catchment	Site	Minimum year	Maximum year	Prop of positive Slopes	Mean slope	Trend	Most recent BCG score
Bungala	Hay Flat Rd	2011	2017	0.23	-0.07	Likely decrease	2.85
Hindmarsh	Hindmarsh Estuary	2015	2017	0.52	0.01	stable	2.81
Hindmarsh	Hindmarsh Falls	2011	2019	0.06	-0.23	Very likely decrease	3.94
Hindmarsh	Hindmarsh Gauge	2014	2020	0.27	-0.03	Likely decrease	2.21
Inman	Inman Divine Gauge	2011	2019	0.91	0.03	Very likely increase	3.75
Inman	Inman estuary	2015	2017	0.90	0.21	Very likely increase	2.49
Hindmarsh	Lamont Rd	2015	2017	0.79	0.19	Likely increase	2.75
Onkaparinga	Lenswood Gauge	2013	2020	0.32	-0.03	Likely decrease	2.2
Onkaparinga	Mylor Bridge	2012	2020	0.24	-0.02	Stable	2.73
Myponga	Myponga estuary	2006	2017	0.01	-0.04	Virtually certain decrease	2.49
Myponga	Myponga pumphouse	2006	2017	0.92	0.03	Very likely increase	2.29
Field River	Railway Tunnel	2015	2021	0.36	-0.02	stable	3
Inman	Swains Crossing Road	2012	2017	0.21	-0.06	Likely decrease	4.79
Gawler	Tanunda Ck Gauge	2013	2017	0.27	-0.04	Likely decrease	3.78
Gawler	Yaldara	2011	2019	0.03	-0.05	Extremely likely decrease	4.36

Fish Condition EMLR

All fish data used for the assessment of trend and condition of the EMLR fish community have been collected as part of the Landscape Board's (formally NRM Board's) fish monitoring program. All data provided by Nick Whiterod of Aquasave are also available through the biological database of South Australia (available here).

There are a total of 59 sites that are regularly assessed for fish community condition across the EMLR using the Aquasave condition model (Whiterod & Hammer 2014). At the time of undertaking the analysis, most of these sites had been assessed most recently in 2021. Based on the most recent sampling, the most common condition score was five out of nine (20%), followed by zero out of nine (19%) and three out of nine (13%) (Figure 9). Based on the Aquasave Condition model, 31 sites were classed as poor (score 6 -9), 25 as moderate (score 3 - 6) and four as good (score 0 - 3) (Figure 10, Table 8). A total of 4 sites were dry in 2021, one more than previous years.

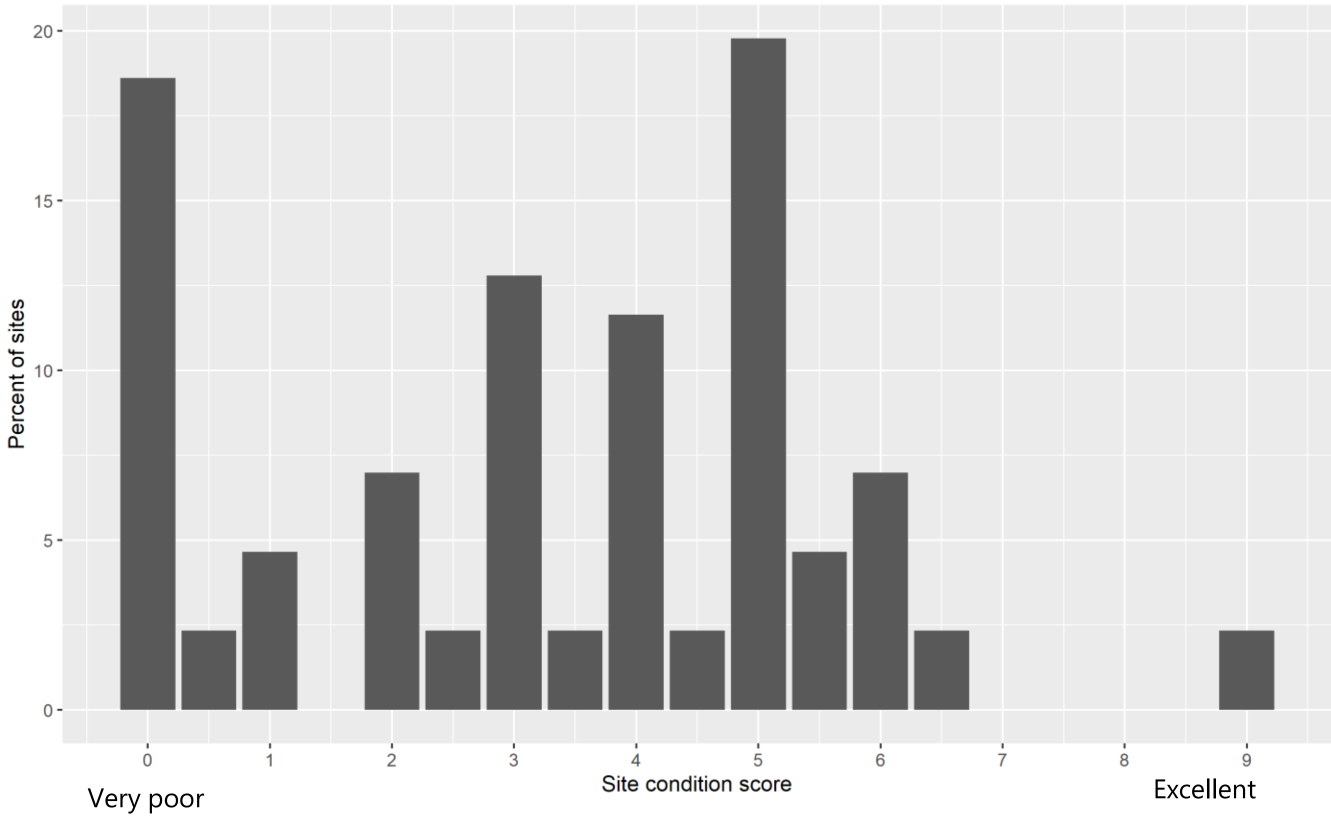

Figure 9: Percentage of sites for each of the most recent AquaSave condition ratings (out of 9) for the Eastern Mount Lofty Ranges fish community.

The four good condition sites were in the upper Angas river, upper Finniss river and the terminal wetland of Tookayerta Creek. The poor and moderate sites were spread evenly across reach types but not across catchments. The catchments to the north showed consistently lower condition scores to those in the south.

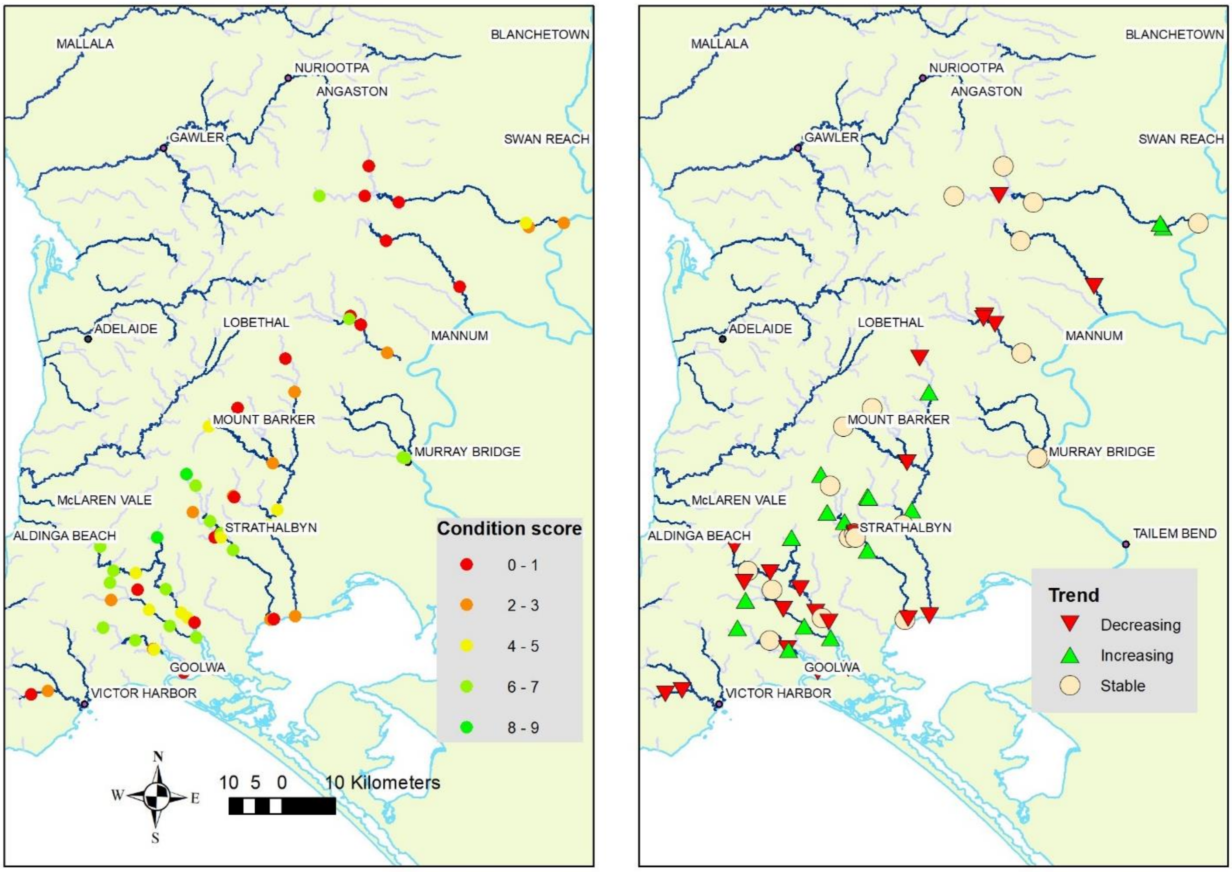

Figure 10: Map of the fish community condition score across the EMLR and Marne Saunders (left) and the trend in condition for sites visited five or more times (right)

Fish Trend EMLR

Based on the 2012 – 2021 data there were a total of 59 sites across the Eastern Mount Lofty Ranges and Marne Saunders that were assessed for fish community condition (five or more visits, Table 8). Of these sites, 24 sites were classed as having a decreasing trend (ranging from likely to virtually certain), 16 were classed as having an increasing trend (ranging from likely to virtually certain) and 20 were classed as stable. Eight of the stable sites showed no variation in condition score across the monitoring window (Stable by default).

Table 8: Condition and trend (2012-2021) results for the Eastern Mount Lofty Ranges fish community condition based on the Aquasave model.

River System	Location	Site ID	Prop of negative slopes	Mean Slope	Trend	Most recent condition score
Angas River	First Weir North Parade	AR_R5_S3	1.00	-0.26	Virtually certain decrease	2
Angas River	Middle Creek junction	AR_R5_S4	0.86	-0.17	Likely decrease	6
Angas River	Turveys drain	AR_R8_S2	0.94	-0.09	Very likely decrease	0
Angas River	Angas Mouth	AR_R8_S1	0.42	0.02	stable	3
Angas River	Willyaroo	AR_R6_S4	0.12	0.02	Likely increase	5
Angas River	Hospital pool	AR_R6_S1	0.35	0.04	stable	4.5
Angas River	Searle St	AR_R3_S2	0.42	0.07	stable	6
Angas River	Paris Creek Road	AR_R2_S9	0.20	0.32	Likely increase	3
Angas River	Martindale	AR_R4_S2	0.25	0.34	Likely increase	6
Angas River	Quarry Rd	AR_R3_S1	0.03	0.60	Extremely likely increase	9

River System	Location	Site ID	Prop of negative slopes	Mean Slope	Trend	Most recent condition score
Angas River	Borders Property	AR_R2_S1	NA	NA	Stable default	0
Angas River	Whitwers Property	AR_R2_S6	NA	NA	Stable default	0
Bremer River	Bakers property	UNK_BRM_1	0.97	-0.26	Extremely likely decrease	2
Bremer River	Harrogate main bridge	BR_R3_S1	0.94	-0.20	Very likely decrease	0
Bremer River	Bremer Mouth	BR_R9_S1	0.87	-0.18	Likely decrease	3
Bremer River	Wandstead Road	BR_R6_S2	0.36	0.04	stable	4
Bremer River	Footbridge near bowls club	BR_R4_S1	0.33	0.09	stable	4
Bremer River	Military Rd	BR_R3_S3	0.17	0.10	Likely increase	2
Bremer River	Highland Valley (a)	BR_R2_S1	0.31	0.13	Likely increase	3
Bremer River	Hartley Gauge	BR_R6_S1	0.16	0.14	Likely increase	4
Bremer River	Highland Valley (b)	BR_R2_S4	0.08	0.22	Very likely increase	0
Bremer River	Bridge St	BR_R4_S4	NA	NA	Stable default	0
Currency Creek	Currency Creek Game Reserve	CC_R7_S1	0.94	-0.52	Very likely decrease	1
Currency Creek	Lions Park	CC_R6_S1	0.94	-0.13	Very likely decrease	3
Currency Creek	Stuarts Bridge	CC_R5_S1	0.46	0.02	stable	5
Currency Creek	ds Goolwa Rd	CC_R6_S2	0.26	0.04	Likely increase	4
Currency Creek	Kilchoan	CC_R3_S1	0.02	0.49	Extremely likely increase	5
Finniss River	Blue Lagoon	FR_R9_S1	0.93	-1.20	Very likely decrease	0.5
Finniss River	Finniss River Junction	FR_UNK_1	0.98	-0.48	Extremely likely decrease	3
Finniss River	us Waterfalls	FR_R7_S1	0.94	-0.24	Very likely decrease	5
Finniss River	Thorn Dairy	FR_R5_S1	0.87	-0.15	Likely decrease	5.5
Finniss River	ds Coles crossing	FR_R6_S1	0.83	-0.15	Likely decrease	4
Finniss River	Railway Bridge	FR_R8_S1	0.77	-0.04	Likely decrease	4
Finniss River	Yundi	FR_R6_S7	0.48	0.00	stable	5
Finniss River	300m ds of Winery Road	FR_R8_S5	0.40	0.02	stable	4
Finniss River	McHarg Creek Rd	FR_R3_S2	0.25	0.11	Likely increase	9
Inman River	Robertson property	IR_R5_S1	0.96	-0.49	Extremely likely decrease	3
Inman River	Kirk Rd	IR_R4_S2	1.00	-0.36	Virtually certain decrease	0
Marne River	Jultand Road	MR_R2_S2	1.00	-0.79	Virtually certain decrease	0
Marne River	Vigars Rd	MR_R2_S1	0.66	-0.14	stable	5
Marne River	Marne Gorge	MR_R5_S1	0.61	-0.08	stable	0
Marne River	Black Hill Springs	MR_R8_S3	0.22	0.13	Likely increase	2.5
Marne River	Three sisters pool	MR_UNK_2	0.00	0.56	Virtually certain increase	4
Marne River	Marne Mouth	MR_R9_S1	NA	NA	Stable default	2
Marne River	Pine Hut Road	MR_R4_S1	NA	NA	Stable default	0
Reedy Creek	Delfabro property	RC_R5_S1	0.96	-0.37	Extremely likely decrease	0
Reedy Creek	Baker Creek Gorge	RC_R5_S2	0.78	-0.28	Likely decrease	5
Reedy Creek	Palmer Rd bridge	RC_R5_S3	0.71	-0.16	Likely decrease	1
Reedy Creek	Mannum waterfalls	RC_R7_S1	0.51	0.00	stable	2
Rocky Gully	At road bridge on outlet channel	RG_R5_S1	0.48	0.01	stable	5.5
Rocky Gully	Rocky Gully wetland	SPR_R5_S1	NA	NA	Stable default	5
Saunders Creek	Lenger Reserve	SA_R5_S2	0.84	-0.23	Likely decrease	1
Saunders Creek	Saunders Creek Gorge	SA_R3_S1	NA	NA	Stable default	0
Tookayerta Creek	Deep Creek Rd	TC_R7_S1	0.95	-0.17	Extremely likely decrease	3.5
Tookayerta Creek	Willowburn Road	TC_R5_S1	0.76	-0.13	Likely decrease	6

River System	Location	Site ID	Prop of negative slopes	Mean Slope	Trend	Most recent condition score
Tookayerta Creek	Cleland Gully Rd	TC_R6_S1	0.33	0.07	Likely increase	3
Tookayerta Creek	us Winery Rd (Railway)	TC_R7_S2	0.13	0.26	Likely increase	5
Tookayerta Creek	Black Swamp	TC_R8_S1	0.00	0.50	Virtually certain increase	6.5
Tookayerta Creek	Brawley Swamp	TC_R4_S1	NA	NA	Stable default	0

Fish WAP Target

The assessment of the fish WAP target was undertaken using fish data sourced from monitoring programs funded by the Landscape Boards (formally NRM Boards). All data are available through the biological database of South Australia (available here).

Across the whole sampling period (2012-2021) there was a total of 303 sampling events that were identified to have Mountain/Obscure Galaxias present between 2012 and 2021 and were assessed against the recruitment risk target (142 from the WMLR, 161 from the EMLR). Across all sampling events there was a total of 257 (84.8%) that were at a high or worse level of risk (Table 9). Of the sampling events assessed, 115 showed no recruitment at all at the time of monitoring. Three or more years with no recruitment is assumed to place the local Galaxias community at extreme risk of a localized extinction event.

Table 9: Level of risk to the recruitment target for Mountain/Obscure Galaxias for the Mount Lofty Ranges based on the number of recruit across the whole assessment period and the most recent sampling event.

Risk level (using WAP risk ratings – see Table 4)	Number of total sampling events	Most recent sampling event
No Recruitment	115	25
Extreme	73	25
Very high	50	12
High	19	8
Moderate	24	8
Low	10	7
Very low	12	3

The proportion of sampling events that had unacceptable levels of risk (high or higher) was much higher in the EMLR (97%) than in the WMLR (71%). This suggested that the cutoff point of 60 recruits might be too high given some of these sites in the EMLR are known to currently have sustainable populations of Obscure Galaxias. The Aquasave fish model uses a much lower cutoff for successful recruitment (9 or more recruits). This approximately equates to the very high risk or lower being classed as a successful recruitment event. However, even using this cutoff, 62% of Mountain/Obscure Galaxias sites had no or unsuccessful recruitment in the last 12 months.

At the most recent sampling event at the time of analysis (2021), there was total of 25 sites that showed no recruitment and 79% of sampling events (70 events) were below the level associated with the WAP target (figure 11). This assessment does not take into account sites that have since not recorded Mountain/Obscure Galaxias, i.e., if no Mountain/Obscure Galaxias were recorded they were not assessed for risk as the population is considered locally extinct. In the WMLR this is hard to assess as the return frequency of sampling is variable; however, in the EMLR there are six sites that historically had Mountain/Obscure Galaxias that have not been captured since 2018.

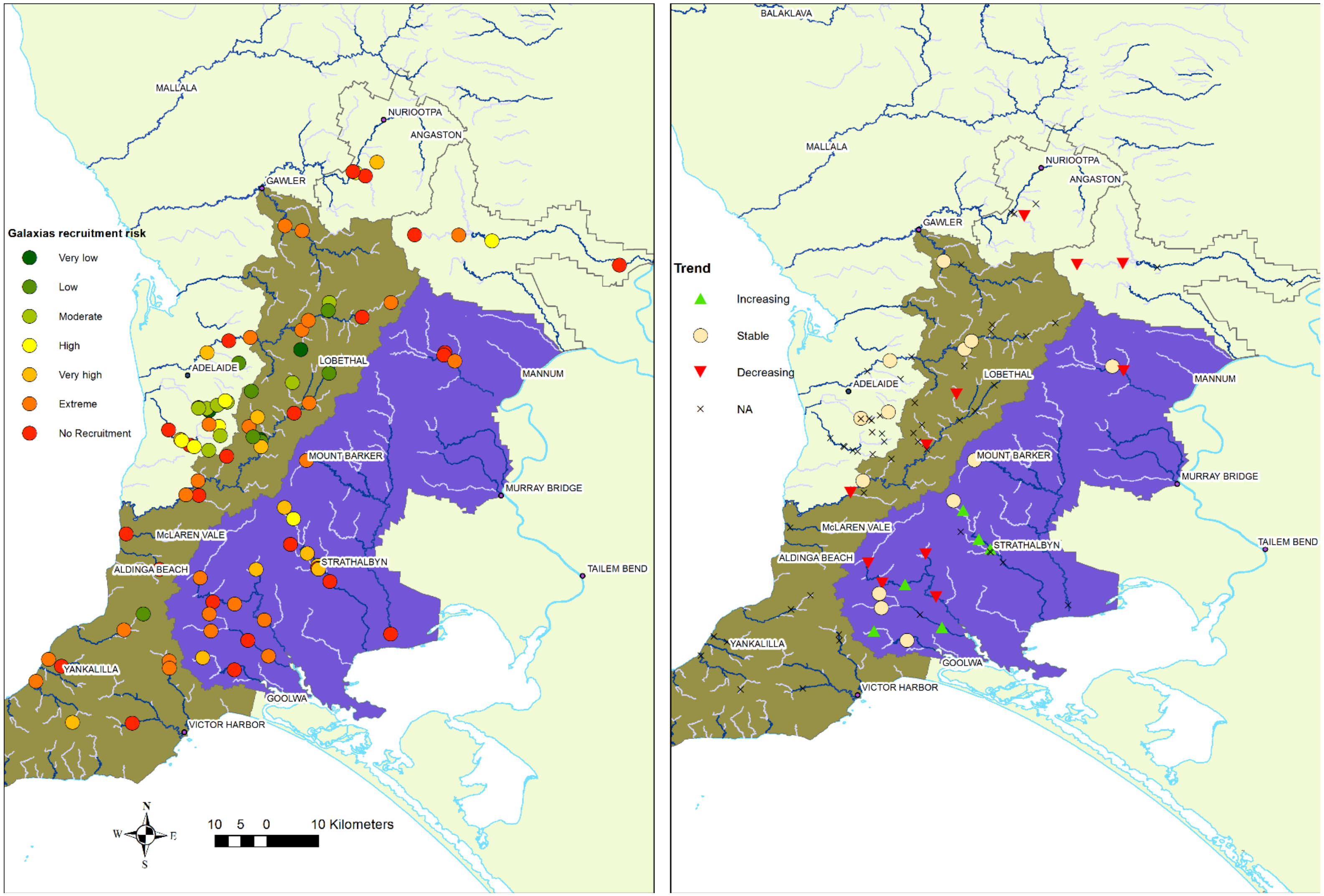

Figure 11: Risk to the Mountain/Obscure Galaxias population based on the level of recruitment the last time Mountain/Obscure Galaxias population were caught at the site and the trend in the recruitment levels of Mountain/Obscure Galaxias population between 2012 and 2021 for all sites that had Mountain/Obscure Galaxias population recorded during the assessment period.

4 Discussion

4.1 Flow trend and condition assessment

The assessment of flow trend and condition was limited by the number of sites that were available for assessment. The criteria of requiring a minimum of 10 years were put in place to minimize the impact of dry/wet years and provide more meaningful results. There are many more operating gauging stations across the two PWRAs that will provide more sites to undertake the assessment in years to come. The assessment could also be undertaken using modelled data. While this does introduce issues associated with modelling, it would provide a more comprehensive view of the trend and condition of the two PWRAs as a whole by allowing for the selection of sites at random, including more ephemeral sites and higher order streams often not suitable for flow monitoring.

The data presented in this report shows that the trend and condition of the sites assessed follow no obvious pattern except for the trend in flowing days either being stable or decreasing. This is most likely attributable to sites that are used for the assessment rather than reflecting the overall trend and condition of sites across the two PWRAs. There are several sites that are impacted by additional water inputs, either in the form of conveyancing flows for Adelaide water supply or from sewage treatment facilities which produces a better flowing environment. However, this is a very localised and separate driver compared to the majority of sites in the two PWRAs. There is also the issue of the period of data influencing the outcomes. Several sites start their data collection in the Millennium Drought and correspondingly show an increase in condition through time while others with data prior to the Millenium Drought, clearly show a drop in condition through the drought and a recovery after.

The condition assessment uses the modelled no dams/extraction scenario as a modelled baseline for comparison. This baseline was chosen as it is the baseline used for the EWR metric assessments that underpin the WAPs. The comparison between this modelled baseline and the actual flow measured at a given site does introduce some issues where the surface water models are not accurately able to model flow at any given location. This happens when there is a complex flow interaction that the models are not able to duplicate such as a sudden influx groundwater or loss of water to the unconfined aquifer. Most of the sites used for this assessment appear to be a good match between the modelled and actual flow; however, one or two are not. This is most evident in the flowing days assessment where sites are modelled as having more flow than they experience. This can be hard to distinguish from the differences caused by the impact of water resource development. Trend is not impacted by this issue.

The trend assessment is only a measure of consistency in modelled results. It does not consider the magnitude of the change. This means that a very small but consistent change will result in a certain trend result even if the change is relatively small, while a more visually obvious trend can be masked by large variations in the data. The trend assessment method is designed to be a very robust assessment, meaning misidentified trends are very unlikely. It also does mean that more subtle trend, or trends in variable data, can be missed.

No assessment of the overall trend or condition across the two PWRAs was undertaken as the sites used do not meet the requirements that underpin such an assessment. For an assessment of that nature, the sites would have to be randomly selected across the stream networks of the area. It is possible the modelled flow data could be used for an assessment of overall area trends but the desire for this assessment was to use real world data. This style of larger assessment would be informative, especially when forecasting impacts due to changes in policy or assessing the impacts of climate change.

4.2 Macroinvertebrate community trend and condition

The assessment of the macroinvertebrate community condition showed some predictable patterns across the two PWRAs. Higher rainfall areas such as the southern coast of the Fleurieu Peninsula and the area around Mount Lofty showed better community condition as opposed to the dryer EMLR. These areas are also associated with higher amounts of remnant vegetation which is known to have a positive impact on macroinvertebrate community condition. The nature of the sampling across the various programs precludes the assessment of an overall condition; however, when all of the various datasets are assessed together it suggests that on the whole the majority of sites across the Hills and Fleurieu region are in a degraded state.

The lack of any sites rated as excellent in either the CMCM scores or the EPA AECRs results is a reflection of the modified nature of the system and it should be noted that in both the CMCM and the AECRs rating system a score of excellent is generally considered not to be possible. This general lack of sites in good or very good condition is an accurate reflection of the macroinvertebrate community condition. Previous assessments have clearly identified that the lack of a suitable flow regime for the macroinvertebrate communities of the Mt Lofty Ranges the master variable in driving macroinvertebrate community condition (Datry et al. 2014, VanLaarhoven 2010, VanLaarhoven 2012). This is not to suggest that other drivers are not important and, in some localised instances, be a more significant driver; however, at the regional scale, improvements to the flow regime will lead to improvements in virtually all other drivers of macroinvertebrate community condition.

The failure of most sites to meet the target established in the WAPs for the Mount Lofty Ranges shows that the management of the resource to achieve the macroinvertebrate outcomes is not currently successful. It is important to note that the CMCM has been developed independently of the WAP process, EWRs and EWPs and there will be a disconnect between the two processes to consider, i.e., does a CMCM score of three or greater accurately reflect the achievement of the macroinvertebrate target for the WAPs? The assumption that the CMCM score of three or greater reflecting the desired condition score has not been validated by any empirical process. Given the likely updates to the WAPs, including targets and objectives, the validation against the existing EWRs and EWPs is of limited value with a suggestion to focus rather on aligning CMCM scores to future targets and objectives, coupled with more flow specific targets and objectives that relate more specifically to the WAP process.

The mixed trend results are mostly related to the short-term window of the assessment as well as the variable nature of the climatic conditions since 2016. The window since 2016 has seen some very wet years as well as two of the driest years on record. The two extreme dry years would have caused species to retreat to refuge locations, significantly limiting their distribution across the landscape. The wet years, especially 2021 and 2022, would have seen range expansion from those refuge habitats but perhaps may have been limited given the low starting conditions. The sites with notable increasing trends include two sites in the Angas River catchment that are downstream of operating low flow devices. While this is not sufficient to claim the implementation of low flows across the region is providing a benefit to the ecology, it is a notable finding that warrants continued investigation.

4.3 Fish

WMLR trend and condition assessment

The assessment of the current condition of the aquatic ecosystems of the WMLR shows that there is considerable variability across the WMLR, both within and between catchments. There is a relatively clear pattern of better condition sites in the southern areas (the Fleurieu Peninsula) as is seen with the flow and macroinvertebrate assessments. The reasons for this are not fully understood; however, the relative impacts of water resource development increases as rainfall decreases. Therefore, the condition of the aquatic ecosystems is more buffered in the southern parts of the region due to the higher rainfall.

The high number of sites assessed in the WMLR does provide good spatial coverage of the region; however, more contemporary data from some of the older sites would help to provide a clearer picture of current condition. The majority of sites were considered to be in the poorer range of condition reflecting the impacted nature of the region and also reflecting the other assessments provided in this report. The better condition (BCG <2) sites were localised to the southern part of the Fleurieu Peninsula except for First Creek in the River Torrens catchment. These sites are all associated with higher rainfall and longer/perennial flow.

The trend assessment had very limited information across most of the area covered by the EMLR and WMLR WAPs. Of the 23 sites that were assessed for trend, only six of them were located outside the Fleurieu Peninsula, and of these six, only two are in area covered by the EMLR and WMLR WAPs. The trends that are reported for the region in most cases are reflective of small but consistent changes in the condition through time. There are very few sites that show changes in order of greater than 1 BCG unit. The exception to this is Hindmarsh Falls that show a change from less than 2 to 4 between 2012 and 2017. This is related to the invasion of Brown Trout to the area (Schmarr et al. 2022).

The reasoning behind the distribution of sites with improving and declining trends in the Fleurieu Peninsula is not clearly obvious and is not reported in Schmarr et al. (2022). Further investigations into these sites may provide additional information; however, as the changes are relatively minor for most sites, it is likely that these changes are related to the timing of sampling events over the 2006-2021 period. Sites with longer term datasets are more likely to report stable trends which sites with short-term datasets (spanning only 3 or 4 years) are more likely to be influenced by wet/dry years or specific events. Longer term datasets will help confirm trends observed across the WMLR.

The sampling regime across the WMLR does not lend itself to this type of trend assessment. The lack of sites with long-term repeat visits means that there is limited information to inform the trend assessment; however, the process of site selection is biased enough to not allow for a regional assessment. The high spatial coverage is good for informing the distribution of species and for monitoring any changes in this (e.g., alien species range expansion). Moving forward, Schmarr et al. (2022) recommend more effort on repeat visits to be able to assess trend while maintaining a degree of new site assessment. This approach would be beneficial for trend assessment and for broader WAP outcome monitoring.

<u>EMLR and Marne Saunders trend and condition assessment</u>

The assessment of condition across the EMLR (and Marne Saunders) PWRAs show a combination of expected and unexpected results. As expected, many sites were in the moderate or poor condition category. Of the three sites that were identified as being in good condition, two sites were in the headwaters of higher rainfall catchments (Quarry Rd in the Angas River catchment and McHarg Creek Rd in the Finniss River catchment) and the third was Black Swamp (the terminal wetland of Tookayerta Creek). All three of these sites are perennial in flow which separates them out from most others in the EMLR.

The spread of sites in moderate and poor condition show no pattern across reach type with an even spread of condition scores from all reach types. This is likely due to the method that selects assessments based on site characteristics and previous fish communities. By tailoring the assessment to the site, the method effectively removes the reach type as a factor. If reach type did show a pattern, then this would warrant further investigation.

The spread of condition scores along the north-south gradient was expected as the northern parts of the EMLR and the Marne Saunders are currently experiencing a prolonged dry period that is manifesting in reduced stream flow. This is most evident in the lack of recruitment in the northern catchments. While 71% of all sites assessed in 2021 showed no recruitment, this was much higher in the northern catchments (86% or two sites). The sites that did show recruitment were for dwarf flathead gudgeon in Reedy Creek mid pool riffle and Murray Hardyhead in the Rocky Gully terminal wetland. Both species are not known for their response to flow.

The results from the neighboring Marne River catchment are cause for some concern as there has been a near total loss of fish from the upper and mid reaches of the system with a single site with surviving Mountain Galaxias

(Vigars Rd). This loss is driven by a general loss of flowing days through the catchment and the associated decline in water quality in the remaining permanent pools. While the Marne River catchment is not part of the HF Landscapes Board region, the drivers of the observed change are likely to continue to move south as the effects of a changing climate continue to be realised.

The trend results for the fish of the EMLR and Marne Saunders river catchments are mixed with some interesting patterns. The poor condition observed in the northern catchments is also reflected in the trend results with only two sites out of the total of 13 showing an improving trend (both in the lowland reach of the Marne River). The southern catchments are mixed with areas showing multiple increasing sites, and other areas showing multiple decreasing sites. The Finniss river shows a general declining trend except for the perennial McHarg Creek site. The driver behind this declining trend is not currently understood. The flow assessment for the Finniss river catchment shows stable flowing period and either stable or decreasing fresh flows.

WAP fish recruitment target

Based on the cutoff of 60 recruits, the level of recruitment of the Mountain/Obscure Galaxias populations across the Mount Lofty Ranges is generally lower than what would be considered sustainable. The driver behind this lack of recruitment success is generally considered to be the lack of a suitable flow regime to promote successful recruitment. The lack of implementation of the low-flow principles in the WAPs suggests that many of the catchments are not providing the environmental water requirements. When this is combined with the dry conditions experienced over the last decade, it is logical that recruitment levels are not meeting the target in the WAPs.

The western slopes of the Mount Lofty Ranges near Mount Lofty and south of Adelaide are showing better levels of recruitment that other areas. When compared to the results in the flow section, this area is also still getting good flows over the low flow season and longer, if not perennial flow.

The trend assessment shows only a few sites getting better, all in the EMLR. The reason for this increase is not currently understood. There are two main possibilities and likely a combination of them is the reason. The first is the populations are recovering from the drought. The trend analysis starts in 2012 when populations were likely still suppressed from the drought so increasing trends could more accurately be described as recovery trends. The second is that, due to the location of the sites showing increasing trends, the implementation of the Flows for the Future Program is having some impacts. This possibility would need further investigation to validate.

4.4 Considerations for next steps

This assessment of trend and condition of ecological indicators was designed to provide an insight into the current ecological health of the aquatic ecosystems of the PWRAs of the MLR. The assessment used the data available and existing methods to assess condition (except for the macroinvertebrate condition assessment). These assessment methods either stemmed from the WAPs or derivative products based on the WAPs and are all linked back to the initial environmental water requirements (EWR) and environmental water provisions (EWP) work that underpin these WAPs. Through this work, and other bodies of work supporting water allocation planning, it has been identified that some of the methods used would benefit from a review and potential update. The review and potential amendment of the WAPs would be a logical time for this to occur.

Some of the issues that could be considered prior to the adoption/roll over of the WAPs include the following.

1) **Updates to WAP condition targets**.
   The condition targets identified in the WAPs are lacking the detail that allows for their assessment to be undertaken. This is either due to the lack of clearly identified methods in the case of macroinvertebrates or the lack of identified threshold values in the case of fish. This assessment makes no attempt to relate the current condition back to the targets in the WAP as it is not an evaluation.

2) **Updates to the flow metrics used for the EWR and EWP description.**
The flow metrics that underpin the EWRs and EWPs have been identified as difficult to use and interpret as well as showing high levels of internal correlation. More recent work has limited the number of metrics to three (as seen in this report); however, these three are still a subset of the original metrics. The two fresh metrics need additional investigation to ensure they are representing the ecological functions being assessed. For most sites these metrics are considered suitable but for dry sites these metrics begin to display nonsensical results. There is also a question over what data are used to generate target values for these metrics (actual, modelled current or modelled no dams/extraction).

3) **Methods used to identify condition need to be standardized.**
This report has presented two different fish condition models and two different macroinvertebrate community condition models. All the condition models presented are valid and each has their own benefits and challenges. Now that the region is being managed by a single entity (Hills and Fleurieu Landscape Board), the opportunity exists to standardize condition assessment methods for fish and macroinvertebrates across the region, and perhaps across the broader Mount Lofty Ranges. As the ultimate end user of the data, the Landscape Boards (supported by DEW Science and data providers) should identify the needs of such condition models and assess if current methods could be more broadly applied or if new methods are required.

4) **Consideration of the impacts of a changing climate.**
The impacts of a changing climate are becoming evident in other areas of South Australia. Flow regimes are changing, generally resulting in less flowing days and overall reduced flow volumes. This suggests that, irrespective of the impacts of water resources development, the water-dependent ecosystems of the Mount Lofty Ranges are likely to change. The identification environmental assets now and into the future will be key for the development of EWRs and EWPs.

5 Relating results to the current WAPs

The intent behind this work is to provide stakeholders with a background understanding of the current condition of the aquatic environment in the two PWRAs of the Mount Lofty Ranges as input to the review of the WAPs. As such, some general notes comparing the results back to the outcomes, objectives and targets are presented for each of the assessments undertaken.

Across all indicators, it is apparent that there is variability due to the climatic conditions experienced as well as a general degraded condition relative to the targets identified in the WAPs. Note that the fish and flow assessment cover periods that start during or just after the Millennium Drought and; therefore, some of the worst conditions for aquatic ecosystems experienced in the state. In this sense, anything other than an improving trend is cause for concern as this reflects a lack of recovery since the drought. It is acknowledged that there will always be a lag period between improved physical conditions and improved ecological conditions; however, 10 years is sufficient for this process. The extreme dry years of 2018 and 2019 could play a role in the lack of defined increasing trends across the region. The process of considering how these sorts of extreme events are considered in WAP target assessment is not covered in this report.

5.1 Flow

The WAPs for the Mount Lofty Ranges use a complex series of flow metrics to describe the desired flow regime. The full suite of metrics were not assessed as part of this work, as the intent is to move away from these metrics to a simplified system that uses the three metrics presented here. However, the three metrics used are a subset of the original metrics, and the bounds that describe their condition, are adapted directly from the WAPs. As noted in the discussion, there is no general trend that can be identified from the flow data.

The strongest result within the flow data is the general stable or declining number of flowing days. This result is made stronger when considering that several of the sites assessed started monitoring during the drought and are still only showing stable results. The WAPs have principles that are designed to protect and restore low flows throughout the catchments. However, these principles have not been fully implemented across any catchment and; therefore, their impact is not apparent at this time. The Flows for the Future Program has a hydro-ecological monitoring program associated with it with assessments and reporting due at the end of the program, though the timeline of this is currently unknown, potentially late 2024 or 2026.

The other two flow metrics are more variable across the region and show roughly equal split between increasing and decreasing. Again, the role of the monitoring period and the impacts of the drought likely play a role here and a repeat of this assessment in the future would provide a clearer contemporary picture.

5.2 Macroinvertebrates

The target identified in the WAPs for macroinvertebrate communities is "moderate or better community condition". Unfortunately, there is no documentation of how this is to be assessed. In this assessment we have used the new CMCM process to define condition using the biological condition framework. For the purpose of this assessment, moderate condition was linked to a condition of three or higher.

Of the 53 sites that were assessed using the CMCM process, only 10 were noted as meeting the moderate condition target. As discussed in section 4.2, there is a disconnect between the condition modelling process and the EWRs and EWPs that needs to be considered. However, the fact that only 10 sites were able to achieve a score of three suggests that the overall community in the region is degraded. While sites in the southern parts of the region were generally in better condition, it is important to note that sites that met the moderate condition target were evenly distributed across the region. This suggests that the impacts of water capture and use are having an impact on the macroinvertebrate community and ultimately means that the WAP target for macroinvertebrates is not being met.

In practice this means that the diversity of macroinvertebrates found across the Mount Lofty Ranges is decreasing. This is especially evident in flow-loving taxa due to the decrease in flowing period and the loss of perennial flowing sites. Associated with the loss of diversity is a loss of function. How this loss of function impacts the river systems is not currently well understood; however, aspects of detritus and nutrient cycling are likely to be impacted.

The ongoing implementation of the principles of the WAPs means that the environmental water provisions defined in the WAPs are not currently being met and, as such, it is to be expected that the macroinvertebrate communities are at a higher level of risk than deemed acceptable under the WAPs.

5.3 Fish

The target identified in the WAPs for fish is "better than marginal recruitment in 7 out of 10 years for Mountain/Obscure Galaxias and Southern Pygmy Perch". This target was identified as it maintains an acceptable level of risk of localised extinctions of these regionally important fish species. The assessment of the target was not possible as there is a lack of suitable time series data across the whole of the Mount Lofty Ranges. The assessment presented here assessed the risk of not meeting the target based on a single year's recruitment.

Across all sites that were assessed, only 46 (15%) sites showed a moderate or lower risk to the recruitment target. This suggests that across the Mount Lofty Ranges the populations of Mountain/Obscure Galaxias are at an unacceptable level of risk of localised extinctions. Using the lower cutoff for successful recruitment from the Aquasave model still showed 62% of sites with unsuccessful or no recruitment. It should also be noted that there are at least seven sites across the Mount Lofty Ranges that have previously had Mountain/Obscure Galaxias that, in recent sampling, no individuals were found. Most notably Jacob Creek in the Barossa and several sites in the Marne river catchment. While these sites are not covered in the Mount Lofty Ranges WAPs, the loss of these populations is a warning of the impacts of water resource development in a changing climate.

Based on the results, it is considered that the target in the WAP for fish is not being met for Mountain/Obscure Galaxias. The assessment was not done for Southern Pygmy Perch as there were not enough data to make a robust assessment.

For much of the Mount Lofty Ranges, Mountain/Obscure Galaxias are the only species of native fish present, especially in the upper reaches. The loss of fish from these sites represents a significant shift in the character of the sites and is likely associated with other significant degradations in flow regime and water quality.

The ongoing implementation of the principles of the WAPs means that the environmental water provisions defined in the WAPs are not currently being met and, as such, it is to be expected that the fish communities are at a higher level of risk than deemed acceptable under the WAPs.

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7 Appendices

7.1 Appendix 1 – macroinvertebrate condition model results (trend and condition)

Site	Year	BCG score	Condition category	WAP Target assessment	Percent negative slopes	Mean slope	Mean slope 90% confidence interval	Trend	Min Year	Max Year
Braeside Road	2022	2.43	Poor	Target not met	86%	-0.0600	-0.157 to 0.035	Likely decrease	2016	2022
Bremer River between MOU and ROD	2022	2.12	Poor	Target not met	NA	NA	NA	NA	NA	NA
Bremer River, near Callington	2022	2.63	Poor	Target not met	NA	NA	NA	NA	NA	NA
Bull Ck Trib	2022	3.62	Fair	Target met	13%	0.1899	-0.118 to 0.482	Likely increase	2017	2022
Bull Creek	2021	2.57	Poor	Target not met	97%	-0.0917	-0.17 to -0.013	Extremely likely decrease	2016	2021
Carrick Creek East	2022	3.56	Fair	Target met	50%	-0.0001	-0.18 to 0.177	About as likely as not increase	2017	2022
Carrick Creek West	2017	3.43	Fair	Target met	NA	NA	NA	NA	NA	NA
Childrens Reserve	2018	1.81	Very poor	Target not met	NA	NA	NA	NA	NA	NA
Church Hill Rd	2020	2.65	Poor	Target not met	NA	NA	NA	NA	NA	NA
Cosgrove Rd Site 2	2020	1.97	Very poor	Target not met	NA	NA	NA	NA	NA	NA
Cosgrove Road	2021	2.45	Poor	Target not met	NA	NA	NA	NA	NA	NA
Cranford Road	2021	2.86	Poor	Target not met	64%	-0.0418	-0.277 to 0.194	About as likely as not increase	2017	2021
Dawson Ck Trib	2022	2.88	Poor	Target not met	NA	NA	NA	NA	NA	NA
Doctors Creek Lower	2021	1.77	Very poor	Target not met	NA	NA	NA	NA	NA	NA
Frames Fire Track	2022	1.57	Very poor	Target not met	NA	NA	NA	NA	NA	NA

Graetz Town Bridge	2021	1.74	Very poor	Target not met	NA	NA	NA	NA	NA	NA
Jutland Water Reserve	2021	2.02	Poor	Target not met	79%	-0.1042	-0.344 to 0.164	Likely decrease	2017	2021
Lartunga	2021	2.99	Poor	Target not met	NA	NA	NA	NA	NA	NA
Lower Dawesley Creek	2022	2.06	Poor	Target not met	NA	NA	NA	NA	NA	NA
Martin Rd	2022	2.54	Poor	Target not met	NA	NA	NA	NA	NA	NA
Meadows	2022	1.79	Very poor	Target not met	53%	-0.0072	-0.172 to 0.154	About as likely as not increase	2016	2022
Mid Mount Barker Creek	2022	2.45	Poor	Target not met	NA	NA	NA	NA	NA	NA
Mid-Rodwell Creek	2022	2.07	Poor	Target not met	NA	NA	NA	NA	NA	NA
Mount Barker Springs	2022	2.53	Poor	Target not met	NA	NA	NA	NA	NA	NA
Myrtle Grove	2020	1.92	Very poor	Target not met	NA	NA	NA	NA	NA	NA
Netherford	2021	1.80	Very poor	Target not met	96%	-0.2983	-0.568 to -0.019	Extremely likely decrease	2017	2021
North Rhyne	2017	2.27	Poor	Target not met	NA	NA	NA	NA	NA	NA
Nunn Rd East	2022	3.54	Fair	Target met	96%	-0.0550	-0.105 to -0.005	Extremely likely decrease	2017	2022
Nunn Rd West	2022	3.95	Fair	Target met	2%	0.1645	0.052 to 0.272	Extremely likely increase	2017	2022
One Tree Hill Creek, near Springton	2021	3.17	Fair	Target met	NA	NA	NA	NA	NA	NA
Paris Creek LFB	2022	1.89	Very poor	Target not met	77%	-0.0387	-0.132 to 0.054	Likely decrease	2016	2022
Paris Creek Road	2022	2.38	Poor	Target not met	13%	0.0872	-0.046 to 0.224	Likely increase	2016	2022
Polworth Drive	2022	3.63	Fair	Target met	66%	-0.0109	-0.06 to 0.038	About as likely as not increase	2017	2022
Quarry Road	2022	2.93	Poor	Target not met	44%	0.0057	-0.07 to 0.081	About as likely as not increase	2016	2022
Red Gum Rd	2022	2.48	Poor	Target not met	36%	0.0219	-0.092 to 0.138	About as likely as not increase	2017	2022
Rushmore Reserve	2021	2.49	Poor	Target not met	59%	-0.0183	-0.162 to 0.127	About as likely as not increase	2016	2021

Schmitt Road	2022	2.64	Poor	Target not met	18%	0.0362	-0.035 to 0.107	Likely increase	2017	2022
Springton Creek	2020	1.91	Very poor	Target not met	NA	NA	NA	NA	NA	NA
Strathalbyn	2022	2.19	Poor	Target not met	96%	-0.1087	-0.207 to -0.008	Extremely likely decrease	2016	2022
Sunnydale Road	2022	2.43	Poor	Target not met	94%	-0.0400	-0.083 to 0.003	Very likely decrease	2016	2022
Upper Bremer River, Harrogate bridge	2022	2.94	Poor	Target not met	NA	NA	NA	NA	NA	NA
Upper Dawesley Creek	2022	2.73	Poor	Target not met	NA	NA	NA	NA	NA	NA
Upper Nairne Creek	2022	2.41	Poor	Target not met	NA	NA	NA	NA	NA	NA
Upper Rodwell Creek	2022	3.32	Fair	Target met	65%	-0.0434	-0.267 to 0.19	About as likely as not increase	2017	2022
Upper Saunders Creek	2022	3.07	Fair	Target met	18%	0.1333	-0.129 to 0.397	Likely increase	2017	2022
Vigars Road	2021	2.21	Poor	Target not met	81%	-0.0850	-0.262 to 0.095	Likely decrease	2017	2021
Western Flat Creek Hack Street	2022	2.89	Poor	Target not met	NA	NA	NA	NA	NA	NA
Whites Rd	2022	2.39	Poor	Target not met	99%	-0.1096	-0.179 to -0.038	Extremely likely decrease	2017	2022
Wild Dog Creek Rd	2022	2.93	Poor	Target not met	96%	-0.0786	-0.15 to -0.004	Extremely likely decrease	2017	2022
Yacca Rd	2022	3.40	Fair	Target met	7%	0.0678	-0.013 to 0.145	Very likely increase	2017	2022