Technical information supporting the 2023 Lower Lakes aquatic and littoral vegetation environmental trend and condition report card

Department for Environment and Water
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Government of South Australia

Department for Environment and Water

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Acknowledgement of Country

We acknowledge and respect the Traditional Custodians whose ancestral lands we live and work upon and we pay our respects to their Elders past and present. We acknowledge and respect their deep spiritual connection and the relationship that Aboriginal and Torres Strait Islanders people have to Country. We also pay our respects to the cultural authority of Aboriginal and Torres Strait Islander people and their nations in South Australia, as well as those across Australia.

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Summary

The 2023 release of South Australia's environmental trend and condition report cards summarises our understanding of the current condition of the South Australian environment, and how it is changing over time.

This document describes the indicators, information sources, analysis methods and results used to develop this report and the associated 2023 Lower Lakes aquatic and littoral vegetation report card. The reliability of information sources used in the report card is also described.

The Lower Lakes aquatic and littoral vegetation report card sits within the report card Biodiversity theme and Inland waters sub-theme. Report cards are published by the Department for Environment and Water and can be accessed at www.environment.sa.gov.au.

1 Introduction

1.1 Environmental trend and condition reporting in SA

The Minister for Climate, Environment and Water under the *Landscape South Australia Act 2019* is required to 'monitor, evaluate and audit the state and condition of the State's natural resources, coasts and seas; and to report on the state and condition of the State's natural resources, coasts and seas' (9(1(a-b)). Environmental trend and condition report cards are produced as the primary means for the Minister to undertake this reporting. Trend and condition report cards are also a key input into the State of the Environment Report for South Australia, which must be prepared under the *Environment Protection Act 1993*. This Act states that the State of the Environment Report must:

- include an assessment of the condition of the major environmental resources of South Australia (112(3(a))), and
- 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))), and
- identify significant trends in environmental quality based on an analysis of indicators of environmental quality (112(3(b))).

1.2 Purpose and benefits of SA's trend and condition report cards

South Australia's environmental trend and condition report cards focus on the state's priority environmental assets and the pressures that impact on these assets. The report cards present information on trend, condition, and information reliability in a succinct visual summary.

The full suite of report cards captures patterns in trend and condition, generally at a state scale, and gives insight to changes in a particular asset over time. They also highlight gaps in our knowledge on priority assets that prevent us from assessing trend and condition and might impede our ability to make evidence-based decisions.

Although both trend and condition are considered important, the report cards give particular emphasis to trend. Trend shows how the environment has responded to past drivers, decisions, and actions, and is what we seek to influence through future decisions and actions.

The benefits of trend and condition report cards include to:

- provide insight into our environment by tracking its change over time
- interpret complex information in a simple and accessible format
- provide a transparent and open evidence base for decision-making
- provide consistent messages on the trend and condition of the environment in South Australia
- highlight critical knowledge gaps in our understanding of South Australia's environment
- support alignment of environmental reporting, ensuring we 'do once, use many times'.

Environmental trend and condition report cards are designed to align with and inform state of the environment reporting at both the South Australian and national level. The format, design and accessibly of the report cards has been reviewed and improved with each release.

1.3 Lower Lakes aquatic and littoral vegetation

Aquatic and littoral vegetation in the Lower Lakes (Lakes Alexandrina and Albert) refers to the plant communities that grow from within a waterbody to its high water mark. Nicol (2017) defined aquatic vegetation as the plant community that requires the presence of surface water at some point in its life history, and littoral vegetation as the plant community that occupies the fringes of the waterbodies. The aquatic and littoral vegetation community in the Lower Lakes is comprised of submergent, amphibious and emergent species: submergent plants complete their life histories under water; amphibious species grow both within and out of water, and have a requirement for wetting and drying to complete their lifecycle; and emergent plants require saturated soil or shallow water but also have requirements for organs (flows, leaves and stems) above the water level (Nicol 2017).

Aquatic and littoral vegetation communities serve important roles in wetland ecosystems, including cultural services, primary production, sequestration of carbon and other nutrients that improves water quality, shoreline stabilisation, and the provision of habitat and food for wildlife (Kansiime et al. 2007). In the Lower Lakes, aquatic and littoral vegetation fulfils these functions, including cultural services for the Ngarrindjeri (Ngarrindjeri Nation 2018) and habitat for nationally threatened fauna, including southern bell frog (Mason 2017), Australasian bittern (O'Connor et al. 2013) and southern pygmy perch (Wedderburn and Barnes 2018).

In the Lower Lakes, aquatic and littoral vegetation communities in very good condition have high species richness, structural diversity and limited cover by invasive and over-abundant native species (Nicol et al. 2021). The primary driver of aquatic and littoral vegetation condition and structure is water regime (Nicol et al. 2018), which encompasses water depth, duration, frequency and timing of inundation and exposure (Mitsch and Gosselink 1993). Water regimes drive zonation and change in species composition and diversity of aquatic and littoral vegetation communities, as each functional plant group responds differently to water residence time, depth and level fluctuations based upon their life histories (Gehrig and Nicol 2010; Nicol et al. 2018).

Salinity is another factor that can influence the condition and structure of aquatic and littoral vegetation communities in the Lower Lakes (Gehrig and Nicol 2010; Nicol et al. 2018). The impact of salinity on aquatic and littoral vegetation is less understood (Nicol 2016). During the peak of the Millennium Drought (2007-2010), species thought to be sensitive to salinity were found to colonise and/or persisted when salinities were extremely elevated, at times exceeding 30,000 electrical conductivity (EC) in the Goolwa Channel (Gehrig et al. 2011). However, over this same period, the extremely elevated salinities may have contributed to the low species diversity of submergent plants, impaired growth of emergent species, and a lack of recruitment by narrow-leaf bulrush (*Typha domingensis*) and river club-rush (*Schoenoplectus tabernaemontani*) (Gehrig et al. 2011; Nicol 2016).

To maintain and improve the condition of aquatic and littoral vegetation in the Lower Lakes, it is important that lake water levels vary seasonally. Lake water levels should range from +0.7–0.9 m Australian Height Datum (AHD) in spring and early summer and not fall any lower than +0.4 m AHD in autumn (DEW 2020a). Salinity should also remain preferably below 1,000 EC and not exceed 2,000 EC in Lake Alexandrina (Nicol 2016). These environmental conditions protect submergent plant species from desiccation and enhance species richness and diversity (Nicol et al. 2021).

2 Methods

2.1 Indicator

The indicator used for the Lower Lakes aquatic and littoral vegetation report card is the achievement of condition indices (Appendix A).

The ecological objective for Lower Lakes aquatic and littoral vegetation as described in the updated *Long-term environmental watering plan for the South Australian River Murray water resource plan area* (DEW 2020b) is presented in **Error! Reference source not found.**. The ecological targets for Lower Lakes aquatic and littoral vegetation were established in the 'Lakes vegetation' chapter (Nicol 2017) of the *LLCCMM Icon Site Condition Monitoring Plan* (DEWNR 2017) (Table 2.1).

Table 2.1. Ecological objective (DEW 2020b) and targets (Nicol 2017) for littoral and aquatic vegetation in the Lower Lakes.

Metric	Description
Ecological objective	Maintain or improve aquatic and littoral vegetation in the Lakes (DEW 2020b)
Ecological targets	Maintain or improve diversity of aquatic and littoral vegetation in (1) Lake Alexandrina, (2) Lake Albert, (3) Goolwa Channel, (4) permanent wetlands and (5) seasonal wetlands as quantified using LLCMM *The Living Murray* vegetation indices (Nicol 2017)

2.2 Data sources

Data were sourced from the Lower Lakes Vegetation Condition Monitoring program conducted by the South Australian Research and Development Institute (SARDI) (Aquatic Sciences) and jointly funded by the South Australian and Australian governments as part of *The Living Murray* initiative.

2.3 Data collection

The methodology for the Lower Lakes aquatic and littoral vegetation condition monitoring followed that of Nicol (2017) as described in the LLCMM Condition Monitoring Plan (DEWNR 2017). Nicol et al. (2021) summarised the method: 'Vegetation condition monitoring is conducted at selected wetland and lakeshore sites across Lakes Alexandrina and Albert, Goolwa Channel, lower Finniss River, lower Currency Creek and the mouths of the Angas and Bremer Rivers. Sites established in spring 2008 and 2009 were re-surveyed on each survey. At each site, transects were established perpendicular to the shoreline and three, 1×3 m quadrats, separated by 1 m were located at regular elevation intervals (defined by plant community) for wetlands or elevations (+0.8, +0.6, +0.4, +0.2, 0 and -0.5 m AHD) for lakeshores. The cover and abundance of each species present in quadrats were estimated using a modified Braun-Blanquet (1932) cover abundance score.'

2.4 Data analysis

2.4.1 Calculation of habitat and icon site scores

Habitat scores were determined by summing the proportion of targets met for each elevation zone and dividing it by the number of elevation zones, i.e. all elevation zones were allocated equal weighing to the overall habitat score (Nicol 2017).

Habitat scores were calculated using the following equation for:

Lake Alexandrina, Lake Albert and Goolwa Channel habitats:

> Habitat score = (proportion of targets met in the littoral zone x 0.33) + (proportion of targets in the aquatic zone x 0.33) + (proportion of targets met in deep water zone x 0.33)

Permanent wetlands:

> Habitat score = (proportion of targets met in the littoral zone x 0.5) + (proportion of targets met in the aquatic zone x 0.5)

Spring and autumn (temporary) wetlands:

> Habitat score = (proportion of targets met in the edge zone x 0.5) + (proportion of targets met in the bed zone x 0.5).

Whole of icon site scores were calculated by summing habitat scores and dividing it by the number (five) of habitats (Lake Alexandrina, Lake Albert, Goolwa Channel, permanent wetlands and temporary wetlands), i.e. all habitats were allocated equal weighting to the overall icon score.

The **whole of icon site score** was calculated using the following equation:

> Icon site score = (Lake Alexandrina habitat score x 0.2) + (Lake Albert habitat score x 0.2) + (Goolwa Channel habitat score x 0.2) + (permanent wetlands habitat score x 0.2) + (temporary wetlands habitat score x 0.2)

2.5 Methods to assign trend, condition and reliablity

2.5.1 Trend

A Bayesian modelling approach was used to assess trend in the data collected for Lower Lakes vegetation. This modelling approach was used as it provides more information surrounding the results and allows for a more detailed assessment of trend based on variability inherent in the data. Bayesian models provide an estimate of the likelihood of the trend in the time series data assessed.

Trend analysis was undertaken in R Studio (R version 4.2.1, R Core Team 2022) using a Bayesian generalised linear model (using the stan-glm function in the rstanarm package, Goodrich et al. (2020), 4,000 runs) with a gamma family. Models aimed to determine the likelihood of trend (either positive or negative) in the proportion of targets met for Lower Lakes vegetation in each assessment period. The model included an interaction effect between time step (years since commencement of monitoring program) and habitat, to allow habitats to have different slopes as well as intercepts. As such, the likelihood of trend could be determined for Lake Alexandrina, Lake Albert, Goolwa Channel, permanent wetlands and temporary wetlands. Slope (trend) was estimated from the posterior distribution resulting from the Bayesian analysis. Trend direction was assessed using calculated probability (as per McBride 2019). A graduated scale was used to describe outcomes. Outcomes from the trend assessment were aligned with the categories used for report cards (Table 2.2).

Table 2.2. Alignment of trend outcomes based upon their likelihood of an increase or decrease (modified from Mastrandrea et al. 2010) with categories used for report cards.

Outcome	Likelihood of outcome	Report card
Virtually certain increase	>+99 to +100%	Getting better
Extremely likely increase	>+95 to +99%	
Very likely increase	>+90 to +95%	
Likely increase	>+66 to +90%	
About as likely as not	-66 to +66%	Stable
Likely decrease	<-66 to -90%	Getting worse
Very likely decrease	<-90 to -95%	
Extremely likely decrease	<-95 to -99%	
Virtually certain decrease	<-99 to -100%	

2.5.2 Condition

A methodology to rate the condition of Lower Lakes aquatic and littoral vegetation was developed in DEW (2020a). The condition rating for Lower Lakes aquatic and littoral vegetation is allocated based on the icon site score in the last condition monitoring assessment (autumn 2022). The matrix used in the conversion of an icon site score to a condition rating is provided in Table 2.3.

Table 2.3. The alignment of icon site scores for Lower Lakes aquatic and littoral vegetation with a condition rating used for report cards.

Icon site score	Condition rating
0.80–1.00	Very good
0.60–0.79	Good
0.40–0.59	Fair
<0.40	Poor

2.5.3 Reliability

The reliability of data to assess the trend and condition of Lower Lakes aquatic and littoral vegetation were scored based upon the method devised by Battisti et al. (2014) with modifications to improve its applicability to the report card process. This scoring system assesses answers to questions relating to the method used for data collection, representativeness and repetition. A scoring system as shown in Table 2.4 was used to determine a final score for data reliability that ranges between 0 and 12. Final scores are then converted into an information reliability rating that ranges between poor and excellent using the matrix in Table 2.5.

Table 2.4. Scoring system for the reliability of data used to assess and analyse trend and condition for Lower Lakes aquatic and littoral vegetation.

Methods	Question	Scoring system		
		Yes	Partially	No
Methods used	Are the methods used appropriate to gather the information required for evaluation?	2	1	0
Standard methods	Has the same method been used over the sampling program?	2	1	0
Representativeness				
Space	Has sampling been conducted across the spatial extent of the Lower Lakes and wetlands with equal effort?	2	1	0
Time	Has the duration of sampling been sufficient to represent change over the assessment period?	2	1	0
Repetition				
Space	Has sampling been conducted at the same sites over the assessment period?	2	1	0
Time	Has the frequency of sampling been sufficient to represent change over the assessment period?	2	1	0

Table 2.5. Conversion of the final score (0–12) of data reliability to an information reliability rating that ranges from poor to excellent for report cards.

Final score	Information reliability
12	Excellent
11	Very good
10	Good
9	Fair
≤8	Poor

2.6 Data transparency

Data transparency for this report card is represented in Appendix B.

3 Results

3.1 Trend

Overall, the icon site score for Lower Lakes aquatic and littoral vegetation condition is virtually certain (>99%) to have increased (i.e. is **getting better**) over the sampling program (2008–2022) (Table 3.1, Figure 3.1). The habitat scores that comprise the icon site score have all increased, with the exception of temporary wetlands (Table 3.1, Figure 3.1). Lake Albert, Lake Alexandrina, Goolwa Channel and permanent wetlands are virtually certain (>99%) to have improved, while temporary wetlands are extremely likely (96%) to have declined.

Table 3.1. Outcomes from the Bayesian modelling assessment of trend for icon site and each location. The likelihood outcomes (improvement or decline) in the icon site score and habitat scores are provided in addition to their associated confidence rating (as per Mastrandrea et al. 2010). The report card trend category was aligned with the confidence rating.

Location	Outcome	Likelihood of outcome	Report card trend category
Icon site	Virtually certain increase	>99%	Getting better
Lake Albert	Virtually certain increase	100%	Getting better
Lake Alexandrina	Virtually certain increase	100%	Getting better
Goolwa Channel	Virtually certain increase	>99%	Getting better
Permanent wetlands	Virtually certain increase	>99%	Getting better
Temporary wetlands	Extremely likely decrease	96%	Getting worse

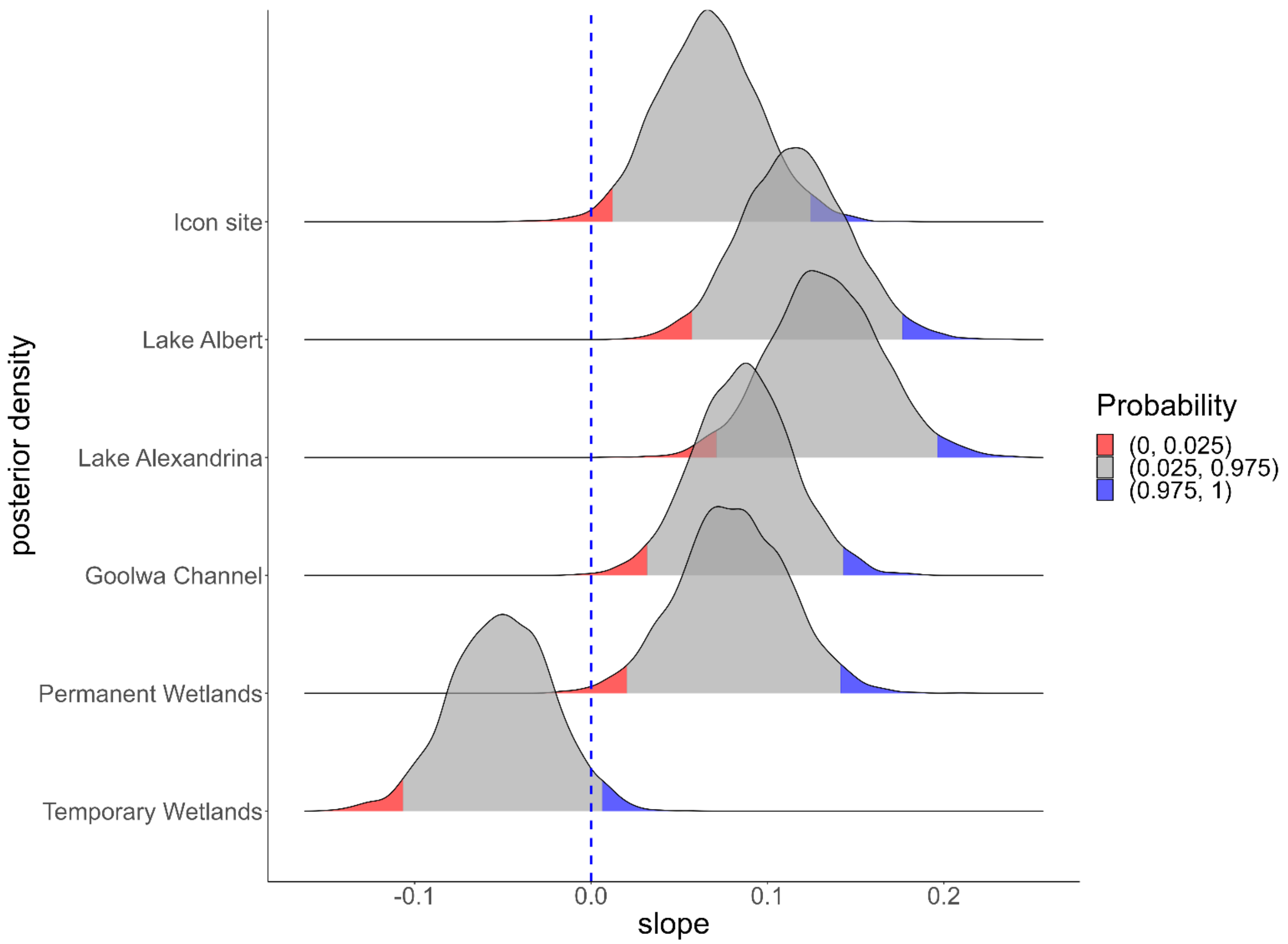


Figure 3.1. Estimated values for the slope generated from Bayesian modelling for the icon site score and habitat scores from spring 2008 to autumn 2022. Posterior slope values >0 infer a positive trend (getting better) and values <0 infer a negative trend (getting worse).

3.2 Condition

The condition of aquatic and littoral vegetation in the Lower Lakes is considered to be **good** as the icon site score was 0.74 in autumn 2022 (Figure 3.2). There was variability between habitats assessed in autumn 2022, with Goolwa Channel and permanent wetlands in very good condition, while Lake Alexandrina, Lake Albert and temporary wetlands were in good condition (Figure 3.3).

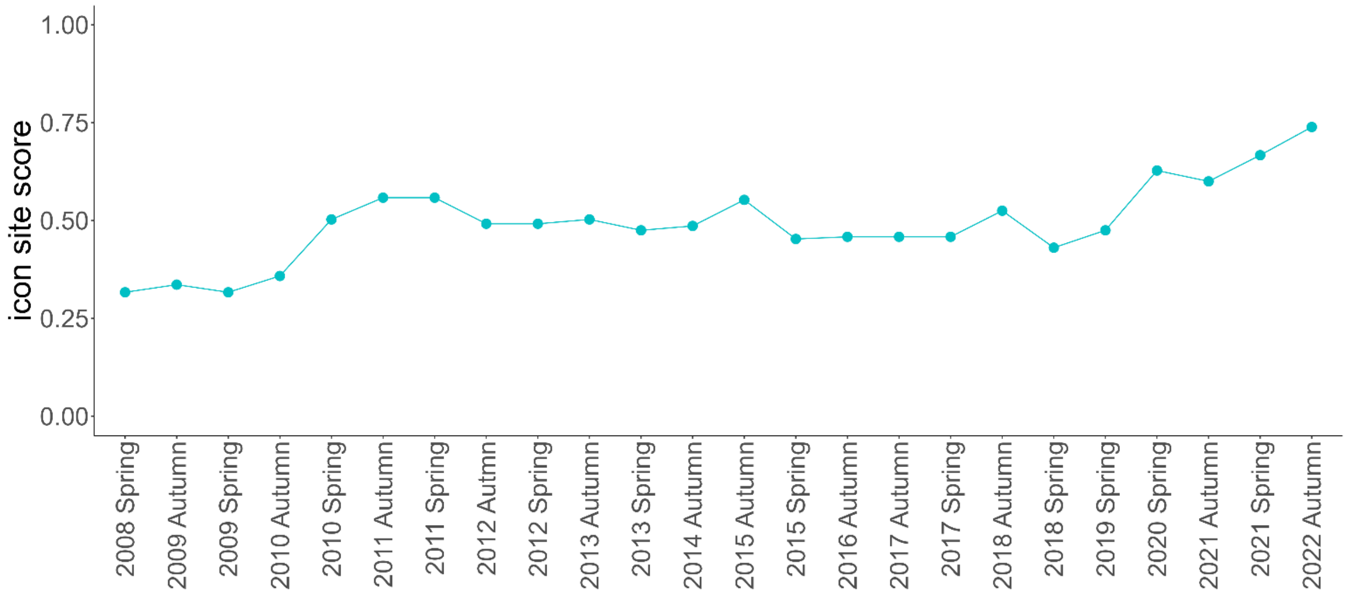


Figure 3.2. Icon site scores for the condition of aquatic and littoral vegetation in the Lakes from spring 2008 to autumn 2022.

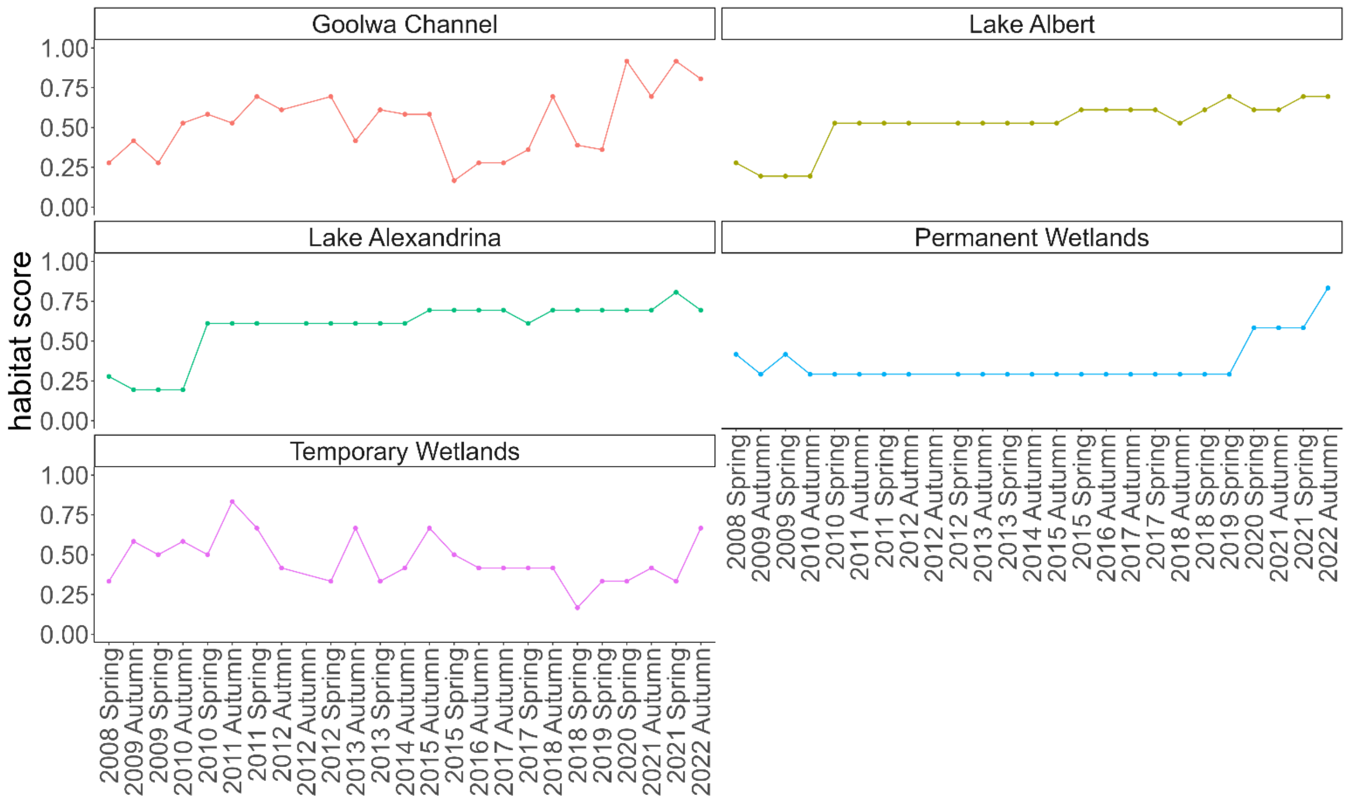


Figure 3.3. Habitat scores for each wetland type: Goolwa Channel, Lake Albert, Lake Alexandrina, Permanent Wetlands, Temporary Wetlands from spring 2008 to autumn 2022.

3.3 Reliability

The overall reliability rating for the Lower Lakes aquatic and littoral vegetation condition report card is **very good** (final score of 11). Justification for the scoring of Lower Lakes aquatic and littoral vegetation condition data reliability is provided in Table 3.2.

Table 3.2. Reliability of aquatic and littoral vegetation data to assess the trend and condition of Lower Lakes vegetation. The methods used in data collection as well as the representativeness, repetition and sample independence of data were scored based upon the answers provided to questions related to each facet of data collection. Answers to questions regarding the methods, representativeness and repetition of data were scored 2 points – Yes, 1 point – Partially, 0 points – No.

Methods	Question	Answer and justification	Score
Methods used	Are the methods used appropriate to gather the information required for evaluation?	**Yes.** Methods were peer reviewed as part of the *Condition Monitoring Plan* (DEWNR 2017).	**2**
Standard methods	Has the same method been used over the sampling program?	**Yes.** The same method has been used over the monitoring program (spring 2008 to autumn 2022).	**2**
Representativeness			
Space	Has sampling been conducted across the spatial extent of the Lower Lakes and wetlands with equal effort?	**Partially.** Sampling effort has been spread over the Lower Lakes, however, is greater in Goolwa Channel than the other habitats.	**1**
Time	Has the duration of sampling been sufficient to represent change over the assessment period?	**Yes.** Sampling has been conducted from 2008 to 2022, and therefore, includes a range of hydrological conditions.	**2**
Repetition			
Space	Has sampling been conducted at the same sites over the assessment period?	**Yes.** All sites were established by 2009 and are monitored during each assessment period.	**2**
Time	Has the frequency of sampling been sufficient to represent change over the assessment period?	**Yes.** Sampling has been conducted annually at a minimum and bi-annual data (autumn and spring) is collected in most years.	**2**
Final score			**11**
Information reliability			**Very good**

4 Discussion

4.1 Trend

The condition of Lower Lakes aquatic and littoral vegetation was determined to be **getting better** over the duration of the assessment period (2008 to 2022). Aquatic and littoral vegetation was found to be improving in condition over the vast majority of habitats within the Lower Lakes, including Lake Alexandrina, Lake Albert, Goolwa Channel and permanent wetlands. The only habitat declining in condition was temporary wetlands. The key driving factor behind the improvement in Lower Lakes aquatic and littoral vegetation condition was lake water levels and fluctuations, referred to as water regime.

The condition monitoring of Lower Lakes vegetation commenced during the height of the Millennium Drought when water levels receded to below sea level (0 m AHD), causing the extirpation of submerged plants, decreased abundance of amphibious and emergent species, and colonisation of terrestrial plants in the littoral zone (Nicol et al. 2021). Over this period, the lack of freshwater flows and evaporation increased the concentration of salt in remaining waters. Salinities in the Lake Alexandrina exceeded 5,000 EC and in the terminal Lake Albert exceeded 15,000 EC. The impacts of these elevated salinities are difficult to distinguish from those associated with lake levels below sea level. However, elevated salinities may have prevented the colonisation of submergent plants in areas of open water at lower elevations (Marsland and Nicol 2009).

Extensive flooding over the Murray–Darling Basin ended the Millennium Drought and greatly improved River Murray flow to the Lower Lakes in 2010–11. The 2010–11 flow event returned the Lower Lakes to normal operating levels (+0.4 to +0.9 m AHD) and greatly reduced salinities in Lake Alexandrina and Lake Albert (DEW 2020). The return to normal operating levels contributed to a significant improvement in Lower Lakes vegetation condition as it ensured the permanent inundation and protection of submergent plants (Nicol et al. 2021).

Since 2010–11, the improvement in whole of icon site scores and habitat scores has been less pronounced, however, there has been continual improvement in the abundance of desirable native plant species. Seasonal fluctuations in lake water levels that became pronounced since 2013–14 (+0.5 m AHD in autumn and +0.85 m AHD in spring to early summer) have likely contributed to this improvement in condition by providing opportunities for amphibious species that require exposure to germinate (Nicol et al. 2021). The whole of icon site score has continued to increase since 2018 as more targets are achieved due to increases in the abundance of desirable native plant species (Nicol et al. 2021). This suggests that it is important to maintain water regimes that vary seasonally between +0.5 m AHD and +0.85 m AHD to provide conditions for continual improvement in vegetation condition (Nicol et al. 2021).

4.2 Condition

The condition of Lower Lakes vegetation was determined to be in **good condition** based upon the most recent survey conducted in autumn 2022. Furthermore, Nicol et al. (2021) found that most of the targets not met in autumn 2022 were trending towards being met, meaning that it is likely that the whole of icon site score will improve if the water regime (+0.5 m AHD to +0.85 m AHD) that has occurred since 2013–14 continues.

5 Conclusion

Lower Lakes aquatic and littoral vegetation is in **good condition** and is **getting better**. This outcome is likely due to the water regime (+0.5 m AHD to +0.85 m AHD) that has occurred since 2013–14, which has permanently inundated submerged plants and provided wetting and drying cycles for amphibious and emergent plants, enabling the completion of their lifecycles.

6 Appendices

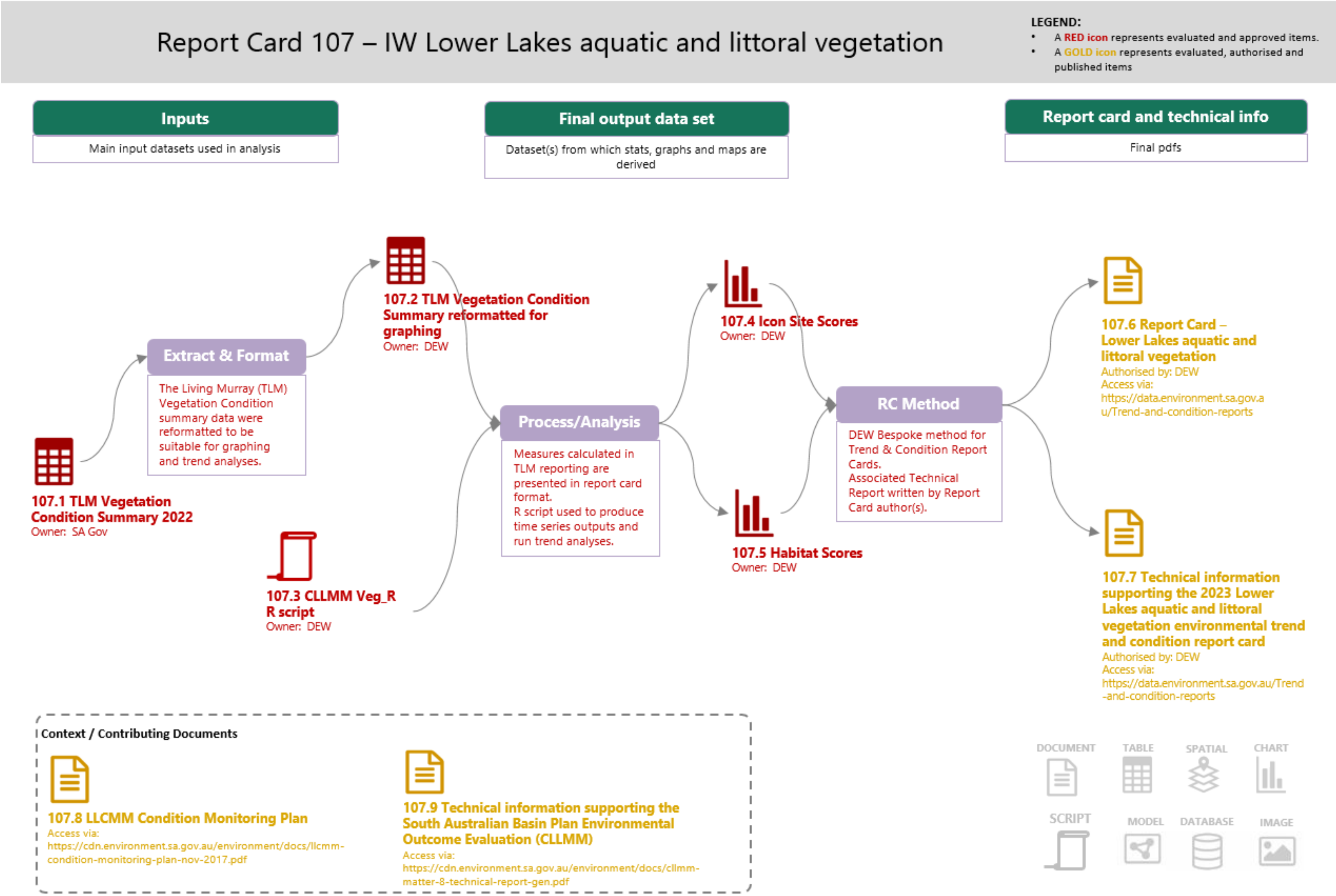
A. Vegetation indices for each habitat in the icon site (Nicol 2017)

Habitat	Zone	Target
Lake Alexandrina	Littoral +0.8 to +0.6 m AHD	<40% of quadrats in any given survey containing >75% combined cover (Braun-Blanquet score of 5) of *Typha* and *Phragmites*
		<20% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Cenchrus* and *Pasplaum*
		Minimum of 50% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater
		Minimum of 50% of quadrats in any given survey contain native emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater).
	Aquatic +0.4 m to 0 m AHD	<40% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Typha* and *Phragmites*.
		Minimum of 20% of quadrats in any given survey contain emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater).
		Minimum of 35% of quadrats in any given survey contain native submergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater).
	Deep water <0 m AHD	Permanent inundation
Lake Albert	Littoral +0.8 to +0.6 m AHD	<40% of quadrats in any given survey containing >75% combined cover (Braun-Blanquet score of 5) of *Typha* and *Phragmites*
		<20% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Cenchrus* and *Pasplaum*.
		Minimum of 35% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater
		Minimum of 35% of quadrats in any given survey contain native emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater).
	Aquatic +0.4 m to 0 m AHD	<40% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Typha* and *Phragmites*.
		Minimum of 20% of quadrats in any given survey contain emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater).
		Minimum of 20% of quadrats in any given survey contain native submergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater).
	Deep water <0 m AHD	Permanent inundation

Habitat	Zone	Target
Goolwa Channel	Littoral +0.8 to +0.6 m AHD	<50% of quadrats in any given survey containing >75% combined cover (Braun-Blanquet score of 5) of *Typha* and *Phragmites*
		<20% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Cenchrus* and *Pasplaum*
		Minimum of 50% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater
		Minimum of 50% of quadrats in any given survey contain native emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)
	Aquatic +0.4 m to 0 m AHD	<50% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Typha* and *Phragmites*
		Minimum of 20% of quadrats in any given survey contain emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)
		Minimum of 40% of quadrats in any given survey contain native submergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)
	Deep water <0 m AHD	Permanent inundation
Permanent wetlands	Littoral >+0.6 m AHD	<35% of quadrats in any given survey containing >75% combined cover (Braun-Blanquet score of 5 or greater) of *Typha* and *Phragmites*
		<20% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Cenchrus* and *Paspalum*
		Minimum of 50% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)
		Minimum of 50% of quadrats in any given survey contain native emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)
	Aquatic <+0.6 m AHD	<40% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Typha* and *Phragmites*
		Minimum of 20% of quadrats in any given survey contain emergent species (other than *Typha* and *Phragmites*) with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)
		Minimum of 50% of quadrats in any given survey contain native submergent species with a combined cover of 5 to 50% (Braun-Blanquet score 2 to 4)
Temporary wetlands (spring)	Edge	<20% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Cenchrus* and *Paspalum*
		Minimum of 50% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)
		Minimum of 50% of quadrats in any given survey contain native emergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)

Habitat	Zone	Target
	Bed	Minimum of 20% of quadrats in any given survey contain native emergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)
		Minimum of 50% of quadrats in any given survey contain native submergent species with a combined cover of ≥25% (Braun-Blanquet score 3 or greater)
		Minimum of 25% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)
Temporary wetlands (autumn)	Edge	<20% of quadrats in any given survey containing >50% combined cover (Braun-Blanquet score 4 or greater) of *Cenchrus* and *Paspalum*
		Minimum of 50% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)
		Minimum of 50% of quadrats in any given survey contain native emergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)
	Bed	Minimum of 20% of quadrats in any given survey contain native submergent species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)
		Minimum of 25% of quadrats in any given survey contain native amphibious species with a combined cover of ≥5% (Braun-Blanquet score 2 or greater)

B. Managing environmental knowledge chart for Lower Lakes aquatic and littoral vegetation



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