

The Coorong, Lower Lakes and Murray Mouth (CLLMM) Research Centre

Research Plan 2023–26

Nick Whiterod

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CLLMM
RESEARCH CENTRE

GOYDER
INSTITUTE
FOR WATER RESEARCH



The Coorong, Lower Lakes and Murray Mouth (CLLMM) Research Centre's primary objective is to develop and deliver locally driven, innovative, and impactful research which reflects the community's priorities in addressing the critical needs of the region's wetlands. The Research Centre brings together our First Nations, local communities and scientists to create and share knowledge with regard to these needs. The Centre also supports our well-informed and engaged community and will empower our future generations to be part of the solution to climate change impacts in our region.

The Goyder Institute for Water Research CLLMM Research Centre, based in Goolwa SA, was established in 2023 through funding by the Australian Government.



Australian Government
**Department of Climate Change, Energy,
the Environment and Water**

The Goyder Institute for Water Research is a partnership between the South Australian Government through the Department for Environment and Water, CSIRO, Flinders University, the University of Adelaide, and the University of South Australia.



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Science Program Summary

The Coorong, Lower Lakes and Murray Mouth (CLLMM) region is of considerable environmental, social, cultural and economic value. The region faces significant challenges posed by the impacts of climate change. The CLLMM Research Centre was established in 2023 in order to meet these challenges. Its purpose is to improve the understanding of the impacts of climate change in the region and to put in place necessary responses to these impacts. The Research Centre brings together our First Nations, local community and scientists to create and share knowledge, support our well-informed and engaged communities, and empower our future generations to be part of the solution.

‘Science and decision-making regarding the Murray Darling Basin should be coming from the local region where the results of all things from the source to the sea culminate. Combining traditional knowledge, community experience plus modern science will benefit our future generations.’

Local community member Gloria Jones

This research plan outlines the approach to develop and deliver the CLLMM Research Centre’s Science Program. It also complements the Research Centre’s First Nations Engagement Plan and its Communications and Engagement Plan. The Science Program provides critical knowledge to First Nations and the community whilst informing management and decision-making of the region as climate change impacts become more acute. The focus of the Science Program is to support the identification of management actions for achieving ecological outcomes that underpin the cultural, social and economic well-being of the region.



The scope of the Science Program includes all water types (surface water, groundwater, fresh, coastal, and marine) and associated social, ecological, economic and cultural disciplines. The Science Program addresses critical and priority knowledge gaps to inform the future management actions for the region such that the CLLMM communities, including First Nations, biota and ecosystems, adapt to a changing climate. The Science Program considers the complex interdependencies which influence the region and help to inform research-users in a way that best meets the needs of our rivers and wetlands, communities, industries and government agencies.

The Science Program has been developed and delivered in an inclusive, collaborative manner which promotes knowledge exchange and sharing whilst building capacity. The locally presented and engaged delivery method of the CLLMM Research Centre creates the opportunity to establish meaningful connections to help facilitate the transfer of research outputs and exchange of knowledge to generate shared understanding while supporting decision-making. The Science Program's outcomes contribute to the fundamental understanding of how the region responds to a changing climate, informing how we prepare for such change. Research outputs are presented in a range of formats, ensuring that they are readily available to decision-makers and the community to facilitate knowledge adoption into policy and planning.

The Science Program of the CLLMM Research Centre

- develops and implements research which aligns with its overarching climate change focus and themes
- focuses on gaps in current knowledge and builds on past and current research
- is informed by the values and priorities of community and First Nations, and aligns with the management and policy needs of research-users
- is overseen, prioritised and evaluated by a robust governance structure
- is delivered by multi-disciplinary project teams of world-leading scientists
- has research-users embedded in project governance and delivery to allow co-design and co-implementation
- ensures accessible and clear communication of research outcomes in a variety of ways to maximise knowledge sharing and translation to meet the specific needs of research-users to inform decision-making and policy.

The Science Program has the overarching focus of understanding the impacts and necessary responses to climate change across the CLLMM region. Within this focus, research themes of climate adaptation, ecosystem services, climate mitigation, threatened species and biodiversity have been identified. Extensive community, First Nations and research-user consultations have identified these priority research topics. Previous research and existing knowledge gaps have also recognised these as priorities. The Research Centre Advisory Forum (RCAF) has confirmed the prioritisation of these research topics. As such, these themes have guided the development of the projects delivered by the CLLMM Research Centre. The projects addressed identified knowledge gaps in our understanding of the how climate change will impact the region.

To date, 24 projects utilising these research themes have been included in the Science Program. These include four **foundational scoping** projects identifying research projects for key thematic areas. There are four **flagship** research projects addressing critical aspects of



the impact of climate change which will guide transformative change in knowledge and understanding across the region. There are ten **research** projects providing knowledge on a broad range of research topics across the region. There are two **knowledge sharing and capacity building** projects, and an student grants program currently supporting five student research projects. Additional projects, including First Nations-led projects, are to be established as warranted. This would occur as the result of foundational scoping projects, alignment with priority research topics or through emerging collaborations with researchers across the Murray-Darling Basin.

The Science Program represents a well-rounded research agenda that aligns with the priorities of the community and First Nations as well as the management needs of research-users in the face of changing climates (Figure 1). Within the climate adaptation research theme, the Climate Adaptation flagship project containing a series of eight sub-projects that provide the modelling to forecast future changes to prevailing conditions across the region, and the anticipated impacts for water quality and nutrient cycling, as well as the incidence of harmful algal blooms. Retrospective synthesis of drought ecology and recovery provides knowledge on how the Millenium Drought impacted the region, and what post-drought recovery has been achieved to provide context for understanding future drought events.

The ecosystem services research theme includes the Ecosystem Services flagship project which will provide knowledge on broader social, economic and ecological implications of climate change, such as fish and fisheries, community health, socioeconomic, First Nations and community values. It will also evaluate what future policy considerations may be necessary. Insight into how the ecosystem services of the region respond to more frequent and intense periods of extreme drought and flooding is to be addressed through the Community adaptation to worsening droughts and floods in the CLLMM research project.

Under the climate mitigation theme, research into a range of climate solutions is to be conducted. This includes exploring options to improve estuarine connectivity, providing an assessment of a blue and teal carbon potential, and evaluating previous revegetation efforts to guide a landscape revegetation strategy for the region.

The threatened species and biodiversity research theme considers key threats to the region's species, biodiversity and habitats, including the ecology and threats to the Coorong's ocean beach. The waterbird project involves a series of four sub-projects focusing on waterbird movement, conservation modelling, condition monitoring and impacts to shorebirds. Research projects on freshwater species (small-bodied freshwater fish and floodplain mussels) will help to understand and plan to mitigate the anticipated impacts of climate change on species that occupy freshwater ecosystems across the region.

The knowledge sharing and capacity building projects of the Research Centre provide an immersive experience to assist discussions on climate change, as well as a student research program to help build capacity for future researchers in the region. A horizon scan of emerging issues will identify future research and engagement priorities.

The model of practice implemented by the CLLMM Research Centre provides a platform for long-term and locally relevant knowledge generation and sharing in the CLLMM region, which is also applicable to other regions of the Murray-Darling Basin.



The CLLMM Research Centre

The term 'CLLMM Research Centre' encompasses all the activities of the Research Centre, including development, management, and delivery of the Science Program along with engagement and knowledge sharing with community, First Nations, and research-users.

Background

The Goyder Institute for Water Research Coorong, Lower Lakes and Murray Mouth (CLLMM) Research Centre was announced by the Federal Minister for the Environment and Water, the Hon Tanya Plibersek MP, in October 2022, following the advocacy of Rebekah Sharkie MP, Deputy Premier Susan Close MP and local community members. The Institute received an \$8 million grant from the Australian Government over four years (2022–26) to establish the CLLMM Research Centre to work with communities and First Nations to investigate the impacts of climate change on the CLLMM region. The Department of Climate Change, Energy, the Environment and Water (DCCEEW) is the funding administrator of the CLLMM Research Centre. The Research Centre entered its establishment phase on 1 July 2023 and is being delivered by the Goyder Institute for Water Research.

Objectives and outcomes

The CLLMM Research Centre's objective is to deliver locally driven, innovative, and impactful research which reflects community and First Nations priorities to provide an evidence base to address management and decision-making of the CLLMM region. The Research Centre also brings together our First Nations, local communities and scientists to create and share knowledge, support our well-informed and engaged community, and empower our future generations to be part of the solution.

The objectives of the CLLMM Research Centre are to

- provide critical knowledge to inform the identification of future management actions such that CLLMM biota and ecosystems adapt to a changing climate, the desired environmental outcomes of the Basin Plan are achieved, and international (Ramsar) obligations are met
- support community well-being, including that of First Nations, through knowledge creation and provision to support management actions for the restoration of a healthy CLLMM that supports local values and the integration and incorporation of the scientific knowledge of First Nations, the community, governments and researchers into the management of the region
- enhance the long-term prosperity of the CLLMM region through locally based research in which community and First Nations can participate and lead in cultural and scientific activities
- establish the CLLMM region as a world-leader of the creation, integration, and adoption of the scientific knowledge of First Nations, communities, governments and researchers for the sustainable management of wetlands
- develop internationally recognised environmental water leaders in South Australia, a local community engaged in science to address future challenges for the region.

By achieving these objectives, the CLLMM Research Centre will deliver the following high-level outcomes



- long-term prosperity of the CLLMM region through locally based research which empowers community and First Nations to participate and lead in cultural and scientific activities
- establishing the CLLMM region as a world leader in the creation, integration, and adoption of the scientific knowledge of First Nations, communities, governments, and researchers for the sustainable management of wetlands
- influencing the desired environmental outcomes of the Basin Plan and seeing that international obligations are met.

A further outcome is the successful implementation of the principle of inclusive participation in the operation of the CLLMM Research Centre. The Research Centre approaches its Science Program creation in a collaborative, bottom-up manner, where community and First Nations are directly involved alongside government agencies and scientists in the development and implementation of research projects, as well as engagement activities. This approach creates a basis for community and First Nations to feel meaningfully connected and supported by the Research Centre. Together, they showcase the CLLMM region as a leader of locally driven knowledge creation and exchange which informs management.

Location

The CLLMM Research Centre is situated in Goolwa, South Australia, in the heart of the nationally and internationally significant wetland region. The Goolwa office provides a base for the team and researchers, as well as a central point to host community discussions and forums, education events for all ages, and provides an immersive experience through virtual and augmented reality to deepen connections with the local environment.

Capacity and activities

The CLLMM Research Centre is managed by four locally based staff under the guidance of the Goyder Institute for Water Research Director. The Science Program is managed by the Science Program Manager. The passion and knowledge of the community, First Nations and research-users, defined as end-users utilising the research outcomes, are critical to the development and implementation of the Research Centre's Science Program. The Goyder Institute for Water Research is a collaborative partnership with the South Australian Government through the Department for Environment and Water (SA DEW), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Flinders University, University of Adelaide and the University of South Australia. The CLLMM Research Centre has access to world-leading scientists, including those from the Goyder Institute for Water Research partner organisations. The Research Centre is focused on knowledge sharing and exchange with community, First Nations and research-users. The Science Program is impactful and incorporated into policy, management and decision-making as well as informing how community and First Nations respond to climate change.



Background

The region

The Coorong, Lower Lakes, and Murray Mouth (CLLMM) region (Figure 1) is critical for the prosperity of the local community, South Australia and Australia. The region supports cultural values that underpin the well-being of First Nations people. It also contributes to the recreational, aesthetic and economic values of the community, including productive commercial and recreational fisheries and other industries, such as tourism. Located at the end of the one million km² Murray-Darling Basin (MDB), the CLLMM region is also of significant environmental value. It is the only place in the Basin where the river meets the sea, with the connection of the freshwater ecosystems (river, tributaries, lakes), the hyper saline Coorong, and marine ecosystems supporting a dynamic and diverse region.



FIGURE 1 LOCATION OF THE (A) COORONG, LOWER LAKES AND MURRAY MOUTH (CLLMM) REGION WITHIN THE (B) MURRAY-DARLING BASIN OF AUSTRALIA



The Science Program will focus on the connected River Murray, tributaries, Lower Lakes, Coorong, Southern Ocean and surrounding landscape. Recognising the linkages of wetlands across spatial scales, the Science Program will consider spatial scales outside of the CLLMM region where appropriate, such as the wetland systems in the locality but outside of the CLLMM Ramsar boundary; drivers of the health of the system; and management interventions upstream and at basin, national and international scales that may have impact on the CLLMM region. It will proactively learn from end-of-Basin wetland systems throughout the world and share learnings from the region internationally.

First Nations

The CLLMM region is culturally significant to the Ngarrindjeri Nation and First Nations of the South-East. It has been their home for thousands of years and will continue to be their home despite future climate change. The First Nations knowledge of the region is critical for the CLLMM Research Centre to understand the implications of future climate change in the region as oral histories and creation stories connect First Nations to place, time and their ancestors. The CLLMM region is described in detail throughout these histories and provides insight into how various environments of the region were created, how these environments interacted with each other, and how to live sustainably within them.

The Ngarrindjeri Nation is an Aboriginal nation currently consisting of three main dialect groups: the Ramindjeri, Yaraldi and Tanganekald. These groups are further divided into 18 Laklinyerar (clans), then into individual family groups who occupy the lands and waters of the CLLMM region, and who hold their own Nga:tjar (totems). The Ngarrindjeri nation extends up the River Murray from Lake Alexandrina and Lake Albert, down the length of the Coorong and through the coastal area to Encounter Bay.

The Boandik, or First Nations of the South-East, are an Aboriginal nation divided into five main tribes: the Booandik; Mootatunga/Meintangk, Putarawutj, Witchintunga and the Ngarkat. Each tribe inhabits their own territory, ranging from north of Lacepede Bay at Salt Creek, South Australia, across to Bordertown on the Victorian border, and then south to the coast where the mouth of the Glenelg River in far-western Victoria forms the south-eastern corner. Each tribe speaks different dialects of the Bunganditj language (language of the Boandik), and all share a common matrilineal kinship.

It is fundamental to respect and integrate the wealth of First Nations knowledge into research being generated by the CLLMM Research Centre. This brings invaluable perspectives that can help to achieve a fully understanding of how we address the issues facing the region. The CLLMM Research Centre aims to support First Nations community well-being by providing knowledge creation and sharing opportunities, and the incorporation of the scientific knowledge of First Nations with that of the community, governments, and researchers into the management of the region. It is imperative to ensure this is done in a collaborative, respectful and culturally appropriate manner (in accordance with the CLLMM Research Centre First Nations Engagement Plan). The Research Centre achieves this through locally based knowledge sharing and research in which community and First Nations can participate and lead in cultural and scientific activities that build upon existing cultural knowledge. It empowers communities to take charge of the management of their land and



waters. The Research Centre creates opportunities to help build First Nations capacity involvement in Centre activities, including co-designing and leading on research, knowledge sharing, and participation in educational activities.

Community and industry

The CLLMM region is home to a population of approximately 40,000 people centred around the major townships of Murray Bridge, Goolwa, Strathalbyn, Tailem Bend, Milang and Meningie. The region's population is expected to grow substantially, with the greatest increases projected for Murray Bridge, Goolwa and Strathalbyn.

The CLLMM region supports a range of industries: agriculture (including irrigated), health care and social support, tourism and commercial fisheries. Many of these are dependent on the region's water resources.

Environmental history and management

The CLLMM region maintains significant cultural, environmental, social, and economic importance (Mosley et al. 2018). Although there has been some debate, the weight of evidence indicates that the Lower Lakes were largely fresh, with moderate tidal influence of seawater during periods of low river inflows over that past 7,000 years (Chiew et al. 2020; Tibby et al. 2022). The pre-development long-term average annual freshwater inflow from the River Murray into the region was more than 13,000 gigalitres (GL), which was sufficient to maintain ecosystems of the region whilst ensuring the Murray Mouth remained permanently open. Since European settlement, the freshwater inflows to the CLLMM region from the River Murray have reduced by approximately half due to upstream river regulation and water abstraction. Across the 1930s and 1940s, a series of five barrages was constructed along the seaward margins of Lake Alexandrina to separate the saline waters of the Coorong and the Murray Mouth Estuary with the freshwater Lower Lakes. The barrages have helped to maintain relatively stable lake levels whilst improving water quality in the lower Murray and Lower Lakes. Fishways have been constructed on each barrage to improve connectivity and to allow migration for species to complete their natural lifecycle by moving between the ocean, Coorong and lakes. The Murray Mouth first closed completely in 1981 due to reduced freshwater flows. Since 2002, dredging has been required to maintain an open mouth except for the periods (2010–15, 2016–17 and 2022–23) associated with, and following, high flows.

The CLLMM region was designated as a Wetland of International Importance under the Ramsar Convention in 1985. It met eight of the nine criteria, including regularly supporting significant populations of waterbirds, conserving significant species or ecological communities, its fish diversity and a range of wetland types (DEH 2000). Under the Ramsar Convention, the Australian Government is obligated to manage all Australian Ramsar sites to maintain their ecological character, to be aware of any changes to ecological character, and to notify the Ramsar Secretariat of any changes to ecological character.

The prolonged and severe Millennium Drought (1996–2010) imposed devastating environmental, economic, social and cultural impact on the CLLMM region (Kingsford et al. 2011; Muller et al. 2018). Critical water shortage between 2007 and 2010 toward the end of the drought resulted in the closure of the Murray Mouth (and ongoing dredging thereafter),



high water scarcity, water restrictions for community and irrigators, broad-scale loss and drying and disconnection of a range of aquatic habitats, exposure of acid sulfate soils, deterioration of water quality, increased salinity including hyper salinity in the Coorong, and exposure of significant First Nations cultural sites. These impacts combined to push the region to the verge of ecological collapse and deteriorate the well-being of local communities and the prosperity of the region, and prompted management intervention (Kingsford et al. 2011; Muller et al. 2018). High flows across the MDB over 2010 and early 2011 led to the return of water availability to the region. Since then, there has been some, but not full, ecological recovery across the region, aided by high flow events observed in 2012, 2016–17 and 2022–23. With agreement on the Murray-Darling Basin Plan in 2012, there has been a provision of water for the environment delivered to the CLLMM region (MDBA 2012; MDBA 2019). The objectives for water for the environment in the region include maintaining flow over the barrages to support connectivity and salt export as well as increasing the variability of lake water levels to maintain ecological function. Further water management and reform is necessary to increase water security to support CLLMM region (Brookes et al. 2023).

Other management initiatives, such as The Living Murray (TLM) program, CLLMM Recovery Project, and Healthy Coorong, Healthy Basin (HCHB), have improved the environmental health of the region and informed management decision-making. The 2022–23 flood event, led to very large volumes of freshwater flowing through the region, and into the adjacent marine environment. Research undertaken by the Goyder Institute for Water Research has explored how the Lower Murray and the marine ecosystem responded to the 2022–23 flood event (see **Error! Reference source not found.**).

Climate change

Climate change is projected to have significant but variable impacts across the Murray-Darling Basin (MDB) (Robertson et al. 2021; Whetton and Chiew 2021). For the CLLMM region at the end of the Basin, the impacts of climate change are likely to manifest through reduced freshwater inflows, warming of land and water, increasing sea level and more frequent and severe storm surges (Chiew et al. 2020; Rees et al. 2022; Western et al. 2019a; Western et al. 2019b). Whilst there is uncertainty in the rate of change, magnitude and influence of these impacts, they will increasingly lead to a cascade of ecological changes over coming decades, which will make management of the region increasingly challenging. Some of the potential impacts to the region are provided below.

For the Coorong, reduced freshwater inflows will lessen the frequency of freshening events, and increasing temperatures would increase evaporation rates, yet sea level rise will act to increase connectivity which will reduce prevailing salinity across both the Coorong North and South Lagoons (Chiew et al. 2020). For the Lower Lakes, reduced freshwater inflows, increased lake evaporation, and seawater ingress will make the maintenance of desired water levels and salinity concentration problematic, resulting in an increased demand on water resources. For the Murray Mouth, reduced freshwater inflows will quite likely lead to permanent dredging being required. Sea level rise will increase sand barrier erosion, possibly resulting in breaches of Sir Richard Peninsula and Youngusband Peninsula (Chiew et al. 2020). The higher sea level would also increase the frequency of overtopping the barrages and barrier islands, allowing the ingress of seawater into the lake and creating challenges



for barrage operations (Chiew et al. 2020). These changes will strongly impact the social, cultural, ecological and economic values of the region (Grigg et al. 2022).

There is increasing recognition of the challenges that climate change will pose for the management of water resources across the MDB. The early insights paper to guide the process for the Basin Plan Review (MDBA 2024) identifies six key climate risks

- Reduced ability for communities to meet their water needs due to reductions in water volume, reliability and quality, increased reliance on groundwater and higher temperatures.
- Adverse impacts to water-dependent ecosystems, habitats and environmental assets due to reductions in water volumes and quality, changes in timing and intensity of rainfall, and higher temperatures and extremes, combined with other environmental change and degradation.
- Impacts on First Nations' objectives and requirements such as spiritual, Cultural, customary, economic, heritage, water rights and interests, due to climate-related changes in river systems and environment, including depleted water supplies and increased water demand.
- Adverse impacts on Basin employment and economic activities, particularly in the agriculture and tourism industries, due to rising temperatures and increased extractive water demand, coupled with increased variability and reductions in water availability, reliability, and quality.
- Adverse impacts on the amenity, liveability, and livelihoods of Basin communities due to changes to stream flow, reduced water quality, or climate-related changes in water-dependent environments.
- Reduced ability to enjoy recreation or benefit from the economic or employment benefits of tourism and recreation activities in the Basin due to climate related changes to the condition of the river system and environment, including reductions in water volume, reliability and quality and/or higher temperatures.

These key climate risks are all particularly relevant to the CLLMM region and targeted research is necessary to inform the decision-making of community, First Nations and management agencies.



Research context

National and Murray-Darling Basin priorities

The CLLMM Research Centre's research plan is strongly aligned with Australia's draft National Science and Research Priorities (Australian Government 2023). This research plan is consistent with several objectives under the key priorities of 'Ensuring a net zero future and protecting Australia's biodiversity' and 'Building a stronger, more resilient nation'. The Research Centre aligns with the Murray-Darling Basin Authority's (MDBA) objective to use the best available peer-reviewed hydrological, environmental, social and economic science, along with local knowledge, to manage the Basin. The research plan consistently aligns with priority themes and priorities under several strategies and programs of the MDBA, such as the Murray–Darling Water and Environment Research Program (MD-WERP), Native Fish Recovery Strategy (MDBA 2020) and The Living Murray (TLM) program.

Past and current research activities

One Basin Cooperative Research Centre (One Basin CRC)

The One Basin CRC focused collaboration developing policy, technical and financial solutions to support and reduce exposure to climate, water and environmental threats in the Murray-Darling Basin. Established in 2022, the One Basin CRC represents a \$50 million program over 10 years, granted through the Commonwealth Cooperative Research Centres Program, to support a new partnership to achieve a more productive, resilient and sustainable Murray-Darling Basin and beyond through the One Basin CRC. The One Basin CRC is a focused collaboration developing policy, technical and financial solutions to support and reduce exposure to climate, water and environmental threats in the Murray-Darling Basin. Research delivered through the One Basin CRC aligns with foresight and decisions, technology and opportunity, and capability and commercialisation programs that address agricultural-water challenges for the Basin.

Murray–Darling Water and Environment Research Program (MD-WERP)

The Murray–Darling Water and Environment Research Program (MD-WERP) is a \$20 million program over four years (2021–25) to strengthen scientific knowledge of the MDB. Through the MD-WERP, three Australian Government partners (DCCEEW, CEWO and MDBA) collaborate with research partners to deliver research across climate adaptation, hydrology, environmental outcomes and social, economic and cultural outcome themes.

Long-Term Intervention Monitoring (LTIM), Environmental Water Knowledge and Research (EWKR), Flow Monitoring Evaluation Research (Flow-MER) and Flow-MER2.0

The CEWO have funded monitoring and research programs across the MDB. From 2014 to 2019, the CEWO funded the Long-Term Intervention Monitoring (LTIM) and the \$10 million Murray-Darling Basin Environmental Water Knowledge and Research (MDB EWKR) projects. The LTIM Project aimed to monitor and evaluate the use of Commonwealth environmental water and the EWKR Project aimed to improve knowledge about ecological responses to



environmental water to better inform adaptive management (Gawne et al. 2020; Thurgate et al. 2020). The Flow Monitoring, Evaluation and Research (Flow-MER) program, delivered from 2019 to 2024, and continued research to deliver improved methods and a richer evaluation of environmental outcomes from Commonwealth environmental water. Flow-MER 2.0, announced in June 2024, represents a further \$90 million investment in monitoring, research and evaluation across the MDB over the next seven years (2024–2031).

The Living Murray (TLM) Program

The TLM program, funded by the MDBA was established in 2002 to improve the health of six designated sites, known as icon sites, including the Lower Lakes, Coorong and Murray Mouth (SA) Icon Site. The TLM program is continuing to return water to the environment through purpose-built infrastructure that helps deliver water to the icon sites and improve the health of the River Murray. The TLM has funded condition and intervention monitoring of key aspects of the ecosystem (Bice et al. 2023; Bice et al. 2020; Wedderburn et al. 2012; Wedderburn et al. 2014; Wedderburn et al. 2020; Wedderburn et al. 2022).

2022–23 Flood response research

The South Australian Department for Environment and Water (SA DEW) initiated two projects to explore the 2022–23 flood response of the South Australian section of the River Murray, including the CLLMM region. As well as undertaking research relating to blackwater risks, groundwater salinity and carp responses, Flood Response (Phase 1) Immediate Investigations included research to understand the immediate response impacts of the River Murray's plume water quality and impacts on marine habitats and species. Flood Response (Phase 2) focuses solely on the Coorong, including investigating the influence of the flooding on the nutrient store, dynamics and food webs of the Coorong. It also includes investigating on-ground ecological restoration actions in the form of macroinvertebrate translocations. Research outcomes will be available by late 2024. Outcomes of both projects will provide valuable insights into the response of the region to once-in-a-generation high River Murray flows, enabling effective management and conservation strategies.

Healthy Coorong, Healthy Basin (HCHB)

Project Coorong is an overarching \$77 million Commonwealth and South Australian Government investment, consisting of numerous projects aimed at restoring a healthy Coorong. This includes the Healthy Coorong, Healthy Basin (HCHB) Action Plan, which outlines possible on-ground works, management tools, research, trials and investigations, and other activities between 2019 and 2024 to restore a healthy future for the Coorong. The Action Plan presents a working vision for the restoration characterised by healthy vegetation with abundant and diverse populations of waterbirds, fish and plants. A large proportion of the research-focused trials and investigations component of the HCHB program was managed by the Goyder Institute for Water Research and led to the development of a series of ecological models and climate adaption tools for the Coorong.



CLLAMMecology

The CLLAMMecology Research Cluster was a partnership between the CSIRO, the University of Adelaide, Flinders University and the South Australian Research and Development Institute (SARDI) Aquatic Sciences that received a total investment of \$5.3 million over three years (2006–09). The aim of the Research Cluster was to develop an ecosystem-level understanding of the Coorong, Lower Lakes and Murray Mouth. CLLAMMecology undertook research to understand the links between the key ecosystem drivers for the region, such as water level and salinity, and key ecological processes, such as the generation of bird habitat and fish recruitment. There were four themes of CLLAMMecology: (1) targeting the response of key species, (2) quantifying productivity and trophodynamics in the system, (3) mapping dynamic habitat availability, and 4) assessing likely ecological responses to a range of alternative futures. This final theme, named CLLAMM Futures, was an integrating theme that combined existing knowledge and knowledge derived from the other themes during CLLAMMecology to develop an ecosystem response model for the Coorong to help evaluate the environmental trade-offs for different scenarios of manipulation of management levers, as well as different future climate scenarios for the Murray-Darling Basin (Lester et al. 2009).

Independent research

The CLLMM region has been the subject of a variety of independent research studies by local and national organisations, which have shaped the understanding and knowledge of the CLLMM region. We are conscious of ensuring that this knowledge is reflected in the development and delivery of the CLLMM Research Centre's Science Program.



Establishing the Science Program

Purpose and principles

The Science Program was developed, and will be delivered, in an inclusive, collaborative manner that promotes knowledge exchange and sharing whilst building capacity. The locally present and engaged delivery method of the CLLMM Research Centre creates meaningful connections to help facilitate the transfer of research outputs and exchange of knowledge to generate shared understanding whilst supporting decision-making. The Science Program's outcomes will contribute to the fundamental understanding of how the region responds to a changing climate, informing how we prepare for such change. Research outputs will be presented in a range of formats, ensuring that they are readily available for decision-makers and the community to facilitate knowledge adoption in policy and planning.

The Science Program of the CLLMM Research Centre will

- develop and implement research that aligns with the overarching climate change focus and themes of the research
- focus on gaps in current knowledge and build on past and current efforts
- be informed by the values and priorities of community and First Nations, and align with the management and policy needs of research-users
- be overseen, prioritised and evaluated by a robust governance structure
- be delivered by multi-disciplinary project teams of world-leading scientists
- have research-users embedded in project governance and delivery to allow co-design and co-implementation
- ensure accessible and clear communication of research outcomes in a variety of ways to maximise knowledge sharing and translation to meet the specific needs of research-users to inform decision-making and policy.

The Science Program will deliver locally driven, innovative, and impactful research that reflects community and First Nations priorities to provide an evidence base to address the critical needs of the CLLMM region.

Research governance

The Department of Climate Change, Energy, the Environment and Water (DCCEEW) is the funding administrator of the CLLMM Research Centre. The Science Program is governed by existing Goyder Institute for Water Research governance structures as well as the newly established governance for the specific purposes of the CLLMM Research Centre (Figure 2). The Research Centre's governance has varying degrees of interaction with the Science Program. The Research Centre Advisory Forum (RCAF) underpins the Science Program, providing strategic guidance, prioritisation and support for projects and engagement opportunities. The Science Program Manager and CLLMM Research Centre staff are responsible for the development and delivery of the research of the Science Program. The Goyder Institute for Water Research, Research Advisory Committee (RAC) provides project endorsement from a Goyder partner perspective whereas the Goyder Institute for Water Research Management Board provides strategic guidance on the operation of the Research Centre. The Commonwealth Steering Committee (CSC) provides high-level



strategic alignment and evaluation of the Science Program. Collectively, the governance structures ensure robust research generation, delivery and connectivity to policy and decision-making across multiple scales.

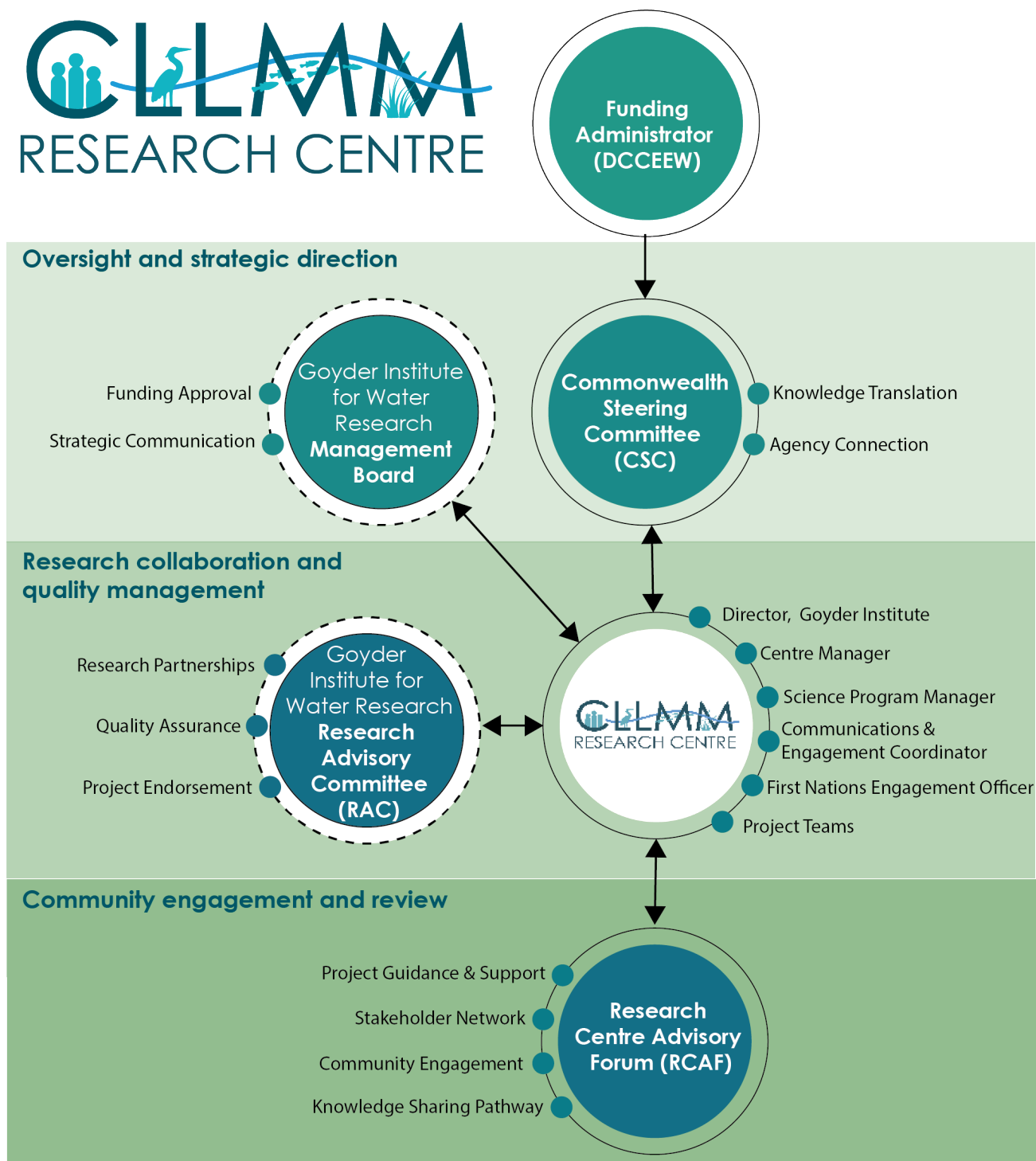


FIGURE 2 THE CLLMM RESEARCH CENTRE GOVERNANCE STRUCTURE SUMMARY

CLLMM Research Centre Advisory Forum (RCAF)

The Science Program's development and delivery is guided by the CLLMM Research Advisory Forum (RCAF). The primary objective of the forum is to support the CLLMM Research Centre in achieving its goals and advancing its mission. The RCAF consists of members of the



community including First Nations, First Nations organisations (Burrandies Aboriginal Corporation, Miwi Inyeri Pelepi Ambi Aboriginal Corporation, Moorundi Aboriginal Community Controlled Health Service, Ngarrindjeri Aboriginal Corporation, Ngarrindjeri Ruwe Empowered Communities) and management agencies (SA DEW, Hills and Fleurieu Landscape Board, Murraylands and Riverland Landscape Board), SA Water, SA National Parks and Wildlife Service, Murray-Darling Basin Authority (MDBA), local councils (Alexandrina Council, Coorong District Council and Rural City of Murray Bridge), and the science leadership group (CSIRO, SA DEW Science, Flinders University, University of Adelaide, and University of South Australia). From early 2024, the RCAF will meet up to six times a year. The current membership of the RCAF is provided in Table 1.

TABLE 1 MEMBERSHIP OF THE CLLMM RESEARCH CENTRE ADVISORY FORUM (RCAF)

ORGANISATIONS
Alexandrina Council
Burrandies Aboriginal Corporation
Community members
Coorong District Council
CSIRO
First Nations Community member
Flinders University
Hills and Fleurieu Landscape Board
Miwi Inyeri Pelepi Ambi Aboriginal Corporation
Moorundi Aboriginal Community Controlled Health Service
Murray Darling Basin Authority
Murraylands and Riverland Landscape Board
Ngarrindjeri Aboriginal Corporation
Ngarrindjeri Ruwe Empowered Communities
Rural City of Murray Bridge
SA DEW Management
SA DEW Science
SA National Parks and Wildlife Service
SA Water
University of Adelaide
University of South Australia



CLLMM Research Centre and research partners

The CLLMM Research Centre Science Program Manager oversees the development and implementation of the Science Program with support from the other CLLMM Research Centre staff (Centre Manager, First Nations Engagement Officer and Communications and Engagement Coordinator) and the Goyder Institute for Water Research Director. The Science Program Manager oversees all aspects of the Science Program's development and delivery. Researchers from the Goyder Institute for Water Research research partners (CSIRO, Flinders University, University of Adelaide and University of South Australia) and non-partner researchers identify a project lead and project teams to implement projects initiated by the Research Centre with support from the Science Program Manager.

Goyder Institute for Water Research, Research Advisory Committee (RAC)

Each research project developed by the CLLMM Research Centre, which is supported by the RCAF, is subject to review and endorsement by the Goyder Institute for Water Research, Research Advisory Committee (RAC). In relation to the CLLMM Research Centre, the RAC ensures that the Institute's research is of international quality, and projects inform management decision-making across multiple scales while also identifying and mitigating any organisational risks to the Goyder Institute partner organisations. The RAC is chaired by the Goyder Institute for Water Research Director and comprises a representative from each research partner, up to two representatives from agencies as determined by the State, and one representative from each of the Institute's affiliate partners: SA Water and the SA Environment Protection Authority. The RAC meets quarterly, with current membership provided in Table 2.

TABLE 2 MEMBERSHIP OF THE GOYDER INSTITUTE FOR WATER RESEARCH, RESEARCH ADVISORY COMMITTEE (RAC)

MEMBERS	ORGANISATIONS	EXPERTISES
Alec Rolston (Chair)	Goyder Institute for Water Research	Director of Goyder Institute for Water Research and leader in water management with a long history of involvement in the CLLMM region
Justin Brookes	University of Adelaide	Expertise in limnology and water treatment and the ecology of the CLLMM region
Lin Crase	University of South Australia	Expertise with applied economics, often in the context of water and agriculture in the Murray-Darling Basin
Tanya Doody	CSIRO	Experience with groundwater dependent ecosystems and ecological responses of floodplain and riparian tree vegetation
Bec Quinn	SA Department for Environment and Water	Expertise with freshwater, River Murray and Coorong science



Peter Goonan	SA Environment Protection Authority	Expertise with hydro-ecological monitoring and ecosystems across South Australia
Paul Monis	SA Water	Expertise in the areas of biotechnology and microbiology
Ilka Wallis	Flinders University	Hydrogeologist with areas of expertise in quantitative hydrogeology and geochemistry
Christopher Wright	SA Department for Environment and Water	Expertise in policy and strategy development, science delivery and preparation of advice

Goyder Institute for Water Research Management Board

The Goyder Institute for Water Research Management Board sets the strategic direction of the Institute and assesses the performance of the Institute against that direction. The Management Board also approves the Manager seeking approval from parties to execute Project Agreements, annual plans, budgets and finance reports. The Management Board provides strategic oversight of the delivery of the CLLMM Research Centre. The Management Board meets quarterly, with current membership provided in Table 3.

TABLE 3 MEMBERSHIP OF THE GOYDER INSTITUTE FOR WATER RESEARCH MANAGEMENT BOARD

MEMBERS	ORGANISATIONS	EXPERTISE
Jody Swirepik (Independent Chair)	Goyder Institute for Water Research	Extensive executive experience across several management agencies, including as Commonwealth Environmental Water Holder
Alec Rolston	Goyder Institute for Water Research	Director of Goyder Institute for Water Research and leader in water management with a long history of involvement in the CLLMM region
Okke Batelaan	Flinders University	Strategic Professor in Hydrogeology, with extensive experience in groundwater hydrology, urban hydrology, ecohydrology, groundwater modelling and land use and climate change impacts on groundwater systems
Dan Jordan	SA Department for Environment and Water	Executive expertise in water management policy, particularly in the Murray-Darling Basin
Carmel Pollino	CSIRO	Expertise in water resources management, including water security, environmental flows, hydrology, ecology and integrated river basin planning



Ben Van Den Akker	The University of South Australia	Expertise in environmental health, microbiology, wastewater management and urban water management
Bronwyn Gillanders	The University of Adelaide	Expertise in freshwater and marine ecology including integrated marine management, coastal carbon opportunities, fish and fisheries and assessing ecological and environmental change

Commonwealth Steering Committee (CSC)

The Commonwealth Steering Committee (CSC) oversees and provides guidance and strategic advice to ensure delivery of research through the Science Program that supports policymaking and is relevant for decision-making. The CSC facilitates promotion and integration of the Science Program outputs to inform Commonwealth decision-making and policy. It is also tasked with providing awareness of other research programs across the Commonwealth to assist in aligning Research Centre activities, avoiding duplication of research and providing advice to effectively value add to current and ongoing research activities.

The CSC evaluates the progress of the project against established deliverables and assesses how project findings are beneficial for the region and its communities. It also provides guidance and perspectives on the integration of research outputs produced by the Research Centre to inform Basin-wide decision-making. It provides advice on the transferability of the outcomes to policymaking. The CSC meets quarterly, with current membership provided in Table 4.

TABLE 4 MEMBERSHIP OF THE CLLMM RESEARCH CENTRE COMMONWEALTH STEERING COMMITTEE (CSC)

MEMBERS	ORGANISATIONS	EXPERTISE
Phil Coates (Chair)	DCCEEW	DCCEEW, Branch Head – Murray-Darling Basin Economics and Science
Sheryl Hedges	DCCEEW	DCCEEW, Branch Head - First Nations Water
Marcus Finn	DCCEEW	DCCEEW, Branch Head - Northern Basin, Science and First Nations
Matt Coleman	MDBA	MDBA, General Manager - Science Acquisition
Alec Rolston	Goyder Institute for Water Research	Director of the Goyder Institute for Water Research and leader in water management with a long history of involvement in the CLLMM region
Bruce Male	DCCEEW	DCCEEW, Director, Water Science and Policy Section
Hamideh Nouri	DCCEEW	DCCEEW, Assistant Director, Water Science and Policy Section



Developing and delivering the research

The Science program's research is developed and delivered using a 10-step process (Table 5). It includes engagement (Step 1) and prioritisation of research topics (Step 2), identification, and establishment of project teams (Step 3) and project planning with input from relevant stakeholders (Step 4). Following development, projects are to be endorsed by governance groups (Step 5). The contracts will then be initiated and approved before the project commences (Step 6). Project delivery (Step 7) includes the involvement of community and First Nations (Step 8) along with concurrent project management (Step 9) and knowledge dissemination (Step 10). Successful implementation of the 10-step process ensures that high-quality research projects are initiated, that delivery reflects community and First Nations priorities, and that the research addresses management needs for the CLLMM region in line with its overarching climate change focus and research themes.

TABLE 5 SUMMARY OF THE STEPS INVOLVED IN DEVELOPMENT AND DELIVERY OF THE SCIENCE PROGRAM

STEPS	ACTIVITIES	APPROACHES	OUTCOMES
1	Engagement with community, First Nations, and research-users to confirm research themes and identify broad research topics	The Science Program Manager led stakeholder engagement, employing diverse platforms for targeted consultation to confirm support for the research themes of the Research Centre and identify broad research topics. These included summarising engagement and research prior to the establishment of the Research Centre, community surveys, targeted meetings with stakeholders, presentations at community conversations, and engagement in community activities. In addition, information was gathered through ad hoc conversations and meetings.	<ul style="list-style-type: none"> • Broadly engaged stakeholders (community, First Nations, research-users) • Establishment of levels of interest for involvement of stakeholders • Identification of hundreds of potential research ideas and topics
2	Prioritisation of research topics by Research Centre Advisory Forum (RCAF)	The Science Program Manager directed the prioritisation process executed during the two RCAF meetings. Ahead of these meetings, members were acquainted with research themes and topics, affording them time to pose questions and offer feedback. During the RCAF sessions, participants individually prioritised four research themes and engaged in an interactive exercise to nominate and discuss priority research topics. This interactive process fostered additional discourse and collaboration among members,	<ul style="list-style-type: none"> • Stakeholder ideas distilled 40 research topics • Opportunity to identify additional research topics • Robust process to prioritise research topics • Identification of priority research topics • Detailing of RCAF members interests and experience



		facilitating the sharing of areas of significance.	
3	Identification of researchers through Expression of Interest (EOI) process and establishment of project teams with expertise on research topics	The Science Program Manager developed initial project scopes for priority research topics and initiated an EOI process in accordance with the agreed-upon research topics to gauge interest from the Goyder Institute's research partners. The process identified researchers possessing the requisite expertise and capacity to participate in project teams for the development and delivery of projects. Collaborative discussion, led by the Science Program Manager, resulted in the identification of project leads and finalised project teams.	<ul style="list-style-type: none"> • 82 researchers (126 EOIs) identified from the Goyder Institute partners with expertise and capacity to develop and deliver research projects • Establishment of multi-disciplinary, multi-organisation project teams of world-leading experts • 82 partner and 14 non-partner researchers (96 researchers in total) along with representatives from more than ten regional organisations will delivery projects
4	Planning by project teams with input from stakeholders to develop projects	The project teams, in collaboration with the Science Program Manager, CLLMM Research Centre staff, and relevant stakeholders, will define scope, establish objectives, tasks, and methodologies, develop communication strategies and opportunities for community, First Nations and research-user involvement in delivery.	<ul style="list-style-type: none"> • Opportunity for stakeholders to guide project development • Development of projects that reflect community and First Nations priorities and management needs of research-users • Identification of stakeholders with interest in participating in project delivery
5	Endorsement of the projects by Research Centre Advisory Forum (RCAF) and the Goyder Institute for Water Research, Research Advisory Committee (RAC)	Facilitated by the Science Program Manager, Research Centre governance will evaluate the projects. This involves the RCAF providing support for the progression of the projects based on the project summaries aligning with Research Centre objectives and values and importance to community, First Nations, and research-users. Detailed project plans and budgets will then be endorsed by the RAC based on the assessment of associated risks.	<ul style="list-style-type: none"> • Robust endorsement process capturing advisory forum and Goyder Institute partner perspectives • Opportunity for further feedback on projects
6	Contract approval and project commencement	Liaison between the Science Program Manager, project leads and partner Research Offices will occur to initiate contracting, involving approval of sub-contract agreements and creation of work orders, to facilitate commencement of project.	<ul style="list-style-type: none"> • Establishing contractually agreed tasks and milestones • Timely implementation of project



7	Project delivery	Implementation of tasks identified in the project plans will be undertaken using agreed project teams and methodologies.	<ul style="list-style-type: none"> • Implementation of tasks of the project • Generation of research knowledge
8	Connection with community and First Nations	Involvement of community and First Nations on scoping, delivery, and completion phases of each research project. Engagement is between the Communications and Engagement Coordinator, First Nations Engagement Officer, project leads and the Science Program Manager. Opportunities for involvement will vary with each project and each stage of the project and will range from targeted workshops/yarning circles, engagement activities, science forums and volunteering opportunities.	<ul style="list-style-type: none"> • Coordination of volunteers and involvement in research projects • Opportunity to emphasise research outcomes and implications to community and First Nations for further dissemination across wider networks
9	Project management: reporting, review, and evaluation	Management of separate projects, including discussions with project leads, budgetary and milestone oversights, risk mitigation, progress reporting and RCAF presentations. Collaborative reporting in line with Research Centre interim and annual report milestones. Research project reporting including technical reporting, factsheets, infographics, and First Nations summaries.	<ul style="list-style-type: none"> • Ensure project is delivered on time and on budget • Provide feedback mechanism to facilitate effective project management and delivery • Establish pathway to share project progress, identify challenges and risks, and articulate research outcomes
10	Knowledge dissemination and assimilation	Knowledge dissemination of research outcomes occurs across all research governance of the CLLMM Research Centre and the Goyder Institute for Water Research as well as to management agencies. Knowledge is then disseminated across wider networks. Knowledge transfer occurs through community and First Nations annual science forums, public educational workshops and events, and regular communications.	<ul style="list-style-type: none"> • Establish tailored approaches to distribute project outcomes to community, First Nations and research-users • Provide platform to inform policy and decision-making

Step 1: Engagement of community, First Nations and research-users

Consistent with the values of the CLLMM Research Centre established in the grant agreement, the research plan is to be developed, and the Science Program delivered in an inclusive, collaborative manner that promotes knowledge exchange and sharing whilst



building capacity. The central focus of the CLLMM Research Centre is creating and sharing knowledge which reflects community and First Nations priorities along with addressing the critical management needs of the region, as outlined in the Research Centre's First Nations Engagement Plan. It is paramount that the Science Program reflects the strong cultural significance and well-informed and engaged community of the region. To achieve this, we will bring together our First Nations, local community and scientists to create and share knowledge through the Science Program. This connection will be achieved throughout the development and implementation of the Science Program. We will continually seek feedback on how the Research Centre is meeting the needs of community and First Nations.

The Science Program was informed by a bottom-up participatory approach that captured the values and perspectives of a broad range of community, First Nations and research-users across the region (Figure 3). The outcomes of engagement that occurred prior to the establishment of the Research Centre (reflected in the Research Centre grant agreement) were initially reviewed to ensure they maintained relevancy. After the Research Centre was established, widespread engagement and consultation was undertaken. This was achieved through informal discussions with community members, Community Conversation events, a CLLMM Research Centre survey, foundational scoping projects and strategic meetings with community groups, First Nations and research-users (Table 6).



FIGURE 3 SOME OF THE ENGAGEMENT ACTIVITIES THAT HELPED IDENTIFY RESEARCH IDEAS AND TOPICS.

The general community was engaged along with community groups such as Kumerangk Hindmarsh Island Landcare Group. First Nations engagement is incorporating not only First Nations organisations (Ngarrindjeri Aboriginal Corporation and Burrendies Aboriginal Corporation) but also the broader First Nations community. First Nations engagement involved initial discussions and relationship building, utilising previous and existing engagement outcomes, involvement in scoping projects, and participation on RCAF. This was always conducted in a collaborative, respectful and culturally appropriate manner. A range of research-users, such as the local governments (Alexandrina Council, Coorong District Council, and Rural City of Murray Bridge), landscape boards (Hills and Fleurieu Landscape Board, Murraylands and Riverland Landscape Board, and Limestone Coast Landscape Board), SA Water, SA DEW, MDBA, Commonwealth Environmental Water Office (CEWO) and DCCEEW, has been engaged. This represents a unique opportunity for those



connected with the region to guide the research to be delivered by the CLLMM Research Centre. In total, more than 1000 individuals from over 50 organisations, community groups and the broader community inputted into the direction of the Science Program.

TABLE 6 SUMMARY OF DETAILS OF ACTIVITIES TO ENGAGE COMMUNITY, FIRST NATIONS AND RESEARCH-USERS

ACTIVITIES	DETAILS
Review of previous research priorities	Synthesis of existing planning to collate previously identified knowledge gaps
Informal discussions with community	Acquire priority topics from community members who may not engage with formal events
Community Conversation events	Broad engagement to identify community and stakeholder priorities
<u>CLLMM Research Centre Survey</u>	Identify priority areas of focus and topics through a structured online survey
Community forums and presentations such as annual science forum	Showcase the research being delivered by the CLLMM Research Centre, ensure research continues to align with priorities and provide opportunities to discuss future needs
Foundational scoping projects	Generate research priorities for specific areas of focus (waterbirds, First Nations, iconic species) through targeted stakeholder engagement
Strategic meetings with key community, First Nations and research-users	Widespread consultation with state and national management agencies and community groups to identify priority areas for research
Research Centre Advisory Forum (RCAF) meetings	Discussions of research projects and align with overarching climate change theme and research direction

A key aspect of this engagement was to ensure the Research Centre was focusing on novel research that is addressing knowledge gaps across the region. This was achieved through a gap analysis that involved synthesising previous and current research across the MDB and CLLMM region, ensuring discussions covered research being conducted and identifying upcoming research priorities by other stakeholders. This approach ensured helped to identify novel potential research ideas and topics (not being addressing by others), establish collaborations and partnerships to value-add to existing research and maximise the value of the research. The project-specific outcomes of the gap analysis are detailed in the Science Program section.

Step 2: Prioritisation of research topics

The engagement undertaken through Step 1 identified numerous ideas that warrant research attention. These ideas were distilled into research topics across research themes that could form the basis of the research delivered through the Science Program. A number of the research topics aligned closely with the flagship areas of focus that had been identified through previous and current stakeholder engagement, and which formed the key research theme of the Research Centre. These were also supported through the granting agreement with the Australian Government and were included in the development of the flagship projects. The remaining 40 research topics were subjected to prioritisation processes



to identify additional projects to be delivered by the Research Centre. The Science Program Manager directed the implementation of the prioritisation process, which was executed during the initial two RCAF meetings (Figure 4).

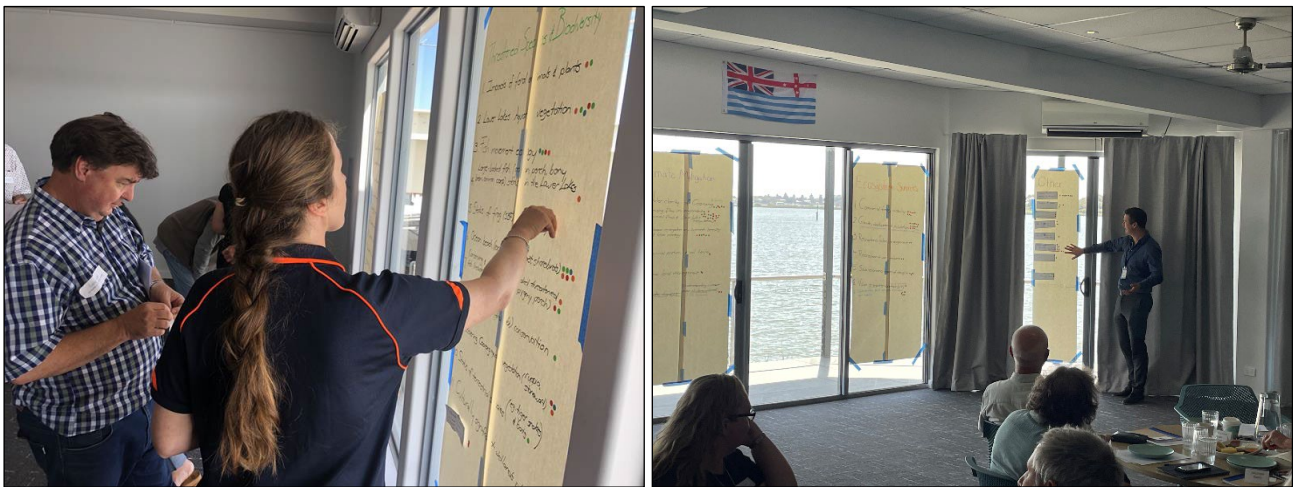


FIGURE 4 THE RESEARCH TOPIC PRIORITISATION BY MEMBERS OF THE RESEARCH CENTRE ADVISORY FORUM

Ahead of these meetings, members were acquainted with the research themes and topics, affording them time to pose questions and offer feedback. During the RCAF sessions, participants individually prioritised four research themes to provide guidance on the relative allocation of resources across the themes. Subsequently, the RCAF engaged in an interactive exercise by nominating their top 10 research project topics from the pool of 40 research topics. This interactive process fostered additional discourse and collaboration amongst the members. The scores for the research topics were aggregated to rank the priority research topics. Through this process, priority research topics were identified to proceed to Step 3.

Step 3: Identification and establishment of project teams

An Expression of Interest (EOI) process was implemented to identify suitable researchers with expertise and capacity to develop and deliver research projects aligning with the priority topics. When responding, each interested researcher had to declare that they were willing to connect with and involve community, First Nations and end-users during project development and delivery; work collaboratively with other project team members; and commit to maximising the impact of the CLLMM Research Centre's Science Program. The EOI was distributed through the RCAF's science leadership group, the Goyder Institute for Water Research RAC, Institute partner organisations' research offices and other avenues to identify suitable researchers from the Goyder Institute for Water Research research partners as well as selected non-partner researchers.

This process identified 82 interested Goyder partner and non-partner researchers with 128 project-specific EOIs across the priority research topics. Through initial discussions of project logistics and scope, project leads were identified, and project teams established. Overall, 82 partner and 14 non-partner researchers (96 researchers in total) along with representatives from more than ten regional organisations will deliver the projects of the CLLMM Research Centre. The project teams have the capacity to be involved, have relevant expertise and



willingness to develop and deliver research projects consistent with the objectives of the Science Program and CLLMM Research Centre.

Step 4: Planning by project team with input from stakeholders to develop projects

Following the identification of project leads and the establishment of project teams, planning for each project was initiated. Through a series of discussions between the Science Program Manager and the project teams along with specific community, First Nations and end-users, individual project scope was established. Objectives, tasks, timeframes and project team roles were articulated; the perspectives of the stakeholders were incorporated; and opportunities were identified for stakeholders to connect with project delivery. This collaborative planning process ensured that projects addressed knowledge gaps and avoided overlap with other projects and the work of stakeholders across the region. It also guaranteed that projects aligned with our overarching climate change focus and the research themes of the Science Program. It fostered positive connection amongst the stakeholders by ensuring their expertise and perspectives were reflected whilst identifying opportunities for stakeholders to connect with project delivery.

Step 5: Endorsement of project

As the project planning continued, a project summary was presented to the RCAF to gain support for the project progressing to further development. The presentation took the form of a written summary detailing project title, research theme alignment, project team, timeframe, summary, technical summary and objectives, approach, stakeholder connections, and management implications. The presentation also provided an opportunity for RCAF feedback and identification of additional stakeholders to engage with during project development and delivery. For projects supported by the RCAF, formal project plans and budgets were developed subject to a second stage of evaluation through the Goyder Institute for Water Research RAC. The RAC was tasked with reviewing project plans, and budgets for projects supported by the RCAF, to ensure they met the requirements of the Goyder Institute for Water Research processes, as well as reviewing any potential reputational risk for the Institute's partner organisations.

Step 6: Contract approval and project commencement

RCAF supported and RAC endorsed projects progressed toward project initiation. Contracting was delivered through the University of Adelaide as Manager of the Goyder Institute for Water Research.

Step 7: Project delivery

Projects are to implement tasks using agreed project teams and methodologies outlined in the endorsed project plans. Projects will be delivered in a timely manner in line with the milestones outlined in the endorsed project plans. Delivery is to be undertaken in accordance with permits and approvals relevant to the tasks of each project. Teams will work with stakeholders in an inclusive and collaborative manner. Risks to project delivery will be acknowledged through individual project risk registers and mitigated over the duration of the project.



Step 8: Connection with community and First Nations

Connecting with community and First Nations will take place during each stage of delivery and project management. During the initial delivery phases, community and First Nations will be given opportunities to learn, understand and provide input into project topic development. Subsequent community and First Nations engagement will follow events and plans described in the CLLMM Research Centre's First Nations Engagement Plan and the Communication and Engagement Plan. Engagement activities will vary, but may include workshops, meetings, volunteering opportunities, seminars and annual science forums. Throughout the duration of the project, stakeholder meetings and regular engagement will occur to ensure transparency with community and First Nations and relevant managing bodies. These will also allow for routine feedback and input into the Science Program.

Step 9: Project management

Each project will be managed by the project lead and team with support from the Science Program Manager and other CLLMM Research Centre staff. Project leads and teams will use project management experience and project management tools within their organisations. The CLLMM Science Program Manager will oversee project delivery to ensure tasks are completed to meet the milestones identified in the endorsed project plan and ensure that any risks are mitigated. Reporting on the progress of projects will align with the reporting requirements of the Research Centre. Project progress will be articulated by using consistent project status diagrams (Figure 5). This project status reporting divides the project into planning, approval, delivery and reporting phases with progress to be updated quarterly. The project status updates will be used in the management reporting of the CLLMM Research Centre and relevant project summaries. The Science Program Manager and Communications and Engagement Coordinator will work collaboratively with each project lead and team to manage stakeholder connections and knowledge dissemination during project delivery. Each project is expected to participate in engagement events, such as the Annual Science Forum, community presentations and workshops. Project written outputs will include combinations of a technical report, factsheet, infographic and a First Nations summary.

Project outputs will be managed in accordance with the Goyder Institute for Water Research's existing policies, procedures and guidelines, and reviewed by the Science Program Manager and other staff when necessary. Technical reporting will also be reviewed by the Science Program Manager and other staff where necessary, and by two independent external reviewers with appropriate expertise. Final reports will be subject to endorsement prior to publication by the Goyder Institute for Water Research RAC who will assess whether changes recommended by the independent reviewers have been addressed appropriately and whether there are any matters that present significant risks to the Institute and its partner organisations. Completed research projects will be subject to the Goyder Institute's formal project evaluation process. Additionally, evaluation by the project lead and CLLMM Research Centre Science Program Manager will occur to identify future improvements in project management and delivery.



How to read the project status updates?

Each project will have a project status diagram, like the one below. These diagrams will be updated quarterly and be included in management reports, relevant project updates and on the website.

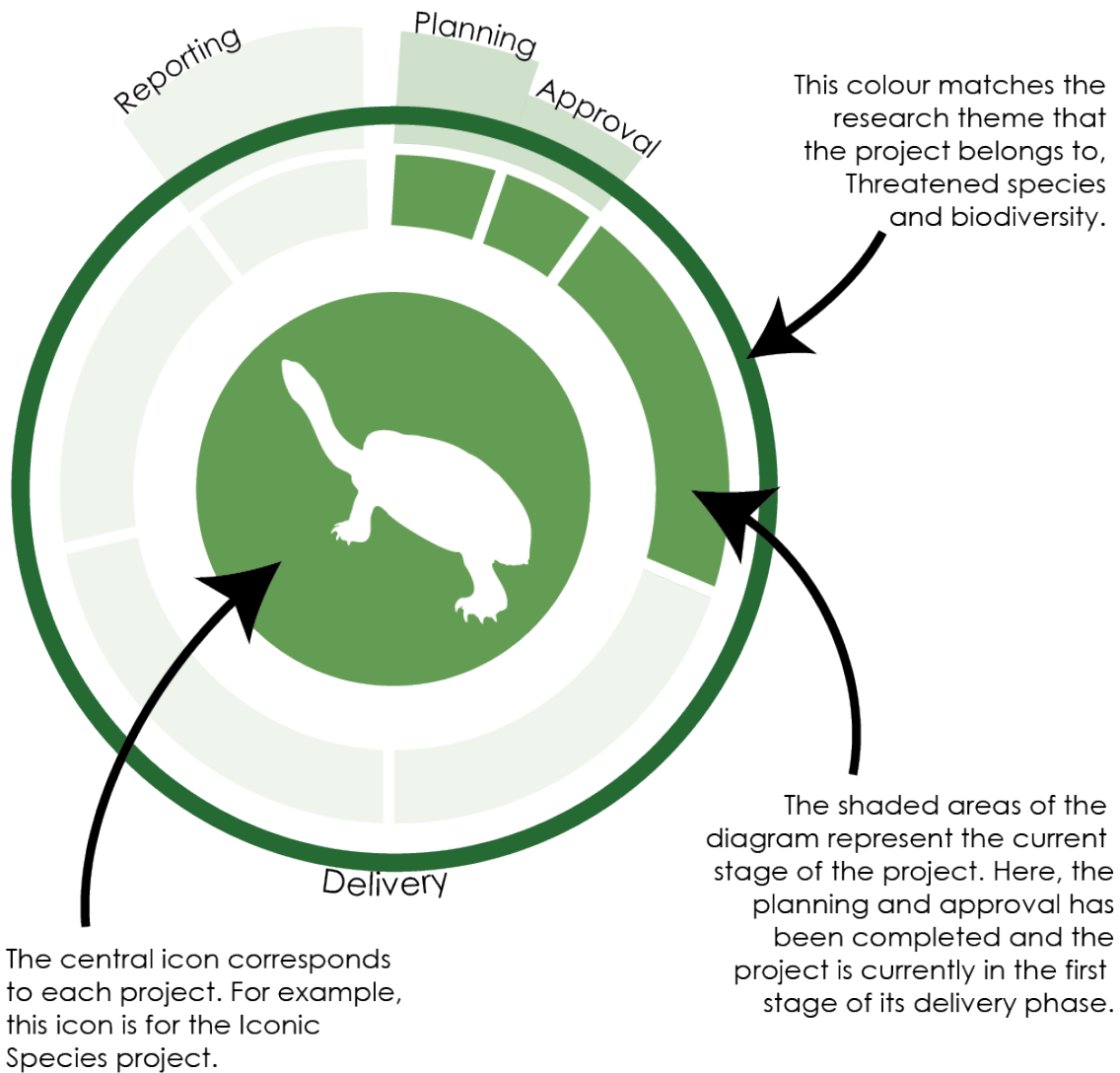


FIGURE 5 HOW TO READ THE STATUS UPDATES FOR PROJECTS OF THE CLLMM RESEARCH CENTRE

Step 10: Knowledge dissemination and assimilation

The Science Program will deliver impactful research and knowledge sharing. The model of practice utilised by the CLLMM Research Centre has created the opportunity for meaningful connections with a broad range of stakeholders, including national, state and local management agencies, business and industry, First Nations, community groups and the general public. These connections will help facilitate the transfer of research outputs and exchange of knowledge to generate shared understanding as well as a supported approach to inform policy and management. Tailored approaches are being established to enable for-purpose dissemination of research outcomes to community, First Nations and



research-users (see CLLMM Research Centre First Nations Engagement Plan and CLLMM Research Centre Communications and Engagement Plan) achieved by

- consulting widely to ensure that community and First Nations priorities and research-user management needs are reflected in the Science Program
- creating a Research Centre governance structure that provides a platform for input from and engagement with a range of stakeholders
- embedding community, First Nations and research-users in project governance and delivery to allow co-design and co-implementation
- ensuring accessible and clear communication of research outcomes in a variety of ways to maximise knowledge sharing and translation to meet the specific needs of research-users.

Community and First Nations will have direct access to the research outcomes with knowledge sharing including involvement in CLLMM Research Centre operations, project delivery, communication events (such as annual science forums), school education programs, and regular communication and informal discussions with CLLMM Research Centre staff. This model of practice along with its governance structures ensures that the CLLMM Research Centre has a platform for the translation of its Science Program outcomes by research-users into decision-making and policy. Research-users have been incorporated into project planning and embedded into project delivery. They will also have tailored dissemination approaches. Project updates and outcomes will also be provided to all the governance structures of the CLLMM Research Centre to provide a further opportunity for assimilation into decision-making and policy. For instance, research-users will have access to research outcomes that can be integrated into strategic planning (new National Water Agreement and Basin Plan reform) currently underway. The CSC and RCAF will play an important role in translating research outcomes and maximising uptake by research users.

The local and regional relevance and strong established stakeholder connections will ensure that the CLLMM Research Centre can achieve effective knowledge dissemination of the Science Program that promotes assimilation into decision-making and policy. The research outcomes will be made available to management agencies to enable it to inform decision-making and policy.



The Science Program

Overarching focus and research themes

The Murray-Darling Basin faces an uncertain future as the long-term impacts of river regulation and over abstraction are increasingly exacerbated by the intensification of climate change. This poses profound challenges for water security, biodiversity and communities across the Basin, and forces transformational change for communities and management. There will be greater demand for water resources and, increasingly, trade-offs will need to be considered. Now more than ever, a strong evidence base is necessary to provide guidance in addressing the critical needs of community and management. The CLLMM region at the end of the Basin is among the most vulnerable to the impacts of climate change and requires science-informed actions to maintain social, economic, environmental and cultural values.

The CLLMM Research Centre's Science Program provides critical knowledge to inform management of the region as climate change impacts become more acute. It considers the complex interdependencies that influence the region and helps to inform end-users in a way that best meets the needs of our rivers and wetlands, communities, industries and government agencies with their decision-making. The Science Program is strongly focused on reflecting community and First Nations values and priorities in the creation and implementation of the research projects. Under the overarching focus of climate change, the research of the CLLMM Research Centre aligns with the research themes established through previous engagement prior to the establishment phase of the Research Centre. These research themes are climate adaptation, ecosystem services, climate mitigation and threatened species and biodiversity (Figure 6).



Climate adaptation: determining the anticipated impacts of climate change on the region and identifying management actions to protect and enhance the ecological, social, cultural and economic values under future climate scenarios

Ecosystem services: establishing the social, economic, ecological and cultural values that the region supports, and identifying those that are critical to maintain into the future for a vibrant and prosperous CLLMM region



Climate mitigation: identifying solutions and new management interventions needed to oversee the ecological, social, cultural and economic values of the region

Threatened species and biodiversity: determining the immediate and future knowledge needs to inform management actions to maintain threatened species and biodiversity across the region



FIGURE 6 RESEARCH THEMES OF THE SCIENCE PROGRAM



Additional projects will be initiated over the duration of the Research Centre. Furthermore, the Research Centre is fostering relationships that will facilitate broader collaborative projects contributing to the Science Program. The projects to be delivered by the CLLMM Research Centre will generate and share knowledge to collectively advance our understanding of the impacts and necessary responses to climate change in our region.

The engagement process and analysis of knowledge gap ensured that the Science Program focused on novel research that is addressing knowledge gaps in the region. For each project, the actions addressing knowledge gaps are provided in detailed in Table 7 to 10.



Foundational scoping projects

A series of short-term foundational research projects is underway to help identify research projects for key thematic areas (Table 7). The foundational research projects involve the review of current knowledge and targeted stakeholder engagement relating to the following focus areas: the development of waterbird research priorities for the CLLMM region, First Nation knowledge and research priorities, identifying iconic species of the region, and horizon scanning for emerging topics across the CLLMM region. The research priorities identified across these foundational research projects will shape longer-term research projects to be implemented over the duration of the CLLMM Research Centre.

TABLE 7 SUMMARY OF THE FOUNDATIONAL SCOPING PROJECTS IN DEVELOPMENT BY THE CLLMM RESEARCH CENTRE

RESEARCH THEMES	PROJECT TITLES	SUMMARIES	ACTIONS TO ADDRESS KNOWLEDGE GAPS
Threatened species and biodiversity	Identification of waterbird research priorities for the Coorong, Lower Lakes and Murray Mouth region	The project will involve literature review of climate change impacts on waterbirds, a series of targeted stakeholder workshops and prioritisation assessment to identify feedback on waterbird research priorities for the CLLMM region.	<ul style="list-style-type: none"> Synthesis of previous research and outcomes of stakeholder consultations to update waterbird research priorities
Threatened species and biodiversity	Foundational iconic species of the Coorong, Lower Lakes and Murray Mouth	This project establishes research priorities for iconic species (nationally threatened and migratory, community important, and culturally significant) across the region	<ul style="list-style-type: none"> Establishment of the first list of iconic species for the CLLMM Compiling of current understanding and knowledge gaps for iconic species
All	Establishing First Nations knowledge and research priorities	This project identifies key knowledge and research priorities for First Nations and establishes a framework for inclusion in research projects.	<ul style="list-style-type: none"> Meaningfully capturing First Nations knowledge and research priorities and translating into research projects
All	Horizon scanning for emerging topics across the Coorong, Lower Lakes and Murray Mouth	This project engages stakeholders to identify and prioritise emerging challenges, and opportunities that will shape the management of the CLLMM region into the future	<ul style="list-style-type: none"> Foresighting of emerging research topics for the CLLMM Integrated approach engaging community, managers and researchers

A summary of the project lead, project overview, key stakeholders and duration for each foundational project are provided below.





Identification of waterbird research priorities for the Coorong, Lower Lakes and Murray Mouth region

PROJECT TYPE	Foundational scoping
THEME ALIGNMENT	Threatened species and biodiversity
PROJECT TEAM LEAD FIRST	Thomas Prowse (University of Adelaide); Ruth Cope (University of Adelaide); Johanna Kuhne (University of Adelaide); Steve Delean (University of Adelaide); Rebecca Boulton (BirdLife Australia); Phill Cassey (University of Adelaide); Justin Brookes (University Adelaide)
TIMEFRAME	October 2023 to May 2024
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>This project will work towards restoration and impact reduction on the culturally significant waterbird species of the CLLMM region in the face of climate change. Many waterbird species are Nga:tjar (totems) for the Ngarrindjeri and First Nations of the South-East. There is a cultural obligation for Ngarrindjeri people to care for the Nga:tjar of the CLLMM region and to keep them on country and healthy. These waterbirds have cultural significance for the Ngarrindjeri people through their role in creation stories and served and continue to serve as a traditional food source through consumption of their meat or eggs. By understanding the behaviours, populations and likely future habits of waterbirds in the CLLMM, we can strive to reduce the loss of cultural practices and culturally significant species during the forecast climate change scenarios.</p>
SUMMARY	The project will involve literature review of climate change impacts on waterbirds, a series of targeted stakeholder workshops and prioritisation assessment to identify feedback on waterbird research priorities for the CLLMM region.
TECHNICAL SUMMARY AND OBJECTIVES	<p>The diverse and abundant waterbird community of the CLLMM played a central role in the region's listing as a Wetland of International Importance under the Ramsar Convention. The CLLMM is an important site for migratory shorebirds of the East Asian–Australasian Flyway, many species of which have suffered population declines. The CLLMM also provides foraging and breeding habitat for non-migratory waterbirds and acts as a habitat refuge for many species during drought conditions. Significant opportunity exists to consult with diverse stakeholders to develop future waterbird research streams, and to engage community scientists in the delivery of this research.</p> <p>The overarching goal is to develop a prospectus for waterbird research priorities in the CLLMM and surrounds, based on workshops with key stakeholder groups. The specific objectives of this proposal are to</p> <ul style="list-style-type: none"> • collaborate with diverse stakeholders, including First Nations groups, government, environmental NGOs (eNGOs) and scientists to identify key knowledge gaps relating to the ecology and management of waterbirds in the CLLMM region



	<ul style="list-style-type: none"> • employ this knowledge to identify priority projects for consideration within the CLLMM Research Centre portfolio over the 2024 to 2026 timeframe.
SUMMARY OF APPROACH	The project involves a literature review of climate change impacts on waterbirds, a series of targeted stakeholder workshops and prioritisation assessment to identify feedback on waterbird research priorities for the CLLMM region.
STAKEHOLDER CONNECTIONS	The project has strong links to community, First Nations and research-users. The project engages numerous stakeholders representing First Nations and community, 'Friends' groups, eNGOs, South Australian and Commonwealth government agencies, and university and government scientists.
MANAGEMENT IMPLICATIONS	By identifying research priorities which will guide research delivery by the CLLMM Research Centre, this project helps to instigate research that has strong management and decision-making implications.





Foundational iconic species of the Coorong, Lower Lakes and Murray Mouth

PROJECT TYPE	Foundational scoping
THEME ALIGNMENT	Threatened species and biodiversity
PROJECT TEAM LEAD FIRST	Ryan Baring (Flinders University); Courtney Glover (Flinders University); Cassie Hoepner (Flinders University); Scotte Wedderburn (University of Adelaide); Ngarrindjeri Aboriginal Corporation; Tara Bonney (Burrandies Aboriginal Corporation)
TIMEFRAME	January 2024 to September 2024
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>This project will work towards restoration and impact reduction on the culturally significant species of the CLLMM region in the face of climate change. The Nga:tjar (totems) of the Ngarrindjeri and First Nations of the South-East include that of dingoes, birds, frogs, fish, turtles and many more. There is a cultural obligation for Ngarrindjeri people to care for the Nga:tjar of the CLLMM region and to keep them on country and healthy. These Nga:tjar have cultural significance to the Ngarrindjeri people through their role in creation stories and served and continue to serve as traditional food sources, companions, omens and more. By understanding the behaviours, populations, and likely future habits of Nga:tjar in the CLLMM, we can strive to reduce the loss of cultural practices and culturally significant species during the forecasted climate change scenarios.</p>
SUMMARY	This project establishes research priorities for iconic species (nationally threatened and migratory, community important, and culturally significant) across the region.
TECHNICAL SUMMARY AND OBJECTIVES	<p>Iconic species are defined for several reasons, including for social, cultural or economic importance. The CLLMM region provides habitats for a diverse range of iconic species which are nationally threatened and migratory, important for community and culturally significant. Several of these species are listed as threatened under Australia's EPBC Act (2023) and at the state level under the National Parks and Wildlife Act (1972).</p> <p>This project identifies an agreed list of species that can define future research projects being implemented by the CLLMM Research Centre. This can be achieved by</p> <ul style="list-style-type: none"> • compiling a list of agreed iconic species with input from scientists, community and First Nations • evaluating the current status (distribution, abundance, and trends) of iconic species with input from experts • reviewing existing research and knowledge to identify gaps in understanding, with a particular focus on implications of future climates • defining research priorities to address gaps in understanding and enhance existing projects • identifying opportunities to communicate the value of iconic species across the region.



SUMMARY OF APPROACH	The project involves a literature review of iconic species, workshopping, and stakeholder engagement to identify key knowledge gaps, particularly under climate change scenarios. It will present recommendations for identified future projects for each species.
STAKEHOLDER CONNECTIONS	The project has strong links to community, First Nations and research-users. The project partners with the Ngarrindjeri Aboriginal Corporation and Burrendies Aboriginal Corporation and engages with First Nations and community.
MANAGEMENT IMPLICATIONS	The project will summarise the current status and implications of future climates for iconic species across the region, which is of strong management importance. In addition, the identification of research priorities relating to iconic species, which will guide research delivery by the CLLMM Research Centre, will help to instigate research that improves management and decision-making. The identification of iconic species will provide a platform to engage with community and First Nations on future changes to the region.





Establishing First Nations knowledge and research priorities

PROJECT TYPE	Foundational scoping
THEME ALIGNMENT	All
PROJECT TEAM LEAD FIRST	Ngarrindjeri Aboriginal Corporation; Burrendies Aboriginal Corporation; First Nations community
TIMEFRAME	2024 to 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations have studied their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future. The research priorities of the First Nations people across the region reflect their deep spiritual connection to the land and waters in ways that may not be readily apparent to the broader audiences.</p> <p>This project may work across various dimensions of restoration, connection, impact reduction, mitigation, and adaptation.</p>
SUMMARY	This project identifies key knowledge and research priorities for First Nations and establishes a framework for inclusion in research projects.
TECHNICAL SUMMARY AND OBJECTIVES	<p>First Nations people have an ancient history and connection with the lands and waters of the Coorong, Lower Lakes and Murray Mouth (CLLMM) region. This connection comes in the form of intricate traditions, culture, knowledge, stories and more, all of which provide a deeper understanding of the natural environment than what is available to non-Indigenous Australians. Therefore, First Nations priorities may not always align with those of non-Indigenous Australians due to cultural differences.</p> <p>This project serves as an opportunity for First Nations people to identify and participate in research of specific interest to the community. The importance of this is to provide additional opportunities for First Nations people to take control of the research and other activities occurring on their land and waters, ensuring on-going strength of the cultural values of the region.</p> <p>The CLLMM Research Centre will support the project team to develop and deliver this project through various stages by</p> <ul style="list-style-type: none"> • identifying current knowledge gaps or requirements within First Nations community • consulting with First Nations community to prioritise research needs • evaluating priorities on their project potential (time frame, resourcing and scope) • developing research projects based on identified priorities • delivering research projects in collaboration with First Nations community and research partners.
SUMMARY OF APPROACH	This project will consult directly with First Nations organisations and community to identify future climate change relevant knowledge gaps and knowledge requirements to protect the cultural values of the region. Control of the design and delivery of the project will be placed with the project team to encourage ownership of the project. Support from the CLLMM Research Centre will be provided where necessary.



STAKEHOLDER CONNECTIONS	<p>The project has strong links to the Ngarrindjeri Aboriginal Corporation, Burrendies Aboriginal Corporation and First Nations community. Additional stakeholders include, but are not limited to, local First Nations organisations, landscape boards, local councils, researchers and the broader community where appropriate.</p>
MANAGEMENT IMPLICATIONS	<p>This project provides power and gives control back to the Ngarrindjeri people to care for their country as described in the Ngarrindjeri Nation Yarlumar-Ruwe Plan (2006). This project provides Ngarrindjeri people with new knowledge of the changes that are occurring on their country and how to mitigate or adapt their culture to preserve it. The project allows Ngarrindjeri people to continue their traditional and sustainable practices, empowered with new knowledge of a manipulated environment.</p>





Horizon scanning for emerging topics across the Coorong, Lower Lakes and Murray Mouth

PROJECT TYPE	Foundational scoping
THEME ALIGNMENT	All
PROJECT TEAM LEAD FIRST	CLLMM Research Centre and stakeholders
TIMEFRAME	October 2024 to April 2025
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>This project will provide opportunity for First Nations priorities to be identified, refined, and documented for future reference within research projects. By undertaking this project, First Nations people will be able to ensure ongoing research into culturally significant topics beyond those currently identified and being researched. Identifying and documenting these priorities will contribute to reducing unnecessary engagement fatigue for First Nations people and organisations in the future.</p> <p>Horizon scanning may assist in preparing for any of the key themes of restoration, mitigation, adaptation, and connection for First Nations people.</p>
SUMMARY	This project will engage stakeholders to identify and prioritise emerging challenges, and opportunities that will shape the management of the CLLMM region into the future.
TECHNICAL SUMMARY AND OBJECTIVES	<p>Horizon scanning is a well-established method for identifying relatively unknown and emerging threats and opportunities that allows sufficient lead time to establish research and develop management actions. The technique helps to gather, organise and prioritise existing and new evidence regarding emerging issues (future threats and opportunities) in a timely, structured and transparent manner. This horizon scanning represents the first opportunity for those with expertise to provide their perspectives on the emerging topics for the CLLMM region.</p> <p>The CLLMM Research Centre will implement horizon scanning to identify emerging topics to inform research and management across the region, with the objective of supporting the project team to develop and deliver their project through various stages by</p> <ul style="list-style-type: none"> • establishing a process to define the scope of the horizon scan and identifying and engaging participants • engaging with participants who canvass their networks and colleagues to identify topics • refining topics through discussion and workshopping • finalising a priority list of topics with accompanying summaries.
SUMMARY OF APPROACH	Horizon scanning during this project will follow standard approaches to identify the most important topics. This will involve a modified Delphi technique to ensure transparency, repeatability and inclusivity of the process. Initially, an expert panel will be established to define the scope of the scanning (including timeframe), identify relevant stakeholder participants, and manage the engagement. Emerging topics will be identified by stakeholder participants submitting two to five topics that they consider novel, largely unknown, and likely to influence the CLLMM region



	<p>over a defined future timeframe. Participants will be encouraged to canvas their networks and colleagues to maximise inclusion of ideas. These topics will be collated to allow scoring (each participant will confidentially scope all topics based on novelty, likelihood and importance) to achieve short-listing. Following reflection, stakeholder participants will have a second opportunity to consider and re-score the topics. The final list of topics will be presented across themes with summaries to articulate key aspects of the topic.</p>
STAKEHOLDER CONNECTIONS	<p>The project will provide an opportunity for community, First Nations, managers and scientists to identify emerging topics for the region.</p>
MANAGEMENT IMPLICATIONS	<p>The horizon scanning exercise will help to identify those topics, either as challenges or opportunities, that will shape research and management of the region in coming decades.</p>



Flagship projects

The four flagship projects align strongly with the research themes under the overarching climate change focus (Table 8). These projects focus on climate adaptation, ecosystem services, ecosystem health and climate resilience, and blue and teal carbon potential across the CLLMM region.

TABLE 8 SUMMARY OF THE FLAGSHIP RESEARCH PROJECTS OF THE CLLMM RESEARCH CENTRE

RESEARCH THEMES	PROJECT TITLES	SUMMARIES	ACTIONS TO ADDRESS KNOWLEDGE GAPS
Climate adaptation	Enhancing the predictive modelling platform and scenarios to guide climate adaptation strategies	This project will establish a platform to assess climate vulnerability of the region whilst informing pathways for adaption to future climates	<ul style="list-style-type: none"> • Refined regionally scientific climate change scenarios to predict future impacts • Enhancing existing modelling to account for sea-level rise and updated flow availability • Forecasting nutrient, water quality and harmful algal blooms
Ecosystem services	Assessing the climate impacts on ecosystem services of the CLLMM	This project identifies the benefits provided by the environment and establishes those that community and First Nations recognise as the most critical to maintain under climate change	<ul style="list-style-type: none"> • Multi-faceted exploration of how climate change will impact values of the region, such as First Nations values, fish and fisheries • Consideration of public health and policy implication of climate change for the region.
Climate mitigation	Blue and teal carbon potential in the Coorong, Lower Lakes and Murray Mouth	This project will establish the carbon abatement potential of marine and freshwater vegetation of the CLLMM region as a solution to mitigate climate change impacts, and to explore the benefits of wetland restoration for people and nature	<ul style="list-style-type: none"> • First comprehensive blue and teal carbon assessment for the CLLMM • Integrated assessment that incorporates values and benefits as well as co-benefits (shoreline and coastal protection) • Exploration of how climate change will influence mitigation potential
Climate mitigation	Reconnecting the waters –exploring barrage transparency as a mechanism to improve ecosystem health and climate	This project focuses on the benefits and risks associated with more flexible barrage operation to promote improved connection	<ul style="list-style-type: none"> • First consideration of the benefits and risks associated with more flexible barrage operation



resilience of the
CLLMM region

between the Lower Lakes
and Coorong

- Insight into how sea-level rise will influence the region

These flagship projects are to be implemented over the duration of the CLLMM Research Centre, and the outcomes will inform transformational change on how the region responds to future climates. A summary of each flagship project is provided below.





Enhancing the predictive modelling platform and scenarios to guide climate adaptation strategies



Predicting CLLMM hydrological and nutrient dynamics for guiding seasonal and long-term climate adaptation strategies



Climate impacts on nutrient loads, biogeochemistry and methane production



Modelling climate change scenarios and their Impact on microalgae communities in the Coorong

PROJECT TYPE	Flagship
THEME ALIGNMENT	Climate adaptation
PROJECT TEAM LEAD FIRST	Justin Brookes (University of Adelaide) Sub-project leads and teams Predicting CLLMM hydrological and nutrient dynamics for guiding seasonal and long-term climate adaptation strategies – Matt Hipsey (University of Western Australia); Peisheng Huang (University of Western Australia); Justin Brookes (University of Adelaide); Sherry Zhai (UWA) Climate impacts on nutrient loads, biogeochemistry and methane production – Luke Mosley (University of Adelaide); Justin Brookes (University of Adelaide) Modelling climate change scenarios and their Impact on microalgae communities in the Coorong – Sophie Leterme (Flinders University); Peisheng Huang (University of Western Australia); Matt Hipsey (University of Western Australia); Justin Brookes (University of Adelaide)
TIMEFRAME	July 2024 to March 2026
CULTURAL SIGNIFICANCE	First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future. This project serves to prepare First Nations people for the adaptation required under climate change. First Nations people have historically been people of change and adaptation. However, with advanced rates of change and a modified system, it is necessary to help prepare First Nations people with future knowledge of the forecasted changes to the climate. This may include planning for and adapting to changes in cultural practices due to altered environments in new ways or new places.
SUMMARY	This project will establish a platform to assess climate vulnerability of the region whilst informing pathways for adaptation to future climates.
TECHNICAL SUMMARY AND OBJECTIVES	The CLLMM region is highly vulnerable to the impacts of climate change. These impacts will manifest by reducing freshwater inflows, warming the land and water and increasing sea level which will lead to a cascade of ecological, social, economic and cultural impacts. The Climate Adaptation flagship project will include a series of linked research sub-projects to guide adaptation planning across the region. It will provide the necessary science and modelling to understand future conditions (flow and sea level). This multi-faceted project has the objective



	of forecasting likely outcomes from climate change on hydrological and physical characteristics, nutrients and water quality, and harmful algal blooms. This knowledge will provide a basis for exploring climate change impacts and necessary adaptation pathways across other projects of the CLLMM Research Centre.
SUMMARY OF APPROACH	<p>The multi-faceted project will involve sub-projects that investigate the impacts of climate change, including</p> <ul style="list-style-type: none"> • hydrodynamical modelling to assess how the water balance, water quality and biological habitats of the region respond to projected climate change • water quality and nutrient cycling modelling to predict how biogeochemical processes will change in response to climate change scenarios • harmful algal blooms modelling to draw on existing datasets to forecast microalgae communities, in particular harmful algae, that we could expect to encounter in future climate change scenarios. <p>The outcomes of this project will underpin modelling scenarios used in other CLLMM Research Centre projects to ensure consistency.</p>
STAKEHOLDER CONNECTIONS	The multi-faceted project will strongly engage and inform a wide range of stakeholders in the region, including First Nations, community, and commercial and recreational fishers, forming strong links with community, First Nations and research-users. There will be opportunities for key stakeholders to guide direction and delivery of the project.
MANAGEMENT IMPLICATIONS	The project will bring together linked research sub-projects to inform management and decision-making by forecasting the impacts of climate change on hydrological and physical characteristics, nutrient and water quality and algal blooms. This knowledge will assist with climate adaptation planning by community, First Nations and research-users.





Assessing the climate impacts on ecosystem services of the CLLMM



Building climate resilience for fish and fisheries in the CLLMM



Climate change and community health: using ecosystem services to better adapt



Building an environmental-economic account for Coorong, Lower Lakes and Murray Mouth



In preparation to care for Country and culture during predicted climate change scenario



Policy considerations for RAMSAR and land tenure in the CLLMM

PROJECT TYPE	Flagship
THEME ALIGNMENT	Ecosystem services
PROJECT TEAM LEAD FIRST	<p>Justin Brookes (University of Adelaide)</p> <p>Sub-project leads and teams</p> <p>Building climate resilience for fish and fisheries in the CLLMM – Qifeng Ye (SARDI); Travis Howson (SARDI); Koster Sarakinis (SARDI); Jason Earl (SARDI); Fred Bailleul (SARDI)</p> <p>Climate change and community health: using ecosystem services to better adapt – Peng Bi (University of Adelaide); Olga Anikeeva (University of Adelaide); Alana Hansen (University of Adelaide)</p> <p>Building an environmental-economic account for Coorong, Lower Lakes and Murray Mouth – Patrick O'Connor (University of Adelaide)</p> <p>In preparation to care for Country and culture during predicted climate change scenario – Scotte Wedderburn (University of Adelaide); Ngarrindjeri Aboriginal Corporation; Burrandies Aboriginal Corporation</p> <p>Policy considerations for RAMSAR and land tenure in the CLLMM – Brendan Grigg (Flinders University)</p>
TIMEFRAME	August 2024 to March 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>This project assists in documenting the values and priorities of First Nations people in the CLLMM region. First Nations culture and values are founded upon historical connection with the land and waters. With disruption to this resulting from colonisation, and further disruption to occur with climate change predictions, there is a responsibility to help preserve the values of the world's oldest living culture against the coming changes. The knowledge recorded from this project will facilitate future planning and management projects. Undertaking this project serves to connect First Nations priorities, perspectives and knowledge to future management decisions and research projects.</p>



SUMMARY	This project identifies the benefits provided by the environment and establishes those that community and First Nations recognise as the most critical to maintain under climate change.
TECHNICAL SUMMARY AND OBJECTIVES	<p>Ecosystem services of the region are already being impacted or will become impacted by climate change. Adapting to changing climate impacts is about building resilience in ecosystems and within the community to face the current challenges and planning for an uncertain but inevitable future.</p> <p>The Ecosystems Services flagship project includes a series of linked research sub-projects to guide adaptation planning across the region. These sub-projects will consider how climate change impacts the region's fisheries, community health, socioeconomics and community and First Nations values whilst reviewing policy instruments to accommodate climate change. Collectively, this project identifies opportunities to help communities be more climate resilient.</p>
SUMMARY OF APPROACH	<p>This multi-faceted project involves sub-projects that investigate the impacts of climate change:</p> <p>Building climate resilience for fish and fisheries in the CLLMM region</p> <ul style="list-style-type: none"> • literature review of fish life histories, water quality and habitat requirements • conceptual modelling of climate impact scenarios for key fish species • fishing industry perceived risks and perspectives for climate adaptation <p>Climate change and community health in Coorong: using ecosystem service to better adapt</p> <ul style="list-style-type: none"> • literature searching, collation and review drafting • interviews and focus group discussions, data collection, cleaning, collation and analyses • community engagement and feedback seeking • regional workshop and recommendation identification <p>Building an environmental-economic account for the CLLMM</p> <ul style="list-style-type: none"> • data inventory of data sources related to ecosystem assets in the CLLMM region • quantification and map of ecosystem services, model calibration and guidance on model improvement and data needs • comprehensive review of exiting valuation studies relevant to ecosystem services in CLLMM region and guideline for future valuations <p>In preparation to care for Country and culture during predicted climate change scenarios</p> <ul style="list-style-type: none"> • yarning circles with First Nations groups to learn of values, concerns and priorities • yarning circles to present flow and sea level rise scenarios and discuss implications for land tenure, hunting access and ecosystem services <p>Policy considerations for RAMSAR and land tenure in the CLLMM</p> <ul style="list-style-type: none"> • mapping of sea level rise to land use type • investigation of legal implications of climate impacts on land tenure
STAKEHOLDER CONNECTIONS	The project will strongly engage and inform a wide range of stakeholders in the region, including First Nations, community, commercial and recreational fishers, and have strong links with community, First Nations and researchers. There will be opportunities for key stakeholders to guide direction and delivery of the project.
MANAGEMENT IMPLICATIONS	The project brings together linked research sub-projects to establish the values of the region, and how they may be impacted under climate change. This will help to direct management and decision-making to



prioritise resources with regard to the values of the region. This knowledge will assist with climate adaptation planning by community, First Nations and research-users.





Reconnecting the waters: exploring barrage transparency as a mechanism to improve ecosystem health and climate resilience of the CLLMM region

PROJECT TYPE	Flagship
THEME ALIGNMENT	Climate mitigation
PROJECT TEAM LEAD FIRST	Brenton Zampatti (CSIRO); Luke Mosley (University of Adelaide); Matt Gibbs (CSIRO); Paul McInerney (CSIRO); Ruan Gannon (CSIRO); Chris Bice (SARDI); Arron Strawbridge (SARDI); Matt Hipsey (University of Western Australia)
TIMEFRAME	July 2024 to March 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>First Nations people of the Coorong, Lower Lakes and Murray Mouth (CLLMM) region have an ancient understanding of the importance of connectivity between the waters of the Coorong, lakes, river and ocean. First Nations people live by the principle of '<i>All Living Things are connected</i>'. Ensuring ongoing connectivity between the waters of the CLLMM is vital to contributing to the overall health of the system, especially from a cultural perspective.</p>
SUMMARY	This project focuses on the benefits and risks associated with more flexible barrage operation to promote improved connection between the Lower Lakes and Coorong.
TECHNICAL SUMMARY AND OBJECTIVES	<p>Connectivity is a recurring theme in First Nations and European culture, and in the scientific understanding of ecological function. In the CLLMM region, the Murray Barrages fragment freshwater and estuarine habitats and, along with reduced river flow, impact the health and function of the Coorong estuary, with associated cultural, environmental and economic impacts. Climate change is predicted to exacerbate these impacts and, as sea levels rise, also lead to overtopping of the existing barrages. Globally, to improve the health of rivers and estuaries, tidal barriers are increasingly being operated in a manner that promotes greater connectivity and more dynamic estuarine interfaces.</p> <p>At the Murray Barrages, promoting a more hydrologically transparent barrage interface, where the two-way flux of water is facilitated under appropriate lake levels and river flows, has numerous benefits to the CLLMM ecosystem, and to the cultural and economic (e.g. commercial fishery) values of the region. However, there are also risks pertaining to upstream water quality (salinity), particularly for stock, domestic and irrigation supply, and the conservation values of freshwater habitats.</p> <p>This project increases understanding of the risk and benefits of greater connectivity, with the objective of</p> <ul style="list-style-type: none"> • exploring opportunities to facilitate the bidirectional movement of water and biota through the barrages • understanding the influence of 'more transparent' barrage operation on (a) the hydrodynamics and water quality of the Lower Lakes and Coorong, (b) the ecology of key fish species, and (c) broader ecosystem function.



	<ul style="list-style-type: none"> • integrating these data in a hydro-ecological model that informs the benefits and risks of more flexible barrage operation, and the potential implications of climate change and sea level rise on lake water quality and ecology.
SUMMARY OF APPROACH	<p>The project will involve three broad lines of investigation of the responses to more dynamic and flexible barrage operation, including</p> <ul style="list-style-type: none"> • hydrodynamics and modelling to assess how risks, in particular high salinity intrusion into the Lower Lakes, can be minimised while achieving increased connectivity • water quality monitoring using water column profiling and loggers to enable the collection of data on the risks (e.g. salinity). • biological monitoring to explore responses (movement, habitat use, spawning) of fish and lower trophic orders.
STAKEHOLDER CONNECTIONS	<p>The project has strong links with community, First Nations and researchers. There are opportunities for key stakeholders (SA Water, Ngarrindjeri, Lakes and Coorong commercial fishers, recreational fishers, and land holders) to guide direction and delivery of the project.</p>
MANAGEMENT IMPLICATIONS	<p>The project informs management and decision-making by</p> <ul style="list-style-type: none"> • guiding ecologically sensitive barrage management • increasing knowledge of the broader impacts of climate change in the CLLMM and possible mitigation measures.





Blue and teal carbon potential in the Coorong, Lower Lakes and Murray Mouth

PROJECT TYPE	Flagship
THEME ALIGNMENT	Climate mitigation
PROJECT TEAM LEAD FIRST	Sabine Dittmann (Flinders University); Luke Mosley (University of Adelaide); Alice Jones (University of Adelaide); Jason Nicol (SARDI); Kieren Beaumont (Flinders University); Sophie Russell (University of Adelaide); Hindmarsh Island Landcare Group; Nature Glenelg Trust; Kerri Muller (AU2100); Ngarrindjeri Aboriginal Corporation; Burrandies Aboriginal Corporation
TIMEFRAME	July 2024 to March 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>This project explores the use of culturally significant aquatic vegetation species for carbon offset. This may promote increased focus and availability of culturally significant vegetation, supporting cultural practices and cultural values through habitat restoration for their Nga:tjar (totems) and food availability.</p>
SUMMARY	This project will establish the carbon abatement potential of marine and freshwater vegetation of the CLLMM region as a solution to mitigate climate change impacts, and to explore the benefits of wetland restoration for people and nature.
TECHNICAL SUMMARY AND OBJECTIVES	<p>Climate change affects the ecosystems and people in the CLLMM region. Blue Carbon Ecosystems (BCE) like saltmarsh, seagrass and supratidal forest, as well as Teal Carbon Ecosystems (TCE) such as freshwater wetlands, can be part of the solution by capturing and storing carbon. To lay the foundations for realising blue and teal carbon wetland restoration in the CLLMM region and adjacent wetlands, this project comprises four main areas of focus:</p> <ul style="list-style-type: none"> • blue and teal carbon as a nature-based solution to climate change – taking stock of available knowledge, detecting main environmental drivers for BCE and TCE, identifying carbon storage potential of key sites, and identifying sites with the highest potential for carbon restoration outcomes • values and benefits of blue and teal carbon for First Nations – identifying traditional uses and values of BCE and TCE in the region, and evaluating the opportunities for cultural benefits through carbon restoration projects • co-benefits from blue and teal carbon conservation and restoration – determining biodiversity benefits of BCE and TCE restoration and assessing shoreline and coastal protection through BCE and TCE • opportunities for blue and teal carbon – assessing the effects of climate change on BCE and TCE and estimating carbon abatement from potential carbon projects at suitable sites. <p>The outputs of the project will include an inventory and metadatabase of knowledge and data, maps and reports.</p>
SUMMARY OF APPROACH	The project involves a combination of desk-top work, field investigations, workshops and training. Field study sites will be representative for certain



	<p>vegetation types and settings, and with different ages of revegetation to allow 'space for time' substitution. Approaches include</p> <ul style="list-style-type: none"> • a stocktake of available data and creation of a metadatabase and map • targeted field surveys to measure carbon stocks and assess environmental drivers affecting BCE and TCE • workshops on traditional use and values of wetland vegetation • field measurements of biodiversity, surface elevation changes and shoreline protection • a generation of maps to synthesise outcomes and illustrate areas of greatest potential and threats • a calculation of potential carbon offset and carbon credit values.
STAKEHOLDER CONNECTIONS	<p>The project has strong links with community, First Nations, councils, NGOs, and consultants. Representatives from these stakeholder groups have contributed to project scoping and will play an active part in the delivery of the project. There will also be opportunities for networking and capacity building through learning skills in field-based carbon assessment methods and taking part in workshops.</p>
MANAGEMENT IMPLICATIONS	<p>The project will inform management and decision-making by</p> <ul style="list-style-type: none"> • establishing foundational knowledge and data for future blue and teal carbon restoration projects and carbon abatement opportunities • providing evidence of the co-benefits of blue and teal carbon restoration for people, biodiversity and shoreline protection.



Research projects

The Science Program also provides knowledge on a broad range of priority research topics across the region (Table 9).

TABLE 9 SUMMARY OF THE RESEARCH PROJECTS OF THE CLLMM RESEARCH CENTRE

RESEARCH THEMES	PROJECT TITLES	SUMMARIES	ACTIONS TO ADDRESS KNOWLEDGE GAPS
Ecosystem services	Community adaptation to worsening droughts and floods in the CLLMM	This project will collaborate with CLLMM communities in planning adaptation responses to the impacts of increased drought and flooding in the region due to climate change.	<ul style="list-style-type: none"> Articulating community values and motivations to guide adaptation planning for the region
Climate mitigation	Understanding and enumerating water management options at the margin: a blueprint for achieving optimal outcomes in the CLLMM	Water is critical to the region, and this project will add to understanding of the value (economic and non-economic) of the water to support management and decision-making across the CLLMM as the impacts of climate change increase.	<ul style="list-style-type: none"> Incorporating stakeholder perspectives to establish the economic and non-economic value of water to enable evaluation of water use scenarios for the region Forecasting impact of climate change on water use in the region
Climate mitigation	Ecosystem responses and sociocultural perspectives on CLLMM landscape revegetation	This project will (a) evaluate the ecosystem responses to historical landscape revegetation in the CLLMM region, (b) assess the sociocultural perspectives of landscape revegetation in the region, and (c) provide future recommendations on landscape revegetation into the region.	<ul style="list-style-type: none"> First medium-term temporal analysis of historical revegetation across the region Combining temporal analysis outcomes with stakeholder insight to define future landscape revegetation strategies for the region.
Climate mitigation	Ecological response to climatic extremes: a review of studies in the CLLMM region	A review of ecological responses to climate extremes (drought and flood) in the CLLMM region to guide ecosystem management under future climate scenarios	<ul style="list-style-type: none"> First systematic synthesis of the ecological responses to droughts and floods across the region Establishing robust approach to predict future ecological responses
Climate mitigation	Coastal beach-dune dynamics and management in the CLLMM under future climate change	This project will focus on understanding the historical and current beach-coastal dune conditions, the future rates of dune migration, and the mitigation strategies	<ul style="list-style-type: none"> Expanding existing research methodology to analyse historical and current, and predict future, rates, of shoreline erosion and dune



		required in response to future climate change and sea level rise	<p>migration across the region</p> <ul style="list-style-type: none"> • Establish vulnerability of coastal dunes and recommend mitigation strategies
Threatened species and biodiversity	Ocean beach ecology and threats: a stakeholder perspective	This project will focus on understanding ecosystem services provided by ocean beaches in the CLLMM region, and how distinct stakeholder groups perceive potential conflicts and threats to those services from current human activities, as well as future threats which may come from climate change.	<ul style="list-style-type: none"> • Collation of values and threats to ocean beaches of the region • Gain insight into stakeholder perceptions on values and threats to prioritise future research and management
Threatened species and biodiversity	Navigating a future for threatened freshwater fish in the CLLMM region in the face of environmental change	This project will utilise modelling, field research and community engagement to explore ways to improve conservation and management of small-bodied threatened fishes in the face of climate change.	<ul style="list-style-type: none"> • Enhancing long-term conservation partnerships to predict fish responses to prevailing conditions to allow forecasting of impacts under future climates
Threatened species and biodiversity	Conserving waterbird populations of the CLLMM and broader landscape under climate change	A series of sub-projects integrating field research of movement, modelling and citizen science to inform the management of the CLLMM and surrounding region to support populations of migratory and non-migratory waterbirds under climate change	<ul style="list-style-type: none"> • Cutting edge research that builds on previous research (and networks) to provide comprehensive knowledge to inform management of waterbird habitats and population under climate change
Threatened species and biodiversity	Mussels in the mud: engaging community power to monitor Lokeri (floodplain mussel) in the Lower Lakes	The citizen science project is strongly linked to Ngarrindjeri culture and wider community concern, including the RLCAG and numerous landholders in the CLLMM region.	<ul style="list-style-type: none"> • First citizen science investigation into the status of floodplain mussel in the CLLMM
All	Hydrology of freshwater soaks on the Youngusband Peninsula in a changing climate	This project focuses on First Nations knowledge generation and sharing and ecological research to better understand how ecological and culturally significant freshwater soaks will be impacted by future climate scenarios.	<ul style="list-style-type: none"> • Extension of existing partnerships to continue First Nations knowledge generation and sharing • Provide first water balance to guide management of the ecological and culturally significant freshwater soaks





Community adaptation to worsening droughts and floods in the CLLMM

PROJECT TYPE	Research
THEME ALIGNMENT	Ecosystem services
PROJECT TEAM LEAD FIRST	Neville Crossman (Flinders University); John Kandulu (Flinders University); Lia Bryant (University of South Australia); Doreen Donovan (University of South Australia); Kerri Muller (AU2100)
TIMEFRAME	August 2024 to March 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>First Nations people of the Coorong, Lower Lakes and Murray Mouth (CLLMM) will potentially be some of the most impacted people from cumulative and more frequent drought and flood events. The destruction, inconsistency and instability of more frequent droughts and floods would have detrimental effects on the social welfare of First Nations people, inhibiting their ability to undertake or preserve significant cultural practices and values. Foreseeing and documenting this impact may help preserve the health of the people themselves, along with future planning for the environment. Economically, many First Nations people rely on 'working on country' or tourism employment, utilising cultural knowledge, practices and natural resources as a way of earning an income. This includes First Nations owned and operated businesses that could be severely impacted by the shifting climates and environment.</p>
SUMMARY	This project will collaborate with CLLMM communities in planning adaptation responses to the impacts of increased drought and flooding in the region due to climate change.
TECHNICAL SUMMARY AND OBJECTIVES	<p>Increased frequency and intensity of floods and droughts under climate change threaten the ecosystem services which underpin community livelihoods. These services are of significant social, cultural and economic value. Examples include recreation and tourism activities, provision of fresh water for consumption and agriculture, cultural and spiritual pursuits, and amenities related to biodiversity and healthy ecosystems. More intense and frequent droughts and floods will compromise the local ecosystem's ability to continue supplying and supporting these services. Consequently, they threaten community well-being and lifestyles. However, the extent of the impact and how communities can respond remains unknown. This project has two main objectives:</p> <ul style="list-style-type: none"> • understanding the risks to the values of the main ecosystem services in the CLLMM from worsening droughts and floods under several climate change scenarios. This involves applying economic valuation tools to estimate the incremental changes between the different scenarios. • partnering with local CLLMM communities using creative methods to document how communities adapt to worsening droughts and floods under climate change. This participatory action research will be a two-way learning experience: the research team will better understand community adaptation and response potentials, and communities will



	<p>better understand the risks posed by climate change-induced floods and droughts, and their options in response.</p> <p>A cross-disciplinary team from economics, social sciences, and cultural and creative industries will be assembled to meet these objectives.</p>
SUMMARY OF APPROACH	<p>This project will</p> <ul style="list-style-type: none"> • review and synthesise existing academic and grey literature on the value of ecosystem services in the CLLMM and the community, and the associated industry dependence on these services, and how this value is impacted by droughts and floods. • build future scenarios of alternative flood and drought regimes under climate change to 2050. • collection of generate secondary data and value transfer to estimate the economic impact of alternative 2050 flood and drought scenarios focusing on the economic viability of water- and flood-dependent enterprises within these communities. • utilise participatory and co-design methods via community workshops to explore future flood and drought scenarios, and people's preparedness and adaptation responses. • create co-designed artefacts (e.g. interactive web-based stories or an exhibition of visual images and stories) related to the impacts on the community and their responses.
STAKEHOLDER CONNECTIONS	<p>This project will be delivered in partnership with communities, including First Nations, farmers, local governments, conservation groups and business leaders through targeted workshops.</p>
MANAGEMENT IMPLICATIONS	<p>Understanding the future threats to the values associated with ecosystems and their services, and the adaptation options communities desire will help ecosystem managers design protection and restoration activities that are most supported by communities.</p>





Understanding and enumerating water management options at the margin: a blueprint for achieving optimal outcomes in the CLLMM

PROJECT TYPE	Research
THEME ALIGNMENT	Climate mitigation
PROJECT TEAM LEAD FIRST	Joanne Tingey-Holyoak (University of South Australia); Lin Crase (University of South Australia); Bethany Cooper (University of South Australia); Jeff Connor (University of South Australia); John Pisaniello (University of South Australia); Kerri Muller (AU2100); Vandana Subroy (University of South Australia); Yuan Gao (University of South Australia)
TIMEFRAME	July 2024 to September 2025
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>This project will hold significance for First Nations culture and people through cultural water allocations. Ensuring that future water management optimisation and planning includes perspectives from First Nations people is vital in order to protect and maintain cultural values in the future against forecast climate scenarios, mitigating their effects. First Nations perspectives will be significant with regard to sustainable water allocations for the environment and preserving cultural practices and traditions which rely heavily on water availability. Accessibility to water through optimal water allocations will assist in ensuring longevity of habitat for Nga:tjar (totem animals) in the region, while also offering a resource for other cultural traditions and consumption.</p>
SUMMARY	Water is critical to the region, and this project will add to understanding of the value (economic and non-economic) of the water to support management and decision-making across the CLLMM as the impacts of climate change increase.
TECHNICAL SUMMARY AND OBJECTIVES	<p>Optimal water management requires an understanding of the value of water in different contexts. Optimising management across the CLLMM region under future climatic conditions requires an understanding of what a desirable condition for the system is and supporting appropriate policies and programs for such conditions. Arguably, one of the most vexing issues related to water management is the attribution of non-extractive values, such as the environmental benefits from water for the environment, and the recreational and cultural gains related to those flows.</p> <p>Economists have developed a range of techniques for enumerating those values so they can be optimised along with the marginal values from consumptive use. These techniques are now well-established in both academic and regulatory settings, but successful deployment requires input from other disciplines to describe ecological and cultural responses to altered flows under changing climate scenarios. Having constructed an optimisation model that harnesses multiple values, it will then be possible to analyse scenarios that capture potential impacts of water redistribution and those related to climate change. Specifically, more frequent and extended low flow events can be modelled to both anticipate vulnerabilities and investigate different institutional arrangements which might help offset some of those impacts.</p>



	A cross-disciplinary team has been established to negotiate the interdependencies required to deliver this project.
SUMMARY OF APPROACH	<p>A mixture of primary and secondary data will be required for this project. In addition, the economic analysis needs to be informed by a synthesis of physical, biogeochemical, ecological and social impacts that are applicable at the regional scale. The approach thus comprises</p> <ul style="list-style-type: none"> • synoptic review and synthesis of physical, biogeochemical, ecological and social barometers to underpin a non-market valuation exercise • a discrete choice experiment both in the region and at a state level to estimate implicit prices for the attributes of a range of outcomes • harnessing residual value of water data in alternative consumptive uses (liaising with Socioeconomic impacts of cumulative droughts and floods project) • a systematic review of secondary data and case analyses for potential benefit transfer to understand other use values and cultural values • development of an optimisation model to evaluate the impacts of alternative watering scenarios including parameterising risks.
STAKEHOLDER CONNECTIONS	The project will grow strong links with community, primary producer groups, First Nations, local councils, and NGOs. Representatives from these stakeholder groups will play an active part in the delivery of the project. There will be opportunity for workshops, networking, and capacity building through analysis of local cases.
MANAGEMENT IMPLICATIONS	<p>The project will support management and decision-making by providing</p> <ul style="list-style-type: none"> • comprehensive primary data of economic benefits, use and non-use values for water in the CLLMM region linked to key water quality variables • an understanding of other use values and cultural values supported by case studies of local practices, businesses and organisations • an evaluation tool to examine the impacts and risks of alternative watering scenarios.





Ecosystem responses and sociocultural perspectives on CLLMM landscape revegetation

PROJECT TYPE	Research
THEME ALIGNMENT	Climate mitigation
PROJECT TEAM LEAD FIRST	Martin Breed (Flinders University); Sacha Jellinek (University of Melbourne); Kerri Muller (AU2100); Jamie Wood (University of Adelaide); Huade Guan (Flinders University); Jason Nicol (SARDI)
TIMEFRAME	January 2025 to March 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>This project works towards restoration and impact reduction on the culturally significant aquatic vegetation species associated with the wetlands and waterways in the CLLMM region. First Nations people in this region hold various cultural histories, traditions and practices which utilise the native vegetation of their country. Additionally, there is a large number of culturally significant native fauna that access this vegetation as habitat or breeding grounds, placing critical importance on the vegetation for Nga;tjar (totem species) retention in the region.</p>
SUMMARY	This project will (a) evaluate the ecosystem responses to historical landscape revegetation in the CLLMM region, (b) assess the sociocultural perspectives of landscape revegetation in the region, and (c) provide future recommendations on landscape revegetation into the region.
TECHNICAL SUMMARY AND OBJECTIVES	<p>Ecosystem restoration through revegetation provides a means to reduce the negative impacts of habitat loss and fragmentation on biodiversity. The Coorong, Lower Lakes Murray Mouth Recovery Program (2011-16) undertook extensive revegetation across five different vegetation communities in response to the Millennium Drought (1996–2010). This federal and state funded program (\$137 million) led to the revegetation of over five million native plants. In 2015, detailed vegetation data were collected at 80 revegetation sites and 20 remnant sites. Comprehensive bird survey data were also collected at 40 of the 80 revegetation sites and also at each of the 20 remnant sites. The most favourable remnant vegetation sites were used to compare the revegetation plantings, thus determining the degree to which the revegetation plantings mitigated adverse ecosystem impacts. Our objectives include</p> <ul style="list-style-type: none"> • repeating the vegetation and bird surveys carried out in 2015 working with First Nations and local community groups • characterising additional key measures of ecosystem responses at the revegetation and reference sites (soil health, plant health and vegetation establishment) • consulting First Nations and local communities on their perspectives on CLLMM landscape revegetation • recommending future landscape revegetate on strategies based on the ecological and sociocultural insights gained from the above objectives.



<p>SUMMARY OF APPROACH</p>	<p>The project will revisit previous revegetation plantings across the region. Objectives (a) and (b) require repeat visits to revegetation and reference sites to undertake</p> <ul style="list-style-type: none"> • vegetation and bird surveys as in 2015 soil biotic surveys (bacteria, fungi, and invertebrates) using established eDNA methods (Breed et al. 2019) • plant health mapping via satellite-based spectral indices, drone canopy temperature surveys for examining plant water stress (Liu et al. 2020) and the LiDAR topography and biomass survey, with ground truthing using ecophysiology methods. <p>A semi-quantitative surveying with landholders, natural resource management workers, community groups and First Nations around the lakes will be undertaken to assess the costs and benefits of revegetation and how the lakeshore environment has responded to the Millenium drought, refilling of the lakes and subsequent higher water levels. This will capture any improvements to revegetation methods developed over the intervening years.</p> <p>Synthesis of the ecological and sociocultural findings and insights from the surveys and mapping will be enhanced with workshop-style consultation of First Nations and the local community to access broader expertise to make future recommendations for activities relating to CLLMM landscape revegetation.</p>
<p>STAKEHOLDER CONNECTIONS</p>	<p>The project draws on revegetation efforts of a range of stakeholders, including SA DEW, Second Nature Conservancy (previously GWLAP), Kumarangk Hindmarsh Island Landcare Group and the Ngarrindjeri Aboriginal Corporation. Engagement with these organisations will occur during the project's development and delivery phases. The project has reliance on other organisations such as the Murraylands and Riverland Landscape Board, Hills and Fleurieu Landscape Board, Limestone Coast Landscape Board, BirdsSA and Birdlife Australia.</p>
<p>MANAGEMENT IMPLICATIONS</p>	<p>The project has a range of potential implications for management, including</p> <ul style="list-style-type: none"> • establishing the extent and types of ecosystem responses from revegetation plantings in the CLLMM region • examining the potential impacts of climate change on revegetation species • characterising the perspectives of practitioners and broader community stakeholders (First Nations, lakeshore landholders, and broader community) on planting strategies and the perceived benefits, priorities, and challenges of revegetation plantings in the CLLMM region • recommending management strategies for revegetation plantings that consider ecosystem responses, perspectives of First Nations and the broader community, impacts of climate change and return of ecosystem services to the region.





Ecological response to climatic extremes: a review of studies in the CLLMM region

PROJECT TYPE	Research
THEME ALIGNMENT	Climate mitigation
PROJECT TEAM LEAD FIRST	Bronwyn Gillanders (University of Adelaide); Brenton Zampatti (CSIRO); Kerri Muller (AU2100); Eddie Banks (Flinders University); Ivan Nagelkerken (University of Adelaide); Margaret Shanafield (Flinders University); Vilma Perez (University of Adelaide); Daniel Chilton (University of Adelaide)
TIMEFRAME	July 2024 to March 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country (ruwe) and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>This project will hold significance for First Nations people by understanding the changes to the environment that occur alongside drought events in the CLLMM region. Understanding how drought affects culturally significant totem species (Nga:tjar) will empower First Nations people to implement management actions to mitigate this affect, or adapt their environments, practices, and traditions to compensate for these changes. First Nations have encountered numerous droughts during their time living on their country and have always adapted in order to overcome them. With unprecedented climate changes being forecast, First Nations people need to be informed of those likely changes, and how to adapt to them. Additionally, First Nations people may provide valuable insights into preparations for the new shifts in climate (e.g. drought), allowing Western society to understand sustainable practices which will maintain the health of Ruwe, Nga:tjar and its people.</p>
SUMMARY	A review of ecological responses to climate extremes (drought and flood) in the CLLMM region to guide ecosystem management under future climate scenarios.
TECHNICAL SUMMARY AND OBJECTIVES	Droughts and floods have significant impacts on estuarine and freshwater ecosystems. Extreme floods, or long droughts due to reduced freshwater inputs coupled to increased evaporation can alter physical and ecological connectivity (lateral and longitudinal) and change ecological communities as well as their biodiversity. Although there are numerous accounts of past droughts and floods, the Millennium Drought (1997-2010) was one of the most severe in Australian history. In this project, we will synthesise and review information on the impacts of droughts and floods on the CLLMM region, what post-drought/flood hydrological and ecological responses have been observed and assess key features of decision-making around preparedness for such extreme climatic events. Key gaps in knowledge and pathways for future research to inform holistic management and facilitate adaptation will be identified.
SUMMARY OF APPROACH	<p>The project will engage key stakeholders to ensure that appropriate cultural and ecological values have been considered in the review.</p> <p>A systematic review to synthesise research studies associated with ecosystem response to droughts and floods in the CLLMM region will be undertaken. This will involve a structured approach using multiple databases to find all available information on responses to drought (and</p>



	<p>post-drought), and flooding in the region. Additional information will be leveraged from those undertaking CLLMM research projects.</p> <p>Mid-project, we will present results to date to First Nations through a yarning circle approach to understand links between their understanding and what we have found in the literature.</p> <p>Droughts and floods are predicted to occur more frequently and be of greater intensity. Therefore, it is important to investigate drought preparedness strategies for the region. This objective will help understand future drought preparedness and response and involve engagement with environmental (including water) managers.</p>
STAKEHOLDER CONNECTIONS	<p>The project will link with community, First Nations, NGOs, managers and policy makers within local and state government. Key engagement will also occur with those managing drought and with those who have undertaken research in this region.</p>
MANAGEMENT IMPLICATIONS	<p>The project will inform management by</p> <ul style="list-style-type: none"> • identifying how drought impacts freshwater availability and corresponding ecological shifts, along with the impact of hydrological and climatic extremes • preparing infographics of how the CLLMM ecosystem responds to droughts and floods • identifying gaps in knowledge and pathways for future research to inform management and facilitate adaptation.





Coastal beach-dune dynamics and management in the CLLMM under future climate change

PROJECT TYPE	Research
THEME ALIGNMENT	Climate mitigation
PROJECT TEAM LEAD FIRST	Patrick Hesp (Flinders University); Adrian Werner (Flinders University); Graziela Miot da Silva (Flinders University)
TIMEFRAME	July 2024 to March 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>This project holds significance to First Nations people through their connection to the coastal dunes in the Ngurunderi creation story, and through their cultural heritage sites (e.g. freshwater soaks and burial grounds in the dunes). The project will work towards impact reduction, climate mitigation and potentially future adaptation to the cultural traditions associated with these sites. Informing and working with First Nations people to discover the likely environmental changes to occur change to the coastal dunes may assist in working to reduce the impact on the associated cultural heritage sites, but also plan for potential future adaptation and management of these sites. Additionally, any shift, breach or other change to the coastal dunes may directly influence other cultural values such as cultural waters (e.g. the Coorong), Nga:tjar (totem species) and other cultural sites on the mainland (e.g. in the case of dune breach/sea water inundation).</p>
SUMMARY	This project will focus on understanding the historical and current beach-coastal dune conditions, the future rates of dune migration, and the mitigation strategies required in response to future climate change and sea level rise.
TECHNICAL SUMMARY AND OBJECTIVES	<p>Coastal dunes are highly vulnerable to the effects of climate change. Factors such as rising sea levels, shifts in wind patterns, and changes in wave dynamics contribute to the erosion of shorelines and the inland movement of coastal dunes. A 2024 study examining a 2-km section of Youngusband Peninsula revealed significant shoreline erosion, occurring at rates of up to 3.3 m/year, and dune migration moving inland at rates of up to 10 m/year. Due to the potentially rapid changes in this dynamic coastal dune environment, it is essential to implement monitoring strategies to observe shoreline erosion, sea level rise impacts, and dune migration.</p> <p>This project aims to enhance understanding of coastal dune dynamics and their response to future climate change and sea level rise. The specific objectives of this project include</p> <ul style="list-style-type: none"> • analysing current and historical dune morphological and vegetation cover changes • predicting future beach and dune changes in response to sea level rise • evaluating dune stability in relation to hydrogeological changes • reviewing and evaluating past and current mitigation strategies adopted for coastal dune management and protection.
SUMMARY OF APPROACH	The project will involve broad investigation approaches to study coastal dune dynamics in the region, including



	<ul style="list-style-type: none"> • a literature review to review publicly available documents, including council and government reports, on coastline changes and adaptation strategies for beaches and dunes in the region from Victor Harbor to Kingston • historical and current dune field analyses to analyse dune field morphological changes and vegetation cover along the Sir Richard Peninsula and Younghusband Peninsula (Murray Mouth to Kingston) over four periods from the 1940s to the present • analytical and numerical modelling to utilise the X-Beach model and the Bruun rule to predict future beach and dune changes in response to sea level rise for representative sections of the coast. This includes examining a range of surf zone-beach types (narrow, steep, reflective beaches like Port Elliot and wide, flat, dissipative beaches like Goolwa) and various wave energies (Goolwa vs Kingston) • groundwater monitoring to establish a long-term monitoring site to observe hydrogeological changes (e.g. groundwater level, salinity, groundwater wave propagation) and dune responses along a representative transect in the region.
<p>STAKEHOLDER CONNECTIONS</p>	<p>The project has strong connections with the community, First Nations, and research-users. Key stakeholders, including the Alexandrina Council, Victor Harbor Council, Hills and Fleurieu Landscape Board, SA DEW, the Coorong District Council, and the Coastal Protection Board, will have opportunities to guide the project's direction and delivery.</p>
<p>MANAGEMENT IMPLICATIONS</p>	<p>The project will inform management and decision-making by:</p> <ul style="list-style-type: none"> • enhancing understanding of beach and coastal dune dynamics in the region • increasing awareness of the broader impacts of climate change in the CLLMM region and potential mitigation measures.





Ocean beach ecology and threats: a stakeholder perspective

PROJECT TYPE	Research
THEME ALIGNMENT	Threatened species and biodiversity
PROJECT LEAD LEAD FIRST	Craig Styan (University of South Australia); Brianna Le Busque (University of South Australia); Dr Laura Falkenberg (University of South Australia); Stefan Peters (University of South Australia), Delene Weber (University of South Australia), vacation research students (UniSA).
TIMEFRAME	September 2024 to March 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>The cultural significance of this project concerns the impact reduction on, and adaptation of cultural practices, traditions and heritage sites associated with ocean beaches. The traditions and practices may include cockle (kuti) harvesting, or the protection of Nga:tjar (totem species) such as varying waterbirds that nest or feed on the ocean beaches. First Nations people of the CLLMM region continue to undertake these traditional practices and obligations today. Understanding the coming changes to ocean beaches will hold significance in preparing First Nations people, culture and businesses to such changes, providing opportunity for adaptations or mitigations to be implemented in the future.</p>
SUMMARY	This project will focus on understanding ecosystem services provided by ocean beaches in the CLLMM region, and how distinct stakeholder groups perceive potential conflicts and threats to those services from current human activities, as well as future threats which may come from climate change.
TECHNICAL SUMMARY AND OBJECTIVES	<p>Ocean beaches are dynamic ecosystems that provide critical habitat for biodiversity, including shorebirds and bivalves. They are subject to varying natural influences, but also a range of direct and indirect threatening processes from humans.</p> <p>The CLLMM region includes the 190-km Youngusband Peninsula and 20-km Goolwa Beach beaches on either side of the Murray Mouth. The nature and degree of threats vary along these beaches, and include vehicle disturbance, recreational and commercial bivalve harvest, pest animals and plants, pollution, erosion and habitat degradation, and climate change and its impacts such as sea level rise.</p> <p>Although there have been previous (expert) assessments of coastal threats along the lower south-east of SA, including the CLLMM region, key to managing human threats is understanding people's motivation for their use of beaches and their (sometimes mis)perceptions about the impacts they are actually having. This project aims to fill that gap by assessing people's understanding of, and their motivations (or not) for protecting beaches and their ecology.</p>
SUMMARY OF APPROACH	<p>This project will have four related components:</p> <ul style="list-style-type: none"> • Development of public data collection tool through the development of a Public Participation Geographic Information System (PPGIS). The PPGIS will collect spatially explicit information from stakeholders about



	<p>where/how people use the CLLMM beaches and what they value most about different areas. It will be developed iteratively with a smaller set of stakeholders helping to establish the preliminary tool by December 2024 before wider roll out during early 2025 to capture high use times and allow UniSA vacation research students to promote/recruit stakeholders in the field. The aim will be to produce a (GIS-based) tool stakeholders can use easily to plot where they use beaches and what aspects are important to them, allowing freedom to input aspects they feel are important, not constrained to specific questions posed by researchers. The PPGIS will continue into winter 2025, aiming for as many contributions as possible (>100 across multiple stakeholder groups), progressively creating an (interactive web-) map that we will analyse spatially and stakeholders will also be able to also query themselves once complete.</p> <ul style="list-style-type: none"> • Semi-structured interviews with a subset of representative stakeholders from different groups identified in the PPGIS. Up to 40 PPGIS participants will be invited to take part in interviews where in-depth discussions will be used to get a better understanding of perspectives, including how they perceive and value different aspects of beaches and assess threats from themselves and other stakeholders, along with how potential management options and the potential impacts of climate change. • Although people's perceptions of values and threats are a focus of this project, grounding that against existing scientific knowledge on the ecology and threats to ocean beaches is important. This will be done via a literature review of publicly available documents, including published papers, technical documents and reports, management plans, research theses, and other sources. • Additionally, a meta-database of the source and location of (relevant) existing historical and ongoing ecological and human use data will be collated (e.g. pipi fishery records, bird nesting records, pest surveys, fishing competition numbers, beach litter collection etc.).
<p>STAKEHOLDER CONNECTIONS</p>	<p>Key stakeholders targeted for the PPGIS will include First Nations, community, researchers (e.g. Flinders Uni; Uni Adelaide; CSIRO), natural resource managers (NPWSA; DEW; EPA(SA); Coastal Protection Board Kingston, Coorong and Alexandrina District Councils; Hills and Fleurieu, Murraylands and Riverland, Limestone Coast Landscape Boards), eNGOS (e.g. BioR; Birdlife Australia; Nature Glenelg Trust; SA Shorebirds Foundation; Coastcare), recreational groups like fishers (e.g. OzFish, Kingston SE Fishing Competition), 4WD enthusiasts (4WD SA), surfers (e.g. Surfing SA; Surfrider Foundation), and other recreational groups (e.g. SLSSA), as well as people who might not access or use the beaches frequently but still value them. We will use a variety of approaches to contact stakeholders, including directly in the field, encouraging use of the PPGIS tool and recruiting for subsequent interviews. Importantly, we hope to also recruit stakeholders using links from other CLLMM Research Centre projects and from the RCAF membership.</p>
<p>MANAGEMENT IMPLICATIONS</p>	<p>By providing insight to stakeholder understanding of the value of and conflicts between beach uses and ecology, management may be able to prioritise future monitoring needs, target education strategies, and assess the feasibility of options including area or seasonal closures.</p>





Navigating a future for threatened freshwater fish in the CLLMM region in the face of environmental change

PROJECT TYPE	Research
THEME ALIGNMENT	Threatened species and biodiversity
PROJECT TEAM LEAD FIRST	Sylvia Zukowski (Nature Glenelg Trust); Scotte Wedderburn (University of Adelaide); Brenton Zampatti (CSIRO); Laura Markham (CSIRO)
TIMEFRAME	July 2024 to March 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>This project works towards restoration, adaptation and impact reduction on the cultural traditions, obligations or history associated with the local small-bodied fish (Pali) of the CLLMM region. First Nations people believe in 'the living body', that is the land (Ruwe), water (Ma:rnmani), people (Palak), animals and plants (Nga:tjar) of the region. The body works in a delicate balance that if disturbed, can disrupt life on a large scale. This belief and knowledge system underpins the significance of small-bodied fish within the region. They play a role in the larger balance of the ecosystem (e.g. as a food source) that First Nations people have a responsibility to uphold. By conserving and managing these fish, the health of Nga:tjar, Ruwe and Ma:rnmani as a whole may be improved and protected against coming climate changes.</p> <p>This project will empower First Nations community with the knowledge and means to fulfil their cultural responsibility and traditions of caring for Ruwe, Pali and other Nga:tjar.</p>
SUMMARY	This project will utilise modelling, field research and community engagement to explore ways to improve conservation and management of small-bodied threatened fishes in the face of climate change.
TECHNICAL SUMMARY AND OBJECTIVES	<p>The CLLMM region supports more than 35 freshwater fish species, including several threatened small-bodied species. Already at risk small-bodied fishes were further impacted by the Millenium Drought. Through captive management, reintroductions and targeted water management, some improvement has been made in habitat and threatened fish populations, yet the conservation status of small-bodied threatened fishes across the region remains tenuous.</p> <p>Drawing on existing partnerships, the objective of this research project is to advance understanding of the conservation ecology of Yarra pygmy perch and its congener, Southern pygmy perch across the region. The project aims to identify relationships between habitat and environmental variables (e.g. flow and lake water levels) to assist the future management of wild and captive pygmy perch populations, reintroduction ecology, and water management. The project seeks to develop knowledge that informs strategies to improve the resilience of small-bodied threatened fish populations in the face of the impacts posed by climate change.</p>
SUMMARY OF APPROACH	The project will investigate the impacts of climate change on threatened freshwater fish by



	<ul style="list-style-type: none"> • undertaking modelling using existing data for Southern pygmy perch and Yarra pygmy perch to link recruitment strength, abundance and distribution to prevailing water levels, flows and habitat • defining pygmy perch spawning periods and growth rates through otolith examinations to determine how they relate to environmental conditions • field surveying to answer questions in relation to modelling outcomes (i.e., best release times, habitat, flow, and predators) • identifying best sites and conservation management actions for Southern pygmy perch and Yarra pygmy perch based on modelling and field research, including for under climate change scenarios.
STAKEHOLDER CONNECTIONS	Community and Ngarrindjeri people will be invited to participate in the field aspects of the research. A presentation and information transfer session will be undertaken following the modelling component. This project will include engagement with stakeholders from local organisations including SA DEW, Murraylands and Riverland Landscape Board, and Hills and Fleurieu Landscape Board.
MANAGEMENT IMPLICATIONS	This project will provide information to guide the future conservation management of Southern pygmy perch and Yarra pygmy perch in the region.





Conserving waterbird populations of the CLLMM and broader landscape under climate change



Movement ecology of waterbirds at multiple scales



Quantifying demographic threats to beach-nesting shorebirds



Conservation modelling for key waterbird species



Shorebird body condition monitoring through community science

PROJECT TYPE	Research
THEME ALIGNMENT	Threatened species and biodiversity
PROJECT TEAM LEAD FIRST	<p>Thomas Prowse (University of Adelaide) Sub-project leads and teams</p> <p>Movement ecology of waterbirds at multiple scales – Thomas Prowse, Ruth Cope, Steven Delean, Rebecca Boulton, Phill Cassey and Justin Brookes (University of Adelaide); David Paton and Fiona Paton (BioR); Heather McGuinness and Micha Jackson (CSIRO)</p> <p>Quantifying demographic threats to beach-nesting shorebirds – Rebecca Boulton, Thomas Prowse, Ruth Cope, Phill Cassey and Justin Brookes (University of Adelaide); Ryan Baring and Diane Colombelli-Negrel (Flinders University); Keith Jones (SA Shorebirds Foundation); Sonia Sanchez Gomez (Birdlife Australia)</p> <p>Conservation modelling for key waterbird species – Steven Delean, Thomas Prowse, Phill Cassey and Justin Brookes (University of Adelaide); David Paton and Fiona Paton (BioR); Ben Taylor (Nature Glenelg Trust); Sonia Sanchez Gomez (Birdlife Australia)</p> <p>Waterbird body condition monitoring through community science – Phill Cassey, Thomas Prowse, Steven Delean, Ruth Cope and Justin Brookes (University of Adelaide); Sonia Sanchez Gomez (Birdlife Australia); Heather McGuinness and Micha Jackson (CSIRO); Keith Jones (SA Shorebirds Foundation)</p>
TIMEFRAME	July 2024 to April 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>This project will work towards restoration, adaptation and impact reduction on the cultural traditions, obligations or history associated with the waterbird species of the CLLMM Region. First Nations people believe in 'the living body', comprised of the land (Ruwe), water (Ma:rnmani), people (Palak), animals and plants (Nga:tjar) of the region. The body works in a delicate balance that if disturbed, can disrupt life on a large scale. This belief and knowledge system underpins the significance of waterbirds within the CLLMM Region. Waterbirds provide a traditional food source for First Nations people (e.g. as meat or egg harvesting), they feed on local</p>



	<p>fish species (providing population control on fish) and are described to help shape the land, lore, and law throughout First Nations creation stories. First Nations people have a responsibility to care for Nga:tjar such as waterbirds. By monitoring waterbird behaviour, movement and other metrics, First Nations people can better understand and manage the health of Nga:tjar, Ruwe and Ma:rnmani in preparation for/during the forecast climate changes in the future.</p> <p>This project will empower First Nations community with the knowledge and means to fulfill their cultural responsibility and traditions of caring for Ruwe, Pali and other Nga:tjar.</p>
SUMMARY	A series of sub-projects integrating field research of movement, modelling and citizen science to inform the management of the CLLMM and surrounding region to support populations of migratory and non-migratory waterbirds under climate change
TECHNICAL SUMMARY AND OBJECTIVES	<p>The diverse and abundant waterbird community of the CLLMM played a central role in the region's listing as a Wetland of International Importance under the Ramsar Convention. The CLLMM is an important site for migratory shorebirds of the East Asian–Australasian Flyway. It provides foraging and breeding habitat for non-migratory waterbirds, and acts as a habitat refuge for many species during drought conditions. The threatening processes impacting waterbirds that use the CLLMM operate at a range of scales from local (e.g. extreme salinity and eutrophication of the Coorong South Lagoon, feral predators, vehicle access) to regional (e.g. upstream water extraction and drought, terrestrialisation of wetlands in the broader network) and global (e.g. loss of staging habitat along the migratory flyway).</p> <p>This project addresses four waterbird research priorities developed in collaboration with diverse stakeholders including First Nations and community groups, eNGOs, government agencies, and university-based scientists. The specific objectives are</p> <ul style="list-style-type: none"> • to study waterbird movement ecology at multiple scales to understand (a) how waterbirds select habitats for roosting, foraging and breeding as conditions change; (b) population connectivity across the broader wetland network; (c) triggers for long-distance movements; and (d) the impact of e-Water delivery on waterbird distributions. • to quantify the impact of disturbance processes on the behaviour and reproductive success of beach-nesting shorebirds • to develop species-specific conservation models for threatened and migratory species, and waterbirds with particular community significance • to collaborate with community scientists to monitor waterbird body condition over space and time.
SUMMARY OF APPROACH	<p>The project comprises four components integrating field studies and modelling to inform management of waterbird populations.</p> <p>Waterbird movement studies will use GPS telemetry to assess habitat selection by waterbirds and the scale of and triggers for long-distance dispersal events. The project will focus on several waterbird species representative of different functional groups (e.g. fairy tern/Talamarari, sharp-tailed sandpiper/Nemineri, black swan/Kungari, pied oystercatcher/Prukai, colonial nesting species). Telemetry data will inform the species-specific modelling components.</p> <p>Quantifying threats to beach-nesting shorebirds will monitor shorebird nests using camera-trap technology to understand the demographic impact of disturbance processes including feral predators and vehicles. The impact</p>



	<p>of these disturbances on shorebird behaviour will simultaneously be studied using GPS telemetry.</p> <p>Conservation modelling for key waterbird species will use historical datasets, First Nations knowledge and telemetry data to predict changes in the extent of suitable habitat and the distributional and/or population-level responses of waterbirds resulting from different management strategies and climate change scenarios.</p> <p>Waterbird body condition monitoring will engage community to capture still images of target species over space and time. In combination with a machine-learning algorithm developed to score the physical condition of individual birds, this project will assess the CLLMM's capacity to allow waterbirds to maintain or improve their body condition during key life history stages.</p>
<p>STAKEHOLDER CONNECTIONS</p>	<p>The project builds on substantial stakeholder relationships developed through past research and a recent community consultation process. Key stakeholders with direct involvement in the research components include</p> <ul style="list-style-type: none"> • First Nations (e.g. traditional knowledge underpinning modelling of the black swan/Kungari harvest under climate change) • government and university scientists (e.g. CSIRO and Flinders University researchers) • eNGOs with specific expertise in the CLLMM system and broader wetland network (e.g. BioR, Birdlife Australia, Nature Glenelg Trust, SA Shorebirds Foundation).
<p>MANAGEMENT IMPLICATIONS</p>	<p>The project has a range of potential implications for management, including</p> <ul style="list-style-type: none"> • an identification of key habitats/wetlands used by waterbirds, and improved understanding of how waterbird habitat selection and movements change with environmental conditions, which can support spatial conservation planning and e-Water delivery strategies under climate change • an estimation of the expected benefits of predator control and vehicle access restrictions on beach-nesting shorebirds • species-specific conservation recommendations for key waterbird species supported by quantitative conservation modelling.





Mussels in the mud: engaging community power to monitor Lokeri (floodplain mussel) in the Lower Lakes

PROJECT TYPE	Research (citizen science)
THEME ALIGNMENT	Threatened species and biodiversity
PROJECT TEAM LEAD FIRST	Scotte Wedderburn (University of Adelaide); William Wilson (Ngarrindjeri Aboriginal Corporation); Julie Jones (River Lakes and Coorong Action Group); Sylvia Zukowski (Nature Glenelg Trust); Bronwyn Gillanders (University of Adelaide); Malcolm Connolly (CSIRO); Brenton Zampatti (CSIRO)
TIMEFRAME	July 2024 to January 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>This project will work towards restoration, adaptation, connection and impact reduction on the cultural traditions, history, obligations and significance associated with Lokeri (floodplain mussel) populations in the CLLMM region. First Nations people believe in 'the living body', comprised of the land (Ruwe), water (Ma:rnmami), people (Palak), and animals and plants (Nga:tjar) of the region. The body works in a delicate balance that if disturbed, can disrupt life on a large scale. This belief and knowledge system underpins the significance of waterbirds within the CLLMM region. First Nations people have a responsibility to care for Nga:tjar such as Lokeri.</p> <p>By monitoring Lokeri populations in the Lower Lakes, First Nations people will better understand and connect with the Lokeri and the cultural traditions and histories surrounding them, such as using them as a food source, or through their significance in water filtration. Improving water quality and clarity has been previously noted as a primary concern by the Ngarrindjeri community, with hopes that this will have subsequent benefits to the broader ecosystem as a result. Restoring Lokeri populations or mitigating the effects of climate change on them may play an important role in improving or maintaining water quality of the CLLMM in the future.</p>
SUMMARY	This project is a citizen-science study that will connect community and First Nations in gaining a better understanding of an important but historically neglected freshwater species of the region.
TECHNICAL SUMMARY AND OBJECTIVES	<p>Freshwater mussels are one of the most at-risk groups of animals in the world, with almost half of all species extinct or threatened. Freshwater mussels are excellent indicators of the environmental health of river systems, particularly water quality. Lokeri (<i>Vesunio ambiguous</i>) is one of 18 species of freshwater mussel in Australia, and it occurs over most of eastern Australia including in the Lower Lakes of the Murray-Darling Basin (MDB). The consequences of changes to river flows and water quality are the main causes of decline in freshwater mussel populations. The current project draws on community concern and the significance of Lokeri to Ngarrindjeri culture. Based on anecdotal information, the Lokeri population of the Lower Lakes has not recovered since the Millennium Drought.</p> <p>The project will garner the interest of landholders, community groups and the Ngarrindjeri community to redress the deficiency in knowledge regarding Lokeri in the Lower Lakes. Specific aims include</p>



	<ul style="list-style-type: none"> • undertaking citizen science baseline monitoring • linking environmental conditions to age and growth of Lokeri.
SUMMARY OF APPROACH	<p>This project will involve an initial rapid search of the species in 2024 (possibly using sonar), with the aim of determining if and where the species currently occurs in the Lower Lakes. Following this, the first objective is to determine the status (e.g. age structure, recruitment) of the Lokeri population in the Lower Lakes through quantitative sampling, which will also be a baseline for future monitoring. To achieve this, citizen scientists will work with ecologists to sift through mud to identify and collect Lokeri at sites revealed during the initial rapid survey. The second objective is to age and examine growth of collected Lokeri. The growth and ageing data will be incorporated into population modelling to inform management of the lakes, particularly the use of water for the environment.</p> <p>The project will have strong community and First Nations involvement in planning and execution of field and laboratory work (data collection) and delivery of the objectives. The deep connection between Ngarrindjeri people and Country, including the CLLMM region, means they are heavily invested in projects of this type due to an inherent obligation to care for all plants and animals. It is important to get the perspective of the Ngarrindjeri community during the early stages of the project through workshops and yarning circles. The workshops may also be an opportunity for the wider community, such as members of the River Lakes and Coorong Action Group (RLCAG), to interact with members of the Ngarrindjeri community in their shared objective of understanding Lokeri in the CLLMM region.</p>
STAKEHOLDER CONNECTIONS	The citizen-science project is strongly linked to Ngarrindjeri culture and wider community concern, including the RLCAG and numerous landholders in the CLLMM region.
MANAGEMENT IMPLICATIONS	The project will summarise the current status of Lokeri across the CLLMM region. Through climate-growth modelling, the project will also determine implications of future climates for Lokeri across the region, which is of strong cultural and management importance. Information generated by the project through the CLLMM Research Centre will help instigate further research to improve management and decision-making. This project will provide a platform to include community and First Nations in planning for future changes to the region.





Hydrology of freshwater soaks on the Youngusband Peninsula in a changing climate

PROJECT TYPE	Research (First Nations priority)
THEME ALIGNMENT	Climate adaptation
PROJECT TEAM LEAD FIRST	Margaret Shanafield (Flinders University); Eddie Banks (Flinders University); Ngarrindjeri Aboriginal Corporation and Ngarrindjeri community; Burrandies Aboriginal Corporation and First Nations of the South East; Department for Environment and Water; Murraylands and Riverland Landscape Board
TIMEFRAME	August 2024 to March 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>Freshwater soaks are traditional sources of life for the First Nations people of the region. They are spiritual places where countless generations of First Nations people and wildlife would go to for sustenance. These soaks have historically provided essential water sources for drinking, cooking, bathing and ceremonial purposes to the First Nations people and Nga:tjar (totem animals/special friends) of the lands and waters.</p> <p>In a changing climate, the First Nations people face significant challenges concerning viability of these freshwater soaks. Variation in rainfall patterns, increased temperatures, increased ocean water levels and increased variability in weather events threaten the availability and quality of water in these soaks. This may significantly impact the spiritual and cultural practices that are associated with these soaks. By further understanding the hydrology of the freshwater soaks and the major threats to them amid climate change, the First Nations people may better understand how to adapt or mitigate these threats to reduce the cultural impact of climate change.</p>
SUMMARY	This project focuses on First Nations knowledge generation and sharing and ecological research to better understand how ecological and culturally significant freshwater soaks will be impacted by future climate scenarios.
TECHNICAL SUMMARY AND OBJECTIVES	Droughts and floods have significant impacts on freshwater ecosystems. In times of drought, groundwater provides a stable source of freshwater to the ecosystem. The Youngusband Peninsula (YHP) hosts a fresh groundwater lens with very low salinity and is the some of the freshest water in the CLLMM region. This high-quality resource supports diverse Australian biota. The water balance of the soaks is controlled by rainfall versus evapotranspiration and seepage into the Coorong. However, despite the critical importance of these soaks in supporting a healthy ecosystem, little is known about how they function hydrologically and what the major environmental drivers and climatic conditions are that threaten their existence. This project will compile and analyse shallow-water level data from recently installed DEW pressure transducer dataloggers. It will also provide initial estimates of evapotranspiration and outflow to establish a water balance. Researchers will examine how this water balance may change under alternative rainfall and temperature conditions, and what that means for protecting significant cultural values. This project builds on



	an already established partnership with the Ngarrindjeri and First Nations of the South East to understand and protect important freshwater resources in the CLLMM region.
SUMMARY OF APPROACH	<p>The Ngarrindjeri community has expressed its strong desire to spend more time on Country at the soaks to better understand them. They will partner with researchers on fieldwork outings, thus facilitating First Nations and Western scientific water-knowledge exchange. During these trips, water level loggers will be downloaded, outflow from the soak gauged, shallow groundwater monitoring wells installed, geophysical surveys conducted to determine shifts in moisture content, and evaporation measured. Data will be collected over the full annual cycle of a wet and dry season to investigate seasonal changes to the soak.</p> <p>The field data will be combined with drone-based light detection and ranging (LiDAR) to map the catchment area of the YHP soak to accurately delineate its boundaries and enable a hydrologic model to be constructed. This model is to be used to test scenarios that account for predicted climate change scenarios impacting both rainfall and evapotranspiration, with the goal of understanding water levels, salinity, and water availability into the future.</p>
STAKEHOLDER CONNECTIONS	The project will link with community, managers, and policy makers within local and state governments. It will further strengthen connections between government and First Nations groups who have expressed a strong connection to the soaks.
MANAGEMENT IMPLICATIONS	<p>The project will inform management by</p> <ul style="list-style-type: none"> • establishing a water balance for an indicative freshwater soak in the poorly understood YHP region. • identifying key controls on one of the highest-quality water resources in the CLLMM region. • engaging with First Nations communities to facilitate a better understanding of a crucial cultural asset.



Knowledge sharing and capacity building projects

The knowledge sharing and capacity building projects focus on innovative ways to share and generate knowledge by the Research Centre (Table 10). This currently includes an immersive experience as a platform to convey changes across the region, and an student grants program. Additional knowledge sharing opportunities will be identified over the duration of the Research Centre.

TABLE 10 SUMMARY OF THE KNOWLEDGE SHARING AND CAPACITY BUILDING PROJECTS IN DEVELOPMENT BY THE CLLMM RESEARCH CENTRE

RESEARCH THEMES	PROJECTS	SCOPE OF PROJECTS	ACTIONS TO ADDRESS KNOWLEDGE GAPS
All	Immersive experience as a platform to convey changes across the region	This immersive platform is a novel way to showcase the region and the research of the CLLMM Research Centre	<ul style="list-style-type: none"> • A contemporary knowledge sharing platform to showcase the region, share knowledge and articulate research outcomes. • Enhancing existing model to account for sea-level rise and updated flow availability
All	Student grants program	Increase science capacity and capability within the CLLMM region by supporting student research aligning with the priorities of the Research Centre	<ul style="list-style-type: none"> • Program to increase research capacity and build relationships whilst addressing novel research topics

An outline of project lead, technical summary, approaches, management implications, key stakeholders and duration for each foundational project are provided below.





Immersive experience as a platform to convey changes across the region

PROJECT TYPE	Knowledge sharing and capacity building
THEME ALIGNMENT	All
PROJECT TEAM LEAD FIRST	Tom Raimondo (University of South Australia); Jack Fraser (University of South Australia); Andrew Cunningham (University of South Australia); James Walsh (University of South Australia)
TIMEFRAME	November 2023 to January 2026
CULTURAL SIGNIFICANCE	<p>First Nations culture and traditions are rooted within an ancient historical connection with country and countless generations of studying their local environment as a way of life. First Nations traditional ways of life, including land and water management, sustainable harvesting, and the conservation of local species can provide vital perspectives into the ways we manage the lands and waters into the future.</p> <p>First Nations people and culture have historically been repressed during colonisation. Thus, their stories, knowledge and history have often gone untold, or have not reached audiences in meaningful ways. The immersive experience holds the potential to convey First Nations stories and histories in a new visual format, and connect them to broader audiences, allowing people to comprehend and understand First Nations creation stories and history as they occur live in front of them.</p> <p>Additionally, the immersive experience will act as a way for First Nations people to visualise the climate changes that will occur across the region and how they may affect their cultural values (e.g. water inundation of cultural sites, and sand dune migration) By visualising these changes, First Nations people may better understand, then adapt to or mitigate these changes in the future.</p>
SUMMARY	This immersive platform is a novel way to showcase the region and the research of the CLLMM Research Centre.
TECHNICAL SUMMARY AND OBJECTIVES	This project involves the creation of an immersive science platform to be used by the Research Centre. It involves the design, development, and implementation of the platform by the Project LIVE (Learning through Immersive Virtual Environments) team at the University of South Australia. The immersive platform will incorporate novel and engaging Augmented Reality (AR) and Virtual Reality (VR) technology. It facilitates engagement with community and First Nations throughout the CLLMM region, including history and values, how the region works from water and ecological perspectives, and future impacts of climate change. Operation of the immersive experience by the Research Centre staff will support the knowledge generation of and engagement with the Research Centre.
SUMMARY OF APPROACH	Immersive experiences describe the perception of being surrounded by, and being a part of, a different environment than our normal day to day. An immersive experience aims to place the user in a captivating environment that stimulates the senses and deceives perception. The unique and dynamic nature of these experiences can help to tell rich and engaging stories, share new perspectives and change thinking, leading to new and innovative insights. AR sandbox technology is a 3D, interactive and tactile tool that incorporates depth tracking technology to map contour lines (lines of equal elevation) onto the sand that adjust to the elevation levels of the sand in real-time. This technology can create immersive experiences that convey complex concepts about landscape



	<p>evolution in an engaging and informative manner. This foundational project will create an immersive experience utilising each of these technologies to be operated in the CLLMM Research Centre.</p> <p>The immersive science platform</p> <ul style="list-style-type: none"> • enables a way to engage with the local and wider community and First Nations via the design, development, and implementation of the immersive experience • provides and effectively conveys a selection of data-driven scenarios to connect and inform visitors to key CLLMM themes and messages • expands visitor familiarity and connections to the region by referencing local landmarks, sites, and regions • connects the actual local environment to the sandbox and augmented reality experiences
STAKEHOLDER CONNECTIONS	This project will enable a way to connect with all stakeholders across the region.
MANAGEMENT IMPLICATIONS	Whilst this knowledge sharing and capacity building project will not directly inform management and policy, the immersive experience will provide a platform to share research outcomes and management with the community, First Nations and research-users.



Student grants program

The objective of the Research Centre student grants is to increase science capacity and capability within the CLLMM region. This is being achieved by supporting undergraduate students undertaking research that aligns with the overarching climate change theme and the research themes of the Research Centre. In this way, the grant program not only addresses knowledge gaps but also builds capacity in the CLLMM region. Five student projects have been identified to date, with more to be supported as they emerge.



Movement ecology of Chestnut Teal in the Coorong and Murray Lower Lakes, South Australia

PROJECT TYPE	Knowledge sharing and capacity building
THEME ALIGNMENT	Threatened species and biodiversity
PROJECT TEAM STUDENT FIRST	Freya Harihill (University of Adelaide); Tom Prowse (University of Adelaide)
TIMEFRAME	2024
SUMMARY	Telemetry studies improve understanding of how waterbirds move between wetlands and respond to changing climatic conditions. This project will use telemetry of Chestnut Teal (<i>Anas castanea</i>) to understand: (1) use of habitats within the CLLMM region (including Ocean Beach) and foraging ranges; and (2) connectivity between the CLLMM and the broader wetland network. By identifying key foraging, roosting and/or breeding habitat, the project is guiding tailored management of the CLLMM and other regional wetlands to support Chestnut Teal, and other dabbling duck species. This project is also exploring the opportunity that telemetry studies have to engage community through the involvement of volunteers and stakeholders in waterbird trapping as well as livestreaming of waterbird locations and/or media illustrating a 'birds-eye' view of waterbird flight paths.



Investigation into the outbreak of avian cholera in the Coorong

PROJECT TYPE	Knowledge sharing and capacity building
THEME ALIGNMENT	Threatened species and biodiversity
PROJECT TEAM STUDENTS FIRST	Long Yin Cheung (University of Adelaide); Tik Yan Lim (University of Adelaide); Darren Trott (University of Adelaide)
TIMEFRAME	2024
SUMMARY	This 4 th year undergraduate veterinary project is focusing on the outbreak of avian cholera in waterbirds in the Coorong that emerged in February 2024. The project is documenting the avian cholera outbreak and investigate the molecular epidemiology of its causative agent (<i>Pasteurella multocida</i>). This project is working closely with management agencies, community and researchers





The threats and implications of climate change on the CLLMM as a site listed under the Ramsar Convention

PROJECT TYPE	Knowledge sharing and capacity building
THEME ALIGNMENT	Climate mitigation
PROJECT TEAM STUDENT FIRST	Anara Watson (Flinders University); Brendan Grigg (Flinders University)
TIMEFRAME	2025
SUMMARY	This law honours project will examine and evaluate the role that the Ramsar Convention plays in the management of the CLLMM region in light of climate change impacts and threats. The project will focus on an analysis of the text of the Ramsar Convention itself, the processes involved in the listing of the CLLMM and the related ecological character descriptions, compliance and enforcement under the Ramsar Convention's Montreux Record processes, compliance and enforcement processes under similar international environmental regimes, the role of the Environment Protection and Biodiversity Conservation (EPBC) Act in relation to Ramsar sites; and state and national legislation and policies and management plans for the CLLMM. These outcomes will emphasise the strengths and weaknesses of the Ramsar Convention and options for reform in light of the need to mitigate climate change impacts across the region.



Investigating the role of communities of prokaryotes and eukaryotes contributing to the microbiome of *Ruppia*

PROJECT TYPE	Knowledge sharing and capacity building
THEME ALIGNMENT	Threatened species and biodiversity
PROJECT TEAM STUDENT FIRST	tbc; Sophie Leterme (Flinders University)
TIMEFRAME	2025
SUMMARY	The seagrass microbiome has been shown to benefit and increase the ecological fitness of the seagrass host. Previous work conducted by my research team has identified the possible role of the microbiome of <i>Ruppia</i> in sustaining its presence in the Coorong. This work was based on the prokaryote community involved in the microbiome. The proposed honours project builds on our previous work, by including new data on the community of eukaryotes involved in the microbiome consortium of <i>Ruppia</i> , thus providing a more comprehensive understanding of (a) the composition of the <i>Ruppia</i> microbiome in the Coorong and (b) the role and contribution of prokaryotes and eukaryotes to the microbiome.





Impact of drought and flood events on phytoplankton communities in the Coorong

PROJECT TYPE	Knowledge sharing and capacity building
THEME ALIGNMENT	Threatened species and biodiversity
PROJECT TEAM STUDENT FIRST	tbc; Sophie Leterme (Flinders University)
TIMEFRAME	2025
SUMMARY	This project builds on previous work conducted by my research team on the plankton communities of the Coorong. It will identify phytoplankton indicator communities of drought and flood events along the length of the Coorong, from the Murray Mouth to Salt Creek. Samples collected during drought and flooding periods have been analysed and data are readily available for analysis. This project will be desk-based.



Conclusions

This research plan for the CLLMM Research Centre articulates the identification and development of the Science Program to assess the impact of climate change on the region. The Science Program aims to support the identification of management actions for achieving ecological outcomes that underpin the cultural, social and economic well-being of the region. The Science Program represents a well-rounded research agenda which aligns with the priorities of community and First Nations as well as the management needs of research-users in the face of changing climates. The Science Program incorporates foundational scoping, flagship, research, and knowledge sharing and capacity building projects. The outcomes of the Research Centre will contribute to the improved understanding of how the region responds to a changing climate, informing how we prepare for such change. The model of practice implemented by the CLLMM Research Centre provides a platform for long-term and locally relevant knowledge generation and sharing in the CLLMM region, which is also applicable to other regions of the Murray-Darling Basin.



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