Flow-MER Basin-scale Evaluation and Research Plan

Commonwealth Environmental Water Holder's Science Program: Flow Monitoring, Evaluation and Research (Flow-MER)

Version 6
30 June 2024

Australian Government
Commonwealth Environmental Water Holder

FLOW Monitoring Evaluation Research

The Flow-MER Program

Flow-MER is the Commonwealth Environmental Water Holder's (CEWH) Science Program's Flow Monitoring, Evaluation and Research Program (Flow-MER). The Program's objective is to monitor and evaluate the delivery of Commonwealth environmental water in the Murray-Darling Basin (The Basin). It provides the CEWH with evidence to inform our understanding of how Commonwealth environmental water is helping maintain, protect, and restore the ecosystems and native species across the Murray-Darling Basin. This work will support environmental water managers, demonstrate outcomes, inform adaptive management, and fulfil the legislative requirements associated with managing Commonwealth owned environmental water.

The Flow-MER Basin-scale Project is being undertaken from 2019 to 2025 and is led by CSIRO in partnership with the University of Canberra, and collaborating with Charles Sturt University, Deakin University, University of New England, SARDI, Arthur Rylah Institute, NSW Department of Primary Industry, Alluvium, Australian River Restoration Centre and Brooks Ecology & Technology. The Program delivers to the Commonwealth Environmental Water Holder, Department of Climate Change, Energy, the Environment and Water.

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Cover photograph

Aerial view of Straw-necked ibis colonies in the Booligal Wetlands
Credit: Will Higgisson (University of Canberra)

Important disclaimer

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ACKNOWLEDGEMENT OF COUNTRY

The Flow-MER Basin-scale team acknowledges the First Nations communities of the lands and waters of Australia, and in particular the First Nations communities of the lands and waters of the Murray–Darling Basin. The river and its tributaries are known by many names including: Millewa (Ngarrindjeri name for the main Murray channel in South Australia), Baarka (Barkindji; Darling River, inland New South Wales (NSW), Warring (Taungurung; Goulburn River, Victoria), Kolety (Wamba Wamba; Edwards River, inland NSW), Kalari (Wiradjuri; Lachlan River, inland NSW), Murrumbidjeri (Wiradjuri; Murrumbidgee River, inland NSW) and Guwayda (Kamilaroi; Gwydir River, northern NSW), amongst others. While the European names will be used here, the authors recognise the important associations and history of the Indigenous names for rivers and streams in the Murray–Darling Basin.

We recognise the intrinsic connection of First Nations people to Country, and we value the enduring cultural, social, environmental, spiritual and economic connection to the rivers, wetlands and floodplains of the Murray–Darling Basin; and express our respect for Elders, past, present and emerging amongst the Nations of the Murray–Darling Basin.

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Abbreviations and terms

Abbreviation / acronym	Definition
ANAE	Australian National Aquatic Ecosystem
ARRC	Australian River Restoration Centre
Basin-scale	Murray–Darling Basin scale analyses of data under LTIM, EWKR and Flow-MER
CAMBA	China Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCCEEW	Department of Climate Change, Energy, the Environment and Water
EWKR	Environmental Water Knowledge and Research Project (2014–19)
Flow-MER	The CEWH's Science Program, Flow Monitoring, Evaluation and Research Program (2019–25)
IP	Intellectual Property
IPCC	Intergovernmental Panel on Climate Change
JAMBA	Japan Australia Migratory Bird Agreement
LTIM	Long-Term Intervention Monitoring Program (2015-2019)
MDBA	Murray-Darling Basin Authority
MDFRC	Murray-Darling Freshwater Research Centre
MDMS	Monitoring Data Management System
MER	Monitoring, Evaluation and Research Program (2019–25)
MVP	Minimum Viable Product
NGO	Non-government organisations
NSW	New South Wales
ROKAMBA	Republic of Korea Australia Migratory Bird Agreement
SA	Selected Areas under the LTIM and Flow-MER programs
SARDI	South Australian Research and Development Institute SARDI
SAG	Science Advisory Group
SE&C	Stakeholder Engagement and Communication
SRA	Sustainable Rivers Audit
TBA	To be announced
the Basin	the Murray–Darling Basin
the Strategy	The MDBA's Basin-wide Environmental Watering Strategy
UC	University of Canberra
UNE	University of New England
QA	Quality Assurance
QC	Quality Control

1 Introduction

1.1 Commonwealth environmental water

The Commonwealth Environmental Water Holder (CEWH) is responsible under the *Water Act 2007* for managing Commonwealth environmental water holdings. The holdings must be managed to protect or restore the environmental assets of the Murray–Darling Basin (the Basin), and other areas where the Commonwealth holds water, to give effect to relevant international agreements. The *Water Act 2007* sets out obligations on the CEWH to report on the contribution of Commonwealth environmental water to the environmental objectives of the *Murray-Darling Basin Plan* (the Basin Plan, 2012).

The Basin Plan sets out the principles for monitoring and evaluating the effectiveness of the plan. These principles are reflected in the Commonwealth Environmental Water - Monitoring, Evaluation, Reporting and Improvement Framework[1]. Monitoring, evaluation and research support the efficient and effective use of Commonwealth environmental water and demonstrate environmental outcomes.

1.2 The Flow-MER program

The CEWH's Science Program invests in monitoring, evaluation and research activities delivered through an integrated program called the Flow Monitoring, Evaluation and Research (Flow-MER) program. This program builds on work undertaken through the Long-Term Intervention Monitoring (LTIM) and Environmental Water Knowledge and Research (EWKR) projects (2014–2020) to monitor and evaluate the contribution of Commonwealth environmental water to environmental outcomes in the Basin.

The Flow-MER program:

- monitors and evaluates ecological responses to Commonwealth environmental water in 7 Selected Areas and at the Basin-scale using established metrics and methodologies
- undertakes science in 7 Selected Areas (Figure 1.1) and at the Basin-scale to research ecological processes and improve understanding and prediction of ecosystem response to water management
- demonstrates outcomes from Commonwealth environmental water and documents these via a regular reporting schedule and engagement and extension activities and
- facilitates a regular, timely and effective transfer of relevant knowledge to meet the adaptive management information requirements of Commonwealth environmental water decision-makers.

Flow-MER monitoring, evaluation and research is undertaken for 6 Basin Themes based on ecological indicators developed for the LTIM project and described in the Environmental Water Outcomes Framework[2]. This framework describes the scientific rationale for the selection of ecological indicators to address the environmental objectives contained within Chapters 8 and 9 of the Basin Plan and addressed in the Basin-wide Environmental Watering Strategy[3] (the Strategy). Each Theme has a set of evaluation questions described in Foundation Reports[4] developed under LTIM, and updated in the Foundation Report

[1] https://www.dcceew.gov.au/water/cewo/publications/cew-monitoring-evaluation-reporting-and-improvement-framework

[2] https://www.dcceew.gov.au/water/cewo/publications/environmental-water-outcomes-framework

[3] https://www.mdba.gov.au/publications/mdba-reports/basin-wide-environmental-watering-strategy

[4] https://www.dcceew.gov.au/water/cewo/monitoring/ltim-project

Updates 2020[5], 2021[6] and 2022 and Methods report[7] (Cuddy and O'Sullivan (eds), 2024). Figure 1.1 shows maps of the Basin and locations of Selected Areas and the boundaries of the 25 valleys described for the Basin.

From 1 July 2024, Flow-MER will transition to a new program (known internally as Flow-MER2.0) with new arrangements and expanded monitoring locations. The arrangements for continued monitoring under the new program are documented in the Flow-MER2.0 Program Framework[8] and supporting strategy documents. Flow-MER Area-scale monitoring will commence under new arrangements from 1 July 2024. In parallel, evaluation of the past (2023–24) water year will be undertaken by the Flow-MER Basin-scale project in 2024–25 as described in this plan. As such, the current and future programs overlap in 2024–25.

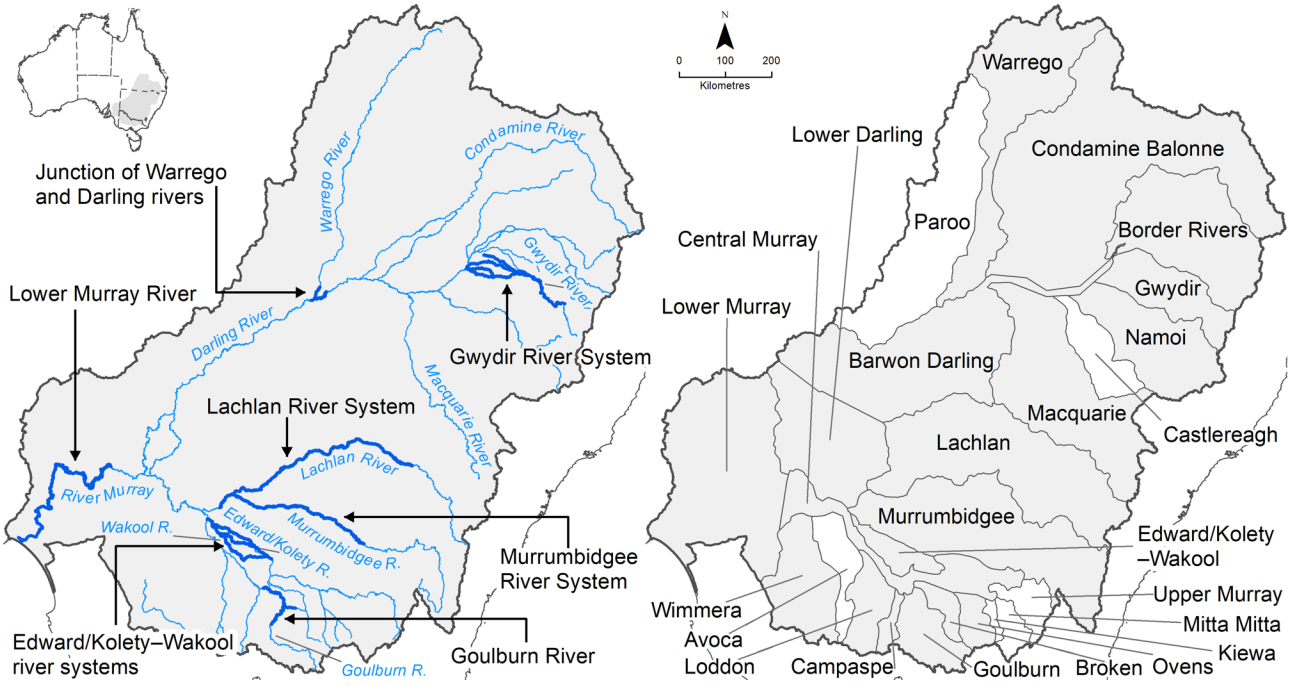

Figure 1.1 The 7 Selected Areas (left map) and 25 valleys (right map) established for long-term monitoring of the effects of environmental watering under the LTIM Project and Flow-MER Program (2014–15 to present)
In the valleys map, shaded grey shows the 19 valleys where the Commonwealth holds water entitlements and which are in scope for evaluation; white identifies those valleys which are not in scope.

1.3 The Basin-scale Flow-MER project

The Basin-scale Flow-MER Project is a 6-year investment in evaluation and research to:

- demonstrate the outcomes of Commonwealth environmental water across the Basin
- support adaptive management of Commonwealth environmental water over time
- support the CEWH to fulfil its legislative requirements under the Basin Plan.

The Flow-MER Basin-scale project integrates the Basin-scale Evaluation (formerly the LTIM project) with Flow-MER research (formerly the EWKR project). Basin-scale Evaluations[9] of environmental outcomes from

[5] https://www.dcceew.gov.au/water/cewo/publications/foundation-report-update-2020

[6] https://www.dcceew.gov.au/water/cewo/publications/foundation-report-update-2021

[7] Cuddy and O'Sullivan (2024) Foundation Theme evaluation approaches and methods. Flow-MER Program. Commonwealth Environmental Water Holder (CEWH), Department of Climate Change, Energy, the Environment and Water, Australia.

[8] Flow-MER2.0: Program Framework, Department of Climate Change, Energy, the Environment and Water, Canberra, 2023.

[9] https://www.dcceew.gov.au/water/cewo/monitoring/ltim-project

environmental watering were undertaken by the LTIM Project up to and including the 2018–19 water year and by the Flow-MER Basin-scale project up to and including the 2023–24 water year (as described in this plan). The Evaluation is undertaken in conjunction with the Flow-MER Selected Areas who provide data at the Selected Area scale that is used in the Basin-scale Evaluation. From 1 July 2025, future Basin-scale evaluations will be undertaken by the (Flow-MER2.0) Basin-scale project under new arrangements[10].

The Basin-scale Project invests in new and ongoing research to support environmental water management and inform and enhance Basin-scale evaluation. Basin-scale research under Flow-MER commenced in July 2019 and is now complete. The research portfolio continued EWKR research and invested in new projects designed to improve our scientific understanding of ecological responses to environmental water management. Final Basin-scale research activities will be written up, published and communicated over this coming year and will continue to inform the Basin-scale evaluation for the 2024–25 year.

This revision (v 6.0) of the Evaluation and Research Plan references the Flow-MER Basin-scale Research Summary 2023 (Thurgate et al. 2024) for detailed information on research outcomes to date.

1.4 Flow-MER Program themes

The Flow-MER Program is organised around Basin Themes based on ecological indicators developed for the LTIM project. The indicators were identified through a process which considered the objectives of the Basin Plan, expected environmental outcomes at the 7 Selected Areas and feasibility of implementation. These are described in the Environmental Water Outcomes Framework[11]. Although described at an earlier point in time, the indicators align sufficiently well with the ecological indicators used in the Strategy[12] to report against the Strategy's indicators. Basin Themes were created to address each of these indicators, referred to in LTIM as 'Basin Matters', and a set of foundation questions were generated. These questions are provided in Basin Matter Foundation Reports[13], with updates provided in the Foundation Report Updates. The questions addressed by the 6 Basin Themes in the annual evaluation are listed in Table 1.1.

Table 1.1 Questions to be addressed in each of the Basin themes

Theme	Questions to be addressed
Ecosystem Diversity	• What did Commonwealth environmental water contribute to ecosystem diversity?
Species Diversity	• What did Commonwealth environmental water contribute to species diversity?
Food Webs and Water Quality[14]	• What did Commonwealth environmental water contribute to patterns and rates of ecosystem respiration? • What did Commonwealth environmental water contribute to patterns and rates of primary productivity? • What did Commonwealth environmental water contribute to dissolved oxygen levels? • What did Commonwealth environmental water contribute to salinity regimes?
Vegetation	• What did Commonwealth environmental water contribute to plant species diversity? • What did Commonwealth environmental water contribute to vegetation community diversity?
Fish	• What did Commonwealth environmental water contribute to sustaining native fish populations?
Hydrology	• What did Commonwealth environmental water contribute towards the restoration of the hydrological flow regime?

[10] Flow-MER2.0: Program Framework, Department of Climate Change, Energy, the Environment and Water, Canberra, 2023.

[11] https://www.dcceew.gov.au/water/cewo/publications/environmental-water-outcomes-framework

[12] https://www.mdba.gov.au/publications/mdba-reports/basin-wide-environmental-watering-strategy

[13] https://www.dcceew.gov.au/water/cewo/monitoring/ltim-project

[14] The Food Webs Theme under EWKR has been added to this Theme for the Flow-MER Basin-scale evaluation project.

1.5 Standard methods

The Basin-scale evaluation quantifies the extent to which expected outcomes from Commonwealth environmental water are achieved.

Monitoring data are collected within Selected Areas as shown in Table 1.2. LTIM defined 3 categories of monitoring based on whether the data could be utilised for Basin-scale Evaluation or for evaluation at the Selected Area, or both. Data from each category are collected using standard methods (although Category III methods, while standardised, may be specific to the Selected Area). Standard methods[15] have been adopted to ensure that data collected at the Selected Areas can be integrated and analysed for the Basin-scale Evaluation. Additional publicly available data are also used to supplement data provided by Selected Areas. The Categories are:

I. **Data required** for quantitative Basin-scale Evaluation. Mandatory monitoring by each Selected Area using standard methods. Data **required** to be reported for Basin-scale Evaluation.

II. **Data optional** for the Basin-scale Evaluation. Optional monitoring by Selected Areas using mandatory standard methods. Where collected, data to be available for Basin-scale Evaluation.

III. **Optional monitoring** by Selected Area using locally appropriate methods. Where collected, data to be available for Basin-scale Evaluation.

[15] https://www.dcceew.gov.au/water/cewo/publications/cewo-ltim-standard-methods

Table 1.2 Data collected by Selected Areas (shaded) for the Basin-scale Evaluation via the Monitoring Data Management System (Appendix A – Data Management Plan)

Data type by Basin Theme		Junction of Warrego and Darling rivers	Gwydir River System	Murrumbidgee River System	Edward/Kolety–Wakool river systems	Lower Murray River	Lachlan River System	Goulburn River
	Hydrology (Channel)							
Food webs and water quality	Stream metabolism - BASE model outputs							
	Stream metabolism - discrete data							
	Stream metabolism - logger data							
	Water quality - daily data							
	Water quality - hourly data							
Vegetation	Vegetation diversity (recruitment)							
	Vegetation diversity (species abundance)							
	Vegetation diversity (community structure)							
	Tree stand condition							
Fish	Individual fish - river and wetland							
	Adult fish catches - river and wetland							
	Larval fish data							
	Fish movement							
Species diversity	Waterbirds diversity							
	Waterbird breeding - colony measures							
	Waterbird breeding - subsample measures							
	Macroinvertebrates							

2 Basin-scale integration approach

2.1 Overview

The Flow-MER Program spans across disciplines, involves people from research and non-research backgrounds, involves uncertainties (reducible and irreducible) and is delivering to an applied, or operational, context. These characteristics are managed using an integrated approach.

The Basin-scale Flow-MER Project integrates evaluation and research to deliver value by ensuring investments in research deliver outcomes to evaluation; investing in modelling and statistical methods to build a scientifically robust approach to evaluation of outcomes; and investing in communication and engagement to bridge Basin-scale and Selected Area projects and more broadly to Flow-MER stakeholders.

Integration supports the demonstration of the contribution of Commonwealth environmental water to Basin-scale outcomes and supports adaptive management. Combined with scientific review, it provides the scientific rigour for stakeholders to have confidence in, and utilise, the information generated by the Project. The science review process includes external review of evaluation reports, as well as review of research activities, by experts drawn from a scientific advisory group of experts in ecological evaluation.

Requirements for successful integration of monitoring and evaluation programs are: (1) clear framing of the problem being addressed and criteria for measuring success of the evaluation and research, (2) integration methods and models that have scientific rigour and sufficiently represent complex, real world problems and (3) new knowledge and outcomes of research and evaluation are used in stakeholder engagement and communication and are an input to decision-making. These requirements are met by:

- **Transition**: This project builds on efforts in LTIM and EWKR, where a clear problem framing and evaluation criteria for success was established. This framing is used in the Basin-scale Flow-MER Project, capturing the capability and knowledge developed in LTIM and EWKR.
- **Visualisation**: A visualisation Cross-cutting Theme provides visualisation tools to support communicating evaluation outcomes. A CEWH user reference group (the Dashboard Advisory Group, the DAG) commenced in 2021 to discuss how these tools can meet stakeholder needs.
- **Engagement and Impact**: To ensure the outcomes of the evaluation meet the decision-making needs of the CEWH and the broader stakeholder community, a Stakeholder Engagement and Communications Cross-cutting Theme commits significant focus, capability and resources to communication and engagement (refer to Appendix B Stakeholder Engagement and Communications Plan and Appendix C Indigenous Engagement Plan). Through engagement, we seek to deliver impact through new knowledge to support management of water for the environment.

2.1.1 Transition from LTIM/EWKR to the Flow-MER program

- The Flow-MER Program builds upon capability, knowledge and methods from the LTIM and EWKR projects. The Basin-scale project is designed to ensure seamless use of LTIM/EWKR data, information and knowledge for Basin-scale evaluation and research activities and promote integration (Table 2.1). This plan builds upon the LTIM and EWKR foundation as follows:
- Category 1 methods are continued from LTIM to ensure that the benefits of long-term, consistent monitoring at Selected Areas are realised.

- While the Basin-scale Flow-MER Project refined evaluation approaches and revised Basin Matter Foundation reports[16], evaluation activities are substantially unchanged. Data management supports efficient and effective use of Selected Area data for Basin-scale Evaluation (Appendix A).
- The Basin-scale Flow-MER Project continued some research activities from EWKR, and focused new research on improving our understanding of ecological responses to Commonwealth environmental water across the Basin, and how we can synthesise and scale our knowledge for evaluation and adaptive management purposes.

Table 2.1 Mapping of activities and Themes from LTIM and EWKR to the Flow-MER Program

	Previous program LTIM	Previous program EWKR	Current program Flow-MER
Activities	Selected Area monitoring		Selected Area Monitoring
			Selected Area Research
	Basin-scale evaluation	Basin-scale Research	Basin-scale Evaluation
			Basin-scale Research
Themes	Hydrology		Hydrology
	Metabolism and Water Quality	Food Webs	Food Webs and Water Quality
	Vegetation Diversity	Vegetation	Vegetation
	Fish	Fish	Fish
	Ecosystem Diversity		Ecosystem Diversity
	Generic Diversity	Waterbirds	Species Diversity

2.1.2 Integration through visualisation

A critical challenge in integrating many different streams of data into a coherent and accessible framework is the challenge of effectively visualising data spatially, temporally and from the perspective of multiple outcomes. A Cross-cutting Data Management and Visualisation Theme was established to develop data management infrastructure and ensure adequate data management, as well as to enhance the project's capability to effectively communicate evaluation outcomes across the project. Visualisation is being used to support the synthesis of Commonwealth environmental water outcomes in static reports, as well as through the prototyping of interactive web-based dashboards. This involves integrating data from across Themes and the results of the Basin-scale evaluation and modelling. The goal is to develop optimum means of presenting raw and processed data, modelling outputs and research results to inform the management of environmental water. So far, interactive web pages have been developed on the Flow-MER website and a prototype interactive tool and dashboards have been developed. These tools will be further developed over the coming year.

2.1.3 Achieving impact through engagement

Through stakeholder engagement and communications, we seek to deliver impact through sharing knowledge. The Stakeholder Engagement and Communications, Data Visualisation and Reporting teams have developed communication products to suit a range of target audiences. This is described in the Stakeholder Engagement and Communications Plan (Appendix B). To achieve integration across science and policy, we recognise the need to establish effective partnerships across the Flow-MER Program. This Plan articulates the process being used to engage with stakeholders in Commonwealth environmental water

[16] https://www.dcceew.gov.au/water/cewo/publications/foundation-report-update-2021

delivery (including Delivery teams), Selected Areas teams and Indigenous groups within the Basin (further described in Appendix C).

2.2 Project structure and themes

The Basin-scale Flow-MER project delivers evaluation and research using a project structure that supports integration (Figure 2.1). The Theme structure is applied across both the Evaluation and Research activities described in this plan. The activities are designed to be complementary, and for research to enhance evaluation. Cross-cutting activities are included in this plan, to provide a cohesive approach across Evaluation and Research and ensure best practice is applied across the Project. The outcome is a seamless integration across Themes and activities for reporting, synthesis and communication (Figure 2.1). The Flow-MER program integrates the outcomes of Evaluation and Research activities through preparation of an annual Synthesis report. This report provides an integrated summary of all outcomes from the Basin-scale Flow-MER project. Project management is fully articulated in the plan at Attachment I.

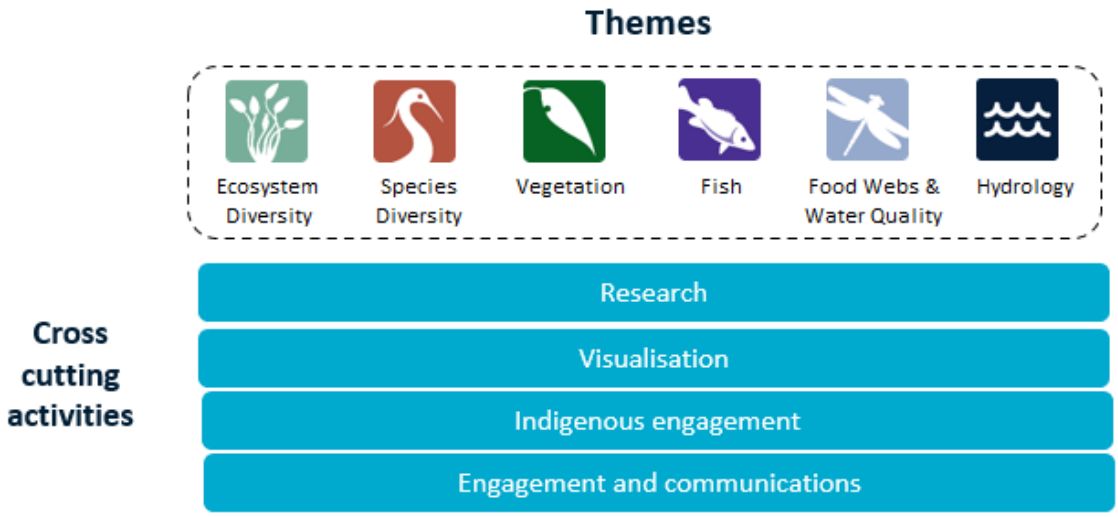

Figure 2.1 Integration across Basin Themes enabled by cross-cutting activities within the Flow-MER Program

3 Basin-scale evaluation plan

This evaluation plan covers the Basin-scale evaluation of the 2023–24 water year, due 30 June 2025, and is the final Basin-scale evaluation under current (LTIM) arrangements. Flow-MER Area-scale monitoring will commence from 1 July 2024 under new arrangements. The Flow-MER2.0 Evaluation Approach and Flow-MER2.0 Basin-scale Evaluation and Research Plan (publication pending) outline the future evaluation approach, commencing at the Basin-scale from 1 July 2025 (next year).

3.1 Overview

The Basin-scale Flow-MER Project Evaluation Plan describes the methodology and processes for delivering an annual evaluation of the contribution of Commonwealth environmental water to environmental outcomes in the Basin. The plan is based on the Environmental Water Outcomes Framework[17], LTIM Logic and Rationale[18], the LTIM Evaluation Plan[19], Basin Matter Foundation Reports[20] and Foundation Report Updates 2020[21], 2021[22] and 2022 (no updates in 2023 or 2024[23]).

The Basin-scale evaluation of the contribution of Commonwealth environmental water to observed environmental outcomes is dependent on the provision of monitoring data from 7 Selected Areas across the Basin (Figure 1.1). Commonwealth environmental water is often delivered in conjunction with other environmental water holdings and non-environmental water releases (such as for irrigation or during high-flow events). When delivered with other water, environmental outcomes cannot be apportioned and Commonwealth environmental water is evaluated and reported as contributing to, or supporting, the observed environmental outcomes.

The Basin-scale Flow-MER Project undertakes an annual evaluation (of the prior water year) and a cumulative evaluation (since 2014–15 when monitoring commenced under LTIM). The outcomes of the evaluation are delivered as Theme-based evaluation reports and an overarching synthesis report. In the first year of Flow-MER, a research synthesis report was delivered in June 2020. During that year, the evaluation of the 2018–19 water year was delivered by the LTIM project[24]. In June 2021, June 2022, June 2023 and June 2024, the Basin-scale Flow-MER Project delivered 6 Thematic reports evaluating the contribution of Commonwealth environmental water to environmental outcomes during 2019–20[25], 2020–21[26], 2021–22[27] and 2022–23 (yet to be published) respectively. These were accompanied by an Evaluation and Research Synthesis report capturing key messages for a wider stakeholder audience.

The Synthesis report and thematic evaluation reports are externally reviewed in addition to reviews by the project leadership team prior to submission to the CEWH. The outcomes of the evaluation are shared at

[17] https://www.dcceew.gov.au/water/cewo/publications/environmental-water-outcomes-framework

[18] https://www.dcceew.gov.au/water/cewo/publications/long-term-intervention-monitoring-project-logic-and-rationale-document

[19] https://www.dcceew.gov.au/water/cewo/publications/cewo-ltim-basin-evaluation-plan

[20] https://www.dcceew.gov.au/water/cewo/monitoring/ltim-project

[21] https://www.dcceew.gov.au/water/cewo/publications/foundation-report-update-2020

[22] https://www.dcceew.gov.au/water/cewo/publications/foundation-report-update-2021

[23] In 2024, Foundation Reports and Foundation Report updates are being compiled into one Methods report (to allow for ease of referencing)

[24] https://www.dcceew.gov.au/water/cewo/publications/2018-19-basin-scale-evaluation-cew-report-and-appendices

[25] https://www.dcceew.gov.au/water/cewo/publications/2019-20-basin-scale-evaluation-cew

[26] https://www.dcceew.gov.au/water/cewo/publications/2020-21-basin-scale-evaluation-cew

[27] https://www.dcceew.gov.au/water/cewo/publications/2021-22-basin-scale-evaluation

Annual Forums, webinars[28] (Flow-MER Fridays) and Learning by Doing workshops and as outlined in the Stakeholder Engagement and Communications Plan (Appendix B). The sequencing and scheduling of activities and reporting obligations are outlined in the attached project management plan (Attachment I).

3.2 Foundation activities

To undertake the Basin-scale evaluation, Theme evaluation teams use water delivery and outcomes data provided by the CEWH's Science Program, along with monitoring data provided by the 7 Selected Areas. Other publicly available data may be used where the relevant data are not collected by Selected Areas. Contextual climate data, watering actions, flow metrics and spatial data (including inundation extent) are prepared by the Basin-scale team and provided to Themes as input to the evaluation. Data arising from the evaluation is managed according to the Data Management Plan (Appendix A).

Foundation activities and planned improvements for 2024–25 are described in Table 3.1. These include activities that inform the evaluation (inputs to Theme evaluations) as well as activities that underpin the evaluation, including those that support scientific excellence and quality assurance (necessary for the credibility of the evaluation), reporting and communication of the evaluation.

Table 3.1 Flow-MER evaluation foundation activities planned for 2024–25, with key leadership personnel listed

Activities are to 30 June 2025. After that date, evaluation occurs within Flow-MER2.0.

Project and leader(s)	Activity summary
Foundation reports **Reporting team**	Update of consolidated Thematic Foundation report as well as improvements for the 2023–24 evaluation detailed in Table 3.1. This minimises the content of the Approach chapter in the evaluation reports. **2024–25: New release of Foundation report should modifications to methods be proposed**
Watering actions table Ethan Wignell (CEWH) Susan Cuddy CEWH Science Section	**Streamline the preparation of the Watering Actions Table (WAT)** The WAT lists CEWH watering actions, dates, volumes, partners and ecological objectives. The table is manually prepared by the CEWH Science Program from Acquittal reports. Officers of the CEWH plan to consult with evaluation teams (to synthesise their needs) and document the current process, as a first step to delivering a more consistent WAT for Flow-MER. A partially automated solution is planned to capture data in a form that can be queried and to semi-automate the WAT production workflow for delivery teams. **2024–25: Scoping study to inform production workflow** **Approval:** Scoping study to be reviewed and approval from CEWH required for next steps
Geodatabase of environmental assets Martin Nolan Susan Cuddy Shane Brooks CEWH Science Program	**Scoping an official spatial layer of all environmental assets that are watered** The ANAE partially captures watercourses and wetland/floodplain assets watered with Commonwealth environmental water. An environmental asset geodatabase for ANAE would assist in linking the WAT actions to the spatial layer and ultimately to the inundation layer to support and improve the evaluation. This would involve CEWH delivery teams and delivery partners to record location and extent of environmental assets receiving Commonwealth environmental water. The first step is a scoping study in collaboration with the CEWH Science Program to outline benefits and determine requirements and options for a future project. **2024–25: Scoping study leading to design options** **Approval:** Scoping study to be reviewed and approval from CEWH required for next steps
Management of Monitoring Data Shane Brooks Susan Cuddy CEWH Science Program	**CEWH Monitoring Data Management System (MDMS) and publishing to Data.gov.au** This activity involves configuration and ongoing management of the MDMS database, annual upload and quality control of monitoring data from Selected Areas, publishing of controlled data for Basin-scale evaluation and publishing of datasets to Data.gov.au. Research data are also published as individual projects complete. In this coming year, we anticipate that the MDMS platform will change

[28] https://flow-mer.org.au/flow-mer-fridays-autumn-2024/

Project and leader(s)	Activity summary
	as a result of the current (as at April 2024) tender process which may result in additional work to quality assure the transfer of historical data to the new platform and capture of 2023-24 data. **2024–25: Respond to changes in the MDMS to quality assure the transfer of historical data and capture of 2023–24 data**
Externally sourced data Jackie O'Sullivan CEWH Science Program	**Scoping and sourcing of additional input datasets for Basin-scale evaluations** Evaluations use monitoring data provided by Selected Areas and a minimal number of external datasets (primarily for Species Diversity). These data are limited in scope and the evaluation teams seek to access other state agency datasets to broaden the scope of evaluations. External data would be subject to requirements established for Flow-MER in consultation with the CEWH Science Program to maintain integrity of evaluations from year to year. A current activity within DCCEEW to establish an Environmental Information System (led by Jane Coram, CSIRO) would assist with identification of suitable data sets. The first step is a desktop study to develop a framework for assessing datasets for inclusion and developing requirements. An inventory of candidate datasets will then be identified (in collaboration with DCCEEW, state agencies and evaluation teams). **2024–25: Scoping study to develop an assessment framework and inventory of potential datasets**
Internal data repository Shane Brooks CEWH Science Program	**Basin-scale project internal data repository** The datasets used by the Basin-scale teams are stored on the Flow-MER data portal. This activity administers and manages the platform and will improve the use of the platform over time. The rationale for undertaking this activity in 23–24 is to maintain critical project infrastructure. **2024–25: Ongoing development and maintenance of internal data repository**
Documenting learnings from the Basin-scale Flow-MER project Carmel Pollino Ross Thompson Susan Cuddy Alison King **Theme leads** Dianne Flett Nikki Thurgate	**Synthesis: What have we learnt from the Flow-MER Basin-scale evaluations** This proposed activity examines the Flow-MER Basin-scale (and potentially LTIM) evaluations from a scientific perspective to assess what we have learned about ecological responses to environmental water and the science underpinning it. This activity will be cognisant of the MDBA's evaluation in 2025, leading into the Basin Plan review in 2026.
	Community of Practice: Documentation of the portfolio approach This proposed complementary activity examines lessons learned on how to work together, co-design principles, and program improvements, written for a broad (including international) audience with possible guidance toolkits and practice notes.
	Assessment of impact: Documenting the impact of Flow-MER evaluations This proposed complementary activity examines the impact of Flow-MER (from the perspective of the Basin-scale project) for program partners, the CEWH and participants. This explores the pathways to impact and where there might be opportunities for improvement. This activity is anticipated to include profiling materials suitable for partner communications. These activities are a legacy of Flow-MER and will inform the future Flow-MER program.

3.3 Basin-scale Evaluation

The Basin-scale evaluation answers specific evaluation questions (Table 1.1) for each of 6 Basin Themes using the best available data, information and knowledge. The outcomes from this evaluation are used to report on the contribution of Commonwealth environmental water to the environmental objectives of the Basin Plan 2012. Where possible, the Themes also report against the objectives of the Strategy[29].

For each Theme, Flow-MER evaluates the ecological response to Commonwealth environmental watering actions for the most recent evaluation year (annual) and since LTIM commenced (cumulative from 2014–15 to present). The activities undertaken in each Theme are summarised below and described in Foundation Reports and Foundation Report Updates 2020, 2021 and 2022. This plan covers 2025 evaluation and reporting for the 2023–24 water year. A brief overview is provided, and activities are detailed in Table 3.2.

[29] https://www.mdba.gov.au/publications/mdba-reports/basin-wide-environmental-watering-strategy

3.3.1 Hydrology Theme

The Hydrology Theme evaluates the overarching question:

- What did the Commonwealth environmental water contribute towards the restoration of the hydrological flow regime?

The Hydrology Theme focuses on the evaluation of the contribution of Commonwealth environmental water to the restoration of the flow regime throughout the Basin, to the benefit of water-dependent ecosystems. Hydrological assessment is undertaken at valley and Basin scale and reports on 4 features of the Basin's flow regime: base flows, freshes, lateral hydrological connectivity with the floodplain and longitudinal hydrological connectivity downstream through the Basin. Evaluation of the contribution of Commonwealth environmental water to flow regimes is based on a comparison of observed streamflow conditions with a hypothetical "no environmental water" scenario (the counterfactual).

The outputs of the Hydrology Theme intersect with other Themes and are used to inform the broader evaluation of Commonwealth environmental water at the Basin scale. Improvements are being made in methods for determining the extent of inundation and lateral and longitudinal connectivity (Table 3.2). The Hydrology evaluation is undertaken by Ashmita Sengupta (CSIRO) and the Alluvium team.

3.3.2 Ecosystem Diversity Theme

The Ecosystem Diversity Theme evaluates the overarching question:

- What did Commonwealth environmental water contribute to ecosystem diversity?

The protection and restoration of different ecosystem types contribute to supporting biodiversity of the Basin. The Basin-scale evaluation of Ecosystem Diversity quantifies the number, extent and distribution of different water-dependent ecosystem types in the Basin that are influenced by Commonwealth environmental water. This aligns with section 8.06 of the Basin Plan (2012).

The Ecosystem Diversity evaluation assesses environmental outcomes of Commonwealth environmental water across both monitored and unmonitored areas. The evaluation does not measure ecosystem responses directly. Rather, the evaluation is a high-level desktop analysis to quantify water-dependent ecosystems that potentially benefit from Commonwealth environmental water. It interprets the diversity of Australian National Aquatic Ecosystem (ANAE) types supported by Commonwealth environmental water at the Basin scale and more specifically within the Basin's 'managed floodplain' (the area of the Basin in which environmental water can be managed).

The Ecosystem Diversity evaluation is undertaken by Shane Brooks of Brooks Ecology.

3.3.3 Species Diversity Theme

The Species Diversity Theme evaluates the overarching question:

- What did Commonwealth environmental water contribute to species diversity?

The Species Diversity evaluation assesses the contribution of Commonwealth environmental water to achieving biodiversity outcomes. The focus of the evaluation is on major faunal groups including threatened and endangered species that would be expected to respond to environmental watering actions.

The evaluation addresses section 8.05 of the Basin Plan – *Protection and restoration of water-dependent ecosystems*, including objectives relating to species and populations, threatened taxa, and communities and ecosystems listed under state and national legislation and international agreements.

The evaluation reports on biodiversity outcomes not covered in the evaluations of Fish, Vegetation and Ecosystem Diversity – for example **frogs, waterbirds**, **turtles** along with other water-dependent aquatic vertebrate reptiles, mammals and birds with reference to listed threatened species as defined under the Commonwealth's *Environment Protection Biodiversity and Conservation Act 1999* (EPBC Act) and relevant state legislation. The evaluation question is addressed through 3 subcomponents:

- What was the contribution of Commonwealth environmental water to the diversity and abundance of frogs, waterbirds, turtles and other water-dependent vertebrates?
- What was the contribution of Commonwealth environmental water to threatened species and ecological communities?
- What was the contribution of Commonwealth environmental water to migratory species listed under international agreements (Bonn Convention, CAMBA, JAMBA or ROKAMBA)?

The evaluation sources data from Selected Areas, complementary State datasets and the Atlas of Living Australia. Improvements are being made (each year) in the sourcing and analysis of datasets (Table 3.2). This coming year, the team together with Heather McGinness, will explore new metrics for evaluating waterbirds for potential inclusion in the Foundation report and the 2024–25 evaluation. The Species Diversity evaluation is undertaken by Skye Wassens, Andrew Hall and team at Charles Sturt University.

3.3.4 Vegetation Theme

The Vegetation Theme evaluates the questions:

- What did Commonwealth environmental water contribute to plant species diversity?
- What did Commonwealth environmental water contribute to vegetation community diversity?

The Vegetation evaluation assesses the contribution of Commonwealth environmental water to achieving groundcover vegetation outcomes. The evaluation addresses section 8.04 of the Basin Plan and focuses on the use of environmental water to support the diversity of groundcover vegetation within the Basin. The evaluation describes annual outcomes from the use of Commonwealth environmental water in Selected Areas, as well as the cumulative outcomes since monitoring began in 2014–15.

Descriptions of the vegetation responses to environmental water are framed in terms of species and community responses and are described in terms of a range of structural and functional attributes. New occurrences of species are registered in a master species list that is published. For the purposes of the evaluation:

- **species diversity** encompasses the presence and abundance of individual plant species; here, we use species richness (number of species)
- **community diversity** includes the composition and structure of vegetation assemblages occurring in different habitat types (riverine, wetland and floodplain).

Structural and functional attributes include water plant functional groups (submerged, amphibious, damp-loving, woody flood-dependent and terrestrial), species growth forms (e.g. forbs, grasses, ferns), native and exotic species, rare and threatened species, and species that are known to be used by First Nations people.

These attributes are commonly used to describe vegetation community composition, providing information about habitat diversity as well as plants with specific social and cultural values.

Improvements are being made to the scope of the evaluation including developing and trialling new metrics for trees and shrubs emerging from Flow-MER research (Table 3.2). The vegetation evaluation is undertaken by Fiona Dyer, Will Higgisson and Alica Tschierschke with additional technical support from other University of Canberra staff as required; and Tanya Doody (CSIRO).

3.3.5 Fish Theme

The Fish Theme evaluates the question:

- What did Commonwealth environmental water contribute to sustaining native fish populations?

Freshwater fish are important indicators of ecosystem health and have critical life history processes linked to hydrology and hydraulics. They are affected by flow both directly through cues to migration and reproduction and indirectly through effects on water quality and habitat and through biotic interactions such as competition and predation. The evaluation addresses section 8.05 of the Basin Plan and outcomes for fish in the Strategy.

The evaluation describes native fish outcomes from the use of Commonwealth environmental water in Selected Areas, as well as the cumulative outcomes since monitoring began in 2014–15 and including outcomes for 2 key species identified by the Strategy – golden perch and Murray cod. The evaluation reports on expected and observed effects of Commonwealth environmental water on fish population trends, parameters and processes across the Selected Areas.

For the cumulative evaluation, quantitative models isolate the contribution of Commonwealth environmental water from other components of the hydrological regime. The use of predictive models and counterfactual flow scenarios provides information on the likely outcomes for fish had Commonwealth environmental water not been delivered to river systems across the Selected Areas. Improvements are being made (each year) to the predictive and counterfactual models (Table 3.2). The fish evaluation is undertaken by Sally Hladyz, Zeb Tonkin, Jarod Lyon, Jian Yen, Chris Bice, Qifeng Ye and team.

3.3.6 Food Webs and Water Quality Theme

The Foodwebs and Water Quality Theme evaluates what did Commonwealth environmental water contribute to:

- patterns and rates of ecosystem respiration?
- patterns and rates of primary productivity?
- dissolved oxygen levels?
- salinity regimes?

The Food Webs and Water Quality evaluation assesses the impact of Commonwealth environmental water on stream metabolism, food webs and water quality in the Basin. Energy flow in food webs is a critical ecosystem function for sustaining biodiversity, along with hydrological connectivity and nutrient cycling. Improved understanding of the influence of flow on the production and breakdown of organic matter in food webs complements our understanding of the influence of flow on habitat and connectivity. This evaluation addresses section 8.06(7) of the Basin Plan – '*food webs that sustain water-dependent*

ecosystems, including by protecting energy, carbon and nutrient dynamics, primary production and respiration' as well as section 9.04 objectives for maintaining adequate water quality.

- **Food webs** refer to the movement of energy between organisms through the consumption and generation of biomass. It describes the pathways for energy to enter aquatic ecosystems via photosynthesis and organic matter processing and transferred to consumers, including fish and waterbirds. These pathways are studied as part of the research projects.
- **Stream metabolism** refers to the transformation of organic matter through primary production and decomposition, which generate and recycle organic matter respectively. These each have a profound effect on ecosystem character and condition through their influence on the capacity of plants to complete their life cycles and the ability of animals to acquire food to survive and reproduce.
- **Water quality** is known to respond to changes in flow and is a significant influence on biota. It is incorporated in the Basin Plan to ensure water quality supports objectives for water-dependent ecosystems, Ramsar wetlands, and their ecological character (Basin Plan, Section 9.04(1) & (2)). Salinity is a key water quality measure and is assessed in this evaluation.

Selected Area stream metabolism data are used to answer the first 3 evaluation questions. The 'metabolic fingerprint' approach is used to interrogate dominant metabolic responses to flows that are common to all Selected Areas. This approach improves correlation of metabolic responses to flow and provides a visual assessment of observed responses against the long-term 'typical' metabolic regime of a Selected Area. The metabolic fingerprints used in evaluation are based on 20,000 daily records of gross primary production (GPP) and ecosystem respiration (ER) from 2014–15 to present.

The evaluation of the salinity regime uses data on salt export from the Lower Murray River Selected Area and electrical conductivity data from the remaining Selected Areas. Improvements are described in Table 3.2. The stream metabolism and water quality evaluation is undertaken by Paul McInerney and Simon Linke (CSIRO).

Table 3.2 Flow-MER Thematic evaluation activities planned for 2024–25, with key leadership personnel listed

Activities are to the 30 June 2025. After that date, evaluation occurs within Flow-MER2.0.

Project and leader(s)	Activity summary
Hydrology Ashmita Sengupta	**Evaluation of contribution of Commonwealth environmental water to meeting Basin-scale hydrological objectives** This activity assesses contribution through quantifying changes in base flows and freshes, and lateral and longitudinal connectivity. In addition to the annual evaluation report, products include observed and counterfactual daily time series of flow at >100 sites through the Basin, spatial map of (annual) extent of inundation coincident (and attributable) to Commonwealth environmental water, and break-down of Commonwealth environmental watering actions by hydrological component within valley (volumes and areas inundated). The team plan to improve methods to (1) validate inundation extent associated with watering actions; and (2) improve the mapping of inundation under tree canopy for implementation in the evaluation of the 2023–24 water year (undertaken and reported by June 2025). Output will include an update to the Foundation approaches and methods report. **2024–25: Improve inundation extent mapping for 2023–24 evaluation**
Ecosystem diversity Shane Brooks	**Evaluation of contribution of Commonwealth environmental water to meeting Basin Plan objectives for representative water-dependent ecosystems** This activity uses the Australian National Aquatic Ecosystem (ANAE) classification to evaluate Basin Plan objectives to ensure that representative populations and communities of native biota are protected/restored; and to assess the contribution of CEW to declared Ramsar wetlands. **2023–25: Ongoing with completion 30 June 2025**

Project and leader(s)	Activity summary
Species diversity Skye Wassens	**Evaluation of contribution of Commonwealth environmental water to meeting Basin-scale species diversity objectives** This activity evaluates the diversity and abundance of frogs, waterbirds (with improvements, see next line), turtles and other water-dependent vertebrates; threatened species and ecological communities as well as migratory species listed under international agreements. **2024–25: Incorporate new evaluation metrics in 2023-24 evaluation**
Species diversity Heather McGinness	**Development of evaluation metrics from waterbird tracking research outcomes** This project will undertake analysis of the waterbird movement tracking research data with the objective of developing new waterbird evaluation metrics for use in the 2023–24 evaluation (due 30 June 2025). Output will be an updated Species Diversity Report. **2024–25: Investigation to be completed by 30 June 2025**
Vegetation Fiona Dyer	**Evaluation of contribution of Commonwealth environmental water to meeting Basin-scale vegetation objectives** This activity evaluates the diversity of groundcover plant species and groundcover vegetation communities. The evaluation will trial new evaluation metrics using knowledge from the non-woody vegetation condition and remote sensing vegetation research projects (described below). The output will be an updated Vegetation Foundation report. **2024–25: Incorporate new evaluation metrics in 2023-24 evaluation**
Tree and shrub cover vegetation Tanya Doody Shane Brooks	**Development of evaluation metrics from remote sensing vegetation research outcomes** This project will explore new vegetation condition metrics using knowledge from vegetation and condition research projects broadening the scope to include trees and shrubs. The metrics are to be developed for potential use in the 2023–24 vegetation evaluation (completed June 2025). The output will be an update to the Vegetation Foundation report and a journal paper. **2024–25: Incorporate new evaluation metrics in 2023-24 evaluation (above)**
Fish Sally Hladyz	**Evaluation of contribution of Commonwealth environmental water to meeting Basin-scale native fish objectives** This activity evaluates the presence and population structures of native fish in Selected Areas. Flow-MER will trial extending the evaluation to include species that have one or more of their life cycles dependent on floodplain inundation. This will be a desktop study and may result in updates to the Fish chapter in the Foundations (Approaches/methods) report. **2024–25: Ongoing with completion 30 June 2025**
Food webs and water quality Paul McInerney	**Evaluation of contribution of Commonwealth environmental water to meeting Basin-scale stream metabolism and water quality objectives** This activity evaluates patterns and rates of ecosystem respiration and primary productivity (to assess stream metabolism) and dissolved oxygen levels and salinity regimes (to assess water quality). **2024–25: Ongoing with completion 30 June 2025**
Delivery of reporting of evaluations Susan Cuddy Martin Nolan CEWH Dashboard Advisory Group	**Transitioning evaluation reporting to online delivery using dashboards** Reporting of outcomes is currently delivered via a suite of reports (Word documents). The Flow-MER Communication team use the information in the evaluation reports to create interactive web-based narratives with links to the evidence in the evaluation teams. This activity will trial tools to deliver technical content of one or two of the evaluations through online dashboards, augmenting the current webpages and building upon the DIMME prototype built by Martin Nolan (visualisation research project). This work will be guided by the CEWH's Dashboard Advisory Group. **2024–25: Progressive transition to new products**
2024 delivery of evidence to CEWH for Basin Plan evaluation Susan Cuddy Alison King Dianne Flett	**Collaborate with CEWH and MDBA on Basin Plan reporting** Under legislative and inter-agency arrangements, the CEWH has reporting requirements for the upcoming review of the Murray-Darling Basin Plan (2012). These requirements include outputs from the Flow-MER program. The Basin-scale team will coordinate with the CEWH's Science Program to deliver the outcomes from the Basin-scale evaluation to the CEWH and the MDBA in time for a 2025 evaluation of the Murray-Darling Plan (which precedes the Plan review). **2024–25: Activity to be substantially complete by 31/10/24**

4 Basin-scale Research Plan

The Flow-MER Basin-scale Research Plan aims to improve the science for managing and evaluating environmental outcomes from Commonwealth environmental water. The Flow-MER Program is the primary means by which the CEWH Science Program undertakes research to deliver improved methods and a richer evaluation of environmental outcomes from Commonwealth environmental water.

The Flow-MER Basin-scale research program is complete. Research outcomes will continue to be communicated and published throughout 2024–25. The outcomes of research are being used to inform:

- the Basin-scale evaluation
- the adaptive management of Commonwealth environmental water at the Basin scale, or
- projects to be delivered under Flow-MER2.0.

Flow-MER research will commence from 1 July 2024 under Flow-MER2.0. The Flow-MER2.0 Research Strategy (publication pending) and the Flow-MER2.0 Basin-scale Evaluation and Research Plan (publication pending) outline the process for developing new research and key research activities.

4.1 Research priorities

This Research Plan was informed by a prioritisation and planning exercise undertaken in Flow-MER Stage 1 in 2019. Areas of research interest were developed in consultation with the Selected Areas and the CEWH and reviewed by scientific experts from the Science Advisory Group. 13 projects were developed, externally reviewed and funded for 2019-2022. Research was funded that would:

- continue and leverage research being undertaken in the Basin
- inform the evaluation of outcomes of Commonwealth environmental water
- build on and complement science networks across Selected Areas
- integrate across physical scales as well as across Basin Themes.

The Research Plan was updated and extended for the period 2023–25 in consultation with the CEWH's Science Program. Research was extended to June 2024 with some selected projects producing additional information into 2025. Completed projects address one or more of the following priorities:

- research funded under Flow-MER and delivering ongoing benefits to the program
- research that assists the CEWH to report under the Basin Plan
- transition to and improve evaluation of outcomes of Commonwealth environmental water
- knowledge exchange to inform adaptive management of Commonwealth environmental water.

4.2 Summary of research projects

Research projects prioritised for funding during Flow-MER are summarised below and in Table 4.1. A full description of the research undertaken and an update on research progress are provided in the 2023 Research Summary (Attachment I).

4.2.1 Waterbird movements

Spatial and temporal scales and drivers of waterbird movements and site use across the Basin

Waterbird diversity, populations, and breeding, foraging and refuge sites are managed through decisions affecting water, habitat and other pressures. This research uses avian satellite transmitters to track the movements of waterbirds at local, area and Basin scales. The data show the spatial and temporal scales and drivers of waterbird movements and site use, including breeding, foraging, stopover, refugia and Ramsar sites. Statistical models have been developed for colonial-nesting straw-necked ibis, royal spoonbill and Australian white ibis; tracking of intermediate egret and great egret, highly dependent on environmental watering, has commenced. The knowledge obtained from this project is directly relevant to the planning and management of Commonwealth environmental water.

In the 2024–25 year this project will focus on knowledge exchange, with ongoing data collection and analysis of still active transmitters and recovery of inactive transmitters (if located). This work will inform new evaluation methods being developed in 2024–25 for use in evaluation from 2025–26.

Research questions

- How do waterbirds move across the Murray–Darling Basin and beyond? Are they moving in response to environmental water or flooding? What does this mean for our perceptions and predictions of waterbird responses to environmental water management?
- Where are birds feeding, roosting and nesting, when and why? What movement and habitat cues, preferences and limitations should we be taking into account in water planning for waterbirds?
- How connected are Australian waterbird populations, spatially and temporally? What are the implications for environmental water management to prevent further population declines?

Research outcomes to-date

- New information has been collected describing waterbird movements and habitat use across the Basin. This includes identification of new breeding, foraging, roosting, stopover and refugia sites and events, including events in sites not monitored on-ground. The project provides this information in a) spatially and temporally explicit forms in real-time to inform immediate management at site scale (e.g. maps of where birds are breeding, maps of where breeding birds are going to get food for their chicks, and reports on physical condition of birds in breeding sites and environmental conditions on-ground); and b) summarised general forms based on statistical modelling across large numbers of birds and sites to guide longer-term planning.
- Identification of spatially explicit common routes for waterbird movement and connectivity, including a major ‘flyway’ crossing the Basin, providing important context for the selection and prioritisation of watering sites.
- The first full-life cycle movement tracking of waterbirds in Australia, with juveniles tracked from their hatching site to their first nesting event as adults years later, again changing assumptions about site fidelity and connectivity, with implications for water and wetland management.
- The first tracking of adult waterbirds moving between important breeding and Ramsar sites, revealing patterns in breeding site connectivity and including the timing and duration of site visits and site abandonments.
- Spatial and temporal movement and habitat selection information for waterbird species of concern has been collected. This allows calculation of movement statistics including foraging and nomadic and

migration distances, home ranges and breeding movements. This informs where, when and for how long environmental water should be allocated to support foraging habitat and food resources.

- Extraordinary breeding events triggered by widespread flooding in 2022 and 2023 have enabled commencement of research on intermediate egrets and great egrets. These species are specialist floodplain users and new data are providing insights into their movement and habitat use.
- Research shows how site or Selected Area-scale waterbird responses to environmental watering measured through local monitoring and evaluation are influenced by Basin- and national-scale responses and drivers. This knowledge assists water managers to better understand waterbird requirements and has implications for water and wetland management and policy.

Knowledge exchange

The waterbird movements project team is active in Knowledge Exchange, including:

- Ongoing direct provision of information to the CEWH's Science Program and Delivery Teams for adaptive management and water planning, including through Learning by Doing workshops, the Flow-MER website, articles, presentations, email updates on waterbird movements, and conversations with the project leader.
- Ongoing project-led public communication of waterbird monitoring results and other information through social media ('Waterbirds Australia'), the CSIRO project website https://research.csiro.au/ewkrwaterbirds/, and the 'Movebank' website: **https://www.movebank.org/cms/webapp?gwt_fragment=page=search_map** (search for: '*Waterbirds, Threskiornithidae, Murray-Darling Basin')*.
- Translation of results to inform improved evaluation of water bird responses to environmental water
- Preparation of scientific journal manuscripts
- **A final report has been completed pending publication.**

4.2.2 Refugia

Identification, characterisation and management of refuge habitat

Refuges are areas critical to maintaining the resilience of ecosystems. Collation and analysis of geospatial and biodiversity datasets have enabled key refugia in the Basin to be mapped. Research shows how ecological refugia are distributed across the Basin and explores options for managing water for these critical areas to support diversity. The systematic conservation planning approach is an objective and repeatable process that could be used to prioritise environmental watering across the Basin.

This project is complete and the spatial data will be used in future evaluations from 2024–25.

Research questions

- Where are the high ecological value depressional wetlands and lakes?
- Where would watering actions deliver the highest ecological value at the lowest cost?
- Have past watering actions captured ecological diversity?

Research outcomes

- Review of habitat condition metrics and biodiversity data in the Basin.
- Refugia mapping models have been identified which can be used to relate hydrologic metrics to persistence of refugia through time and space.

- Map of key refugia in parts of the Basin – a spatial layer of refugia planning units has been created, where planning units are defined as freshwater depressional wetlands and lakes in the ANAE, and showing sites on the manageable floodplain and sites that are actively managed for Commonwealth environmental water.
- A spatial dataset of wetland complexes has been generated that corrects for artificial boundaries that may be present (e.g. bridges, pipelines, roads) between water bodies. Spatial statistics measure the shared boundary between adjoining wetland and lakes. Including a connectivity dataset that shows distance to major and/or minor watercourse.

This project is complete – Final report available here.

4.2.3 Condition

Influence of ecosystem condition on responses to environmental water

This research identifies ecosystem condition attributes to explain environmental outcomes from environmental watering in different ecosystem types. The aim is to apply measures of ecosystem condition to adjust expected outcomes and therefore tailor evaluation to better match the context under which water is being delivered. Research is linking species outcomes to the ecosystems that support them and determining how the condition of those ecosystems influences outcomes from environmental water. The outcomes of this work apply to ecosystem type mapping, environmental water prioritisation frameworks and setting of expected outcomes for watering actions.

This project continued to June 2024 focussing on case studies on inundation requirements and inundation frequency for trees. This work will be reported and transitioned to evaluation in 2024–25.

Research objectives

- Identify ecosystem condition attributes to explain watering outcomes in different ecosystem types.
- Assess and recommend data sources to estimate condition of ecosystems at the Basin-scale.

Research outcomes

- Review of condition metrics and data in the Basin.
- An index of condition has been developed and implemented.
- Work with the Vegetation Theme has generated condition metrics including water stress.
- Collation of a dataset describing vegetation responses to watering from all sites through to the beginning of the LTIM project.
- Working on a high-resolution inundation dataset with the hydrology theme to relate to vegetation responses.
- Research is being extended to demonstrate environmental water impacts to the condition of ANAE classes over time, including water requirements and inundation frequency for trees.

Knowledge exchange

- Publication of results

- A data framework for combining information on watering action objectives, timing and duration with inundation extent mapping to improve resolution of spatial and temporal scales of water delivery in the Basin.
- The outcomes of this work are intended to improve existing evaluation activities for vegetation that assess ecosystem response, in particular, informing a more sophisticated understanding of why responses may or may not be observed at particular times.

4.2.4 Scaling

Developing an approach to scaling for evaluating ecosystem diversity

This project develops methods to scale the evaluation of watering outcomes from individual sites up to the whole-of-Basin. For example, small scales which occur at individual wetlands, up to large scales where the entire river system is impacted by large volumes of water being used to flush rivers and fill adjacent wetlands. Currently the project team are assessing the variability of diversity responses to water within and between ANAE ecosystem types. This work will enable us to evaluate basin-scale ecosystem diversity at different scales and spatial arrangements of management actions in the Basin.

This project is complete and reporting and transition to evaluation undertaken in 2024–25.

Research questions

- How diverse are the sampling locations from which we are drawing inference
- Does the spatial scale at which ecosystem diversity is defined change our perception of outcomes from water delivery at local versus catchment scales? Can we aggregate to larger spatial scales?

Research outcomes

- Development of multiscale ecosystem diversity metrics that link to the ANAE classification mapping.
- Ecosystem richness has been used to test methods for carrying out assessments at different scales. This has indicated the most appropriate scales for assessment of trends. Finer scale measures of diversity are being used to support visualisation of local scale responses to environmental watering.
- GIS quantification of landscape ecology metrics (patch diversity, evenness, connectivity, contiguity, aggregation, dispersion) at range of spatial scales linked to scales of delivery of Commonwealth environmental water.
- An area-weighted aggregation approach for wetland units at asset and valleys scales is being tested using MDBA tree stand condition and application of the Geosciences Wetland Insights Tool (WIT) to Basin ANAE polygons, aggregating ANAE polygons to the scale of wetland complexes.

Knowledge exchange

- This new data framework and aggregation approach will be applied to the Flow-MER evaluation.
- Preparation and publication of final report.

4.2.5 Non-woody plant responses

Characterising condition for non-woody vegetation in floodplain-wetlands

This research aims to characterise condition for non-woody wetland and floodplain vegetation at different levels of ecological organisation and different spatial and temporal scales. This will improve the evaluation

of outcomes for non-woody vegetation at a basin-scale, develop benchmarks for evaluation of outcomes and enable extrapolation to unmonitored areas. By characterising condition in a structured framework, using both ecological data and societal values, practical guidance can be given to waters managers to help inform the development of benchmarks, watering objectives and monitoring metrics. Outcomes from the project will be directly relevant to Flow-MER evaluation of vegetation and more broadly applicable to monitoring and evaluation of non-woody vegetation outcomes from environmental watering.

This project is complete pending finalisation of a short summary report (to summarise the Thesis published for this project) and transition to evaluation in 2024–25.

Research questions

- How can we improve the evaluation of outcomes for non-woody vegetation at a basin-scale?
- Can we develop benchmarks against which to evaluate outcomes for non-woody vegetation?
- Can we extrapolate outcomes to unmonitored areas?

Research outcomes

- This research is developing a framework of hierarchical condition benchmarks and a process for evaluating success of outcomes for non-woody vegetation at a Basin-scale.
- By characterising condition in a structured framework, using both ecological data and societal values, practical guidance can be given to waters managers to help inform the development of benchmarks, watering objectives and monitoring metrics.
- Conceptual resilience response models have been developed for 5 broad non-woody vegetation types: submerged benthic herbfields, tall reed beds, sedge-rushlands, aquatic grasslands, and ephemeral herbfields under drier and wetter hydrological scenarios.

Knowledge exchange

- Papers published on the outcomes of surveys of environmental water management practitioners and community perceptions of the value of vegetation in river-floodplain systems. Further papers are underway.
- Outcomes from this research are to be used to inform Basin-scale vegetation evaluation. A condition framework which is intended to be immediately applicable to evaluation of the effects of environmental watering on non-woody vegetation.

4.2.6 Remote sensing of woody vegetation

Remote sensing trends and temporal condition responses of woody vegetation to environmental water

This research uses ground-truthed remote sensing to assess vegetation response to environmental watering. Monitoring of condition of woody vegetation is challenging because of the large scale and a lack of simple condition metrics. This research has developed a condition assessment tool (AMLETT) which is being applied at a basin scale. This research improves understanding of vegetation response to water availability (including environmental watering) which can inform prioritisation of environmental water for woody vegetation. It can contribute to identifying water requirement thresholds to inform environmental flow management for vegetation and floodplain, wetland and river ecosystems.

This project transitions to knowledge exchange and evaluation by June 2024 and informs the future Flow-MER program.

Research questions

- What do existing remotely sensed models tell us about the antecedent and current condition of long-lived woody floodplain vegetation at regional and basin-scales?
- How can we translate remotely sensed evapotranspiration into basin-wide condition metrics and identification of key thresholds?
- How are vegetation condition and trends related to hydrology across scales?
- What was the condition of long-lived woody floodplain vegetation prior to the involvement of Commonwealth environmental water and how has this changed?

Research outcomes

- Regression models have been developed relating measured field evapotranspiration to remote sensed values for two tree species, in two environments.
- Visualisation products have been created for ET modelled outputs from 2012 for each pixel within 100-year Basin flood extent for Barmah and Calperum/Chowilla.
- An innovative, fine scale (20 m) method to map fractional tree canopy cover across the Murray-Darling Basin has been developed.
- Continue updating models and develop a higher resolution data set to allow for a more robust remote sensing estimates of evapotranspiration.
- Use condition outputs to compare against the Basin's tree stand condition tool outputs for the same moment in time. Analyse small case studies of watering actions and tree condition responses in area where comparative field data is available.

Knowledge exchange

- 22-year tree evapotranspiration (ET) spatial dataset (30 m, monthly timeseries) from 2000 is available on CSIRO's Data Access Portal.
- Manuscripts have been prepared from work to date.
- Collaborative work with the condition project is underway to incorporate spatial ET into an ecosystem condition assessment to help understand trajectories of change for the Basin tree estate.
- Outcomes from this research are to be used to inform basin-scale vegetation evaluation. A condition framework which is intended to be immediately applicable to evaluation of the effects of environmental watering on non-woody vegetation.
- A final report has been completed pending publication.

4.2.7 Fish populations

Fish population models to inform Commonwealth environmental watering

Fish population models are a basin-scale tool for assisting water management and are useful in evaluating different watering scenarios, in evaluating the likely outcomes and in helping to set monitoring targets. While population models have been used for the past 10 years to predict fish responses to a range of management scenarios, this research will explicitly link flow management to whole-of-lifecycle responses for a suite of native fish species. Predictive population models are powerful tools for adaptive management to test likely population responses to a range of management scenarios. Fish population models could be used to test the impacts of timing and duration of environmental flows or sequences of flows.

Research complete and published. Refinements to models and sensitivity testing was undertaken in 2023–24 and knowledge exchange will be undertaken in 2024–25. This project informs adaptive management.

Research questions

- What is the contribution of Commonwealth environmental water to key native fish population processes including movement, reproduction and survival at the selected area scale?
- How could this contribution be improved to enhance native fish populations?

Research outcomes

- Population modelling used data collated from across a variety of State and Commonwealth (including Flow-MER) monitoring programs and from several expert workshops.
- Basin-wide metapopulation (i.e., a group of separated yet interacting ecological populations) models were developed for golden perch (14 populations areas) and bony herring (9 populations) and individual Murray cod population models were developed for 6 Flow-MER Selected Areas.
- Murray cod Selected Area, Golden perch Basin-scale and first-generation Bony herring Basin-scale models are complete and operational.
- All models for Murray cod were run using observed flows at corresponding river gauge sites and then used to assess population trajectories modelled against flow scenarios with and without Commonwealth environmental water (i.e. a counterfactual approach).
- Overall population trajectories for Murray cod are predicted to be highly sensitive to hypoxic events, causing a significant drop in the modelled adult population. These events are predicted to occur every 7 years in most of Selected Areas.
- For most Selected Areas, Murray cod are predicted to have increased recruitment in response to CEW (using counterfactual comparison). However, this enhanced recruitment only translated into a predicted increase in adult population size in Gwydir and Lachlan River populations.
- The greatest responses of Murray cod to CEW are predicted to be under circumstances where a moderating process, such as hypoxic blackwater or cold-water pollution, was occurring.
- The meta population models developed for golden perch (at a whole of Basin scale) predict broadly stable population dynamics, despite large increases in population sizes in the middle years of the study period and subsequent declines during the Millennium drought.
- The meta population models developed for bony herring (at a whole of Basin scale) predict a general decline since 2010.
- For both golden perch and bony herring, modelling predicts responses to flow and temperature with marked fluctuations in both the southern and northern Basin in response to flow, resulting in relatively greater levels of recruitment occurring during periods of high flow and flooding.
- Refinements to the models incorporated latest findings from related research of fish movement and integrated more northern catchments as well as sensitivity testing.

Knowledge exchange

- The development of Basin-scale fish population models is a major innovation that can inform decision-making for connected water events across a range of geographic and temporal scales.
- The population models can be used to help guide recovery targets (timelines and spatial areas), while also informing the development of watering scenarios or complementary management measures.

- The golden perch metapopulation model enables whole-of-basin decision-making in relation to this highly mobile and ecologically complex species.
- The bony herring model is a novel construct and provides a basin-scale metapopulation model for a species with a different life history to that of golden perch.
- Models are directly relevant to adaptive management of environmental water and are being used to test environmental water scenarios provided by CEWH's delivery teams.
- Publication of results in peer-reviewed articles and other targeted communication activities.
- Final report has been published.

This project is complete – Final report available here.

4.2.8 Fish movement

Flow, movement and fish population dynamics in the Murray–Darling Basin

Movement is essential for fish population persistence and in riverine systems, is fundamentally linked to river hydrology. Research evaluated flow triggers for local and regional scale fish movement to help standardise environmental water among fish species and regions in the Basin. Research used otolith microchemistry and fish movement datasets (from acoustic tags) to build a statistical model to determine fish movement in relation to river hydrology, including environmental watering. These fish movements are an important part of resilience and recovery from disturbance events such as blackwater events and dry-down. Understanding fish movement allows managers to manage for fish passage, support refugia for migrating fish and to understand landscape scale fish movements in terms of population resilience.

This project is complete. This project informs adaptive management.

Research questions

- What is the role of river hydrology in determining regional and inter-regional fish movements in the Murray–Darling Basin?
- How does this vary by life-history stage and species in different Murray–Darling Basin rivers?

Research outcomes

- The project used datasets derived from electronic (acoustic and radio telemetry) and natural (otoliths) tags to construct Basin-wide statistical movement models for golden perch and Murray cod. The objective was to use these existing complementary datasets to quantify the role of river hydrology in determining regional and inter-regional fish movements in the Basin.
- The microchemistry data provides chemical 'signatures' for different catchments. It is possible to measure the 'signature' of different growth bands within the fish otoliths and therefore determine where the fish has been feeding. In combination with tagging data, results show that fish can move very large distances within the Basin, often associated with high flow events. It is also clear that some parts of the Basin act as 'nursery' areas that support fish populations elsewhere.
- Statistical models were generated that enabled prediction of golden perch and Murray cod short-term movements in relation to river discharge events from the telemetry dataset and golden perch immigration/emigration in relation to river hydrology.

- Complementary electronic (radio telemetry) and natural (otolith) data revealed that event-based river discharge (and thus environmental water) positively influences both regional and inter-regional movement of golden perch and Murray cod.
- Across their broad geographic range, both golden perch and Murray cod undertook regional (>5 km) and inter-regional movements substantially influenced by the magnitude of river discharge. Both regional and interregional movement of Murray cod and golden perch can be facilitated by increased river discharge. This is relevant when considering flow connectivity and fish barriers such as weirs.
- Despite examples of large-scale movements, a large proportion of golden perch populations remained within their natal (birth) region throughout their entire lifetime.
- Modelled movement of both species was also found to be highly variable among river catchments, thus understanding of regional movement is important for fish and flow management.

Knowledge exchange

- Fish populations are connected to one another via movement of individuals along river systems. These movements are likely to be an important part of resilience and recovery from disturbance events such as hypoxic blackwater events and dry-down. Understanding fish movement allows managers to manage for fish passage, support important refugia for migrating fish and to understand the potential for landscape scale fish movements to provide resilience for populations.
- There is the potential to create metrics for fish connectivity through the Basin that could be used to evaluate the effective use of environmental water to facilitate fish movement and support resilience of local populations. The movement data will assist in interpreting the processes which are driving patterns seen in the evaluation data already collected.
- Movement data has been used to visualise fish movement and identification of which parts of the Basin are functioning as units for fish meta populations.
- Additional analyses of acoustic data is proposed to determine directionality and distance of fish movements in response to flows.
- Publication of results in peer-reviewed articles and other targeted communication activities.
- Work has been communicated through a CEWH Learning by Doing Workshop (March 2024).
- Final report has been published.

This project is complete – Final report available here.

4.2.9 Ecosystem energetics

Developing an environmental water energetics response model

Research aimed to develop a modelling framework to evaluate the contribution of Commonwealth environmental water to food webs in the Basin. An energetics response model was developed to predict the trophic carrying capacity of rivers and wetlands in response to environmental water delivery. The bioenergetic model aims to show how food webs respond to flow, focussing on refuge habitats, wetlands and flowing water habitats. Energetic relationships have been modelled and can be used to determine energetic impacts of different flow scenarios. This research was designed to improve the certainty of scientific predictions for ecological outcomes in response to environmental watering, and was tested in the Lachlan River system.

Testing the extensibility of the energetics response model

New and related work in the coming year explored food web responses to environmental flows in a new system (the Murray River). Collation of data (existing data) and application of the model across the Murray River (for 14 sites over 15,000 km) is informing applicability of the model more broadly in the Basin.

This project is finishing up early in 2024–25 and will then be published and communicated. Final report is in draft form. This project informs adaptive management.

Research questions

- How does environmental watering influence the flow of energy through to vertebrate consumers such as fish and birds?
- How can energetics response model support prediction of the trophic carrying capacity of rivers and wetlands in response to environmental water delivery?

Research outcomes

- A review of outputs from EWKR was completed in mid-2020 and led to a bioenergetic modelling framework and a case study model for the river channel. The framework integrates dissolved organic carbon, chlorophyll, fish and other biota abundance measures from selected areas. A case study wetland model was completed using field data from the Hattah Lakes.
- The river channel model is time dynamic, and in the wetland systems, the case study model is a state-change, i.e. looking at snapshots at distinct time points to see how the system has changed.
- Diet connections and growth/consumption rates for key taxa were reviewed and experiments on short-term growth of golden perch, large scale mesocosm experiments and studies on the Barwon and Lachlan rivers have provided information for model development.
- A major experiment was completed in late 2020 to manipulate food quality to understand whether energy limitation would prevent golden perch larvae from surviving the transition from larvae to juvenile. There is evidence of clear differences in growth rates depending on food quality, providing preliminary support for the idea that food limitation may be important in limiting fish recruitment.
- Findings show that during overbank flooding, the concentration and total load of organic carbon entering the system increase, and so too do the relative amounts being consumed and entering into the food web. Inundation of the mid and upper section of lowland river banks leads to significantly higher concentrations of organic matter and zooplankton abundances.
- The growth of larval golden perch can be limited by the availability of microzooplankton. Inputs of organic matter associated with flow events may provide resources for increasing microzooplankton and relieving food limitation. Resource pulses associated with flow events can lead to substantial short-term increases in zooplankton with measurable increases in fish biomass weeks later.

Knowledge exchange

- It is well understood that environmental flows can be used as a cue to trigger native fish breeding. However, it now seems likely that some flow conditions may favour larvae physically and in terms of what food resources are available. This modelling work can provide information about the contribution of CEW to the biomass of food web groups, including native fish species.
- The ecosystem energetics framework provides a useful way to integrate long-term monitoring data and knowledge of food webs within the Basin. The model can provide estimates of food web

production between flow scenarios, for example, X kg/km2 per year more fish due to CEW. Outputs are estimates and reflect the quality of data and our knowledge of Basin food webs.

- Wetland case study model for the Gwydir available.
- Publication of results to continue.
- A final report has been completed pending publication.

4.2.10 Flow-ecology relationships

Understanding flow-ecology relationships to predict responses to watering

The Flow Ecology Relationships Project aimed to understand relationships between flow and ecological outcomes and model these relationships to inform adaptive management and evaluation. A novel suite of hydrometrics were developed and using non-woody vegetation communities as a case study, the research identified the hydrology or inundation metrics driving observed changes in vegetation condition. Generalisable statistical models were developed that improve understanding of flow responses of non-woody vegetation and identify flow drivers that shape community patterns.

This project is complete. Project outcomes will inform future research and evaluation.

Research questions

- What are the relationships between flow and ecological outcomes?
- How can these relationships be conceptualised and expressed in a common framework for use across Selected Areas and between Themes with suitable indicators, parameters and input data?
- What model features, components and structures are required for a common method to be fit-for purpose (considering data inputs, desired outputs and spatial and temporal scales)?

Research outcomes

- Compilation and creation of a suite of generalisable hydrometrics. These metrics address the need to represent both in-channel and floodplain components of the flow regime and generalise across space to compare different hydrological settings. These metrics are used to link hydrology and ecological outcomes and provide inputs for both statistical analysis and predictive modelling.
- An assessment of the effectiveness and suitability of different model attributes for assessing Commonwealth environmental water counterfactual flows. This work identified key modelling features needed for the counterfactual.
- Quantified ecological response relationships associated with changes in hydrology across different spatial units and enable the quantification of outcomes associated with different hydrology inputs. The resulting model delivers predictive counterfactual modelling for the vegetation theme.
- Statistical analysis of Flow-MER vegetation data identified flow components of importance and quantified the contribution of flow to understory vegetation outcomes.
- Modelling predicts expected outcomes from flows with and without Commonwealth environmental water and quantifies the benefit resulting from watering over different time periods from watering events to flow regimes.

This project is complete – Final report available here.

4.2.11 Integrative basin modelling

This research generated an Integrative Basin Model framework to model ecological response to environmental watering. The modelling framework integrates across desired outcomes, laying the foundation for future tools for evaluating the value and outcomes of environmental water, explore scenarios, and help understand the reasons for those outcomes at the Basin scale. The framework was developed using Flow-MER information, combining knowledge and scale across Themes and Selected Areas. The framework has potential future use as a management tool. Key areas of development beyond previous tools exist in understanding the interactions between different Themes and locations and in creating synthesised metrics that combine information in space and time, as well as across biotic groups.

This project is complete. Project outcomes will inform future research and evaluation.

Research questions

- Develop a framework to inform planning & evaluation at Basin scale over the medium term (3 to 20 years) in an objective and repeatable way, based on best available science.
- Ensure that the framework has the capacity to integrate responses among taxa, locations and in time and that it has the flexibility to incorporate new knowledge as it arises.
- Provide a framework to assist with the evaluation of the impact of environmental watering via the use of scenario comparisons of current condition versus a counterfactual and to enable forward-looking management.

Research outcomes

- The Integrative Basin Model framework combines knowledge and scale across Themes and Selected Areas for evaluating the outcomes of environmental water and compare scenarios.
- The Vegetation evaluation was used as an initial case study and successfully demonstrated that the framework could include interdependence between species or groups, where success in one group depends on the status of another species or group.
- With the Foodwebs and Diversity Themes, demonstrations using wetland metabolism, and bird breeding events show capacity of the model for integration across species and in space.
- The model demonstrated species responses and interactions, capability to incorporate interactions in space and time and outputs based on adaptive management requirements.

Knowledge exchange

- This framework could assist with adaptive management of environmental watering via the use of modelled comparisons between potential management or climatic scenarios.
- The model was developed as a demonstration for the Lachlan Selected Area and there is the opportunity to utilise the framework for evaluation of that Selected Area.
- Final report completed and journal article manuscript in draft.

This project is complete – Final report available here.

4.2.12 Visualisation dashboard

The **Visualisation Project** integrated data from across Themes to develop data visualisation products for communicating the outcomes of basin-scale monitoring, evaluation and research. The goal was to develop optimum means of presenting raw and processed data, modelling outputs and research results to inform decision making. An interactive data and mapping tool prototype was developed and implemented as an R Shiny dashboard. This powerfully illustrates the potential for these approaches to be used to inform 'real time' reporting in the future. Visualisation summaries were developed for the Flow MER Basin Scale Evaluation reports. This project enabled the production of report summaries directly linked to the evaluation activity through the provision of water year and cumulative summaries which included key findings and visualisations related to the use and outcomes of Commonwealth environmental water.

This project is complete and components transitioned to evaluation.

Research objectives

- Develop data visualisation products for communicating the outcomes of basin-scale monitoring, evaluation and research to help inform policy and decision makers
- Develop optimum means of presenting raw and processed data, modelling outputs and research results to communicate Basin-scale monitoring, evaluation and research.

Research outcomes

- Considerable data has been collected across the Basin on the outcomes of different management interventions. The objective in this project is to allow real time visualisations of that data in order to inform management decisions.
- This research integrated data from across themes to communicate Flow-MER outcomes through a web-based interactive mapping and data explorer (dashboard).
- LTIM and Flow-MER monitoring data have been explored and methods of visualising the results prototyped. This supports visualisation of Basin-scale evaluation outcomes.

Knowledge exchange

- A dashboard of spatial data and preliminary visualisations of LTIM data has been demonstrated.
- A technical report has been finalised and published by CSIRO (data visualisation).
- Visualisation has been moved from Research to Evaluation. A viewer for the Watering Actions Table has been created and shared (and will be updated annually) and a pilot of interactive delivery of a dashboard of some evaluation results is underway.

This project is complete – Final report available here.

4.2.13 Indigenous engagement

Co-designing engagement with Indigenous peoples for better environmental water delivery

The objective of this activity is to frame the engagement of Indigenous perspectives on Australian water management with a particular focus on environmental water. This project meets a need for contextual information and synthesis around Indigenous perspectives on water management to provide a key input to advancing environmental water management. This research recognises challenges achieving productive

and sustainable partnerships with Indigenous people at a national scale and addresses those challenges in narrative form. The research takes a prospective view, describing examples of successful engagement with environmental water through case studies developed in partnership with traditional owners on-country.

This project is complete and will inform future research and evaluation.

Research objectives

- To summarise Indigenous engagement approaches, perspectives and challenges for the 7 Selected Areas with the aim of detailing current activity and identifying emerging opportunities.
- To develop a Case Study on Kamilaroi country in northern NSW which illustrates approaches to engagement.

Research outcomes

- Engaging with Indigenous groups is a challenge in many parts of the Basin. This research explored approaches to simplify engagement while protecting cultural values and intellectual property.
- Research commenced with a historical timeline of Indigenous Engagement in water management.
- This research summarised Indigenous engagement approaches, perspectives and challenges for the 7 Selected Areas through an online survey. Approaches to engagement were summarised and a set of potential methods for engagement developed. Report available on request.
- Ongoing work on Kamilaroi Country is implementing these methods to understand how Indigenous communities wish to be engaged in environmental water management. This work identifies barriers to engagement and to identify cultural values relevant to environmental water delivery.

Knowledge exchange

- An initial review of methods of Indigenous engagement, a reflective narrative and analysis of Indigenous engagement around water, and methods for engagement have been published.

This project is complete – Final report available on request.

Table 4.1 Flow-MER research projects mapped to project themes, with key leadership personnel shown

Theme[1] and leader(s)	Project and leader(s)	Research summary
Biodiversity **Heather McGinness**	Refugia Joanne Bennett	**Identification, characterisation and management of refuge habitat** This project helped us understand how ecological refugia are distributed across the Basin and the potential for water management of these areas to support diversity. **Complete and research report published**
	Waterbird movement tracking Heather McGinness	**Spatial and temporal scales and drivers of waterbird movements and site use across the Basin** This project quantifies spatial and temporal scales of waterbird movements and habitat selection across the Murray-Darling Basin. It uses satellite tracking technology and advanced analysis and modelling approaches to investigate relationships between waterbird movements, habitat selection, environmental watering, flooding, and other variables. Outputs will include a research report and associated journal paper manuscripts. **2024–25: Transition to knowledge exchange. Ongoing data collection if transmitters still active. Report ready to be published.**

Theme[1] and leader(s)	Project and leader(s)	Research summary
	Condition Shane Brooks Tanya Doody	**Understanding how ecosystem condition modulates ecological responses to environmental watering** This project identified ecosystem condition attributes that help to explain watering outcomes in different ecosystem types. It identified measures of ecosystem condition that could be used to adjust expected outcomes and tailor evaluation to better match the context under which water is being delivered.
	Tanya Doody Shane Brooks	**Extension:** This work will describe changes in ecosystem condition to demonstrate how environmental water impacts the condition of a subset of ANAE classes over time. It will use northern and southern basin case studies to quantify change over time and link water requirements and inundation frequency for trees. **2024–25: Transition to knowledge exchange. Report to be published.**
	Scaling Shane Brooks	**Developing an approach to scaling for evaluating ecosystem diversity** This project developed approaches for scaling evaluation of watering outcomes from individual habitat patches to the whole Basin. The aim is to develop a multi-scale approach to evaluate diversity at spatial scales aligned to the scale of watering actions. Output is a research report and spatial layers. **Complete and report in preparation.**
Vegetation **Tanya Doody**	Non-woody plant responses C Campbell Fiona Dyer	**Developing condition benchmarks for non-woody vegetation** This research developed a framework of hierarchical condition benchmarks and a process for evaluating success of outcomes for non-woody vegetation at a Basin-scale. **Completing and summary report ready to be published.**
	Remote sensing vegetation Tanya Doody	**Remote sensing trends and temporal condition responses of woody vegetation to environmental water** This project determined critical thresholds of remotely sensed water use to assess the influence of environmental water; relationships between vegetation response and water regimes; inform prioritisation of environmental water for woody vegetation; and quantify links between vegetation change and hydrology. **2024–25: Transition to knowledge exchange. Report ready to be published.**
Fish **Zeb Tonkin**	Fish populations Charles Todd	**Fish population models to inform Commonwealth environmental watering** Population models demonstrates the benefits of environmental water to fish populations. Improving the robustness of the population models. **Additional work proposed for 2023–24 to add value to research outputs.** Extension. Population models to be reviewed for sensitivity and uncertainty. **Complete and research report published.**
	Fish movement Brenton Zampatti Jason Thiem	**Flow, movement and fish population dynamics in the Murray-Darling Basin** This project develops new models and refines existing models for fish movement of a small number of fish species in the Murray-Darling Basin to inform population level responses to management of flows. **Complete and research report published.**
Food Webs and Water Quality **Paul McInerney**	Ecosystem energetics Paul McInerney	**Developing an environmental water energetics response model** This project developed a bioenergetic model for food web response to flow, initially focussing on refuge habitats, then extended to wetlands and flowing water habitats. **Extension: Explore food web responses to environmental flows the Murray River.** Exploration of data and model across the Murray River (for 14 sites over 15000 kilometres. Data collected in another project and analysed to inform this work. **To be completed early in 2024–25. Report ready to be published.**
Modelling **Danial Stratford**	Flow ecology relationships Danial Stratford	**Developing flow-ecology relationships for evaluation modelling** This project undertook data analysis to understand flow-ecology responses and developed these into a scientifically sound modelling method for Flow-MER evaluation. **Completed and research report published.**

Theme[1] and leader(s)	Project and leader(s)	Research summary
	Visualisation Martin Nolan	**Cross theme resources for data visualisation** This project integrates data across Themes to develop data visualisation products for communicating the outcomes of basin-scale monitoring, evaluation and research. It develops optimum means of presenting raw and processed data, modelling outputs and research results to inform policy and decision making. **Completed and research report published.**
	Integrative modelling Rebecca Lester	**Integrative Basin Modelling Research** The research project developed an integrative framework and systems thinking for integration across Themes and the Basin. This framework was developed for future use as a management tool for both evaluation and research. **Completed and research report published.**
Communication and Engagement **Siwan Lovett**	Indigenous engagement Bradley Moggridge	**Indigenous engagement research** This project summarises and synthesises Indigenous engagement practices and experiences. A case study in the Gwydir catchment explores the mechanisms for effective engagement and culturally appropriate collection and synthesis of data. **Selected Area survey report** completed and available on request.

Appendix A Data management plan

[Updated to reflect the changed data storage platform as a result of the decommissioning of the AARNET[30] Cloudstor platform in December 2023]

A.1 Introduction

The Data Management Plan provides guidance on protocol and specifications for data management expectations from the Commonwealth Environmental Water Holder (CEWH) and CSIRO for the Basin-scale Project.

Data protocols apply to all data collected within the Basin-scale Project. The standards and specifications within this plan are intended to:

- clarify ownership of the data
- improve data consistency and availability of information
- enable information sharing within the project and externally
- meet legal, ethical and funding requirements.

Data sets are defined here as being spatial (e.g. a shape file or geodatabase or a Web Feature Service) or aspatial (e.g. database, spreadsheet, model or code). For example, a data set could be a set of gauge data from multiple sites, or a single vegetation spatial layer.

The Basin-scale Project will meet the requirements outlined below, cataloguing and storing information through the Monitoring Data Management System (MDMS) for evaluation data and, where applicable, a relevant CSIRO data access facility.

The MDMS is the CEWH data management portal for evaluation data. Under the Basin-scale Project contract, CSIRO is obligated to maintain and use this portal. CSIRO will use and deliver data to the MDMS according to best practices of Data Management, as described in this Data Management Plan.

Cloudstor (aarnet.edu.au/cloudstor) is a secure research data storage and file transfer site that is provided by the Australian Academic Research Network (AARNet) and is part of the Australian National Data Service (ANDS). In late 2021, we established a site for storing and managing access to key project datasets for use by the project teams. This proved to be very successful. However, Cloudstor was decommissioned in late 2023. The Data management team investigated alternate platforms and moved seamlessly to a Flow-MER Google Drive site in December 2023 (ref 2023–24 Foundation activity).

As research and other relevant data is finalised and quality assured, it is uploaded to data.gov.au. This is managed jointly by members of the CEWH's Science Team and the Flow-MER data management team.

[30] Australian Academic Research Network, established as part of the Australian National Data Service.

A.2 Ownership and Intellectual Property

All data collected in the Basin-scale Project is owned by the CEWH. The Principles on open public sector information acknowledge that government-funded and held information is a national resource that should be managed for public purposes.

The Intellectual Property for data and outputs will be vested in the Australian Government as per the CSIRO-CEWH Agreement. It will be made part of the creative commons as per Australian Government information policies. Data acquired for use within Flow-MER Program should have a Creative Commons Attribution 4.0 Australia licence (CC BY; Creative Commons By Attribution licence) that allows for the data to be used across Flow-MER Program partner agencies and derived data sets to be published. However, moral rights will be retained by individuals, with authorship and contributions acknowledged in all associated documentation where appropriate.

A.3 Availability

The Department of the Environment Information Strategy 2013-2017 states

> Open access to Government funded information is the default position of the department with exception only for privacy, security or confidentiality reasons.

Data and information products from the Basin-scale Project are to be discoverable, accessible and re-usable by decision-makers, land managers, researchers and the community. The exception is sensitive data.

Research data will be made available through data.gov.au.

A.4 Accessibility

The Australian Government Public Data Policy Statement requires the CEWH and CSIRO to:

- make non-sensitive data open by default to contribute to greater innovation and productivity improvements across all sectors of the Australian economy
- where possible, make data available with free, easy to use, high quality and reliable Application Programming Interfaces (APIs)
- make high-value data available for use by the public, industry and academia, in a manner that is enduring and frequently updated using high quality standards
- where possible, ensure non-sensitive publicly funded research data is made open for use and reuse
- only charge for specialised data services and, where possible, publish the resulting data open by default
- build partnerships with the public, private and research sectors to build collective expertise and to find new ways to leverage public data for social and economic benefit
- securely share data between Australian Government entities to improve efficiencies, and inform policy development and decision-making
- engage openly with the States and Territories to share and integrate data to inform matters of importance to each jurisdiction and at the national level
- uphold the highest standards of security and privacy for the individual, national security and commercial confidentiality

- ensure all new systems support discoverability, interoperability, data and information accessibility and cost-effective access to facilitate access to data.

The Australian Government Digital Continuity Policy states that Digital information is discoverable when it can be easily found. It is accessible when it can be easily retrieved and read in context and it is usable when it can be easily evaluated or understood, edited, updated, shared and reused as appropriate by those who need it.

A.5 Data standards

Data standards are adopted from the *Data management guidance document* prepared by Shane Brooks, for the LTIM Project and now the Flow-MER Program.

Data sets derived by the project are to follow the standard methods where applicable. The individual Themes are responsible for carrying out their own QA/QC process to ensure that the data meet the required quality.

Project derived data must be accompanied by appropriate metadata. For project derived data sets, it is the responsibility of the data set author to write the metadata. Standardised metadata should be used where available. For spatial data, for example, the ANZLIC Metadata Profile based on the international metadata standard ISO 19115 is to be used. Where standardised metadata is not available, data should be provided with as much accompanying documentation as possible to enable a metadata statement to be completed prior to publication. A minimum set of metadata elements is required, and these are:

- Title of the data set
- Abstract (summary of the data content including the purpose for which they were collected. A standard project description should also be included (the text for which will be provided by the data management team.)
- keywords
- metadata author contact details, including organisation
- lineage
- data collection history (e.g. methods, scale, sources)
- coordinate reference system (for spatial data only)
- key dates (at least one date must be entered)
- restrictions on use (licensing conditions, see data licences section above)
- other conditions that apply to the use and publication of the data.

All metadata generated in the project will be captured by project teams and reviewed by the data management team.

A.6 Storage and publishing

The Australian Government Public Data Policy Statement requires data to be published:

- on or linked through data.gov.au for discoverability and availability
- in a machine-readable, spatially-enabled format
- with high quality, easy to use and freely available API access
- with descriptive metadata

- using agreed open standards
- kept up to date in an automated way
- under a Creative Commons By Attribution licence unless a clear case is made to the Department of the Prime Minister and Cabinet for another open licence.

All data, including third party data sets and project derived data sets, will be stored on a project centralised storage unless otherwise specified. From late 2021 to late 2023, this was a CSIRO-account on the Cloudstor site[31], migrated to a CSIRO account on Google Drive in December 2023.

All data will be made available publicly and published in accordance with Australian Government policy where applicable.

All teams have access to each other's data, including third party data sets. Teams will be required to list all of their acquired and derived data sets in their progress reports so that other teams are aware of what is available.

Individual data management requirements for evaluation and research data are described below.

A.6.1 Evaluation data: management through the Monitoring Data Management System

This section outlines continuing arrangements of data, originally collected through the LTIM Project and now the Flow-MER Program. The intent of the Basin-scale Project is to adopt the data management strategy used in LTIM (Brooks; Brooks and Wealands, 2013a; Brooks and Wealands, 2013b).

Selected Areas will continue to manage their own data (ranging from structured to ad hoc) and submit a copy annually to a central database (Monitoring Data Management system; MDMS) that serves as a repository and aggregator for the Basin-scale Evaluation. We recommend each Selected Area has a data manager.

- Data are submitted to the MDMS by Selected Areas using csv formatted tables uploaded via a web interface.
- Expectations are that final data are submitted to the MDMS in a complete (i.e. QA/QC checks, with metadata) and timely fashion, no later than 22 December of each year.
- New data are given preliminary status and undergo some automatic quality checking (spelling, data ranges, formats). Providers are given feedback via email regarding any errors so they can fix and resubmit, with final quality checked data to be entered by 22 December, annually.
- When uploading is complete, the data are manually extracted from the MDMS and summaries generated and sent back to data providers to further quality check to ensure the stored data match the intended data supply before data are moved to final status for sharing.
- Basin team data products are to be stored in the MDMS (e.g. time series flow data). Spatial data and model code will be curated through the CSIRO Basin-scale site (from December 2023, Google Drive).

Only final data is shared to the Basin evaluation team and third parties on request.

[31] CEWH Flow-MER Data Landing Page.xlsx - CloudStor (aarnet.edu.au)

A.6.2 Research data: management through a CSIRO data portal

As an interim measure (awaiting final delivery through the Australian government's data.gov.au), and where applicable, research data and code collected or developed as part of the Basin-scale Project will be stored on a secure site (from December 2023, a password protected Google Drive site).

Research data can also be housed in the MDMS where it complements other monitoring data, is in a simple tabular data, and is made up of multiple locations that need to be aggregated.

A.6.3 Sensitive data storage

All Basin-scale Project Research which requires the involvement or study of humans or their data must comply with the requirements specified in the National Statement on Ethical Conduct in Human Research (2007 updated 2018) and any relevant State and Federal legislative requirements e.g. Privacy Act 1988.

In the Basin-scale Project we will ensure sensitive or confidential data (for example and research involving Indigenous peoples and communities) is stored in accordance with CSIRO's Social Science Human Research Ethics Committee approvals as per the National Statement on Ethical Conduct in Human Research 2007.

This can include (not limited to):

- make arrangements to securely store any culturally sensitive information gathered during the project and to protect participant's privacy
- establish processes to ascertain what is sensitive/confidential e.g. through conducting background literature reviews, talking to previous researchers, interviews with participants, feedback from an Indigenous reference group
- members of the research team are aware of the provisions under Indigenous customary protocols for not-naming or showing images of recently deceased people in publications/reports
- hold discussions with Indigenous research collaborators as to where the research materials will be stored so that they have access, as requested
- prioritise storing or providing mirror copies of relevant materials in local community knowledge centres or keeping places. Where there are no local facilities, copies of recordings and other relevant materials (as discussed) will be made available in hard copy and digital forms to relevant people.

As at 30 June 2024, some of these data are stored in a CSIRO Teams private channel, accessible only by (and to) the few people in the Indigenous engagement team, the Basin-scale Project Leader, and the data manager.

A.7 Freedom of Information

This Data Management plan aligns to the requirements set out in the *Freedom of Information Amendment (Reform) Act 2010.* The requirements are met through:

- the Data Management Plan itself will be published
- the Data Management Plan has strategies to ensure published data is accurate, up-to-date and complete
- data collected under the Basin-scale Project is considered a national resource and will be published free of charge and available for public use
- data is published under a creative commons licence and to our knowledge there are no national or State secrets or privacy concerns that warrant exclusions.

A.8 References and resources

Brooks S Data management guidance document.

Brooks S and Wealands S (2013a) Functional Requirements for LTIM Data Management. Draft Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 2013 December, 8pp.

Brooks S and Wealands S (2013b) Long-term Intervention Monitoring Project Data Management Strategy. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 01.4/2013, June, 26pp.

Digital Continuity Principles, National Archives of Australia.

The Department of the Environment Information Strategy 2013-2017

The Australian Government Public Data Policy Statement

Principles on open public sector information

National Statement on Ethical Conduct in Human Research 2007

Privacy Act 1988

Freedom of Information Act

Freedom of Information Amendment (Reform) Act 2010

Appendix B Stakeholder Engagement and Communication Plan

This document is supported by an annual operating plan that provides operational detail. The Plan for 2024–25 has been simplified to reflect that during this year SE&C transitions to Flow-MER2.0.

Stakeholder engagement and communication activities are a vital component of the Flow-MER Program, ensuring that work undertaken within the context of the broader mandate of the CEWH is practically applied. These activities are also important in enabling stakeholders to have confidence in, and use, the information generated through the Basin-scale Project. The Stakeholder Engagement and Communication Plan uses collaborative approaches in recognition of the important role of the CEWH, Selected Area Project teams and environmental water delivery partners in meeting communication objectives.

B.1 Objectives

- Engage with stakeholders thoughtfully, value knowledge, develop trusting relationships over time, respect cultural and local contexts, and promote successful outcomes.
- Collaborate with the CEWH and environmental water delivery partners to ensure that the outcomes from monitoring and evaluation are informative and meet their needs.
- Explain why Flow-MER is needed to support the delivery of Commonwealth environmental water so that it can benefit the Basin's rivers and communities.
- Inform a broad stakeholder audience about the Basin-scale project to increase community confidence in the science informing environmental watering policy and decisions.
- Work with Selected Areas to increase awareness and understanding of the multiple benefits that Commonwealth environmental water provides to ecological and human communities.
- Integrate Indigenous culture throughout all activities by ensuring language, place names and cultural references are fundamental parts of our strategy and delivery. Ensure all intellectual property is protected, and agreements established where knowledge transfer occurs.
- Maintain a website, plus online and hard copy resources to share the science undertaken through the Flow-MER Program and provide access to scientific information using stories, webinars, workshops, videos, and images, to attract interest and engage target audiences.

B.2 Approach

Stakeholder engagement and communication is a core component of the Basin-scale project. A Cross-cutting Theme has been created to ensure stakeholder engagement and communication objectives are met and a dedicated team has been put in place to ensure resources are focussed in this area.

The Stakeholder Engagement and Communication Theme is led by Siwan Lovett (ARRC) and includes Pat Gudhka, Andy Lowes, Isobel Bender, Masha Artamanova and Chris Walsh. These key personnel work with the project leaders, project coordinator, project manager, Theme leaders and other members of the project team on focussed communication activities. The team add specialist expertise in stakeholder engagement,

deep networks in Basin communities and the capability to engage a wide cross-section of stakeholders in government, communities, and Indigenous groups. The team use feedback and evaluation to keep the plan relevant and activities focussed on the needs of the CEWH (and reflected in annual operating plans).

In addition, Project leaders, Theme leaders and the Project coordinator use the governance structure, reporting deliverables and meeting schedule set out in this plan to underpin extensive engagement with primary users including the CEWH, Officers of the CEWH, delivery teams and partners, as well as the project team and Selected Area teams and collaborating organisations. The project leaders include science communication in their planning to ensure that adequate attention is paid to the very important role of science engagement, publishing, presentation and communication in furthering the objectives of the Basin-scale project. Each year, the Stakeholder Engagement and Communications Plan and annual operational plan are reviewed to ensure outcomes are delivered and the CEWH can value add to the communication efforts. Responsibilities are summarised in Table B.1.

Table B.1 Communication responsibilities

Stakeholder Groups	Project leaders and Coordinator	Theme leaders and senior scientists	Stakeholder Engagement and Communication team	Officers of the CEWH
CEWH	X			X
Flow-MER Program	X	X	X	X
Environmental water managers	X	X	X	X
Indigenous Groups			X	X
Science community	X	X		
Water agencies, NGOs and managers	(X)		X	X
Basin communities and the public			(X)	X

B.3 Activities

B.3.1 Collaborate as a capable, confident communications team

We value our strengths and share ideas about how we can best deliver our goal of inspiring and enabling the Basin-scale project to achieve great results. We spend time together as a team, face-to-face, online and via the phone to ensure we support each other, allocate tasks, and manage our portfolio of communication and engagement responsibilities.

Deliverables

- a Stakeholder Engagement and Communication team who are enjoying their work and inspiring others to do the same - leading by example
- accessible and approachable team providing support and advice to the wider Flow-MER Program.

B.3.2 Develop engagement and communications infrastructure

Develop and maintain Flow-MER website, social media platforms (Facebook, LinkedIn, Instagram) and explanatory brochures/postcards/fact sheets explaining Flow-MER and why it is important. Over time, the content of these has shifted from raising awareness, to sharing findings, implications of findings for

management, and recommendations. Storytelling is a key engagement and communications approach, along with photographs, infographics, and maps that people can explore.

Stories and content generated across the Flow-MER Program may are shared on other related websites such as the Commonwealth Environmental Water Holder (DCCEEW), MDBA, Victorian Environmental Water Holder, CSIRO, Institute of Applied Ecology, Australian River Restoration Centre, and partner websites. The underlying principle for all Flow-MER Basin-scale project communications is that one story is used multiple times, and on many platforms, to extend reach and cater to a wide range of audiences.

To enable this to happen, stories are made available in a range of formats so that they can be easily shared and used on different website platforms and media. We also develop relationships with key partner communications personnel so that they can tailor content so that it is meaningful for their networks.

Deliverables

- Flow-MER website sharing Theme, Basin-scale and Selected Area stories and content
- social media platform to share stories (Facebook, LinkedIn, Instagram), linked to CEWH (DCCEEW), CSIRO, UC and other partner agencies
- webinars, videos, infographics, maps and visualisations to engage with people and share findings
- place based postcards, fact sheets and guides to explain environmental watering and to share findings across the Basin-scale Flow-MER activities are used to raise awareness and engage target audiences.

B.3.3 Communications support for the Basin-scale Flow-MER project team

Provide support and advice to the Basin-scale team as they develop and deliver their engagement and communication strategies, organise activities and interact with stakeholders. The Stakeholder Engagement and Communication team are in close contact with the Basin-scale and Selected Area teams so that they can build engagement and communications activities into their annual plans, rather than at the end of projects. We are focused on ways to achieve both local and Basin-scale communication and engagement outcomes, while at the same time retaining the authenticity of local community connections and culture.

Deliverables

- communication collaboration and support via workshops, email, phone calls, editing and design
- active sharing of engagement ideas and outcomes
- Indigenous connection understood and culturally appropriate ways of engaging determined.

B.3.4 Build strong and meaningful partnerships with Indigenous groups in delivering Commonwealth environmental water

Our Indigenous engagement and communication strategies at Selected Area and Basin-scale needs to build on current strengths, relationships, and networks, as well as supporting and developing engagement capability in areas requiring assistance. The Basin-scale project aims to deliver messages of environmental water benefits with community and cultural outcomes. Some areas have had Indigenous people excluded for many years, this is an opportunity for Traditional Owners to reconnect with their Country and be involved in Caring for Country and Water.

We seek to learn about and build upon successful Indigenous engagement through the CEWH's communication team and Selected Areas. In our communications, culturally sensitive and appropriate engagement approaches are used (Appendix C). We work with collaborating across Flow-MER to develop products and approaches specifically for sharing Indigenous insights and knowledge.

Deliverables

- Locally developed protocols on respectfully engaging Traditional Owners (via University of Canberra)
- Newsletters and web content (tell a Deadly Story)
- Videos of water flowing and Traditional Owners on Country
- Activities during Reconciliation Week and NAIDOC Week.

B.3.5 Synthesise knowledge for Basin-scale understanding

One of our key roles is to synthesise knowledge from the Selected Areas and Themes to provide Basin-scale understanding about the outcomes of environmental watering research, monitoring and evaluation. Each year we work with the Flow-MER team to develop communications outputs that contain key messages drawn from research and monitoring and evaluation activities. This knowledge is used to underpin web stories, policy briefings and input to the Annual Forum. We also look at ways to present synthesised knowledge through digital storytelling, exploring content using new technology and innovative approaches to communication.

Deliverables

- Up to 4 synthesis stories per year drawn from the Selected Areas and Themes that are shared multiple times via web, social media, pod casts, webinars and policy briefing
- In collaboration with cross-cutting teams, explore how to present our research findings in innovative ways (e.g. interactive maps)
- Report summaries with links to full reports, presentations, and publications to reach the scientific community in Australia and internationally.

B.3.6 Forums / gatherings / conferences

Each year the Project team use the Annual Flow-MER Forum, the annual research showcase and other conference and meeting opportunities to share findings from across the portfolio of activities. We target environmental water managers, and anyone interested in the work we are doing. We use a mix of presentations, on-country interpretive walks, and social events.

In addition to these events, we target relevant conferences and workshops for Basin-scale Project team members to attend, for example, the Australian Stream Management Conference, the Australian Freshwater Science Society, MODSIM and the Australian Society for Fish Biology.

Deliverables

- Forums, events, and gatherings
- Branded content and supporting materials for a consistent and professional look and feel.

B.3.7 Deliverables

Table B.1 provides an outline of proposed activities and deliverables. These are finalised in an annual communication prepared and approved by Project Leaders in the first quarter of each year.

Table B.1 Communication activities and deliverables

Activity	Proposed deliverables	Timeline
Collaborate as a team	Monthly catch ups on phone, skype Online communication tools (MS Teams)	Monthly catch ups Weekly coordination
Communications & engagement infrastructure	Interactive, story-based Flow-MER website Editing and publishing 7 x articles each quarter on the Flow-MER website, integrated research across Selected Areas and Basin Themes Notifications to Flow-MER community email list Social media stories on Facebook and Twitter Flow-MER Fridays webinar series held every six months. Hard copy resources – postcards, fact sheets, guides depending on content and priorities.	Monthly creation, collation and distribution of articles Two social shares per week on Facebook plus post boosting Quarterly creation and distribution of email newsletter Hard copy resources – editing, design, printing
Communication support for Basin-scale Flow-MER team	Time with Basin Theme and Selected Areas to explore synergies Indigenous engagement support and guidance	Each Basin Theme Selected Area will have time annually with the SE&C team
Meaningful Indigenous engagement	Locally developed protocols on respectfully engaging Traditional Owners (UC) Newsletters and web content (tell a Deadly Story) Use of Traditional names Activities during Reconciliation Week and NAIDOC Week	Content for Flow-MER website Reconciliation Week and NAIDOC presence
Synthesise basin-scale knowledge	Synthesis stories from across the Basin Themes developed and shared Data visualisation, maps, interactive ways of accessing new knowledge in collaboration with cross-cutting team	Synthesis stories shared via website, and Flow-MER email newsletter Presentations Time allocated to working Themes
Forums, events, and gatherings	Communication and engagement events (format detailed in operational plan) Branded content and supporting materials for a consistent look and feel	Events (detailed in operational plan) Template for PowerPoint presentations Training on an as needs basis

B.4 Ethics

All stakeholder engagement activities for the Basin-scale project are subject to CSIRO's Human Ethics policies. All human research conducted by CSIRO and our subcontractors or partners must comply with the *National Statement on Ethical Conduct in Human Research* (2007 updated 2018)[32] and any relevant State and Federal legislation e.g., *Privacy Act 1988*[33].This is a requirement of CSIRO's Ethical Conduct in Human Research[34] policy and applies to our research both within Australia and overseas. All work undertaken will require meeting of the requirements of the National Statement. This will be a requirement for contracting any research with human participation.

All Indigenous Engagement will adhere to the Indigenous Engagement Plan (Appendix C).

[32] https://nhmrc.gov.au/about-us/publications/national-statement-ethical-conduct-human-research-2007-updated-2018

[33] https://www8.austlii.edu.au/cgi-bin/viewdb/au/legis/cth/consol_act/pa1988108/

[34] https://my.csiro.au/Policy-Portal/Research-ethics/Ethical-Conduct-in-Human-Research

Appendix C Indigenous Engagement Plan

This document provides a protocol and guidelines for Indigenous Engagement in Flow-MER.

Acknowledgement of Traditional Owners and Country

CSIRO and collaborators acknowledge the Traditional Owners of Australia and pay respect to the past, present, and future Elders of the nation.

Introduction

The Indigenous Engagement Plan provides direction on the expectations of CSIRO and the Office of the Commonwealth Environmental Water Holder (CEWH) to ensure effective and authentic integration of Indigenous priorities, values, and aspirations in the Basin-scale Flow-MER Project.

Indigenous people are key stakeholders in the future of environmental water in the Murray–Darling Basin. All research undertaken in the Basin impacts Indigenous peoples, and CSIRO and collaborators recognise and respect the knowledge Indigenous peoples have in managing Australia's land, water, biodiversity, and cultural heritage.

Ethics approvals

All Basin-scale research or other activities that involve humans or the use of human data must undergo review and receive approval by CSIRO's Social Science Human Research Ethics Committee before project commencement or the receipt of any data (these approvals are then reciprocal for all University Ethics Committees).

This will ensure that the project complies with the requirements specified in the *National Statement on Ethical Conduct in Human Research* (2007 updated 2018) and any relevant State and Federal legislative requirements e.g. *Privacy Act 1988*.

This includes research that involves community and Indigenous engagement in participatory action research, surveys, interviews, or observation, access to personal documents or materials, and access to people's information via an existing published or unpublished source or database.

Principles for Indigenous engagement

CSIRO and the Office of the CEWH expect that all Basin-scale project activities are carried out with respect for Indigenous peoples' priorities, values, and aspirations. All relevant research projects are required to include planning for building meaningful partnerships with Indigenous peoples.

The Australian Institute of Indigenous and Torres Strait Islander Studies (AIATSIS) has developed *Guidelines for Ethical Research in Australian Indigenous Studies* which supplies principles to ensure that research with and about Aboriginal and Torres Strait Islander peoples follows a process of meaningful engagement and reciprocity between the researcher and the individuals and/or communities involved in the research.

Under the Guidelines Aboriginal and Torres Strait Islander peoples are full participants in research projects that concern them, share an understanding of the aims and methods of the research, and share the results of this work. At every stage, research with and about Indigenous peoples must be founded on a process of meaningful engagement and reciprocity between the researcher and Indigenous people. It should also be recognised that there is no sharp distinction between researchers and Indigenous people. Indigenous people are also researchers, and all participants must be regarded as equal partners in a research engagement.

Pathways and mechanisms

Basin-scale Project Team members are expected to engage using the AIATSIS *Guidelines for Ethical Research in Australian Indigenous Studies* which include the following categories:

- rights, respect, and recognition
- negotiation, consultation, agreement, and mutual understanding
- participation, collaboration, and partnership
- benefits, outcomes and giving back
- managing research: use, storage, and access
- reporting and compliance.

In practice, this would include the following (not limited to) procedures:

- acknowledge Indigenous peoples in the Murray-Darling Basin as the Traditional Owners and Custodians of the land
- acknowledge and recognise the diversity of Indigenous peoples and communities in the Murray-Darling Basin, including their different languages, cultures, histories, perspectives and aspirations
- ensure that Indigenous people are equal participants in research projects. Where possible and applicable, facilitate co-design of research projects
- ensure that the appropriate Ethics Approvals are in place for any consultation and communication processes (including processes on consent, participation, Intellectual Property etc.)
- where possible, research should benefit Indigenous peoples locally and generally. For example, Indigenous people who contribute (traditional knowledge, practices and innovations, cultural expressions and intellectual property) to a research project should receive fair and equal benefits
- acknowledge that all information shared by participants is shared with government and public and can be attributed or anonymous
- use existing governance structures to channel engagement, such as Land Councils, Murray Lower Darling Rivers Indigenous Nations (MLDRIN), Catchment Management Authorities and Local Government and community bodies
- ensure sensitive or confidential data (for example, any research involving Aboriginal and Torres Strait Islander peoples and communities) is stored in accordance with CSIRO's Social Science Human Research Ethics Committee approvals as per the National Statement on Ethical Conduct in Human Research 2007 [see Sensitive data storage section in Basin-scale Flow-MER Project Data Management Plan (Appendix A)].

Please also refer to the Basin-scale Project Stakeholder Engagement and Communications Plan (Appendix B) which includes information on stakeholder engagement.

Intellectual Property rights

Article 31 of the *Declaration on the Rights of Indigenous Peoples* (2007 United Nations) states Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as the manifestations of their sciences, technologies and cultures, including human and genetic resources, seeds, medicines, knowledge of the properties of fauna and flora, oral traditions, literatures, designs, sports and traditional games and visual and performing arts.

CSIRO and the Office of the CEWH expect that all Basin-scale project activities will acknowledge Indigenous people and all information, views, or knowledge they share with Basin-scale Project researchers is shared with government and public whether attributed or anonymous.

Intellectual Knowledge protocols in research include (but are not limited to) the following:

- discuss what Intellectual Property means and agree on how it will be managed during the project (including consent, publishing, and data storage)
- utilise release forms for the recording, filming or photographing Indigenous culture, sites and larger landscapes
- include attribution and provenance of data (records the names of people, communities, and clan/ language groups)
- ensure acknowledgements and credits remain traceable in databases or records so that connections with the original sources of Indigenous knowledge are not lost
- discuss the possible secondary use of any data generated through the project, and
- acknowledge that all information shared is shared with government and public and can be attributed or anonymous.

References and resources

The Department of the Environment and Energy's Engage Early guidelines also provide guidance on engagement and consultation of Indigenous peoples.

Department of Aboriginal and Torres Strait Island Partnerships – Protocols for Consultation

United Nations – Declarations on the Rights of Indigenous Peoples

Share our Pride

National Statement on Ethical Conduct in Human Research (2007 updated 2018)

Privacy Act 1988.

Guidelines for Ethical Research in Australian Indigenous Studies

Thurgate N, Cuddy SM, King AJ, Flett D, Thompson R, Pollino C, Bennett JM, Brooks S, Campbell C, Doody TM, Dyer F, Hitchcock JN, Holt G, Lester R, Lloyd-Jones L, Lowes A, Lovett S, McInerney P, Macqueen A, McGinness H, Moggridge B, Nolan M, Rees G, Stratford D, Thiem J, Todd C, Tonkin Z, Wassens S and Zampatti B (2024) Flow-MER Basin-scale research: Summary 2023. April 2024 release. Report prepared for the Commonwealth Environmental Water Holder (CEWH), Department of Climate Change, Energy, the Environment and Water, Australia.

https://flow-mer.org.au

Australian Government
Commonwealth Environmental Water Holder

Partners

CSIRO

UNIVERSITY OF CANBERRA

Collaborators

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Government of South Australia
Department of Primary Industries and Regions

SARDI
South Australian Research and Development Institute

une University of New England

NSW Government | Department of Primary Industries

DEAKIN UNIVERSITY

ARRC Australian River Restoration Centre