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**Commonwealth Long-Term Intervention Monitoring Project:**

**Stage 1 Mid-Term Review and Evaluation**

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Prepared by

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Front cover photo: Freshwater meadow, Wimmera, Victoria, R. Butcher

# Executive Summary

This report contains an independent ‘program level’ Mid-Term Review and Evaluation (MTRE) of the Commonwealth’s Long Term Intervention Monitoring (LTIM) Project undertaken by Prof Barry Hart (Director, Water Science Pty Ltd) and Dr Rhonda Butcher (Principal, Waters Edge Consulting).

The LTIM Project is the main program for addressing the Commonwealth Environmental Water Office (CEWO) requirements under the *Water Act 2007 (Cwlth)* and Murray-Darling Basin Plan. The LTIM Project commenced on-ground monitoring in June 2014, after an initial two-year scoping and development phase. The monitoring will occur over a five-year period, ending in June 2019.

The LTIM Project is world-leading in its scope, both spatially (the entire Murray-Darling Basin) and temporally (5 years), objectives and budget (over $30 million over 5 years). It is seeking to achieve an outcome – assessment of the effectiveness of Commonwealth environmental water delivery in achieving local and Basin-scale ecological outcomes – that has never been attempted before anywhere in the world. It is a highly ambitious project.

The objectives of this MTRE are (in brief): to assess the structure of the LTIM Project; to review progress, effectiveness, achievements and outputs of the LTIM Project from the first three years of monitoring (2014-15 to 2016-17); to assess what is working well and what can be improved in the short and longer term; and to provide a series of recommendations and associated management responses related to the review findings for the CEWO’s consideration.

The evidence for this MTRE was obtained from two sources: first, from a review of relevant reports; and second from interviews with CEWO staff, the Murray Darling Freshwater Research Centre Director and Basin Matter leads; the leads of the seven Selected-Area teams and selected team members; and relevant staff from the Murray-Darling Basin Authority (MDBA).

### LTIM Project structure

The LTIM Project structure is sound and does not need to be fundamentally changed. However, it appears that the LTIM Project has shifted emphasis with the focus on the Selected Area outcomes now occurring at the expense of the Basin-scale evaluation. This is a concern since this Project was established as the main program for assessing the CEWO requirements under the Murray-Darling Basin Plan, a Plan that is focused on improvements at a Basin-scale. The CEWO should review whether this apparent changed Project focus will impact on their capacity to report on the contribution of Commonwealth environmental water at a Basin-scale.

There are also a number of modifications that could be made over the next few months and in future iterations that would strengthen the Project. These are discussed fully below (with recommendations) and include: first, to review and clarify the Project objectives; second, to work to further improve the collaboration and coordination between the Selected Area teams and the Basin Matters team perhaps by establishing a *Project Steering Committee*; third, to review the LTIM Project Management arrangements, including consideration of desirability of establishing a *Science Leader* position; and fourth, to develop a *Program Evaluation Strategy* as part of the MERI process to assist in assessing the efficiency, effectiveness, relevance and sustainability of the LTIM Project.

### Progress

***Area-scale evaluation*** *–* the Selected Area projects are generally being run effectively and appear largely to be on track to meet their stated objectives, with constraints relating to watering actions being responsible for most issues with achieving short term expected outcomes. Two areas were identified that need attention: first, objectives need to be reviewed to ensure they are SMART[[1]](#footnote-1) or at least achievable and measurable; second, the ecological outcomes of each local-area watering action need to be more specifically addressed; third, the contribution of Commonwealth environmental water in meeting the objectives of the Basin Environmental Watering Plan need to be better accounted for; fourth, the scaling up of the Area-scale assessments and evaluations to the entire Selected Area need more attention; and fifth, the short and long term evaluation questions need to be more specifically addressed. Additionally, this review has also identified issues with collaboration, reporting and review that need to be addressed (see below).

***Basin-scale (Basin Matters)* *evaluation*** – this aims to use data being generated by the Selected Area teams to determine the contribution of Commonwealth Environmental Water (CEW) at the Basin-scale to achieving the Basin Plan Environmental Watering Plan objectives relating to biodiversity, resilience, water quality and ecosystem function. These learning’s will be used to inform adaptive management. Each of the Basin Matter evaluation reports and the synthesis report has been assessed in terms of meeting the stated objectives and reporting requirements. Some Basin Matters are not meeting expectations because of data limitations (i.e. lack of wetland inundation data), lack of ecological response to base flows or freshes (i.e. stream metabolism) or simply require longer data sets to establish linkages to watering actions. Additionally, this review has also identified issues with quantitative Basin-scale modelling, the monitoring data management system, collaboration, reporting and review that need to be addressed (see below).

***Adaptive management*** – this review found that while there is considerable attention on the capture of adaptive management learning’s each year by the Selected Area teams, this could be done more systematically. We have identified two changes that could improve the situation: first, the many informal and formal discussions that lead to changes in planning and water delivery need to be captured and added to an accessible and searchable database; and second, there appears to be no report that captures and synthesises the way this increased knowledge is changing the way in which the CEWO delivery teams are managing environmental water.

### Possible modifications to the Project

***Project structure***

As noted above the LTIM Project structure is sound and does not need to be fundamentally changed, although we have identified a number of modifications that could be made over the next few months to strengthen the Project. First, the LTIM objectives and key evaluation questions need to be reviewed (**Recommendation 1**). The LTIM Outcome Framework was developed prior to the completion of the Basin Environmental Watering Strategy (BEWS) and as such there is a misalignment between the four Basin Matters in the BEWS (hydrology and connectivity, fish, vegetation and waterbirds) and the Basin Matters monitored under LTIM, in that waterbirds are not monitored as part of the LTIM Project. Additionally, the watering objectives underpinning the watering actions are not SMART. Second, to further improve the collaboration and coordination between the Selected Area teams and the Basin Matters team CEWO should consider perhaps by establishing a *Project Steering Committee* (**Recommendation 4**); third, the LTIM Project management arrangements should be reviewed, including consideration of desirability of establishing a *Science Leader* position (**Recommendation 5**); and fourth, a *Program Evaluation Strategy* as part of the MERI process should be developed to assist in assessing the efficiency, effectiveness, relevance and sustainability of the LTIM Project (**Recommendation 6**).

***LTIM Objectives***

*Review and update LTIM objectives and Key Evaluation Questions (KEQ)* – as part of the adaptive management of the LTIM Project, the objectives and KEQs needs to be refined using SMART criteria. In addition, the Area and Basin-scale evaluation needs to be aligned to the expected outcomes and targets set in the BEWS. Both these modifications are linked to the primary objective of LTIM to evaluate the contribution of CEW to meeting the objectives of the Basin Plan Environmental Watering Plan. The lack of the use of SMART criteria in setting objectives is pervasive throughout the water planning process right through to the LTIM project. Effective process and outcome evaluation cannot be achieved without establishing a baseline against which to assess trends. To move away from a purely narrative based output, some specific amendments or revisions to the objectives and KEQ are required (**Recommendation 1**).

*Expectations from the Basin-scale evaluation* – during the first three years of Project implementation many issues (some quite unexpected) have emerged and solutions had to be found at both the Selected Area and Basin-scale. This is not unexpected given the scope and experimental nature of this LTIM Project. However, the time taken to find solutions to these quite difficult issues has meant that some of the more long-term objectives have had less attention than was originally envisaged. Consequently, some of the initial expectations of the Basin-scale evaluation are unlikely to be met and need to be revised. These include: the Basin-scale quantitative models; and the inferring of the outcomes of Commonwealth environmental water in areas not monitored as part of the LTIM Project (**Recommendation 11**).

*Assessment of the contribution of Commonwealth environmental water* – many of the key evaluation questions being addressed at both the Area-scale and Basin-scale are focused on the contribution of the *Commonwealth* environmental water to key ecological outcomes, such as fish breeding, wetland vegetation community diversity and ecosystem diversity. This has caused problems with the reporting of ecological outcomes as a result of environmental watering events where the Commonwealth’s contribution may be only part and sometimes a quite small part of the total environmental water delivered. This issue has now been partially resolved, although we believe this is still extremely open to interpretation as the KEQs do not have SMART objectives.

*Improve the expected outcomes for large multiple-scale watering actions* - the CEWO is increasingly moving toward coordinated large-scale watering actions that influence multiple assets and rivers, and the monitoring and evaluation process needs to be modified to ensure the adaptive management can be undertaken at this large scale (**Recommendation 2**).

*Expected outcomes for key ecosystem types (Ecosystem Diversity)* - the increased focus on multi-scale watering actions has implications for the ecological scale of expected outcomes; that is the need to consider ecosystems in addition to species and populations. There is a need to better understand how key ecosystem types influence Basin biodiversity, resilience, ecosystem function and water quality. The CEWO needs to develop 1-year and 5-year expected outcomes for ecosystem diversity (**Recommendation 3**).

***Area-scale evaluations***

This MTRE has identified four areas where there could be improvements in the Area-scale evaluations: first, meeting the stated objectives; second, interactions and collaboration; third, reporting; and fourth, initiating independent technical review of the annual reports. The assessment of progress towards meeting objectives was of necessity a high level evaluation and focused on the provision of services for evaluation, adaptive management and context as per the contracts with the Selected Area teams. Most Selected Area teams are not fully meeting the requirements – mainly in relation to failing to scale up to whole of Selected Area, cumulative evaluation of results and reporting on Basin-scale data collected at the Area-scale. Interaction and collaboration is a fundamental requirement of the LTIM project, this has been improved considerably with increased interaction between the Selected Area teams, but still requires work to improve collaboration between the Selected Area and Basin Matter teams. Improved reporting is also seen as critically important to the legacy of the LTIM Project, as is independent review of the science (**Recommendations 7, 8 and 9**).

***Basin-scale evaluations***

*Meaning of Basin-scale evaluation* – The concept of what constitutes a ‘Basin-scale evaluation’ or an ‘integrated Basin-scale evaluation’ is still poorly articulated. Presumably, a Basin-scale evaluation will be made up of the aggregation of subsets of the Basin; these may be large sub-regions (e.g. northern and southern Basins) or single catchments. But even the integration of the components making up a catchment is not a simple matter. We have recommended that CEWO establish a process to better define this term and to scope how a ‘Basin-scale evaluation’ would be undertaken (**Recommendation 10**).

*Development of quantitative models* – There is no clear plan for how the Basin Matters team will develop, test and implement quantitative models for fish, vegetation and metabolism in the 18 months to the LTIM Project’s completion. There is an urgent need for a comprehensive *modelling development plan* to be developed (**Recommendation 11**).

*MDMS QA/QC issues* – Data quality control issues continue to impact on the ability of the Basin Matters team to complete their annual evaluations in a timely manner. We have recommended that resolution of this issue be one of the first tasks of the new Steering Committee (**Recommendation 12**).

*More detailed hydrological information and improve inundation mapping* - the availability of hydrological information relating to watering actions is highly variable and is limiting the assessments of hydrological outcomes and ecological responses. Equally, the high uncertainty about the fate of water in the landscape after it is released is also limiting Area-scale and Basin-scale evaluations. The volumes in storage and the rates and timing of delivery are well known, but the physical extent of water covering the land and the duration it persists in wetlands and on floodplains is much more poorly understood (**Recommendation 13**).

***Collaboration***

This review has identified a continuing need to support moves to improve collaboration between the Selected Area teams, and between the Selected Area teams and the Basin Matters team. The benefits of this improved collaboration needs to be assessed (**Recommendation 14**). Additionally, there is a need to provide a more formal collaboration component to the Project’s structure for the remainder of the Project, perhaps by the establishment of a *Project Steering Committee* (**Recommendation 4**).

***Reporting and communication***

Reporting is a key product of the LTIM Project, but currently there is a lack of a strategy that outlines the objective(s), audience(s) and types of reports, fact sheets and web products to be produced annually. The Selected Area teams need to either: (a) more faithfully follow the terms of their contract regarding annual reports; or (b) perhaps produce two reports annually - a relatively short *general report* suitable for water managers and other stakeholders, and a detailed *science report* containing the information currently in the appendices, together with a synthesis of the scientific ecological outcomes for the Selected Area (and beyond if possible). Additionally, the Basin Matters and Synthesis reports need to be reviewed with a view to making them more accessible to a wider audience (**Recommendation 15**). A particular problem for the Synthesis reporting is the difficulty in accessing relevant data and information from other non-LTIM monitoring programs. There is an urgent need to consolidate these data into a central location (Recommendation 14). An effective science communicator(s) should be engaged to assist the Selected Area and Basin Matters teams with their reports (**Recommendation 17**).

***Capture of adaptive management information***

There are some excellent interactions between the Selected Area and CEWO Delivery teams that are resulting in a considerable number of learnings that are being translated into better management of the Commonwealth’s environmental water. However, the capture of these adaptive management learnings could be improved and done more systematically. Two improvements were identified: first, better documentation of the many informal and formal discussions that lead to changes in water delivery, with this information recorded in an accessible and searchable database; and second, the production of an annual report that captures and synthesises the way this increased knowledge is changing the way in which the CEWO Delivery Teams are delivering environmental water (**Recommendation 18**).

***Project Steering Committee***

This review has identified the need for a more structured and collaborative approach to the running of the LTIM Project. We recommend the establishment of a Project Steering Committee composed of: the CEWO Project management team; the CEWO Delivery Team leads; the MDFRC Director; and the Selected-Area team lead. The CEWO and MDFRC Director would jointly chair the Steering Committee (**Recommendation 4**).

***Independent Science Review Committee***

This review has identified a significant lack of independent peer review of the LTIM Project. Some internal review is occurring within the Selected Area teams and (recently) between the Basin Matters and the Selected Area teams. The recommended Project Steering Committee will assist in strengthening these internal review processes. However, there is still need for independent peer review of the science. CEWO have commenced an independent review process with this current mid-term review and evaluation process. The next critical point will be to review the LTIM Program at its completion. CEWO should establish an *Independent Science Review Committee* to review the quality and relevance of the science (Selected Area and Basin Matters) and other aspects of the Project in year 5, and to make recommendations of modifications to the Project relevant to LTIM Phase 2 (**Recommendation 19**).

### Recommendations

***Recommendation*** *1: that the Basin-scale evaluation questions are reviewed to assess whether they are all still relevant, and the likelihood that they will be adequately addressed by June 2019. In light of this review to the CEWO should make any modifications that would update the expectations of the Basin-scale evaluations.*

***Recommendation 2:*** *that for multiple-scale watering actions, CEWO ensures the full range of expected ecological outcomes are determined and communicated to the appropriate LTIM Project teams.*

***Recommendation 3:*** *that the CEWO develop expected outcomes for the ecosystem diversity Basin Matter.*

***Recommendation 4:*** *that a LTIM Project Steering Committee be established, consisting of the CEWO, CEWO Delivery Teams, Selected Area team leads and the MDFRC Director. CEWO should also consider whether the MDBA should also be invited to join this Committee.*

***Recommendation 5:*** *that the CEWO review the management of the LTIM Project with a view to identifying a single Program Manager and a Science Leader.*

***Recommendation 6:*** *that the CEWO urgently develop an Evaluation Strategy for the LTIM Project.*

***Recommendation 7:*** *that the Selected Area teams focus more attention in their annual reports on: addressing the key evaluation questions; the ecological outcomes of each local-area watering action, and scaling up the Area-scale assessment and evaluations to the entire Selected Area.*

***Recommendation 8:*** *that consideration be given to requiring the Selected Area teams to produce two reports annually: first, a relatively short general report suitable for water managers and other stakeholders; and second, a detailed science report containing the information currently in the Appendices.*

***Recommendation 9:*** *that the CEWO consider having a detailed independent peer review undertaken during 2018 of the quality of the science being reported by the Selected Area teams, with the focus being on the initial MEP, and the 2016-17 annual evaluation reports.*

***Recommendation 10:*** *that the CEWO organise a process to clarify the scope and consistency of basin-scale evaluations, the process consisting of the preparation of a discussion paper, followed by a workshop with key researchers and managers to provide a sensible outcome.*

***Recommendation 11:*** *that the MDFRC develop a comprehensive project modelling plan as a matter of urgency, and that this Plan be agreed to by the proposed Project Steering Committee. Additional funds or reallocation of existing funds may be required to ensure the development of the Plan, and the subsequent development and testing of the models, is achieved.*

***Recommendation 12:*** *that the new Project Steering Committee be tasked with resolving the continuing issues associated data QA/QC and the MDMS.*

***Recommendation 13:*** *that the need for improved hydrological data and information, and inundation mapping be urgently addressed.*

***Recommendation 14:*** *that the proposed Project Steering Committee formally evaluate the benefits of this improved collaboration between the Selected Area and Basin Matters teams as one of its first tasks.*

***Recommendation 15:*** *that a review of the annual Basin Matters and Synthesis reported be undertaken, with a view to restructuring them to make them more accessible to a wider audience.*

***Recommendation 16:*** *that a common database be established to hold all relevant data relating to environmental water monitoring in the Murray-Darling Basin; this will require cooperation between CEWO, MDBA and state agencies to achieve.*

***Recommendation 17:*** *that an effective science communicator(s) be engaged by CEWO or MDFRC to assist the Selected Area and Basin Matters teams to make their various reports more readable, and to assist CEWO to produce more structured and targeted information products related to the LTIM Project.*

***Recommendation 18:*** *that the capture of adaptive management learning’s be improved and done more systematically, in particular with the development of a accessible and searchable database to contain the learning’s, and the production of an annual report that syntheses how this increased knowledge is changing the way in which environmental water is being delivered.*

***Recommendation 19:*** *that an Independent Science Review Committee be established to review the quality and relevance of the science being developed by the Selected Area teams and the Basin Matters team.*

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# Introduction

This report contains an independent ‘program level’ Mid-Term Review and Evaluation (MTRE) of the Commonwealth’s Long Term Intervention Monitoring (LTIM) Project undertaken by Professor Barry Hart (Director, Water Science Pty Ltd) and Dr Rhonda Butcher (Principal, Waters Edge Consulting).

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The objectives of this MTRE are (in brief): to assess the structure of the LTIM Project; to review progress, effectiveness, achievements and outputs of the LTIM Project from the first three years of monitoring (2014-15 to 2016-17); to assess what is working well and what can be improved in the short and longer term; and to provide a series of recommendations and associated management responses related to the review findings for the CEWO’s consideration.

The evidence for this MTRE was obtained from two sources: first, from a reviewof relevant reports (Program Logic documents; Area-scale Monitoring and Evaluation Plans (MEP); Basin-Matter Evaluation Plans; and Area-scale and Basin-scale 2015-16 evaluation reports – see Appendix A); and second, from interviews with CEWO staff (project managers, Water Delivery Teams), the Murray Darling Freshwater Research Centre (MDFRC) Director and Basin Matter leads; the leads of the seven Selected-Area teams and selected team members; and relevant staff from the Murray-Darling Basin Authority (MDBA) (See Appendix C for discussion points). This review has been impressed with the large number of talented, highly skilled, experienced and committed scientists and water managers involved in the Project.

This MTRE report covers: the background to the LTIM Project; a review of the Project structure; a high level evaluation of the Project’s progress under three headings - Area-scale evaluation, Basin-scale evaluation, and Adaptive Management; possible modifications to the Project; some considerations for LTIM Phase 2; and finally a series of recommendation for CEWO’s consideration.

# Background

## LTIM Project objectives

Since 2008, the Commonwealth has acquired environmental water with the aim of rebalancing the water resources of the Murray-Darling Basin (MDB) to ensure the environmental assets of the Basin are protected and where needed also restored. The Commonwealth Environmental Water Holder (CEWH) manages the Commonwealth’s environmental water portfolio. At the 31 January 2018, the portfolio totalled 1,836 GL (long-term average).[[2]](#footnote-2)

The *Water Act 2007* *(Cwlth)* requires the CEWH to perform its functions and exercise its powers consistently with and in a manner that gives effect to the Basin Plan (Commonwealth of Australia 2012). Specifically, the CEWH must ensure that Commonwealth environmental water is managed in accordance with the Basin Plan’s environmental watering plan (BWP; Commonwealth of Australia 2012) and the Basin-wide environmental watering strategy (BEWS; MDBA 2014). The CEWH is also expected to have regard to the Basin annual watering priorities as well. The Water Act (in part via the Basin Plan) places a number of obligations on the CEWH, including principles of monitoring, evaluation and reporting requirements.

In response to the requirements of the Water Act and the Basin Plan, the CEWO has established a Long Term Intervention Monitoring (LTIM) Project, with the aim of supporting improved decision making through the application of the principles of adaptive management, good governance and reporting.

***Intervention*** monitoring is one of three types of monitoring included in the CEWO Monitoring, Evaluation, Reporting and Improvement (MERI) Framework (CEWO 2013) - the other two being *operational* and *program* level monitoring. Intervention monitoring is a key step in the MERI process that underpins evaluation, reporting of outcomes and improved decisions, and future monitoring through the adaptive management process. The CEWO MERI Framework includes two types of intervention monitoring: *targeted monitoring* of selected watering actions, and *long-term monitoring* of Selected Areas.

The LTIM Project objectives, in order of priority, are (Gawne et al. 2014):

* Evaluate the contribution of Commonwealth environmental watering to the objectives of the Murray-Darling Basin Authority’s (MDBA) Environmental Watering Plan;
* Evaluate the ecological outcomes of Commonwealth environmental watering at each of the seven Selected Areas;
* Infer ecological outcomes of Commonwealth environmental watering in areas of the Murray-Darling Basin not monitored;
* Support the adaptive management of Commonwealth environmental water;
* Monitor the ecological response to Commonwealth environmental watering at each of the seven Selected Areas.

The Outcomes Framework developed by MDFRC represents a hierarchy of expected outcomes based around the environmental watering objectives stated in the Murray-Darling Basin Plan (MDBA 2012). Expected outcomes are referred to as Basin Matters, which were identified as achievable:

* Within a one year timeframe (1 year expected outcomes);
* Within a one year to five year timeframe (5 year expected outcomes).

Table 1: Objectives relevant to Commonwealth environmental water management (CEWO 2013).

|  |  |  |
| --- | --- | --- |
| Basin Plan Reference | Basin Plan Objective | Short label |
| Environmental watering plan | “to protect and restore water-dependent ecosystems of the Murray-Darling Basin” (Basin Plan, Chapter 8, Part 2, 8.04(a)) | Biodiversity |
| “to protect and restore the ecosystem functions of water-dependent ecosystems” (Basin Plan, Chapter 8, Part 2, 8.04(b)) | Ecosystem function |
| “to ensure that water-dependent ecosystems are resilient to climate change and other risks and threats” (Basin Plan, Chapter 8, Part 2, 8.04(c)) | Resilience |
| Water quality and salinity management plan | “to ensure water quality is sufficient to achieve the above objectives for water-dependent ecosystems, and, for Ramsar wetlands, sufficient to maintain ecological character” (Basin Plan, Chapter 9, Part 3, 9.04 (1) & (2)) | Water quality |

## LTIM Project development

The LTIM Project commenced in 2012 with the awarding of a contract to the MDFRC to lead the Project’s development. The MDFRC, under the previous director (Dr Ben Gawne), assembled a team of experts who spent two years (2012-2014) in developing a detailed logic and rationale for the project and providing technical advice to the Selected Area teams during the development of the Monitoring and Evaluation Plans (MEP). The process undertaken is well documented in Gawne et al. (2013).

In brief, the LTIM Project development involved five steps:

1. **Establishing the scientific rationale that would allow prediction of the likely ecological outcomes of Commonwealth environmental water use**

This involved in integration of four major inputs:

* A hierarchy of Basin Plan Environmental Water Plan (EWP) objectives that classifies these objectives in a way that is helpful for environmental water managers, practitioners and scientists, and also sets out the scientific basis of how delivery of environmental water will contribute to meeting EWP objectives;
* A suite of conceptual models (cause-effect diagrams) that use the best available science to link EWP objectives to changes in flow;
* The ecological roles of the major hydrological flow types described in the Basin Plan (i.e. base flows, freshes, bank full and overbank flows) and their influence on biodiversity, ecosystem function, resilience and water quality; and
* The range of possible water availability scenarios over the course of five years.

These inputs were then used to develop a generic set of expected outcomes over both less than 1-year and 1 to 5-year periods at each of the seven LTIM ‘Selected Area’ sites (discussed below).

1. **Determining the scope of the LTIM Project**

The LTIM Project was established at seven ‘Selected Area’ sites. These are (with the major water-related assets in brackets):

* Edward–Wakool river system (in-stream and fringing wetlands);
* Goulburn River (in-stream and fringing wetlands);
* Gwydir River system (in-stream, wetlands and floodplains);
* Lower Lachlan River system (in-stream and fringing wetlands);
* Murrumbidgee River system (in-stream, fringing wetlands and floodplains);
* Lower Murray River (in-stream, connected wetlands, floodplain and temporary non-connected wetlands);
* Warrego- Darling River system.

The CEWO engaged consortium-monitoring teams, led by research institutions, to develop and implement the 5-year MEP for each of the seven Selected Areas. The focus of each MEP is to determine whether Commonwealth environmental water is achieving the outcomes expected of it at the local-scale, but to also capture data, which would contribute to basin scale evaluation of the influence of Commonwealth environmental water.

The seven areas included in the LTIM Project were selected to cover areas where Commonwealth environmental watering occurs and to complement, rather than duplicate, monitoring activities by other organisations/programs such as asset scale monitoring by Basin states under Long Term Watering Plans. For example, a number of high profile wetland areas (e.g. the Coorong and Lower Lakes; Barmah-Millewa Forest; Hattah Lakes and Macquarie Marshes) were not included as these were assumed to be adequately covered in The Living Murray or state-based programs.

1. **Identifying and prioritising the monitoring indicators**

A three-stage process was undertaken to identify a range of both *effect* indicators (that provide information relevant to reporting against objectives) and *causal* indicators (that help to explain the effects), including:

* Stakeholder workshops in each Selected Area to provide a local perspective on ecological values and management priorities;
* Prioritising the objectives against: whole of Basin reporting obligations; the potential for the monitoring indicators to help in evaluating ecological outcomes in non-monitored areas; and the value of the indicators in helping with adaptive management of the Commonwealth’s environmental water;
* Prioritising the causal indicators based on their potential importance in assisting decision-making by the CEWO Delivery Teams.
* This process identified 18 monitoring priorities and 40 priority indicators, with a subset of the indicators identified as priorities in all seven Selected Areas; these included hydrological connectivity, ecosystem diversity, vegetation condition, vegetation diversity, fish population condition, fish community diversity, water quality and river channel metabolism. The tenth indicator was a generic category to cover responses by high value species such as threatened and endangered species.

It is understood that waterbirds were also considered as an indicator, but were not recommended as either a Selected Area or Basin-scale indicator, because of funding limitations and the fact that other waterbird monitoring programs are operative.

Consideration was also given to the standardisation of methods, sampling design and analysis. However, there was considerable resistance to this from the Selected Area teams, and a compromise was reached that saw three categories of indicators developed, these being (Hale et al. 2014):

* Category I – mandatory indicators and standard protocols to be used in Basin-scale evaluation;
* Category II – optional indicators with mandatory standard protocols; and
* Category III – optional indicators with Selected Area specific protocols and mandatory reporting requirements.

1. **Deciding on the evaluation process**

Evaluation of the monitoring results is required to identify change due to environmental watering and to support possible adaptive management of the monitoring programs. Outcomes evaluation of the LTIM Project is undertaken each year at multiple spatial and temporal scales; broadly, the evaluation is focused on assessing:

* The outcomes of the Commonwealth environmental watering against the expected outcomes for each Selected Area, which is addressed in each of the Selected Area (Area-scale) annual evaluation reports;
* The contribution of the Commonwealth environmental watering to the objectives of the Basin Plan, which is addressed in the Basin Matter (Basin-scale) annual evaluation and synthesis reports.

1. **Determining how adaptive management could be incorporated into the LTIM Project**

Gawne et al. (2014) noted that *‘Effective adaptive management requires processes* (to be developed) *to generate, communicate, assimilate and apply new knowledge to improve monitoring, evaluation, system understanding and future interventions’*, and further that the *‘LTIM will include the development of statistical models that will facilitate the generation, assimilation and application of knowledge to future management decisions’.* They suggested that the information being collected through the LTIM Project could contribute to the development of (a) species population models, and (b) simple ecosystem models. To date (February 2018) no models have been developed. However, there has been some progress on the development of quantitative large-scale models for fish, vegetation and metabolism that is discussed in Section 4.2.2.

## LTIM Project delivery

As noted above, the primary aim of the CEWO LTIM Project is to evaluate the ecological response of Murray-Darling Basin water-related assets to the added Commonwealth environmental water. This is to be achieved by evaluating these ecological responses at two scales: the Area-scale and the Basin-scale.

The *Area-scale evaluations* are provided by the seven Selected Area teams. Each Selected Area team was required to provide a detailed MEP before they commenced. The MEP were developed using a standard template, and with technical advice from the technical advisory group led by MDFRC. Each Selected Area team was required to draft a MEP using the standard methods developed through the program logic design phase undertaken by MDFRC. The MEP were reviewed by the technical advisors and feedback provided to CEWO on each of the MEP.

We provide a ‘high level’ assessment of these MEP’s and the Selected Area 2015-16 annual evaluation reports in Section 4.1 below, but have not undertaken a detailed review of the various programs, the data collected, the analysis of these data, or the interpretation (evaluation) of the data. Such a detailed review should be undertaken.

The ‘Basin Matters’ team led by the MDFRC provide the *Basin-scale evaluations*. The development of the Basin-scale evaluation is described in the LTIM Project Logic and Rationale document (Gawne et al. 2013) and the Basin Evaluation Plan (Gawne et al. 2014). Six ecological indicators, Basin Matters, underpin the Basin-scale evaluation:

* ***Ecosystem diversity*** – the aquatic ecosystem types (e.g. wetlands, rivers, streams) that benefited from Commonwealth environmental water;
* ***Hydrology*** – river flow and wetland water regimes modeled with and without Commonwealth environmental water;
* ***Stream metabolism and water quality*** – rates of in-stream primary productivity and decomposition, salinity and pH;
* ***Vegetation diversity*** – plant species’ responses with respect to extent, diversity and condition;
* ***Fish*** – short- and long-term responses of fish with respect to movement, condition, abundance and diversity; and
* ***Generic diversity*** – effects on diversity of all biota from monitoring and observations.

The Basin-scale reports are based on the data and evaluations contained in the Selected Area reports (Gawne et al. 2014) and on Category I indicator data collected by the Selected Area teams. Those for 2015-16 are reviewed in Section 4 below.

Finally, the information in the Basin Matters evaluation reports is brought together in a ‘Basin-scale Synthesis Report’ that provides an integrated assessment across the three themes of the Basin Plan: biodiversity, ecosystem function and resilience (Gawne et al. 2013). Basin-scale evaluations are done annually (to date done for 2014-15 and 2015-16) and for the cumulative 5-year period (to date done for 2014-16) (Gawne et al. 2017).

# Review of LTIM Project structure

## Logic and rational - Alignment with the Environemtnal Watering Plan objectives/requirements

The Basin Plan was released (November 2012) and the Basin-wide Environmental Watering Strategy (BEWS) was completed in 2014 (MDBA 2014). The BEWS, a part of the Environmental Watering Plan (Chapter 8 of the Basin Plan), is intended to help environmental water holders and waterway managers plan and manage environmental watering at *a Basin-scale,* and over the long term to meet the environmental objectives (MDBA 2014). Expected outcomes by 2024 for four components of the Basin’s water-dependent ecosystems are the focus of the BEWS; these include river flows and connectivity; native vegetation; waterbirds; and native fish (MDBA 2014). The BEWS is the means by which the Environmental Watering Plan objectives are assessed.

Annual environmental watering priorities for the Basin are prepared to inform annual planning and prioritisation of environmental watering across the Murray ̶ Darling Basin. They are developed to meet the long-term outcomes in the [BEWS](https://www.mdba.gov.au/publications/mdba-reports/basin-wide-environmental-watering-strategy-2014) and aim to deliver the Basin Plan's objectives of protecting and restoring the Basin's rivers, wetlands and floodplains (MDBA 2017).

## Implementation

As outlined in Section 2, the structure of the LTIM Project was developed over a two-year period (2012-2014) by the CEWO in collaboration with a team of technical advisors coordinated by the MDFRC. Activities over a five-year period (2014-2019) will include:

* ***Area-scale evaluation*** – monitoring and evaluation of the ecological response of water-related assets to Commonwealth environmental water (CEW) in the seven Selected Area sites;
* ***Basin-scale evaluation*** – aggregation and integration of this area-scale data and knowledge to provided Basin-scale evaluation of the ecological response of water-related assets to CEW;
* ***Temporal evaluation*** – both the Area-scale and Basin-scale evaluations are done annually, and will also be done cumulatively over 1-5 years as the program is rolled out;
* ***Adaptive management*** – the LTIM Project is built around the assumption that there will be a number of ‘learnings’ as the project is rolled out, and that these need to be captured and used to modify technical and decision-making aspects of the Project during time, as well as inform water planning decisions (see definition of adaptive management as per Basin Plan in Section 5).

The Project structure is logical and has been very well planned (see Figure 1). Additionally, the LTIM Project objectives are well focused and sensible (see Section 2.1), although adequately addressing them in five years will be challenging.

The three main structural components of the Project are (Figure 1): the seven Selected Area teams, the Basin Matters team, and the CEWO Water Delivery teams. The seven Selected Area teams are contracted to collect data in their areas for two purposes:

* First, to provide data of relevance to the Basin-scale evaluations, i.e. addressing the first objective above. Largely standard methods (Category I indicators) are being used for this monitoring, with these data being analysed and use by the Basin Matters team in their Basin-scale evaluations, with some input from the Selected Area teams (see also below);
* Second, to provide data and analyses of more relevance at the local scale, and to address the second LTIM objective above. For this purpose, Category II and III indicators are being monitored and evaluated.

Additionally, the Selected Area teams are all interacting closely with the CEWO water delivery teams (and their various Stakeholder Advisory Groups) in planning annual environmental water delivery regimes, and in reporting back to these groups on the ecological outcomes of each particular environmental watering event. This aspect is covered in more detail in the Adaptive Management section below (Section 4.3).

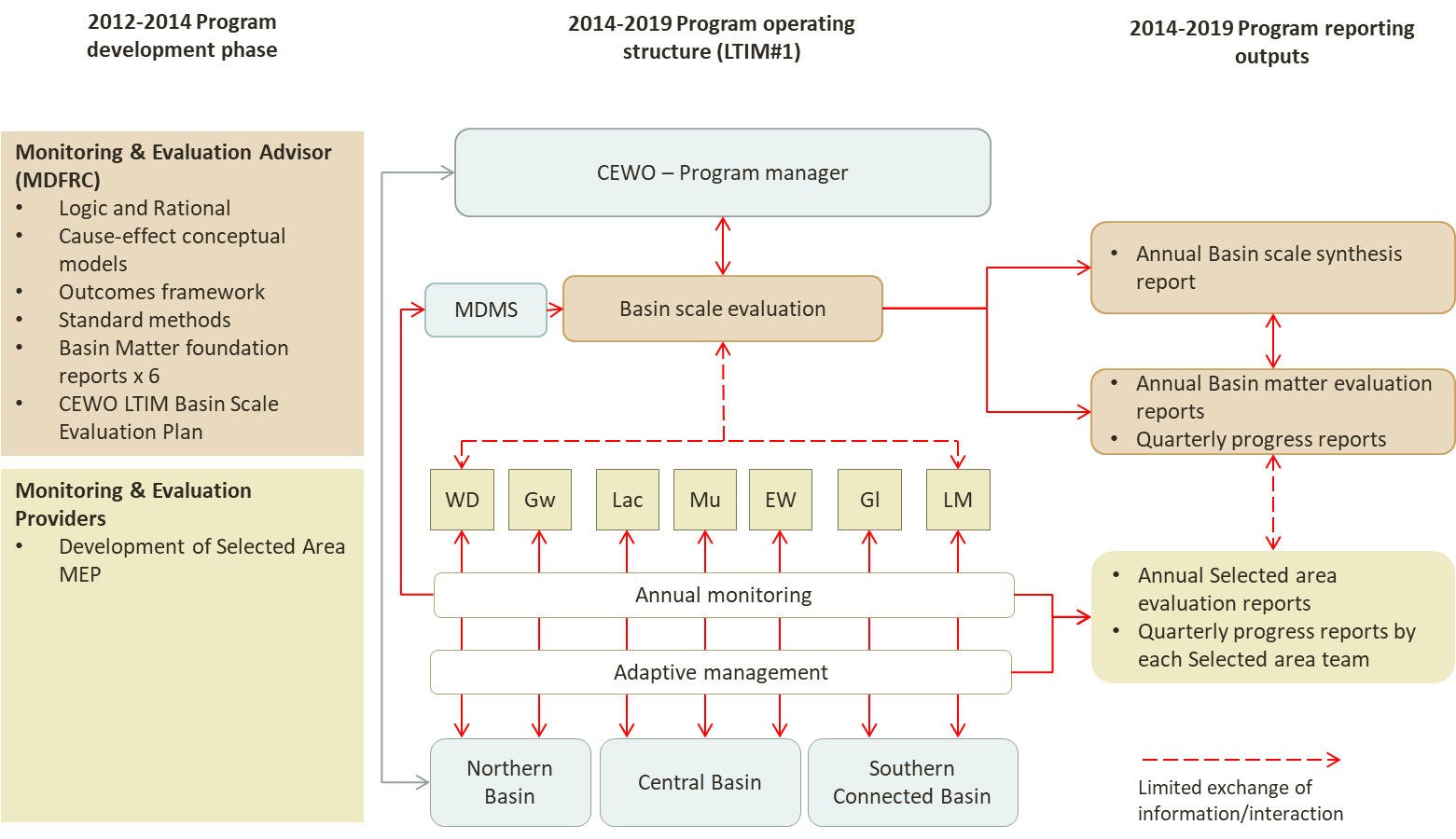


Figure 1: Schematic of LTIM Project development and output phases and operating structure

## Discussion

It is clear that the original development of the LTIM Project structure was rather ‘top down’ with little interaction between the MDFRC development team and the Selected Area teams. This was understandable given the logic at that time, where the Selected Area teams were seen as ‘providers’ (or ‘contractors’) of the necessary data, with the Basin Matters team doing the analysis and evaluation at the Basin-scale.

This ‘top down’ approach created considerable resentment in the Selected Area teams who felt their involvement would have resulted in a more collaborative LTIM Project and also improved the selected indicators and monitoring and analysis methods adopted. The Project has become more collaborative, although this has taken some time to achieve and has taken valuable time away from the main game. This is a key lesson for those planning the continuation of the LTIM Project (we will refer to this potential new project as LTIM 2).

The original intent of the LTIM Project was to focus on the Basin-scale evaluation with the input at the Selected Areas being the smaller component of the program. In the early scoping phase it was anticipated that approximately 70% of the funding would be targeted at the Basin-scale outcomes and evaluations as per the requirements to contribute to Basin-scale evaluation under the Basin Plan and BEWS. The project appears to have shifted emphasis with the focus on the Selected Area outcomes now occurring at the expense of the Basin-scale evaluation. We are not aware of the reasons for this changed focus, but note first that the LTIM Project was established as the main program for assessing the CEWO requirements under the Water Act 2007 and the Murray-Darling Basin Plan, and second that the Basin Plan is focused on improvements at a Basin-scale. We urge CEWO to review whether this apparent changed Project focus will impact on their capacity to report on the contribution of Commonwealth environmental water at a Basin-scale.

We were also somewhat surprised to discover that there was no single manager of the LTIM Project, but that management was spread between four groups within CEWO – these being: the CEWO Aquatic Ecosystems & Science Section who are responsible for coordinating the management of the LTIM Project[[3]](#footnote-3), and the three CEWO delivery teams who are responsible for the Selected Area team contracts. We are not aware of the internal coordination linkages within CEWO, but our experience suggests that such a dispersed project management system is unlikely to be efficient and effective.

In addition to the desirability that the LTIM Project has an agreed and recognisable Project Manager, we believe it would be of value to the Project if there was also an agreed and recognised Science Leader. This is further discussed in Section 5.3.

## Findings

The LTIM Project structure is sound and does not need to be fundamentally changed. There are, however, a number of modifications that could be made over the next few months and in future iterations that would strengthen the Project.

These are fully discussed in Section 5.1 (with recommendations) and include: first, to review and clarify the Project objectives; second, to work to further improve the collaboration and coordination between the Selected Area teams and the Basin Matters team perhaps by establishing a *Project Steering Committee*; third, to review the LTIM Project Management arrangements, including consideration of desirability of establishing a Science Leader position; and fourth, to develop a Program Evaluation Strategy as part of the MERI process to assist in assessing the efficiency, effectiveness, relevance and sustainability of the LTIM Project

# Evaluation of LTIM project progress

## Area-scale

The CEWO has contracted seven teams, largely associated with research institutions, to undertake monitoring and evaluation in the seven Selected Areas, these being: Edward–Wakool River; Goulburn River; Gwydir River; Lower Lachlan River; Murrumbidgee River; Lower Murray River; and Warrego- Darling River system.

Our review of their progress has been based on: *review* of the M&E Plans, the 2015-16 Annual Reports, and a selection of Quarterly Reports; and *interviews* with the team leads, other team staff and the CEWO delivery teams. It would have been useful to have also had the 2016-17 Annual Reports for review, but these are not yet available.

### Findings

***Meeting stated objectives:***

This review has found that the Selected Area projects are generally being run effectively. A detailed assessment of progress of each Selected Area project is provided in Appendix G. Table 2 below provides a high level assessment of the level to which each Selected Area project is on track to meet the LTIM project objectives.

Table 2: Assessment of Selected Area progress against LTIM Project objectives as per CEWO contracts. Green – evaluation on track to be achieved; Yellow – evaluation has possibility of being achieved but dependent on watering conditions or other constraint; Red – objectives not adequately addressed or evaluation not on track to be achieved.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Selected Area | 1.Contribute to objectives of the MDBA EWP | 2. Evaluation of CEW at Area- scale | 3. Infer to non-monitored areas | 4. Adaptive management | 5. Monitor response to CEW |
| Edward-Wakool |  |  |  |  |  |
| Goulburn |  |  |  |  |  |
| Gwydir |  |  |  |  |  |
| Lower Lachlan |  |  |  |  |  |
| Lower Murray |  |  |  |  |  |
| Murrumbidgee |  |  |  |  |  |
| Warrego-Darling |  |  |  |  |  |

Our assessment has highlighted several areas that need attention at the area-scale to meet the stated LTIM project objectives, including:

* To evaluate ecological outcomes of Commonwealth environmental watering at each Selected Area the expected outcomes need to be SMART[[4]](#footnote-4), or at the least *achievable* and *measureable*. In some cases the local-area watering action objectives and/or expected outcomes are not able to be adequately addressed as the objective originally developed by the CEWO delivery teams are not SMART. For example, the Warrego-Darling evaluation report lists ‘salinity’ as the expected outcome (as per Commonwealth of Australia 2014), but this provides no guide as to what the expected response to watering should be. There is also concern that the LTIM short and long term key evaluation questions are also not SMART.
* There are only two Selected Areas that attempt to account for the contribution of Commonwealth environmental water to meeting the objectives of the Murray Darling Basin Authority’s Environmental Watering Plan – the Gwydir and Warrego-Darling. All other Selected Area evaluation reports focus on the Area-scale outcomes linked to area watering. This reflects the shift in focus of the LTIM project from Basin scale reporting to Area-scale reporting.
* There is inadequate attention to the requirement to scale up the Area-scale assessment and evaluations to the entire Selected Area. The majority of the results presented focus on the reach, zone, river or wetland scale, but in most cases do not make clear statements for the entire Selected Area. For example, the Lower Lachlan evaluation report (Dyer et al. 2016) refers to catchment outcomes for some matters, but it is not clear if this refers to the entire Selected Area or the larger Lachlan catchment. Occasionally the counterfactual – inferring outcomes to non-watered area – is included in the evaluation reports, but this is not consistently done across the Selected Area reports.
* In general, the Area-scale evaluation reporting requirements are not fully met (see Appendix G). In addition to the points made above, there is inconsistency across the Selected Areas as to the degree that both short and long term evaluation questions are addressed, not all of the key evaluation questions listed in the MEP are included (most are, but not all), and the requirement to provide cumulative evaluation of data has not been addressed adequately, if at all.

The observations made above have to be made in the context that only two years of data have been collected and that had a third round of evaluation reports may present a different picture. Also we are aware that there have been some modifications to the Monitoring & Evaluation Plans since the commencement of the Project. We have been told that no changes have been made to the original evaluation questions, but that there have been some changes to M&E Plans along the way. These changes fall into three categories:

Changes to Category I monitoring – these are initiated and managed by the Basin Matters team, with the CEWO ensuring any changes are reflected in updated M&E Plans;

Changes from Category I to Category III monitoring – these changes, for example for larval fish data, were initiated by the Selected Area teams and approved by CEWO to allow ‘preferred’ (opposed to Category I) methods to be used Selected Area teams. This had consequences for the Basin evaluation; and

* Changes to Category III monitoring – Selected Area teams sometimes request changes such as change of schedule due to flooding, a revised cost structure due to sickness, or the introduction of new technology in place of old technology. These need to be approved by the CEWO.

Overall, the very clear positive outcome of the LTIM Project at the Area-scale is the significant contribution being made to the adaptive management of water planning and delivery at the Area-scale. This is the overwhelming opinion of all involved that this aspect of the project has had considerable benefits for the management of Commonwealth environmental water.

***Interactions and collaboration:***

Interactions between the Selected Area teams and the CEWO Water Delivery Teams are very good. We heard from the Delivery Teams that the researcher involvement in the annual water deliver planning, and additionally in suggesting potential modifications to specific watering events, is excellent and has resulted in the Delivery Teams having essentially real-time scientific information upon which to base their decisions. These interactions are an excellent example of the ‘active’ adaptive management described by Horne et al. (2017) and O’Donnell and Garrick (2017).

Interactions between the Selected Area teams and their Stakeholder Advisory Committees are also very good. We heard that researchers have been prepared to provide up-to-date and understandable information on the ecological outcomes that have been achieved as a result of particular watering events, and when needed they are also prepared to speculate on what outcomes might be expected from modified watering events.

Interactions between the Selected Area teams and the CEWO LTIM project management team (Aquatic Ecosystems & Science Section) have also been very effective. The Selected Area teams indicated to us that these interactions have been very professional, and that the CEWO staff have a keen appreciation of some of the difficulties being experienced, and have worked hard to seek practical solutions to these issues.

Interaction and collaboration betweenthe seven Selected Area teams is a requirement of their contracts, however it has been recognised within the Selected Area teams (and the CEWO) that increased collaboration would lead to better Project outcomes. To this end the CEWO provided additional funds ($400,000) in 2017 to the MDFRC to support additional activities aimed at improving collaboration within the LTIM Project.

Until recently, the collaboration between the Basin Matters and Selected Area teams has been poor, although it has improved in recent times. These teams are benefitting from this funding by being able to review each other’s annual reports and to hold one or two workshops each year on topics of their choosing (see also Section 5.6).

***Reporting:***

The Selected Area annual evaluation reports are overly detailed and often not written in a way that addresses the intent of their contracts. The contracts require an annual report with three sections: an executive summary (1-2 pages); a stand-alone main body suitable for a water managers and interested audience (containing context, evaluation and adaptive management components – around 20 pages); and separate appendices for any detailed results and methods suitable for a technical or academic audience.

It is the main body of the reports in particular that needs attention. In most cases they are too long, overly complex, and many cases do not directly/adequately address the key evaluation questions. We address this issue in more detail in Section 5.7.

Appendix G presents a summary of the progress of each Selected Area in meeting the reporting requirements as specified in the contracts. Some of the issues identified have been mentioned above; however another key finding is that there is no consistency in how each Selected Area report the key ‘take home’ messages. It was quiet a time consuming task to find the information to check against each of the reporting requirements – some reports did this exceptionally well, others less so.

***Review:***

There appears to be no documented process for reviewing Selected Area projects or their annual reports, such as the Program Evaluation Strategy developed for the Environmental Water Knowledge Research (EWKR) project (Hodge et al. 2015).

We were told that CEWO staff comment on the Selected Area draft annual reports, but currently there is no process for peer review (independent or otherwise) of the technical components (i.e. the technical appendices) of the annual reports. The technical appendices have not been reviewed in detail as part of this review, although we have needed to partially review the 2015-16 appendices to be able to evaluate the main reports. We were told that most Selected Area teams have a process where teams members are involved in the review of the more technical aspects of the annual reports (the appendices), but we have no evidence of the extent or rigor of these reviews.

We have also been informed that from late 2017, the Basin Matter team members (Sam Capon, Mike Grace and Rick Stoffels) will review certain sections of the Selected Area annual reports.[[5]](#footnote-5) The objectives and scope of these reviews will be:

* Obtain an overview of Selected Area ecological response to flows prior to and up to the current Basin-scale reporting period. This overview will help to place Basin scale quantitative analyses in context, while at the same time providing the necessary foundation for qualitative synthesis of managed flow outcomes at the Basin scale;
* Strengthen collaboration between the Selected Area and Basin matter teams, by achieving a shared understanding of the collective challenges in interpreting the monitoring data;
* Strengthen the quality of LTIM reporting by gaining a shared understanding of the inferences concerning flow impacts that are emerging from the monitoring, and how to strengthen those inferences;
* Identify common issues and challenges that may require targeted discussion at the LTIM Annual Forum;
* Determine whether the information required for Basin-scale synthesis is within Selected Area reports and, if not, identify additional material that could be included, stating the reasons it is required; and
* Identify any issues with the manner in which material is presented within the Selected Area reports, and suggest possible improvements, towards achieving more accessible and cogent reporting.

The introduction of the Basin Matter team review of the Selected Area annual reports is a welcome addition. However, we believe it is imperative that a more formal, independent review of the quality of the science in these technical reports is undertaken before the completion of this phase of the LTIM Project (see also Section 5.9). Such an independent review is crucial to ensuring the credibility of the LTIM Project - it is after all a science-based project.

## Basin-scale

### General

The Basin-scale component of the Project is being run through the MDFRC, who have contracted a team of experts to conduct Basin-scale evaluations using six Basin Matters (Gawne et al. 2017):

* hydrology – river flow and wetland water regimes modeled with and without Commonwealth environmental water;
* ecosystem diversity – the aquatic ecosystem types (e.g. wetlands, rivers, streams) that benefited from Commonwealth environmental water;
* stream metabolism and water quality – rates of in-stream primary productivity and decomposition, salinity and pH;
* vegetation diversity – plant species’ responses with respect to extent, diversity and condition;
* fish – short- and long-term responses of fish with respect to movement, condition, abundance and diversity;
* generic diversity – effects on diversity of all biota from monitoring and observations.

The development of the Basin-scale evaluation is described in the LTIM Project Logic and Rationale document (Gawne et al. 2013) and in the Basin Evaluation Plan (Gawne et al. 2014a, b). The Selected Area teams are using standard methods to collect data on fish, vegetation and metabolism, with these data (and Area-scale evaluations) then used by the relevant Basin Matters team member to provide an integrated analysis across the Basin.

Annually, the Basin Matters team produce reports addressing each of the Basin Matters (see Appendix B for references). The Basin-scale evaluation aims and evaluation questions being addressed by each of the Basin-Matters are listed in Table 3.

Table 3: Key evaluation questions (KEQ) for each Basin Matter (from Gawne et al 2014 Evaluation plan). Each KEQ begins with the wording “What did Commonwealth environmental water contribute to…?”

|  |  |  |
| --- | --- | --- |
| Basin Matter | 1 year KEQ | 1-5 year KEQ |
| Hydrology | * Restoration of the hydrological regime * Hydrological connectivity | * Restoration of the hydrological regime * Hydrological connectivity |
| Ecosystem diversity | None identified | None identified |
| Stream metabolism and water quality | * Patterns and rates of decomposition * Patterns and rates of primary productivity * pH levels * Turbidity regimes * Salinity regimes * Dissolved oxygen levels | * Patterns and rates of decomposition * Patterns and rates of primary productivity * pH levels * Turbidity regimes * Salinity regimes * Dissolved oxygen levels |
| Vegetation | * Vegetation species diversity * Vegetation community diversity | * Vegetation species diversity * Vegetation community diversity |
| Fish | * Sustaining native fish reproduction * Sustaining native larval fish growth and survival * Sustaining native fish survival | * Sustaining native fish populations |
| Generic diversity | * Other vertebrate species diversity * Other vertebrate populations | * Other vertebrate populations |

The Selected Area data are added to a Monitoring Data Management System (MDMS), which is then available for use by both the Selected Area and Basin Matters teams. It was recognised early in the LTIM Program development that such a data management system was imperative given the reliance on multiple stakeholders and contractors contributing data towards reporting and evaluation obligations. Considerable effort went in to ensuring that data being collected was of high quality, complete, compatible and available to data users in consistent and standardised formats to meet reporting and evaluation needs (Brooks and Wealands 2013a, b).

It is intended that the Basin-scale evaluation will seek to predict what would have happened in the absence of environmental watering. Currently, this is being done using conceptual models that relate watering characteristics and antecedent conditions to ecological outcomes. The intent is to develop quantitative predictive models to do this within the 5-year timeframe of the LTIM Project. These quantitative models will also be used in assessing the ecological outcomes in areas where watering actions are unmonitored, and to assist in addressing the third objective above.

The final stage of the annual Basin-scale evaluation requires an estimation of the overall outcomes across the Basin, and then a judgement of their significance to the objectives of the Basin Plan. This process involves synthesising the evaluations from the Selected Areas and then linking these to the Basin Plan objectives by translating local or site-scale outcomes to the three high level Basin Plan objectives – biodiversity, ecosystem function, and resilience. This analysis is currently reported in the Basin-scale evaluation synthesis reports (e.g. for 2015-16 see Gawne et al. 2017).

### Findings

Our review of the progress of the Basin-scale evaluations has been based on: review of Foundation Reports, Basin-Matters Foundations Reports, the 2015-16 Basin Matters and Synthesis Reports, and a selection of Quarterly Reports; and interviews with the MDFRC Director and Basin Matter leads, Selected Area leads and CEWO staff. The evaluation of the progress of the Basin-scale evaluations is presented in Appendix F.

***Meeting stated objectives:***

In this section we review progress of the Basin-scale component of the LTIM Project in meeting objectives 1, 3 and 4 above.

**Objective 1** (*Evaluate the contribution of Commonwealth environmental watering to the objectives of the Basin Environmental Watering Plan*)

This objective is being addressed annually through the six Basin Matters reports and the integrated Synthesis report (Gawne et al. 2017). Our assessment on whether the Basin Matter (and Selected Area) team is on track to achieve this objective by June 2019 is summarised in Table 9, with more detail given in Appendix F.

Table 4: Assessment of progress of each Basin Matter against LTIM Project objectives. Green – evaluation on track to be achieved; Yellow – evaluation has possibility of being achieved but dependent on watering conditions or other constraint; Red – objectives not adequately addressed or evaluation not on track to be achieved.

|  |  |  |  |
| --- | --- | --- | --- |
| Basin Matter | 1.Contribute to objectives of the MDBA EWP | 3. Infer to non-monitored areas | 4. Adaptive management |
| Hydrology | Inundation data limitations |  |  |
| Ecosystem diversity | Need expected outcomes to be specified |  |  |
| Stream metabolism and water quality | Water quality; flow constraints for metabolism outcomes; model development |  |  |
| Vegetation | Model development |  |  |
| Fish | Model development |  |  |
| Generic diversity | Some data limitations |  |  |

We noted earlier that because the LTIM Project is not monitoring waterbirds it cannot fully address this first objective since the BEWS is focused around four key components of river hydrology and connectivity, fish, vegetation and waterbirds. As discussed further in Section 5.1, aligning the Basin-scale evaluation with BEWS is seen as desirable.

We find that the Basin Matters reports for 2015-16 are somewhat inconsistent in how they address this primary objective. The hydrology report directly addresses the annual watering priorities for the 2015-16 watering year and the specific priorities as stated in the BEWS. Four of the Basin Matter evaluation reports provide a summary section at the end of the report.

In addition there is some inconsistency in how water quality is addressed within the LTIM Project. Water quality is identified in the Logic and Rational document as a Level 1 objective, and a Basin Plan objective in the Outcomes Framework (Table 2, Gawne et al. 2013), yet it is not included as a theme in the Synthesis report. We would recommend that consideration be given to including Water Quality as a theme so as to match the Outcomes Framework and Logic and Rational. This would be captured under the Recommendation 1 – see Section 5.2.5.

The 2015-16 Synthesis report makes a real attempt to integrate and synthesise the Basin-scale information from both the LTIM Project, and to some degree, other sources (e.g. TLM, MDBA fish monitoring, Joint Venture M&E Program, State agency monitoring) (Gawne et al. 2017). We were told that this collation and evaluation of monitoring data from water-related assets that receive Commonwealth environmental water, but are not part of LTIM, has proved to be very difficult because there is no central repository for this monitoring data, and in some cases is not easily accessible. This is particularly evident in the Generic Diversity Basin Matter report, as there is very little data from the northern basin included.

Some of the findings made in regards to the Selected Area evaluations also apply to the Basin-scale evaluation; most notably those relating to a lack of SMART evaluation questions and failure to fully address the evaluation reporting requirements. A further issue for the Basin-scale evaluation reports is a lack of consistency in language used relating to objectives. The different Basin Matter reports variably use *Basin objectives*, *Basin Plan objectives*, *Basin Plan environmental objectives, the environmental objectives contained within the Environmental Watering Plan*, *longer term objectives of the Environmental Watering Plan*, and so on. Improved review processes for Basin-evaluation reports should address these issues.

**Objective 3** (*Infer ecological outcomes of Commonwealth environmental watering in areas of the Basin that are not monitored*)

We found that little is occurring to address this objective. Inferring ecological outcomes in other areas will largely depend upon the development of the quantitative predictive models. Progress with the model development is a concern and is addressed below and in Section 5.5.1.

**Objective 4** (*To support the adaptive management of Commonwealth environmental water*)

Our review of progress in addressing this objective is covered in Section 4.3 below.

The main finding from our review of progress in meeting the Basin-scale objectives is that it seems unlikely that the objectives will be fully meet by June 2019. Thus, we suggest that CEWO needs to manage expectations, and modify the existingobjectives where necessary to make the outputs more realistic and achievable.

***Quantitative Basin-scale modelling:***

Three of the Basin Matters team, covering fish, vegetation and metabolism, are contracted to develop and implement quantitative predictive models by June 2019. A high level summary of what these models will look like has been reported in the relevant Foundation Basin Matter reports (Stoffels et al. 2015; Grace 2015; Capon et al. 2015).

A summary of the progress to date with these three models is provided below:

* *Fish model[[6]](#footnote-6)*

The Basin Matters fish team have outlined a comprehensive approach to the development of quantitative models to predict the effects of flow event on fish spawning, recruitment and movement, fish populations and fish community structure at both an area-scale (both within and outside the LTIM Project) and Basin-scale (Stoffels et al. 2015). A timeline for these activities is also provided.

Using the first two years of data (2014-16), models that relate the probability of fish spawning to flow and temperature at both Selected Area–scale and Basin-scale have been reported for Golden Perch, Silver Perch, Murray Cod, Australian Smelt, Bony Herring, and Carp Gudgeon (Stoffels et al. 2017).

However, over the past three years there have been a number factors that have resulted in the fish modelling component being less well advance than expected. These include: time spent in resolving fish sampling issues; loss of Category I larval fish sampling; issues with data added to MDMS; and some shift in focus to assist Selected Area in modelling the effects of flow and temperature on the movement of Golden Perch and Murray Cod.

In view of the above, we believe it unlikely that the original fish modelling program can be completed by the end of the LTIM Project. Therefore, we recommend that the fish Basin Matters team provide, as part of the Modelling Plan recommended below, a revised plan for the fish models that will be developed and tested by the end of the Project.

* *Vegetation model[[7]](#footnote-7)*

The Basin Matters vegetation team are contracted to develop quantitative model(s) for predicting vegetation responses to environmental water delivery. It is intended that *“The model response variables will include the presence and abundance of selected species (e.g. key representatives of each functional group) and a range of metrics used to characterise vegetation community responses in the aggregated analysis (i.e. species richness, total cover, functional diversity)*” and that Bayesian hierarchical models will be used (Capon et al. 2015).

It is expected that the development of these models will be complicated by the different data collection approaches in different regions; the sampling design program will result in data collected at multiple scales across the Selected Areas. As a result predictor variables will come from sampling unit and point scale (e.g. soil characteristics, distance from stream channel), as well as the reach/zone and Selected Area scale (e.g. recent and long term hydrology). These constraints will require tailored statistical models to be developed, to ensure the estimated eco-hydrological relationships are robust and transferable to areas beyond the monitoring locations. We were told that the models to be developed should have the capacity to account for relationships between response variables and predictor variables at the finest unit of observation at each Selected Area (e.g. quadrat or transect), and that these relationships should be able to be scaled up to levels that are useful for management decision making (e.g. river reaches, sub-catchments or even catchments). A hierarchical approach to modelling will facilitate the development of cross-scale models, while the Bayesian approach provides a framework to predict outside the sampling domain while accounting for predictive uncertainty.

However, it appears that this model development has not yet commenced, and that there is no timeline for completion, meaning that there must be concern that the original vegetation modelling program can be completed by the end of the LTIM Project. Therefore, we recommend that the vegetation modelling team provide, as part of the Modelling Plan recommended below, a revised plan for the vegetation models that will be developed and tested by the end of the Project.

* *Metabolism model[[8]](#footnote-8)*

The Basin Matters metabolism team are contracted to develop a reach-scale model for estimating primary production and ecosystem respiration as a function of flow. A statistical model (BASE – Bayesian Stream Metabolism Estimation) has already been developed for this purpose (Grace 2015).

In the latter part of 2017, the current BASE metabolism model was independently validated (by Dr Jim Thomson, ARI) and its implementation simplified. The updated model and user notes are expected to be available to Selected Area teams by the end of February 2018. Presumably this will also address the concern expressed by a number of the Selected Area teams regarding the overly conservative acceptance criteria for data fit to the BASE model.

The metabolism team is currently developing a new metabolism metric – the amount of organic carbon created (by photosynthesis) or consumed per river km per day. From this it should be possible to estimate the amount of potential food created at the base of the food web, which in turn may also be related to fish carrying capacity (and potentially whether the native fish populations are resource limited or not). This will require an estimate of the cross-sectional area as a function of flow for each logger site, which is currently being provided by the hydrology Basin Matters team.

It seems progress towards the development of reach-scale metabolism models that relate flow to various stream metabolic indicators (and perhaps also organic carbon produced and consumed) is on target to provide useful outputs by the end of the LTIM Project. However, we have no information on what is planned or indeed feasible regarding area-scale, catchment-scale or Basin-scale metabolism models.

We recommend that the metabolism Basin Matters team provide, as part of the Modelling Plan recommended below, a detailed plan for the metabolism models that will be developed and tested by the end of the Project, including a timeline with milestones.

This review has found that while some discussions have occurred regarding predictive model development, there is little evidence that much progress has been made to date (February 2018). Thus, there is concern regarding the capacity of these teams to develop, test and implement these quantitative models in the 18 months before LTIM is completed.

We have recommended in Section 5.5.1 that the Director MDFRC and the relevant Basin Matters team members urgently develop a Modelling Plan (see also Recommendation 11). This should contain: the types of models that will be developed; the scale (area, catchment, Basin) the model(s) will focus on; what data will be used to populate the models; what the model outputs will be; who will develop the models; how they will be tested; how uncertainty will be handled; and a timeline for their development (with milestones).

It may be that additional funds need to be found to resource the development of the Modelling Plan and the subsequent model development and testing. We urge CEWO to make every attempt to find these funds if they are needed, because these models will play a vital role in predicting the area-scale ecological outcomes of different watering regimes, and the ecological outcomes in non-monitored assets.

***Monitoring Data Management System:***

The data collected by Selected Areas monitoring is used to evaluate local outcomes from watering and also to contribute to the analysis and evaluation of Basin-scale objectives.

All Selected Area teams have a contractual obligation to upload their data onto the MDMS. However, rather than entering data directly into MDMS, the teams use their own data management systems and export a copy in the required formats to the MDMS (see also below). There is some disquiet within the Selected Area teams regarding the difficulties in using the MDMS.

The MDMS is the main source of data for the Basin Matters team evaluations, and is also the long-term archive of data for the CEWO. The MDMS aggregates the seven Selected Area data sets into a single data set for each indicator (Category I or Category III data in entered in a standard format) for Basin-scale evaluation, which is a very useful function. However, it is not clear to us how much the Selected Area teams use the MDMS for their reporting rather than using their own data management systems.

Even if the Selected Area teams do not use the MDMS in generating their evaluation reports, the fact they are required to add their data to this system has advantage in that the automatic QA/QC function is able to highlight data issues (some but not all) so they can be corrected before the Basin Matter teams even see the data. However, we were not able to assess whether this data checking function assisted the Selected Area teams since we suspect the Selected Area teams using their own data management systems and not the MDMS.

We were told[[9]](#footnote-9) that the current system is flexible enough to keep inputting data for future iterations of LTIM, and that in the future other researches (outside LTIM) are also expected to have access to the data, which will add to its usefulness.

However, we have been made aware of some issues with the current MDMS, including:

* The interface is outdated, overly complex, not user friendly, and only works on a PC and not on a Mac. In practice only one person per Selected Area team has learned how to operate the system, with most people finding it a chore to use. For the Basin Matters team, Shane Brooks acts as the data manger and extracts data and passes it onto the relevant team member;
* As noted above, the Selected Area teams use their own data management systems and export a copy in the required formats to the MDMS, which makes QA/QC checking challenging. We understand that finding and fixing errors in the exported data sets is currently quite time consuming. The database has the technical ability to do this checking, with controls slowly being tightening up. The expectation is that the QA/QC checking will be more effective and less onerous in the near future;
* As the number of data sets increases, extracting these large data sets will be challenging as apparently it has been in 2017. We understand that the software provider is currently working on an improved ‘data extraction tool’, which should help.

We have been told[[10]](#footnote-10) that in terms of risks and cost/time blowouts for the Basin Matter reporting, these MDMS and QA/QC issues continue to have a major impact, entailing literally weeks to months in delays each year before the Basin Matters team can commence their actual evaluations. While some of the issues with the MDMS are software (or IT) related the main problem appears to problems associated with the input of data from the Selected Area teams to the MDMS (people problems). It seems that stronger data governance is required, perhaps by the CEWO developing more robust QA/QC procedures that include a data manager to ensure compliance.

We have recommended that resolution of this issue should be one of the first tasks of the new Project Steering Committee.

***Collaboration*:**

Collaboration between the Selected Area and Basin Matters teams has been poor, but is improving. We have been told of a number of recent changes that have been instituted to improve the situation, including: the Selected Area teams now have an opportunity to comment on drafts of the Basin Matters annual reports; the Basin Matters team have an opportunity to comment on drafts of the Selected Area annual reports; and the two groups are able to get together at the Annual Forum. The CEWO have made additional funds available to assist various collaborative activities to occur (see above).

However, despite the changes outlined above, we believe there is still inadequate collaboration. We suggest there would be value in changes that would permit the Selected Area team members to work with the relevant Basin Matters team member from the early stages of the Basin Matters annual reports, and where appropriate be recognised as joint authors. This change would improve collaboration and also likely lead to higher quality reports.

We have also sought to assess the adequacy and effectiveness of the collaboration between Basin Matters team members. The evidence we have gathered suggests that interaction is minimal, largely due to budget constraints. We are aware that the Basin Matters team recently had a two-day meeting in Melbourne (December 2018) to discuss collaboration and the production of the 2016-17 Basin Matters and Synthesis Reports. A further Basin Matters team meeting is to be held in May or June 2018.

Our finding is that collaboration within the Basin Matters team has significantly improved over the past 6 months, that the Basin Matters team members are all very committed to LTIM, and that collaboration opportunities have been limited because of a lack of funds. The CEWO should determine if this additional funding to the Basin Matters team is required to increase the opportunities for collaboration.

***Reporting:***

There appears to be a lack of clarity as to the audience for these annual Basin Matter reports. Presumably, they contribute to the annual reports the CEWO provide to the MDBA addressing their requirements under the Basin Plan (Note: we have not seen any of these reports or discussed with the MDBA their assessment of the quality of the reports). The audience (or audiences) for these Basin Matters reports and the Synthesis report needs to be better articulated. Improvements would include short (10 page) easy to read summaries of each of the Basin Matters reports that would be suitable for publication on the CEWO and MDFRC web sites. The MDFRC should consider engaging a science communicator to assist with this process. This is further covered in Section 5.7 below.

***Review:***

We are aware that CEWO staff comment on the draft annual Basin Matters reports, but we are not aware that any independent science review of these reports occurs. We believe there would be advantage if this occurred (see Sections 5.5 and 5.9 below).

## Adaptive management

### General

The fourth LTIM objective is *‘to support the adaptive management of Commonwealth environmental water’*. Arguably, the most important part of the LTIM Project leading to adaption of the management of Commonwealth environmental water has been the very close working relationships established between the seven Selected Area teams and the three CEWO Delivery Teams. We have outlined above how this is working very well.

The three CEWO Water Delivery Teams (Northern Basin, Central Basin and Southern Basin) all told us that their close interaction with the relevant Selected Area teams was providing practical scientific information and advice on the relationships between various flow components and possible ecological outcomes in a timely manner (and mostly well ahead of formal reporting). This had resulted in improved decision-making regarding particular environmental watering events.

Webb et al. (2017) identified two particular advantages in the management of environmental water that flow from these science-manager partnerships. ‘*First, researchers have better access to ongoing and up-to-date information on forecasted flows from the water and catchment management authorities to target sampling periods. Second, practitioners see field verification of management intentions.’*

It should be noted that there are two aspects of adaptive management within the LTIM project. The first, improving environmental water management has been covered above. The other is the adaption that has occurred with the management of the LTIM Project, and this has been significant and most impressive. We have discussed earlier the transformation from a very ‘top down’, perhaps ‘command and control’, Project at the start, to a more collaborative Project. This has not occurred without some angst and with considerable adaption by all parties. We believe there would be considerable advantage if this journey was written up and published so that the legacy is not lost.

### Findings

***Capture of the relevant learning’s***

Information relating to the relevant learning’s that are contributing to adaptive management of the Commonwealth’s environmental watering is being reported at three levels:

* The individual Selected Area teams are required to provide a section in their annual evaluation report and Quarterly reports where relevant adaptive management information has been generated and recorded;
* The CEWO process – annual water planning process, portfolio management plans, and acquittal reports;
* The annual Basin Matters Synthesis Report also attempts to synthesize information from the Selected Area annual reports. The 2015-16 Synthesis Report (Gawne et al. 2017, Section 4) captures many of the science learning’s related to flow-biota relationships, namely: the way timing of water delivery affects the outcomes for biota; the importance of rate of fall for vegetation; the variation in the spawning response of flow-cued spawners (e.g. golden perch) to freshes; and the importance of variable water regimes in maintaining (and restoring) biodiversity (vegetation, waterbirds) at both wetland and landscape scales.

Our review found that while there is considerable attention on the generation and use of adaptive management learning’s each year by the Selected Area and Basin Matters teams, this could be done more systematically. We have identified two changes that could improve the situation:

* First, the many informal and formal discussions that lead to changes in water delivery need to be captured and added to an accessible and searchable archive system so they are not lost and can be called upon at a later time by multiple users; and
* Second, there appears to be no report that consolidates these learning at an appropriate scale, nor is the way this increased knowledge is changing the way in which the CEWO delivery teams are delivering environmental water being adequately captured, although this may in part be captured in acquittal reporting.

We suggest that the adaptive management outcomes are central to showcasing the long-term success of the LTIM Project. Therefore, a mechanism by which the learning’s are accessible to managers and the public is needed (see Sections 5.7 and 5.8 for more discussion).

# Possible modifications to the Project

Before addressing some possible modifications aimed at improving the LTIM Project, we believe it important to reiterate our earlier conclusion that this Project is world-leading in its scope, both spatially (the entire Murray-Darling Basin) and temporally (5 years), objectives and budget (over $30 million over 5 years). It is a highly ambitious project that it is seeking to achieve an outcome – assessment of the effectiveness of Commonwealth environmental water delivery in achieving local and Basin-scale ecological outcomes – that has never been attempted before anywhere in the world.

## Program structure

The LTIM Project structure is sound and does not need to be fundamentally changed. There are, however, a number of modifications that could be made over the next few months and in future iterations that would strengthen the Project.

First, the LTIM objectives and key evaluation questions need to be reviewed. The LTIM Outcome Framework (CEWO 2013) was developed prior to the completion of the BEWS and as such there is a misalignment between the four Basin Matters in the BEWS (hydrology and connectivity, fish, vegetation and waterbirds) and the Basin Matters monitored under LTIM, in that waterbirds are not monitored as part of the LTIM Project. Additionally, the watering objectives underpinning the watering actions are in general not SMART.

Second, while collaboration between the Selected Area teams and the Basin Matters team has improved, more still needs to be done in the final two years of the Project to cement this necessary collaborative approach. We have recommended that consideration be given to the establishment of a *Project Steering Committee* to assist with improving Project coordination and collaboration (see Section 5.3 below).

Third, we noted above our surprise that there was no single manager of this LTIM Project, with the management largely with the CEWO Aquatic Ecosystems & Science Section, but also involving the three CEWO Delivery Teams. While this aspect is not part of our terms of reference, we urge CEWO to review whether this is the most efficient and effective way to run this very important and complex project, and whether there is a need for an identifiable single Program Manager and a Science Manager.

Fourth, the LTIM Project lacks a clearly defined Program Evaluation Strategy as part of its MERI process to assist in assessing the efficiency, effectiveness, relevance and sustainability of the Project. The CEWO should urgently develop such a strategy and could consider using the evaluation strategy being used by the Murray-Darling Basin Environmental Water Knowledge and Research (MDB EWKR) project (Hodge et al. 2015) as a guide.

## LTIM objectives

This Section covers the need to review the current expectation from the Basin-scale evaluations, assessment of the contribution of the CEW, and the updating (or setting) of objectives for multi-scale watering events and key ecosystem types.

### Expectations from the Basin-scale evaluation

The expectations for this Project were set in 2013-14. There has now been three years of Project implementation, during which time many issues (some quite unexpected) have emerged and solutions had to be found at both the Selected Area and Basin-scale. This is not unexpected given the scope and experimental nature of this LTIM Project.

However, the time taken to find solutions to these quite difficult issues has meant that some of the more long-term objectives have had less attention than was originally envisaged. Consequently, some of the initial expectations of the Basin-scale evaluation are unlikely to be met. These include: the Basin-scale quantitative models; and the inferring of the outcomes of CEW in areas not monitored as part of the LTIM Project.

We have recommended that the Basin-scale evaluation questions are reviewed for their relevance and feasibility, and modified if need to ensure the expectations of this Project can be adequately met by June 2019 (**Recommendation 1**). A review of how water quality is treated in the Basin-scale evaluation should be included in this process.

### Assessment of the contribution of Commonwealth environmental water

We note that many of the key evaluation questions being addressed at both the Area-scale and Basin-scale are focused on the contribution of the *Commonwealth environmental water* to key ecological outcomes such as fish breeding, wetland vegetation community diversity and ecosystem diversity*.*

We were told that this particular Commonwealth focus, while understandable, has caused some problems with the reporting of ecological outcomes as a result of environmental watering events where the Commonwealth’s contribution may be only part, and sometimes a quite small part, of the total environmental water delivered.

This difficulty has been largely addressed by the CEWO who have broadened the interpretation to focus on assessing the outcomes for all environmental water, and where possible assess the contribution of Commonwealth’s water, as documented below[[11]](#footnote-11):

***What does ‘with and without Commonwealth environmental water’ mean for evaluation purposes?***

*The issue of what ‘with/without CEW’ means for LTIM evaluation purposes has come up, and specifically what the contract means when it says that Providers must: ‘quantify to the fullest extent possible the marginal benefit of Commonwealth environmental water and other held environmental water delivered in conjunction with Commonwealth environmental water’ (Schedule 3, Clause 4).*

*The overarching purpose of the LTIM Project is to monitor and evaluate the contribution of Commonwealth environmental water to Basin Plan environmental objectives.  Nonetheless, the reality is that CEW is often only part of the picture, and delivered in conjunction with other held or planned environmental water or on the back of natural flows for example.*

*The question of when Providers should try and separate the relative contribution of CEW to the overall outcome of a watering action with multiple water sources will invariably depend on* ***what the management objective is****.*

*In situations where multiple water sources are delivered, it may be appropriate to separate the relative contribution of CEW to the overall outcome.  A hypothetical example may include where CEW is being delivered following a State watering or natural event to extend the duration of wetland inundation in support of water bird breeding. The CEW component has a specific objective here that can be separated from the overall outcome – to extend the duration of inundation for a certain period of time/water level/recession rate etc so that the waterbirds can successfully finish their breeding activity. Understanding exactly what CEW is contributing to a hydrograph may also be important when mapping biotic samples to flows from upstream tributaries.*

*Conversely, it may be inappropriate to separate the relative contribution of CEW to the overall outcome of a watering action with multiple water sources. In those circumstances, CEW is only part of the picture, and we monitor and evaluate the effects of environmental watering as a whole - given that the action design (and thus expected outcomes or watering objective) would likely have been different, had the additional non-Commonwealth water not been available. An example may include where TLM, VEWH and CEW is being delivered in conjunction to achieve a fresh which a distinct hydrograph shape to trigger golden perch spawning. Under such circumstances, Providers should be looking to assess the outcome of the watering action as a whole - recognising as important context the multiple sources and volumes of water that contributed to it.*

### Improve the expected outcomes for large multiple-scale watering actions

The 2015-16 Synthesis Report (Gawne et al. 2017) noted that the CEWO is increasingly moving toward coordinated large-scale watering actions that influence multiple assets and rivers, and that it is important for the monitoring and evaluation process to be modified to ensure the adaptive management can be undertaken at this larger scale.

The delivery of environmental water to local assets is complex enough without the need to determine (and deliver) ecological outcomes at multiple scales. Currently, the communication of the expected outcomes from the multiple-scale watering actions is imperfect so that the full range of expected outcomes that have guided the multiple-scale environmental water delivery may not be clear to monitoring teams. This can reduce the effectiveness of evaluation and limit the ability of the LTIM Project teams to provide advice on adaptive management of environmental water. Accordingly, we have recommended that this issue be addressed (**Recommendation 2**).

### Expected outcomes for key ecosystem types (Ecosystem Diversity)

The 2015-16 Synthesis Report (Gawne et al. 2017) also noted that the increased focus on multi-scale watering actions has implications for the ecological scale of expected outcomes; that is there is a need to consider ecosystems in addition to species and populations.

It has been argued that there is a need to better understanding how key ecosystem types influence Basin biodiversity, resilience, ecosystem function and ecosystem services. Delivering Commonwealth environmental water for ecosystem objectives will require that the LTIM Project move beyond counting the ecosystem types watered or whether some types have had watering targets met. There will be a need, for example, to ‘shape’ flow regimes so that patterns of spatio-temporal variability along a river are preserved, or perhaps to deliver water at critical times to maintain life forms or ecosystem processes.

The CEWO currently does not have documented 1-year or 5-year expected outcomes for ecosystem diversity[[12]](#footnote-12) and needs to develop these (**Recommendation 3**). CEWO delivery teams often plan to link ecosystem types to water availability scenarios, such as directing water to maintain permanent water systems in dry years, or augmenting overbank flows to the floodplain in wet years, but these actions rarely have explicit ecosystem outcomes.

### Recommendations

***Recommendation*** *1: that the Basin-scale evaluation questions are reviewed to assess whether they are all still relevant, and the likelihood that they will be adequately addressed by June 2019. In light of this review to the CEWO should make any modifications that would update the expectations of the Basin-scale evaluations.*

***Recommendation 2:*** *that for multiple-scale watering actions, CEWO ensure the full range of expected ecological outcomes are determined and communicated to the appropriate LTIM Project teams.*

***Recommendation 3:*** *that the CEWO develop expected outcomes for the ecosystem diversity Basin Matter.*

## Project management

This review has identified the need for a more structured and collaborative approach to the running of the LTIM Project. To this end we recommend that the CEWO consider three modifications to the Project.

### Project Steering Committee

The CEWO should consider the establishment of a Project Steering Committee composed of: the CEWO Project Management team; the CEWO Delivery Team leads; the MDFRC Director; and the Selected-Area team lead. The CEWO Project Manager and the MDFRC Director would jointly chair the Steering Committee. CEWO should also consider whether the MDBA should also be invited to join this Committee. We suggest the Steering Committee meet two monthly, with two meetings per year face-to-face and the others via Skype or video link.

### Management of the Project

We noted above our surprise that there was no single program manager of this LTIM Project, with program management spread between four CEWO groups. While this aspect is not part of our terms of reference, we urge CEWO to review whether this is the most efficient and effective way to run this very important and complex project.

Additionally, we have raised the possibility that a project *Science Leader* be identified and recognised. This we believe would be of value to the Project for two reasons: first, it would highlight the fact that this is an innovative science-based project, and second, it would provide leadership to ensure that the science underpinning this Project is of the highest quality.

### Program evaluation strategy

The LTIM Project lacks are clearly defined Program Evaluation Strategy as part of its MERI process. Evaluation, in this sense, is defined as a systematic and objective assessment of an ongoing or completed project, program or policy, from its design and implementation through to results. The aim is to assess the efficiency and effectiveness in achieving the stated objectives and intended outcomes/results. Evaluations also assess the relevance and sustainability of outputs in terms of their contribution to short, medium and long-term outcomes. Evaluation provides the basis for adaptive management, via distillation of lessons learnt and from sharing of knowledge.

Ideally, such an Evaluation Strategy would have been developed prior to this MTRE; however it is recommended that such a strategy be urgently developed to enable the scope of the end of LTIM Phase 1 evaluation to be defined prior to the completion of the project.

***Recommendation 4:*** *that a LTIM Project Steering Committee be established, consisting of the CEWO, CEWO Delivery Teams, Selected Area team leads and the MDFRC Director. CEWO should also consider whether the MDBA should also be invited to join this Committee.*

***Recommendation 5:*** *that the CEWO review the management of the LTIM Project with a view to identifying a single Program Manager and a Science Leader.*

***Recommendation 6:*** *that the CEWO urgently develop an Evaluation Strategy for the LTIM Project.*

## Area-scale evaluation

This review has found the Selected Area projects are generally being run effectively (see Section 4.1). However, we have identified four areas where there could be improvements:

* Meeting the stated objectives – there is a need for Selected Area teams to focus more attention in their evaluation reports on: first, addressing all the key evaluation questions listed in the MEP (and these need to be better stated so they are at least achievable and measurable); second, assessing the ecological outcomes of each local-area watering action and also how these meet the objectives of the Basin Environmental Watering Plan, third, to scaling up the Area-scale assessment and evaluations to the entire Selected Area; and fourth, providing a cumulative evaluation of the data.
* Interactions and collaboration – interactions between the Selected Area teams and between the Selected Area teams and the CEWO Delivery Teams, stakeholder groups are very good. Collaboration between the Selected Area teams and the Basin Matters teams is improving, but still requires attention.
* Reporting – the current Selected Area annual reports are overly detailed and not written in a way that addresses the intent in the contracts. We have made recommendations aimed at improving these reports.
* Review – there is no documented process for reviewing the Selected Area projects or their annual reports. From later 2017 we understand that the Basin Matter team will take a larger role in reviewing these reports, which is welcome. However, more is needed and we have recommended that a more detailed independent review be undertaken.

***Recommendation 7:*** *that the Selected Area teams focus more attention in their annual reports on: addressing the key evaluation questions; the ecological outcomes of each local-area watering action, and scaling up the Area-scale assessment and evaluations to the entire Selected Area.*

***Recommendation 8:*** *that consideration be given to requiring the Selected Area teams to produce two reports annually: first, a relatively short general report suitable for water managers and other stakeholders; and second, a detailed science report containing the information currently in the Appendices.*

***Recommendation 9:*** *that the CEWO consider having a detailed independent peer review undertaken during 2018 of the quality of the science being reported by the Selected Area teams, with the focus being on the initial MEP, and the 2016-17 annual evaluation reports.*

## Basin-scale evaluation

This review has identified four areas where more effort is needed to ensure the stated LTIM Project outcomes are achieved: better definition of what is meant by ‘basin-scale evaluation’; the development and use of the quantitative models; upgrading the Monitoring Data Management System; more detailed hydrological information; and improved inundation mapping.

### Meaning of ‘basin-scale evaluation’

There is no consistent agreement of what constitutes a ‘Basin-scale evaluation’ or an ‘integrated Basin-scale evaluation’. Three types of analysis were identified in the initial LTIM Basin Evaluation Plan (Gawne et al. 2014): aggregative analysis; qualitative analysis; and quantitative analysis. Conceptually, the idea is to synthesize ‘*observed outcomes* (at the Selected Area or local scale) *in order to evaluated their contribution to achieving Basin Plan objectives at a larger spatial or longer temporal scale’* (Gawne et al. 2014, p6). However, currently there is a lack of detail on how this aggregation or integration will be undertaken.

In fact, it is difficult to see how a single assessment of the Basin as a very large and complex system could be undertaken. More sensibly, a Basin-scale evaluation will be made up of the aggregation of subsets of the Basin; these may be large sub-regions (e.g. northern and southern Basins) or catchments. But even the integration of the components making up a catchment is not a simple matter.

We recommend that a process be established to better define this term and what it actually means to undertake a ‘Basin-scale evaluation’. This is also of relevance to the MDBA who have commenced with addressing Basin-scale evaluation in their recent 2017 Basin Plan Evaluation Reports[[13]](#footnote-13). The process we suggested would involve: first, the preparation of a discussion paper; and second, the running of a workshop of key researchers and managers to provide a sensible outcome (**Recommendation 10).**

### Development of quantitative models

We have documented above (Section 4.2.2) our concern regarding the capacity of the Basin Matters team to develop, test and implement quantitative models for fish, vegetation and metabolism in the 18 months to the LTIM Project’s completion.

We believe there is an urgent need for a comprehensive *modelling development plan* to be developed to better define: the types of models that will be developed; what data will be used to populate the models; what the model outputs will be; who will develop the models; how they will be tested; how uncertainty will be handled; and a timeline for their development (with milestones).

We have recommended that this plan should be developed by the MDFRC (and perhaps approved by the recommended new Project Steering Committee), and needs to be done within the next few months (**Recommendation 11**). Additional funds or reallocation of existing funds may be required to ensure the development of this Plan, and the subsequent development and testing of the models, is achieved.

### Monitoring Data Management System

MDMS and QA/QC issues continue to have a major impact, entailing literally weeks to months in delays each year before the Basin Matters team can commence their actual evaluations. We have recommended that resolution of this issue be one of the first tasks of the new Steering Committee (**Recommendation 12**).

### More detailed hydrological information

The 2015-16 Synthesis Report (Gawne et al. 2017) noted that the availability of hydrological information relating to watering actions is highly variable and is limiting the assessments of hydrological outcomes and ecological responses.

This is particularly serious when attempting to predict responses to environmental watering at places (assets) that are not monitored. The hydrological information on the key aspects of the water regime that are important to target biota, include: depth and duration of inundation, and rates of rise and fall at both sites where monitoring data are collected and unmonitored sites. We have recommended that this issue be urgently addressed (**Recommendation 13**).

### Improve inundation mapping

The 2015-16 Synthesis Report (Gawne et al. 2017) and the Joint Venture (JVSC 2017) have noted that the ability to evaluate the contribution of Commonwealth environmental water to achieving objectives of the Basin Plan is currently limited by high uncertainty in the fate of water in the landscape after it is released. The volumes in storage and the rates and timing of delivery are well known, but the physical extent of water covering the land and the duration it persists in wetlands and on floodplains is much more poorly understood.

The initial planning for Basin evaluation was contingent on good floodplain inundation data both with and without Commonwealth environmental water being available (Gawne et al. 2014). The lack of good inundation mapping is limiting the Basin-scale evaluations for several Basin Matters (e.g. Ecosystem Diversity, Vegetation Diversity, Generic Diversity).

The Joint Venture Monitoring & Evaluation Program members held a workshop in June 2017 to discuss the need for reliable and accessible inundation mapping in the Basin (JVSC 2017). The workshop focused on inundation maps derived from remotely sensed Landsat satellite observations because they can be used to monitor inundation extents in near-real time. Similarly, the long-term archive means a time series of inundation maps can be used to manage flow regimes, develop inundation models as well as to validate inundation model outputs.

The inundation mapping workshop concluded that there is a compelling need for reliable and accessible Basin-wide inundation mapping, and that the most significant benefit would be to increase the efficacy of jurisdictional monitoring, evaluation and reporting obligations. The Workshop also recommended further investment to meet the identified need for Basin-wide accessible and reliable inundation mapping. We have recommended that this issue be urgently addressed (**Recommendation 13**).

***Recommendation 10:*** *that the CEWO organise a process to clarify the scope and consistency of basin-scale evaluations, the process consisting of the preparation of a discussion paper, followed by a workshop with key researchers and managers to provide a sensible outcome.*

***Recommendation 11:*** *that the MDFRC develop a comprehensive project modelling plan as a matter of urgency, and that this Plan be agreed to by the proposed Project Steering Committee. Additional funds or reallocation of existing funds may be required to ensure the development of the Plan, and the subsequent development and testing of the models, is achieved.*

***Recommendation 12:*** *that the new Project Steering Committee be tasked with resolving the continuing issues associated data QA/QC and the MDMS.*

***Recommendation 13:*** *that the need for improved hydrological data and information, and inundation mapping be urgently addressed.*

## Collaboration

We have identified a need to continue to support moves to improve collaboration between the Selected Area teams, and between the Selected Area teams and the Basin Matters team. The improvements that have occurred over the past three years have not been lead centrally, but have emerged largely through individual actions by Selected Area team members.

There is a need to provide a more formal collaboration component to the LTIM Project’s structure for the remainder of the Project. One mechanism that would achieve this more collaborative approach would be to establish a *Project Steering Committee* (**Recommendation 4**). We also recommend that one of the first tasks for the Steering Committee should be to formally evaluate the benefits of this improved collaboration between the Selected Area and Basin Matters teams.

***Recommendation 14:*** *that the proposed Project Steering Committee formally evaluate the benefits of this improved collaboration between the Selected Area and Basin Matters teams as one of its first tasks.*

## Reporting and communication

Effective reporting is a key product of the LTIM Project, but currently there is a lack of a strategy that outlines the objective(s), audience(s) and types of reports, fact sheets and web products to be produced annually.

Our review of the Selected Area annual reports (Section 4.1.1) found that there would be value in modifying the structure of the current reporting guidelines. In particular, the main body of the reports, aimed at water managers and interested non-technical audiences, are generally too long and overly complicated. The CEWO should consider requiring the Selected Area teams to produce two reports annually: first, a relatively short *general report* suitable for water managers and other stakeholders; and second, a detailed *science report* containing the information currently in the appendices, together with a synthesis of the scientific ecological outcomes for the Selected Area (and beyond if possible) (**Recommendations 7 and 8)**.

Additionally, a strong theme in the interviews was the need for improved communication in a number of key areas of the LTIM Project. We suggest that the engagement of an effective science communicator(s) to assist the Selected Area teams in the writing of their general reports would result in positive improvements in the reporting.

The Basin Matters and Synthesis reports need to be reviewed with a view to making them more accessible to a wider audience (**Recommendation 15)**. A particular problem for the Synthesis reporting is the difficulty in accessing relevant data and information from other non-LTIM monitoring programs. This additional data is held by the MDBA, The Living Murray (TLM) monitoring and the state agencies. There is an urgent need to consolidate this data into a central location (**Recommendation 16)**.

We have also recommended that the CEWO or MDFRC (or both) engage an effective science communicator(s) for two reasons: first, to assist the Selected Area and Basin Matters teams in producing reports that are more readable for the target audience, and second, to assist CEWO in producing better information products related to the LTIM Project (**Recommendation 17**).

***Recommendation 15:*** *that a review of the annual Basin Matters and Synthesis reports be undertaken, with a view to restructuring them to make them more accessible to a wider audience.*

***Recommendation 16:*** *that a common database be established to hold all relevant data relating to environmental water monitoring in the Murray-Darling Basin; this will require cooperation between CEWO, MDBA and state agencies to achieve.*

***Recommendation 17:*** *that an effective science communicator(s) be engaged by CEWO or MDFRC to assist the Selected Area and Basin Matters teams to make their various reports more readable, and to assist CEWO to produce more structured and targeted information products related to the LTIM Project.*

## Capture of adaptive management information

This review found (Section 4.3) that there are some excellent interactions between the Selected Area and CEWO Delivery teams. These are resulting in a considerable number of learning’s that are being translated into better management of the Commonwealth’s environmental water.

However, we also identified that the capture of these adaptive management learning’s could be improved, particularly if it was done more systematically. Two improvements were identified: first, better documentation of the many informal and formal discussions that lead to changes in water delivery, with this information recorded in an accessible and searchable database; and second, the production of an annual report that captures and synthesis the way this increased knowledge is changing the way in which the CEWO Delivery Teams are delivering environmental water.

***Recommendation 18:*** *that the capture of adaptive management learning’s be improved and done more systematically, in particular with the development of a accessible and searchable database to contain the learning’s, and the production of an annual report that syntheses how this increased knowledge is changing the way in which environmental water is being delivered.*

## Independent Science Review Committee

We have identified a significant lack of independent peer review of the LTIM Project science. There is some internal review occurring within the Selected Area teams and (recently) between the Basin Matters and the Selected Area teams. The recommended Project Steering Committee will assist in strengthening these internal review processes.

However, there is still need for overall independent peer review of the science. CEWO have commenced a independent review process with this current mid-term review and evaluation process.

The next critical point will be to review the LTIM Program or close to at its completion. CEWO should establish an *Independent Science Review Committee* to review the quality and relevance of the science (Selected Area and Basin Matters) and other aspects of the Project in year 5, and to make recommendations of modifications to the Project relevant to LTIM Phase 2.

***Recommendation 19:*** *that an Independent Science Review Committee be established to review the quality and relevance of the science being developed by the Selected Area teams and the Basin Matters team.*

# Some considerations for LTIM Phase 2

## Evaluation LTIM Project Phase 1

An independent reviewer (or review team) should be contracted to undertake an end-of-Project evaluation of LTIM Project Phase 1. This will not be a fast process and may take several months. CEWO will also need to give consideration to having an interim plan for the 2019-2020 watering year to ensure monitoring data continues to be captured. This may require a 12-month extension for some elements of LTIM Phase 1.

## Update Program Logic and structure for LTIM Phase 2

The LTIM Phase 1 evaluation should also provide comment on the possible structure, governance, logic and rationale of LTIM Phase 2. Our review has identified four key issues that will need to be addressed in settling the form of LTIM Phase 2

The first issue will be to review the overall objectives of the Project so that they are more closely aligned with the updated BEWS (to be done in 2019) and also with major programs such as the MDB EWKR. Additionally, there is a need to better manage expectations about what can (and cannot) be achieved with Commonwealth environmental water. For example, in many catchment it is not possible to use environmental water to reconnect floodplains either because of a lack of water to achieve the high flows needed, or of policy or political constraint on over-bank flows.

The second issue will be to review the advantages and disadvantages of the current structure with separate Area-scale and Basin-scale evaluations. Our view is that the current structure is perhaps overly emphasising the area-scale projects over the Basin-scale evaluations. This may have occurred as a result of the Project governance, where with the Selected Area teams are contracted to and managed by the Water Delivery Teams, who have a largely site or local focus. However, it should be remembered that the main reason LTIM was established was to address the CEWO’s requirements under the Basin Plan, and these are Basin-scale.

The third issue will be to map the monitoring efforts being undertaken by the MDBA and the Basin states to look for sources of complementary data, identify knowledge gaps and to help prioritise selection of areas and indicators to be included in LTIM 2. Monitoring of the Long Term Watering Plans will come on line post 2019, and should greatly increase the potential data sources.

The fourth issue will be to achieve better alignment between LTIM 2 and other environmental watering monitoring programs, particularly those being undertaken by MDBA and the state agencies.

There are also two other concepts that those planning LTIM Phase 2 might consider:

* *Emerging new concepts in flow restoration* – Thomson et al. (2017) have reviewed recent papers on responses to flow restoration in the Murray–Darling Basin and complemented this with inferences from the global literature. They found that ecological responses to flow restoration are often inconsistent, site and taxon specific and difficult to detect. They have proposed a conceptual model for understanding responses to flow restoration that incorporates key factors influencing the size of ecological responses to restoration, including: existing ecological condition, legacy impacts of past change, interactions with other variables, life-history traits of taxa and broad-scale and long-term trends due to climate or land-use change.
* *Assessment of rivers as social-ecological systems* – Parsons and Thoms (2017) and Parsons et al. (2016) have suggested that the assessment of river health in Australia should go beyond the current bioassessment, and monitoring the resilience of rivers as social-ecological systems.

# Summary of recommendations and management response required

A summary of the recommendations arising from out review are presented in Table 5 along with some suggested responses and timeframe in which action is required.

Table 5. Summary of recommendations and suggested management response/actions and timing

| Recommendation | Suggested management response/action | Timing |
| --- | --- | --- |
| 1. That the Basin-scale evaluation questions are reviewed to assess whether they are all still relevant, and the likelihood that they will be adequately addressed by June 2019. In light of this review to the CEWO should make any modifications that would update the expectations of the Basin-scale evaluations. | Establish working group from Selected Area and Basin Matter team to develop SMART objectives and KEQ.  Seek Project Steering Committee approval of updated objectives and KEQ  Working group to liaise with delivery teams to develop SMART objectives | Immediately |
| 1. That for multiple-scale watering actions, CEWO ensure the full range of expected ecological outcomes are determined and communicated to the appropriate LTIM Project teams. | Project management by the CEWO water delivery teams | Annual/ongoing |
| 1. That the CEWO develop expected outcomes for the ecosystem diversity Basin Matter. | CEWO in collaboration with relevant Basin Matter team members  Approval by Project Steering Committee | Within 6 months |
| 1. That a LTIM Project Steering Committee be established, consisting of the CEWO, CEWO Delivery Teams, Selected Area team leads and the MDFRC Director. CEWO should also consider whether the MDBA should also be invited to join this Committee. | CEWO management | Immediately |
| 1. That the CEWO review the management of the LTIM Project with a view to identifying a single Program Manager and a Science Leader. | CEWO in collaboration with MDFRC Director | Immediately |
| 1. That the CEWO urgently develop an Evaluation Strategy for the LTIM Project. | Outsource to independent contractor – needs to be independent from current project staff  Oversight of development of Terms of Reference by Project Steering Committee | Within 6 months |
| 1. That the Selected Area teams focus more attention in their annual reports on: ecological outcomes of each local-area watering action, and scaling up the area-scale assessment and evaluations to the entire selected area. | CEWO management in collaboration with Selected Area team leaders  Approval by Project Steering Committee | Immediately/ongoing |
| 1. That consideration be given to requiring the Selected Area teams to produce two reports annually: first, a relatively short general report suitable for water managers and other stakeholders; and second, a detailed science report containing the information currently in the Appendices. | CEWO management in collaboration with Selected Area team leaders | For next set of Annual Evaluation Reports |
| 1. That the CEWO consider having a detailed independent peer review undertaken during 2018 of the quality of the science being reported by the Selected Area teams, with the focus being on the initial MEP, and the 2015-2016 and 2016-17 annual evaluation reports. | CEWO management | In the second half of 2018 |
| 1. That the CEWO organise a process to clarify the scope and consistency of basin-scale evaluations, the process consisting of the preparation of a discussion paper, followed by a workshop with key researchers and managers to provide a sensible outcome. | CEWO in collaboration with MDFRC | In the second half of 2018  Could be done in conjunction with the 2018 Annual Forum |
| 1. That the MDFRC develop a comprehensive project modelling plan as a matter of urgency, and that this Plan be agreed to by the proposed Project Steering Committee. Additional funds or reallocation of existing funds may be required to ensure the development of the Plan, and the subsequent development and testing of the models, is achieved. | MDFRC Director and relevant Basin Matters team members  Consider need for independent peer review of the modelling plan by recognised world leader(s) in the field | Immediately |
| 1. That the new Project Steering Committee be tasked with resolving the continuing issues associated data QA/QC and the MDMS. | Project Steering Committee with input from Shane Brooks | One of the first tasks |
| 1. That the need for improved hydrological data and information, and inundation mapping be urgently addressed | Collaborate with MDBA and other data suppliers (e.g. NSW OEH) to coordinate progress at the Basin scale – possibly via a working group | Initiate discussion and identify stakeholders within 6 months |
| 1. That the proposed Project Steering Committee formally evaluates the benefits of this improved collaboration between the Selected Area and Basin Matters teams as one of its first tasks. | Project Steering Committee | One of the first tasks |
| 1. That a review of the annual Basin Matters and Synthesis reports be undertaken, with a view to restructuring them to make them more accessible to a wider audience. | MDFRC Director with CEWO management | During 2018 |
| 1. That a common database be established to hold all relevant data relating to environmental water monitoring in the Murray-Darling Basin; this will require cooperation between CEWO, MDBA and state agencies to achieve. | Establish a working group to resolve (CEWO, MDBA, state agencies) | During 2018 |
| 1. That an effective science communicator(s) be engaged by CEWO or MDFRC to assist the Selected Area and Basin Matters teams to make their various reports more readable, and to assist CEWO to produce more structured and targeted information products related to the LTIM Project. | CEWO in collaboration with MDFRC Director  Establish a Communications strategy for LTIM Phase 1 outcomes – to be rolled out over final two years  Oversight by Project Steering Committee | During 2018 |
| 1. That the capture of adaptive management learning’s be improved and done more systematically, in particular with the development of a accessible and searchable database to contain the learning’s, and the production of an annual report that syntheses how this increased knowledge is changing the way in which environmental water is being delivered. | Project Steering Committee | During 2018 |
| 1. That an Independent Science Review Committee be established to review the quality and relevance of the science being developed by the Selected Area teams and the Basin Matters team. | CEWO management | Early in 2018 |

# Acknowledgements

We wish to sincerely thank all who participated in the interviews for this review. We were able to tap a huge knowledge pool, to obtain insightful comments on what was working well and not so well with this Project, and to discuss possible modifications to the Project. An outstanding feature of these discussions was the widespread enthusiasm for the LTIM Project.

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# Appendix A: MTRE objectives

Table 6. Objectives of LTIM MTRE

|  |  |
| --- | --- |
| Number | Objective |
| 1 | To assess overall progress towards meeting the stated LTIM Project objectives as specified in the foundation documentation (noting that independent review of foundation documents occurred at time of publication). The approach will be to:  1a Review program logic and design in terms of meeting requirements under Water Act (2007) and Murray-Darling Basin Plan, in particular mapping against Basin Wide Environmental Watering Strategy (MDBA 2014);  1b Review individual area-scale projects (at high level, see also 2a below) and assess their contribution to meeting LTIM Project objectives. |
| 2 | To assess implementation and effectiveness of the LTIM Project at the program level. The approach will be to:  2a Assess individual area-scale projects (based on area-scale MEP and 2015-2016 evaluation reports) to establish if they are on track to meeting stated objectives for each region;  2b Identify any risks to the successful implementation of area-scale projects;  2c Assess whether the LTIM Project is on track to meeting stated objectives - establish what is working (combines outputs from 2a);  2d Identify any risks to the LTIM Project outcomes - establish what is not working (combines outputs from 2b). |
| 3 | To review the effectiveness of the LTIM Project’s current approach to adaptive management.  3a Identify what adaptive management processes have occurred, and what changes have been implemented;  3b Identify any challenges and how they were addressed;  3c Areas to be considered include management arrangements, work planning (in relation to sharing of data), project-level monitoring and evaluation systems, and reporting. |
| 4 | To provide a review and evaluation report of the LTIM Project containing:  4a Recommendations for improvement of the current program;  4b Recommendations for consideration in determining the scope of LTIM Stage 2;  4c Recommend possible management responses to the MTRE report (e.g. presentation/workshop with CEWO and suggestions on who does what and by when?). |

# Appendix B: Documents reviewed in MTRE

The main documents reviewed for the MTRE are listed below.

## Foundation documents

|  |  |
| --- | --- |
| **Environmental Water Outcomes Framework** | CEWO (2013). *Commonwealth Environmental Water – The Environmental Water Outcomes Framework, Commonwealth Environmental Water Office, December 2013 V1.0*, Commonwealth Environmental Water Office, Canberra. |
| **Logic and Rationale** | Gawne, B., Brooks, S., Butcher, R., Cottingham, P., Everingham, P., Hale, J., Neilson, D., Stewardson, M. and Stoffels, R. (2013). *Long Term Intervention Monitoring Project: Logic and Rationale Document (Final Report)*, Publication 01/2013, Murray Darling Freshwater Research Centre, Wodonga, 109 pp. |
| **Basin Evaluation Plan** | Gawne, B., Roots, J., Hale, J. and Stewardson, M. and Stoffels, R. (2014). *Long Term Intervention Monitoring Project: Basin Evaluation Plan*, Publication 42/2014, Murray Darling Freshwater Research Centre, Wodonga, 55 pp. |
| **Standard Methods** | Hale, J., Stoffels, R., Butcher, R., Shackleton, M., Brooks, S., Cottingham, P., Gawne, B. and Stewardson, M. (2014). *Long Term Intervention Monitoring Project: Standard Methods.* Publication 29-2/2014, Murray Darling Freshwater Research Centre, Wodonga, 175 pp. |

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| --- | --- |
| **Ecosystem diversity** | Brooks, S. (2015). *Long Term intervention Monitoring Basin Matter – Ecosystem diversity foundation report*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 74/2015, May, 9pp. |
| **Hydrology** | Stewardson, M., Guarino, F., and Gawne, B. (2015). *Long Term Intervention Monitoring Basin Matter – Hydrology foundation report*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 66/2015, May, 9pp. |
| **Stream metabolism and water quality** | Grace, M. (2015). *Long Term Intervention Monitoring Basin Matter - Stream Metabolism and Water Quality foundation report*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 69/2015, May, 9pp. |
| **Vegetation** | Capon, S., Campbell, C., and Steward-Koster., B. (2015). *Long Term Intervention Monitoring Basin Matter – Vegetation Diversity foundation report*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 68/2015, May, 11pp. |
| **Fish** | Stoffels, R., Bond, N., Pollino, C., Broadhurst, B., Butler, G., Kopf, R.K., Koster, W., McCasker, N., Thiem, J., Zampatti, B., and Ye, Q. (2016). *Long Term Intervention Monitoring Basin Matter - Fish foundation report*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 65/2015, May, 11pp. |
| **Generic diversity** | Baumgartner, L., Hale, J., and Gawne, B. (2015). *Long Term Intervention Monitoring Basin Matter – Aggregation of Selected Area biodiversity outcomes (generic diversity) foundation report*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 67/2015, May, 5pp. |

## Area-scale Monitoring and Evaluation Plans

|  |  |
| --- | --- |
| **Edward-Wakool** | Watts, R.J., McCasker, N., Baumgartner, L., Bond, N., Bowen, P., Conallin, A., Grace, M., Healy, S., Howitt, J.A., Kopf, R.K., Scott, N., Thiem, J., and Wooden I. (2014). *Monitoring and Evaluation Plan for the Edward-Wakool Selected Area*, Commonwealth of Australia 2014. |
| **Goulburn** | Webb, A., Sharpe, A., Koster, W., Morris, K., Pettigrove, V., Grace, M., Vietz, G., Woodman, A., Earl, G., and Casanelia, S. (2014). *Long-Term Intervention Monitoring Project for the lower Goulburn River: Final Monitoring and Evaluation Plan*. Commonwealth of Australia 2014. |
| **Gwydir** | Frazier, P., Ryder, D., Garraway, E., and van der Veer, N. (2015). *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project Gwydir River System Selected Area Monitoring and Evaluation Plan.* Commonwealth of Australia 2014. |
| **Lower Lachlan** | Dyer, F., Broadhurst, B., Thompson, R., Jenkins, K., Brandis, K., Driver, P., Saintilin, N., Bowen, S., Packard, P., Gilligan, D., Thiem, J., Asmus, M., Amos, C. Hall, A., Martin, F., and Lenehan, J. (2015). *Long Term Intervention Monitoring and Evaluation Plan Lachlan River system*, Commonwealth of Australia 2014. |
| **Lower Murray (version 2 2016)** | SARDI, University of Adelaide, CSIRO, EPA, DEWNR and In Fusion(2016). *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project Lower Murray River Selected Area Monitoring and Evaluation Plan*. Version 2, Commonwealth of Australia 2016. |
| **Murrumbidgee** | Wassens, S., Jenkins, K., Spencer, J., Thiem, J., Bino, G., Lenon, E., Thomas, R., Kobyashi, T., Baumgartner, L., Brandis, K., Wolfenden, B., Hall, A. , and Scott, N. (2014). *Murrumbidgee Monitoring and Evaluation Plan*, Commonwealth of Australia 2014. |
| **Warrego-Darling** | Frazier, P., Ryder, D., Southwell, M., and Southwell, E. (2015). *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area*, Commonwealth of Australia 2014. |

## Area-scale Evaluation Reports 2015-2016

|  |  |
| --- | --- |
| **Edward-Wakool** | Watts, R.J., McCasker, N., Howitt, J.A. Thiem, J., Grace, M., Kopf, R.K. Healy, S. and Bond, N. (2016). *Commonwealth Environmental Water Office Long-Term Intervention Monitoring Project: Edward-Wakool River System Selected Area Evaluation Report 2015-16.* Report prepared for Commonwealth Environmental Water Office. Commonwealth of Australia. |
| **Goulburn River** | Webb, A., Baker, B., Casanelia, S., Grace, M., King, E., Koster, W., Lansdown, K., Lintern, A., Lovell, D., Morris, K., Pettigrove, V., Sharpe, A., Townsend, K., and Vietz, G. (2016). *Commonwealth Environmental Water Office Long-Term Intervention Monitoring Project – Goulburn River Selected Area evaluation report 2015-16*. Report prepared for the Commonwealth Environmental Water Office |
| **Gwydir** | Southwell, M., Frazier, P., Hancock, P., Martin, B., Burch, L., van der Veer, N., Frost, L., Ryder, D., Tsoi, WY., Butler, G., Spence, J., Bowen, S., and Humphries, J. (2016). *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project Gwydir River System Selected Area – 2015-16 Draft Evaluation Report*, Commonwealth of Australia 2016. |
| **Lower Lachlan** | Dyer, F., Broadhurst, B., Tschierschke, A., Thiem, J., Thompson, R., Driver, P., Bowen, S., Asmus, M, Wassens, S., and Walcott, A. (2016). *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Lower Lachlan river system Selected Area 2015-16 Monitoring and Evaluation Synthesis Report*. Commonwealth of Australia, 2016. |
| **Lower Murray** | Ye, Q., Giatas, G., Aldridge, K., Busch, B., Gibbs, M., Hipsey, M., Lorenz, Z., Mass, R., Oliver, R., Shiel, R., Woodhead, J. and Zampatti, B. (2017). *Long-Term Intervention Monitoring of the Ecological Responses to Commonwealth Environmental Water Delivered to the Lower Murray River Selected Area in 2015/16.* A report prepared for the Commonwealth Environmental Water Office, 2016. |
| **Murrumbidgee** | Wassens, S., Spencer, J., Thiem, J., Wolfenden, B. Jenkins, K., Hall, A., Ocock, J., Kobayashi, T., Thomas, R., Bino, G., Heath, J., and Lenon, E. (2016). C*ommonwealth Environmental Water Office Long-term Intervention Monitoring project Murrumbidgee River System Selected Area evaluation report*, Commonwealth of Australia 2016. |
| **Warrego-Darling** | Frazier, P., Ryder, D., Southwell, M., Butler, G., van der Veer, N., Burch, L., Martin, B., Frost, L., and Cawley, R., and Tsoi, W.S., (2017). *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area – 2015-16 Final Evaluation Report*, Commonwealth of Australia 2017. |

## Basin Matter Evaluation Reports 2015-2016

|  |  |
| --- | --- |
| **Ecosystem diversity** | Brooks, S. (2017). *2015–16 Basin-scale evaluation of Commonwealth environmental water – Ecosystem Diversity*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 144/2017, May, 45pp. |
| **Hydrology** | Stewardson, M.J., and Guarino, F. (2017). *2015–16 Basin-scale evaluation of Commonwealth environmental water — Hydrology*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 142/2017, October, 45pp., plus annex |
| **Stream metabolism and water quality** | Grace, M. (2017). *2015–16 Basin-scale evaluation of Commonwealth environmental water — Stream Metabolism and Water Quality.* Final Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 143/2017, October, 58pp. |
| **Vegetation** | Capon, S., and Campbell, C. (2017). *2015–16 Basin-scale evaluation of Commonwealth environmental water – Vegetation Diversity.* Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 145/2017, August, 87pp. |
| **Fish** | Stoffels, R.J., Bond, N.R., and Guarino, F. (2017). *2015–16 Basin-scale evaluation of Commonwealth environmental water – Fish.* Final Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 146/2017, October, 72pp. |
| **Generic diversity** | Hale, J. (2017). *2015–16 Basin-scale evaluation of Commonwealth environmental water — Generic Diversity.* Final Report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 147/2017, September, 61pp. |
| **CEWO watering actions** | CEWO (n.d.) 2015–16 Basin-scale evaluation of Commonwealth environmental water – Environmental watering actions. |
| **Synthesis Report** | Gawne, B., Hale, J., Brooks, S., Campbell, C., Capon, S., Everingham, P., Grace, M., Guarino, F., Stoffels, R., and Stewardson, M. (2017). *2015–16 Basin-scale evaluation of Commonwealth environmental water – Synthesis Report*. Final report prepared for the Commonwealth Environmental Water Office by The Murray–Darling Freshwater Research Centre, MDFRC Publication 141/2017, October, 47 pp. |

# Appendix C: Interview approach and key responses

## Approach

Each LTIM Project team member and stakeholder interviewed was sent a short introduction to the MTRE and a list of questions. The questions related to the program strategy, progress towards results, implementation, adaptive management, reporting, future planning and key lessons.

The interviews focused on what’s working well and what’s not, adaptive management processes and practices, reporting and interactions between the various key team groups (i.e. Selected Area teams, Basin Matter teams, CEWO project managers and the CEWO water delivery teams). Not all questions were addressed in the interviews.

A set of summary notes from the interview were sent to each of the interviewees with the option of clarifying points, and or adding more comments. From these notes the key responses have been distilled into the following main topics:

* LTIM Program as a whole – approach, foundation documents, design, strategy, progress etc.
* Project specific responses either for Selected Areas or Basin Matter evaluation covering implementation, reporting, adaptive management
* CEWO interaction – project management and water delivery teams
* Key lessons
* Future planning

## Participant responses

Abbreviations used in responses:

BM – Basin Matter

CEW – Commonwealth environmental water

EWAG – Environmental Watering Advisory Group

MEP – Monitoring and evaluation plans

SA – Selected Area

TAG – Technical Advisory Group

*\* Individual participant responses removed from this edition of the report by CEWO\**

# Appendix D: Outcomes Framework

Expected Outcomes from environmental watering at the Basin-scale are presented in Table 7 (shaded). Expected Outcomes to be monitored as part of LTIM for Basin and/or Selected Area evaluation and indicated with an \* and Expected Outcomes which may be monitored (i.e. are optional) are indicated with ^ (Gawne et al. 2014, Commonwealth of Australia 2017).

Table 7. Summary of expected outcomes at the Basin-scale.

| Basin Plan objectives (MDBA 2012 – see Appendix E this document) | Basin Outcomes (Commonwealth of Australia 2013) | | Basin-wide Environmental Watering Strategy – Expected Outcomes (Commonwealth of Australia 2017) | Five-year Expected Outcomes (Gawne et al. 2014) | One-year Expected Outcomes (Gawne et al. 2014) |
| --- | --- | --- | --- | --- | --- |
| Biodiversity  (Basin Plan S. 8.05) | **Ecosystem diversity** |  |  | • **Species diversity** |  |
| **Species diversity** | **Vegetation** | * Maintenance of the current extent of river red gum, black box, coolibah forest and woodlands; existing large communities of lignum; and non- woody communities near or in wetlands, streams and on low- lying floodplains * Maintain the current condition of lowland floodplain forests and woodlands of river red gum, black box and coolibah * Improved condition of southern river red gum | • **Vegetation diversity\*** | • Reproduction |
| • **Condition\*** |
| **• Growth and survival\*** | • Germination • Dispersal**\*** |
| Macro-invertebrates |  | • Macro-invertebrate diversity |  |
| **Fish** | * Improved distribution of key short and long-lived fish species across the Basin * Improved breeding success for short-lived species, long-lived species and mulloway * Improved populations of short- lived species, long-lived species, Murray cod and golden perch. | **• Fish diversity\*** | **• Condition\*** |
| **• Larval and juvenile recruitment\*** | **• Larval abundance\***  **• Reproduction\*** |
| Waterbirds | * Maintained current species diversity of all current Basin waterbirds and current migratory shorebirds at the Coorong * Increased abundance with a 20– 25 per cent increase in waterbirds by 2024 * Improved breeding events for colonial nesting waterbird species and an increase in nests and broods for other waterbirds | • Waterbird diversity |  |
| • Waterbird diversity and population condition (abundance and population structure) | • Survival and condition**^**  • Chicks**^**  • Fledglings**^** |
| **Other vertebrate diversity** |  | **• Adult abundance\*** | **• Young\*** |
| Ecosystem Function  (Basin Plan S. 8.06) | **Connectivity** |  | * Maintained base flows - at least 60 per cent of natural levels * Improved overall flow * Maintained connectivity in areas where it is relatively unaffected * Improved connectivity with bank-full and/or low floodplain flows * Maintain the Lower Lakes above sea level |  | **• Hydrological connectivity including end of system flows\*** |
| * Improved movement with more native fish using fish passages |  | **• Biotic dispersal and movement\*** |
|  |  | • Sediment transport**\*** |
| **Process** |  |  |  | **• Primary productivity (of aquatic ecosystems)\*** |
|  |  | **• Decomposition\*** |
|  |  | • Nutrient and carbon cycling**\*** |
| Resilience  (Basin Plan S. 8.07) | **Ecosystem resilience** |  |  | • Population condition (individual refuges)**^** | • Individual survival and condition (individual refuges)**^** |
|  | • Population condition (landscape refuges)**^** |  |
|  |  | • Individual condition (ecosystem resistance) |
|  | • Population condition (ecosystem recovery) |  |
| Water quality  (Basin Plan S. 9.04) | **Chemical** |  |  |  | **• Salinity\*** |
| **• Dissolved oxygen\*** |
| **• pH\*** |
| • Dissolved organic carbon**^** |
| Biological |  |  |  | • Algal blooms |

# Appendix E: Overall and Specific Basin Plan Objectives

|  |  |  |
| --- | --- | --- |
| Overall Basin Plan objectives | Objective specifics | LTIM reference |
| to protect and restore water-dependent ecosystems of the Murray-Darling Basin (Basin Plan, Chapter 8, Part 2, 8.04(a)) | Chpt 8, Part 2, 8.05   1. This section sets out particular objectives relating to the protection and restoration of the water-dependent ecosystems of the Murray-Darling Basin. 2. **An objective is to protect and restore a subset of all water-dependent ecosystems** of the Murray-Darling Basin, including by ensuring that: 3. declared Ramsar wetlands that depend on Basin water resources maintain their ecological character; and   Note: See paragraph 21(3)(c) of the Act.   1. water-dependent ecosystems that depend on Basin water resources and support the life cycles of species listed under the Bonn Convention, CAMBA, JAMBA or ROKAMBA continue to support those species; and 2. water-dependent ecosystems are able to support episodically high ecological productivity and its ecological dispersal. 3. An objective is to protect and restore biodiversity that is dependent on Basin water resources by ensuring that: 4. water-dependent ecosystems that support the life cycles of a listed threatened species or listed threatened ecological community, or species treated as threatened or endangered (however described) in State law, are protected and, if necessary, restored so that they continue to support those life cycles; and 5. **representative populations and communities of native biota are protected and, if necessary, restored**. | Biodiversity |
| to protect and restore the ecosystem functions of water-dependent ecosystems (Basin Plan, Chapter 8, Part 2, 8.04(b)) | Chpt 8, Part 2, 8.06   1. This section sets out particular objectives relating to the protection and restoration of the ecosystem functions of water-dependent ecosystems. 2. An objective is that the water quality of Basin water resources does not adversely affect water-dependent ecosystems and is consistent with the water quality and salinity management plan 3. An objective is to protect and restore connectivity within and between water-dependent ecosystems, including by ensuring that: 4. the diversity and dynamics of geomorphic structures, habitats, species and genes are protected and restored; and 5. ecological processes dependent on hydrologic connectivity:   (i) longitudinally along watercourses; and  laterally between watercourses and their floodplains (and associated wetlands); and  (iii) vertically between the surface and subsurface;  are protected and restored; and   1. the Murray Mouth remains open at frequencies, for durations, and with passing flows, sufficient to enable the conveyance of salt, nutrients and sediment from the Murray-Darling Basin to the ocean; and 2. the Murray Mouth remains open at frequencies, and for durations, sufficient to ensure that the tidal exchanges maintain the Coorong’s water quality (in particular salinity levels) within the tolerance of the Coorong ecosystem’s resilience; and   Note: This is to ensure that water quality is maintained at a level that does not compromise the ecosystem and that hydrologic connectivity is restored and maintained.   1. the levels of the Lower Lakes are managed to ensure sufficient discharge to the Coorong and Murray Mouth and help prevent river bank collapse and acidification of wetlands below Lock 1, and to avoid acidification and allow connection between Lakes Alexandrina and Albert, by:   (i) maintaining levels above 0.4 metres Australian Height Datum for 95% of the time, as far as practicable; and  (ii) maintaining levels above 0.0 metres Australian Height Datum all of the time; and   1. barriers to the passage of biological resources (including biota, carbon and nutrients) through the Murray-Darling Basin are overcome or mitigated. 2. An objective is that natural in-stream and floodplain processes that shape landforms (for example, the formation and maintenance of soils) are protected and restored. 3. An objective is to support habitat diversity for biota at a range of scales (including, for example, the Murray-Darling Basin, riverine landscape, river reach and asset class). 4. An objective is to protect and restore ecosystem functions of water-dependent ecosystems that maintain populations (for example recruitment, regeneration, dispersal, immigration and emigration) including by ensuring that: 5. flow sequences, and inundation and recession events, meet ecological requirements (for example, cues for migration, germination and breeding); and 6. habitat diversity, extent, condition and connectivity that supports the life cycles of biota of water-dependent ecosystems (for example, habitats that protect juveniles from predation) is maintained. 7. An objective is to protect and restore ecological community structure, species interactions and food webs that sustain water-dependent ecosystems, including by protecting and restoring energy, carbon and nutrient dynamics, primary production and respiration. | Ecosystem function |
| to ensure that water-dependent ecosystems are resilient to climate change and other risks and threats (Basin Plan, Chapter 8, Part 2, 8.04(c)) | Chpt 8, Part 2, 8.07   1. This section sets out particular objectives relating to ensuring that water-dependent ecosystems are resilient to climate change and other risks and threats. 2. An objective is that water-dependent ecosystems are resilient to climate change, climate variability and disturbances (for example, drought and fire). 3. An objective is to protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna, including during drought to allow for subsequent re-colonisation beyond the refugia. 4. An objective is to provide wetting and drying cycles and inundation intervals that do not exceed the tolerance of ecosystem resilience or the threshold of irreversible change. 5. An objective is to mitigate human-induced threats (for example, the impact of alien species, water management activities and degraded water quality). 6. An objective is to minimise habitat fragmentation. | Resilience |
| to ensure water quality is sufficient to achieve the above objectives for water-dependent ecosystems, and for Ramsar wetlands, sufficient to maintain ecological character (Basin Plan, Chapter 9, Part 3, 9.04 (1) & (2)) | Chpt 9, Part 3, 9.04   1. The water quality objective for declared Ramsar wetlands is that the quality of water is sufficient to maintain the ecological character of those wetlands.   Note: See paragraph 21(3)(c) of the Act.   1. The water quality objective for water-dependent ecosystems other than declared Ramsar wetlands is that the quality of water is sufficient: 2. to protect and restore the ecosystems; and 3. to protect and restore the ecosystem functions of the ecosystems; and 4. to ensure that the ecosystems are resilient to climate change and other risks and threats.   Note: See the overall environmental objectives of the environmental watering plan in section 8.04. | Water quality |

# Appendix F: Assessment of progress by Basin Matter evaluation

|  |  |  |
| --- | --- | --- |
| **Green – Evaluation on track and likely to be achieved** | **Yellow – Evaluation will possibly be achieved but dependent on watering conditions or other constraint** | **Red – Evaluation questions not adequately addressed, or not on track to be achieved.** |

**This assessment of the Basin Matter and Synthesis reports is very high level and does not constitute a detailed evaluation of the conceptual premise, methods or evaluation techniques. The ratings are based on only two years of LTIM and conditions/results may change in the final years of the program.**

**Whilst some of the expected outcomes set at the Basin-scale may not be achieved, this in itself is not necessarily a failure, since the knowledge gained from this project will be significant – even if the outcome isn’t what was originally hypothesised.**

**In most cases, identification of some aspect not being on track reflects one or more of the following:**

* **no measurable objectives/expected outcomes given (e.g. ecosystem diversity);**
* **outcome unlikely to be achieved due to constraints;**
* **and/or ecological response not observed as expected.**

**In these cases, there may be a need to refine objectives and or manage expectations.**

Basin-scale evaluation is intended to evaluate the extent to which the expected outcomes of a watering action are achieved and then use the Outcomes Framework to evaluate the extent to which these outcomes contribute to the environmental objectives of the Basin Plan. Each step in the evaluation process will be based on the same starting question, specifically (Gawne et al. 2014):

*How does the observed outcome of Commonwealth environmental water compare to both the expected outcome and the outcome predicted to occur in the absence of Commonwealth environmental water?*

The following lists the objectives of the project and requirements for reporting – these have been used as guides to assess the progress of the BM team in meeting objectives, evaluation and reporting requirements. Bolded text are the areas in which there is inconsistency between the Basin Matter evaluation reports, and or, requirements have not been met.

*The Services in priority order aim to:*

1. evaluate ecological outcomes of CEW at each Selected Area;
2. evaluate the contribution of CEW to the objectives of the Murray Darling Basin Authority’s Environmental Watering Plan;
3. infer ecological outcomes of CEW in areas of the Murray-Darling Basin not monitored;
4. support the Adaptive Management of CEW; and
5. monitor the ecological response to CEW at each Selected Area.

*Annual reports are to include:*

*Evaluation*

*a) evaluate* ***the extent*** *to which the* ***expected outcomes*** *identified in the Basin Evaluation Plan, and identified for environmental watering in the years 2014-15 to 2018—19,* ***have been achieved****;*

*b) evaluate the outcomes of environmental water use based on available information using one or more of the following approaches:*

*i. monitored results;*

*ii. quantitative evaluation;*

*iii. qualitative evaluation;*

*iv. inferred using scientific opinion and the outcomes framework; or*

*v. inferred using expert scientific opinion and other evidence.*

*c) clearly identify which of the above approaches was used for the evaluated outcome;*

*d) for the* ***expected outcomes identified in the Evaluation Plan****, provide clear answers to each relevant evaluation question;*

*e)* ***quantify to the fullest extent possible the marginal benefit of Commonwealth environmental water*** *and other held environmental water delivered in conjunction with Commonwealth environmental water;*

*f) the evaluation of expected outcomes (both less than one year and one to five years)* ***after the first year will need to be cumulative*** *by considering the evaluation of results from the previous years*

*g) include, where possible, preliminary findings in relation to* ***one to five year*** *expected outcomes (if necessary these may be supported by qualitative results in the earlier years leading to quantitative evaluation in the later years);*

***Adaptive management***

*h) use monitoring and evaluation outcomes and expert scientific opinion to provide implications for future management of Commonwealth environmental water and how to improve for the future;*

*Context*

*i) provide context of the* ***environmental conditions across the Basin****;*

*j) provide brief context to the watering actions and links to the expected outcomes from the watering action and previously evaluated outcomes;*

In addition a progress status rating is provided for each Basin Matter (see tables below).

**General findings for Basin-scale evaluation:**  As the objectives, outcomes and KEQ for the Basin-scale evaluation are not SMART (other than time bound) it is difficult to evaluate if they are being achieved/addressed effectively and efficiently. In addition having only two years data also limits the evaluation as many of the Basin-scale questions will require longer periods of data collection. It will be essential to establish a detailed outcomes evaluation plan (similar to that developed for EWKR project) on which to base the final LTIM Phase 1 program evaluation.

The lack of expected outcomes for ecosystem diversity is seen as a significant issue for the LTIM project as there are very specific objectives for this matter in the Basin Environmental Watering Plan.

Currently there are many unqualified statements such as *almost certainly promoted*, *likely to have been enhanced* used in the reports, most notably in the Synthesis report. This is mostly due to having only two years data.

Additionally, there is no clear plan for how the Basin Matters team will develop, test and implement quantitative models for fish, vegetation and metabolism in the 18 months to the LTIM Project’s completion. There is an urgent need for a comprehensive modelling development plan to be developed (See Recommendation 11 in main report).

The progress ratings given in Table 8 are largely, but not entirely, a consequence of the timing of this evaluation.

Table 8. Progress status for each reporting requirement for Basin-scale evaluation.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Evaluation | | | | | | | Adaptive management | Context | |
| a | b | c | d | e | f | g | h | i | j |
| Hydrology | Specific to BEWS – different to all other Basin Matters | Inundation data limitations | Model development |  |  | Limited evaluation in 2015-16 | No 5 year outcomes |  |  |  |
| Ecosystem diversity | No expected outcomes stated in BM report |  |  |  |  |  |  |  |  |  |
| Stream metabolism and water quality | Flows inadequate |  | Model development |  |  |  |  |  |  |  |
| Data limitations |  |  |  |  |  |  |  |  |  |
| Vegetation |  |  | Model development |  |  |  |  |  |  |  |
| Fish |  | Spawning model not run | Model development |  |  |  |  |  |  |  |
| Generic diversity |  | Data access limitations |  |  |  |  |  | Not addressed |  | Cross ref to other Basin Matter reports |
| Synthesis - integrated evaluation | Limited data – no statement re extent outcomes achieved |  | Not really needed in the Synthesis – have an upfront cross ref to technical appendices | Not specifically addressed – consistency issues |  |  | Inconsistency issues. No consideration of 5 year outcomes |  |  |  |

### Hydrology

Only two one year expected outcomes for hydrology are included in the outcomes framework: for connectivity and biotic dispersal. There are no stated five year outcomes for this Matter (Gawne et al. 2014). The hydrological outcomes reported on inform the broader evaluation of biodiversity, ecosystem function and resilience at the Basin scale and underpin the outcomes for the other Basin Matters. Basin-scale evaluation for the hydrology Matter seeks to address the following questions:

* What did Commonwealth environmental water contribute to restoration of the hydrological regime?
* What did Commonwealth environmental water contribute to hydrological connectivity?

“The evaluation of flow regimes is based on a comparison of streamflows recorded at these sites during the 2015–16 year (*actual* case) with streamflows that would have occurred in the absence of the Commonwealth environmental water program (*baseline* case).” Stewardson and Guarino (2017), p4

“As such, inundation area linked to Commonwealth environmental water has been classed with low confidence Basin wide and will remain this way until accurate, reliable and accessible inundation mapping is made available to support defensible and robust monitoring and evaluation” Stewardson and Guarino (2017), p7

“Commonwealth environmental water delivery is often coordinated with delivery of water by other environmental water holders; hence, the evaluation considers the combined hydrological effect of all environmental water delivery. Where possible, we also indicate the contribution of the Commonwealth environmental water component to the total hydrological effect of all environmental water” Stewardson and Guarino (2017), p7

**Findings:** The hydrology evaluation report presents a solid assessment of environmental watering at sites, valley (adapted from SRA) and Basin-scale. The use of the score cards for each valley that received water is a good way to present the information and links the data more closely to the annual watering priorities at the Basin-scale. Two limitations were identified in the interviews – limited data for some areas and also a lack of inundation mapping of wetland and floodplain systems. Neither of these issues are considered likely to significantly hamper the evaluation of CEW to restoration of the hydrological regime or connectivity; however, if addressed, the outputs from the project would be improved.

The Basin-scale evaluation report for hydrology is significantly different to that of the other Basin Matter reports in that it focuses on addressing the annual watering priorities as opposed to specified expected outcomes (see Stewardson and Guarino 2017).

Table 9. Assessment of progress for Basin-scale evaluation of hydrology.

|  |  |  |
| --- | --- | --- |
| Basin-scale KEQ | Rating | Justification |
| What did Commonwealth environmental water contribute to restoration of the hydrological regime? |  | Score card assessment showing how well the Annual Environmental Watering Priorities were met in the valleys receiving Commonwealth environmental water in 2015–16 (See Table 7, pp40-41, Stewardson and Guarino (2017)). Actual KEQ not addressed in the report. |
| What did Commonwealth environmental water contribute to hydrological connectivity? |  | Lateral connectivity in which floodplains and wetlands are connected to their parent rivers via overbank flows are limited due to constraints. Also inundation mapping has not advanced to allow anything other than stating a system is wet or dry – also the definition of ‘wet’ varies across Selected Areas. For example wet in the Warrego Darling SA means that ecosystem has been wet in the past 12 months – not necessarily that it is wet at the time of sampling. Extent of inundation is currently only possible. |

### Ecosystem diversity

The primary, overall biodiversity objective of the Basin Plan is ***to protect and restore water-dependent ecosystems of the Murray-Darling Basin (Basin Plan, Chapter 8, Part 2, 8.04(a)).*** All of the specific Basin Plan biodiversity objectives are based around ecosystem level outcomes – this is not reflected in the LTIM outcomes framework. In addition the biodiversity Basin Plan objectives are written to support Australian obligations under various treaties/conventions/legislation (i.e. Ramsar, migratory species – JAMBA, CAMBA etc., EPBC listed species and communities), with the emphasis being on the representative or subset of *ecosystem type* that support these.

Not assessed at Selected Area-scale, other than in the Gwydir.

**Findings:** At the inception of the LTIM Project the expectation was that there would be robust inundation data for ecosystem types both with and without Commonwealth environmental water – this has not eventuated. There was also the expectation that Basin-scale evaluation would include an assessment of the types and extent of wetlands inundated by Commonwealth environmental water and use conceptual modelling to infer ecological responses based on the timing, duration and wetland type inundated (Gawne et al. 2014). Several of the other Basin Matters are reliant on this information and therefore evaluation/interpretation of findings to date are limited (Gawne et al. 2017). Recent updates to the ANAE mapping and classification for the MDB will necessitate a revision of outcomes in the first couple of years so that results are consistently presented and provide for multi-year comparisons (Brooks 2017).

The Basin Matter evaluation report provides a useful summary of the extent of watering of ecosystem type and compares the situation 2014-15 with that in 2015-16. It also provides a useful discussion of the lessons regarding adaptive management.

We have recommended (Recommendation 3) that key evaluation questions for ecosystem diversity be developed, with links to representativeness (multiple scales), support for critical life stages, and support of migratory species. These should be included in the Basin-scale evaluation in years 4 and 5 of Phase 1.

Table 10. Assessment of progress for Basin-scale evaluation of ecosystem diversity.

|  |  |  |  |
| --- | --- | --- | --- |
| Expected outcome | Basin-scale KEQ (Gawne et al. 2014) | Rating | Justification |
| None specified in program logic (Brooks 2017) | What did CEW contribute to ecosystem diversity? |  | Assigned red as no stated expected outcomes and also there is currently a lack of inundation data available which will hamper Basin-scale evaluation. The Basin Plan EWP objectives are quite specific in relation to protecting and restoring representatives of all aquatic ecosystem types found within the Basin, ensuring those that support critical life stages of migratory species covered under international treaties and nationally listed species dependent on environmental water are sustained or improved.  The failure to have specified ecosystem diversity outcomes is considered a significant issue for the LTIM project. |

### Stream metabolism and water quality

**Stream metabolism**

Basin-scale evaluation will address the following short-term (one-year) and long-term (five-year) Basin-scale evaluation questions regarding stream metabolism (from Grace 2015):

* What did Commonwealth environmental water contribute to patterns and rates of decomposition?
* What did Commonwealth environmental water contribute to patterns and rates of primary productivity?

“Based on the information from the first 2 years of the LTIM Project, it appears that, in line with the Entrainment Model, rates of primary production and ER are unlikely to respond to base flows or freshes on a per unit volume basis when constrained within the river channel.” Grace (2017), p24

“Monitored outcomes of freshes and base flows in the first 2 years (2014–16) did not detect any significant changes in rates of gross primary productivity or ER with the addition of environmental water, although individual positive responses of specific actions occurred at specific sites.” Grace (2017), p41

“As emphasised earlier in this report, no major ‘improvements’ in primary production and ER rates as a result of environmental watering actions were detected due to the types of these watering actions delivered over the first 2 years of the LTIM project.” Grace (2017), p45

“LTIM monitoring did not detect any effect of Commonwealth environmental water on stream metabolism in the southern Selected Areas, which can, in part, be attributed to water being delivered as in-channel flows (base flows and freshes) in the dry years 2014–16.” Gawne et al. (2017), p17

**Findings:** Concern has been expressed by a number of people interviewed about the likelihood of this indicator being successful in achieving the intended outcomes. In addition some described the Basin-scale objectives as descriptive only and therefore not achievable. More generally the constraints in each of the Selected Areas and types of flows delivered largely restrict engagement of the floodplain and as such limit nutrient inputs to the river channel. Data compliance is an issue with low levels of acceptance at several of the Selected Areas, and problems with data loggers also reduce the amount of data available. We also have some concerns over the ability of the current approach to modelling to be able to achieve the evaluation needed to meet the objectives as currently stated (see Recommendation 11).

If there are no flows of the required magnitude to engage the floodplains in the Selected Areas in which metabolism is being assessed for Basin-scale evaluation then it is considered likely that the outcome will be ‘negative’ in the sense that there were inadequate flows to promote primary productivity. Although some recent information for the Goulburn Selected Area suggests there is reasonable productivity within the channel.

The 2017-18 Basin Plan annual water priority for river connectivity is to *improve connectivity between freshwater, estuarine and marine environments and improve habitat conditions in the Coorong by optimising and managing inflows through the Lower Lakes* (MDBA 2017). Current assessment of the resource availability scenario for 2017–18 shows all Selected Areas to be wet or very wet in 2017-2018 (MDBA 2017), which may initiate opportunities for entrainment to be assessed. Grace (2017) states that *it is vital that watering actions not occur with the same magnitude and at exactly the same time each year*.

Table 11. Assessment of progress for Basin-scale evaluation of stream metabolism.

|  |  |  |  |
| --- | --- | --- | --- |
| Selected Area | Indicator | Rating | Justification |
| Edward-Wakool | Cat I indicators |  | Flows not sufficient in Edward-Wakool to inundate floodplains hence influence metabolism (Watts et al. 2016) |
| Goulburn | Cat I indicators |  | Higher flows that remain within the river channel are unlikely to introduce significant amounts of nutrients which in turn will constrain primary production (Webb et al. 2017). Discharges greater than 18,000 to 19,000 ML/d are required to connect the main channel of the lower Goulburn River to flood-runners (GBCMA unpubl. cited in Webb et al. 2017). Freshes in the Goulburn were associated with no change or a decrease in rates of GPP and ER per unit volume, which is most likely the result of dilution (Grace 2017). |
| Gwydir | Cat I indicators not sampled |  | No data available (Grace 2107) |
| Primary productivity Cat III indicators |  | There is not yet sufficient information on flow–metabolism relationships to determine whether CEW will attenuate the high turbidity in the Gwydir and therefore facilitate primary production or suppress photosynthesis further (Grace 2017). |
| Lower Lachlan | Cat I indicators |  | Larger (double river height) translucent flows generated a response in GPP and ER due to increased nutrients – but not eflows. Question remains to be seen if large enough eflows will be delivered to achieve expected outcomes attributable to CEW. No data for two watering actions and the larger translucent flows – only about a third of the data collected could be used in the evaluation (Grace 2017). |
| Lower Murray | Cat I indicators |  | Base flows delivered to the Lower Murray were coordinated with weir pool manipulations which enhanced lateral connectivity resulting in entrainment (Grace 2017). |
| Murrumbidgee | Cat I indicators |  | No CEW actions targeting in-channel responses of ecosystem function, nutrient cycling or stream metabolism in the Murrumbidgee River during 2015–16 (Grace 2017). During 2015–16, primary production and ER in the Murrumbidgee River varied with time at both sites, with little evidence of a strong relationship between flow (freshes) and metabolism. Peak values of these parameters occurred during both (relatively) high and low flows. Mean (and median) values were typical of, if not slightly lower than, other rivers in the Basin. |
| Warrego-Darling | Cat I indicators |  | Very high turbidity in the Darling River is likely to have greatly reduced the viable light climate for phytoplankton and benthic algal growth. No CEW targeted stream metabolism outcomes in the Warrego. |

**Water quality**

Basin-scale evaluation will address the following short-term (one-year) and long-term (five-year) Basin-scale evaluation questions regarding water quality (from Grace 2015):

* What did Commonwealth environmental water contribute to pH levels?
* What did Commonwealth environmental water contribute to salinity regimes?
* What did Commonwealth environmental water contribute to dissolved oxygen levels?

“..data collection for pH, turbidity, salinity (electrical conductivity), and nutrient and chlorophyll-a concentrations was sporadic and typically at frequencies of every 2–6 weeks. The lack of continuous monitoring (except for DO and temperature collected using the loggers acquiring metabolism data) is a constraint imposed by the overall project budget. Hence, it is extremely difficult to attribute the effects of watering actions on any parameter other than DO. However, aggregated water quality data are useful to help explain patterns of metabolism at catchment and Basin scales.” Grace (2017), p 13

“In terms of an evaluation of the management of Commonwealth environmental water, there are three considerations:

1. the extent to which watering actions undertaken to achieve biodiversity, ecosystem function or resilience outcomes influenced water quality
2. the effectiveness of watering actions undertaken to ameliorate threats from acute water quality events, including cyanobacterial algal blooms, oxygen-depleted blackwater and acidification
3. the effectiveness of watering actions undertaken to achieve long-term improvements in water quality, including the export of salt.” Grace (2017), p23

“Commonwealth environmental water has the capacity to influence water quality as evidenced by the outcomes in the Gwydir and Edward–Wakool. In the Edward–Wakool, Commonwealth environmental water is believed to have had a beneficial effect by preventing the development of the low dissolved oxygen conditions found in a nearby site which did not receive water.” Grace (2017), p25.

**Findings:** The 2015-16 data indicated that CEW influenced water quality in the Gwydir and Edward–Wakool. Some of the Selected Areas have not specified water quality KEQs or expected outcomes in the evaluation reports, despite data being collected. It is unclear why there are no KEQs for nutrients. Grace (2017) reported that the water quality data collected was sporadic and mostly at frequencies of every 2–6 weeks, collected at times when other data were collected. In general, there is a lack of continuous data for water quality expect for dissolved oxygen and temperature for evaluation of Basin-scale questions.

There is an apparent discrepancy between the intended approach to evaluation as presented in the Basin Evaluation Plan (Gawne et al. 2014) and the actual Basin Matter evaluation report (Grace 2017). In the Outcomes Framework and Evaluation Plan water quality is variably listed as the primary element of the Basin Matter (See Section 3.4 in Gawne et al. 2014, 18), which links to it being one of the four Basin Plan objectives. Stream metabolism also links to a Basin Plan objective, ecosystem function, as an indicator for assessing one year outcomes. The Synthesis report doesn’t treat water quality as a theme, as it focuses on the objectives of the Environmental Watering Plan; not the Basin Plan objectives (which includes water quality). It would appear that the intended emphasis has shifted from water quality to stream metabolism. This needs to be resolved.

Table 12. Assessment of progress for Basin-scale evaluation of water quality.

|  |  |  |  |
| --- | --- | --- | --- |
| Selected Area | Indicator | Rating | Justification |
| Edward-Wakool | Nutrients and Carbon – Cat I  Carbon characterisation – Cat III  Poor water quality events – Cat III |  | Counterfactual observed where the one site that did not receive CEW developed low dissolved oxygen (Grace 2017). |
| Goulburn | Dissolved oxygen and temp – Cat I  Spot data for EC, pH, temp, DO - Cat III |  | Not addressed at area-scale. |
| Gwydir | Water quality Cat I  Water quality - water chemistry, nutrient and particulates Cat III |  | Single location on Gwydir River for Cat I logger data. |
| Lower Lachlan | None specified in 2015-16 evaluation report, but assume they are as stated in Grace (2015). |  | Not sure what is being assessed - Can’t make a statement re progress if KEQ or objectives are not presented in the report. Nutrients are sampled and discussed in relation to metabolism, but no KEQ/expected outcomes are stated for water quality. |
| Lower Murray | Dissolved oxygen and temp – Cat I  Matter transport: salinity, dissolved nutrients, particulate organic nutrients, chlorophyll a – Cat III |  | Watering actions were effective in exporting salt and nutrients which would be expected to contribute to 1–5-year improvements in water quality in the Basin (Grace 2017). |
| Murrumbidgee | Dissolved oxygen and temp – Cat I  Water quality – Cat III |  | On track for both river and wetlands water quality outcomes at Area-scale. Data may not be adequate for Basin-scale evaluation. Not clear which methods are used for water quality – assume they are Cat III methods. |
| Warrego-Darling | Water quality – Cat I  Water quality – Cat III |  | Dependent on receiving flows. Continuous monitoring of the dependant variables at two sites in the Darling zone. |

### Vegetation

Basin-scale evaluation will address the following short-term (one-year) and long-term (five-year) Basin-scale evaluation questions regarding:

* What did CEW contribute to plant species diversity?
  + How did Commonwealth environmental water affect the presence, distribution and abundance of individual plant species?
* What did CEW contribute to vegetation community diversity?
  + How did Commonwealth environmental water affect the composition and structure of particular vegetation communities?
  + How did Commonwealth environmental water affect the composition and structure of particular vegscapes?

**Findings:** Excellent report – clearly articulates intended linkages between Basin Plan EWP objectives, expected outcomes, KEQ and 1 and 1-2 year observed and predicted outcomes. Only a couple of minor issues identified. Need to specify what the primary and secondary expected outcomes are in this report to truly evaluate if expected outcomes have been achieved. As with the other Basin Matters there is no statement of condition prior to watering – the requirement to provide context of the environmental conditions across the Basin is not met.

The report focuses on the Gwydir, Murrumbidgee and Lower Lachlan systems, and the Warrego and Darling rivers. Ten CEW actions with expected vegetation diversity outcomes were monitored across the six Selected Areas during 2015-16. Report provides a good description of what happened with each watering action. Good discussion of the effects of CEW on plant species diversity at Selected Areas broken into river channel systems and wetland and floodplain systems. Also presents a good discussion of the effects of CEW on plant species diversity at the individual Selected Areas.

Summary presented in Table 15 is excellent/ very useful.

Table 13. Assessment of progress for Basin-scale evaluation of vegetation.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Expected 5 year outcome (Capon et al. 2017) | Expected 1 year outcome (Capon et al. 2017) | Basin-scale KEQ | Rating | Justification |
| Greater plant species diversity | Establishment, growth, spread and reproduction of hydrophilic taxa | What did CEW contribute to plant species diversity?   * How did CEW affect the presence, distribution and abundance of individual plant species? |  | Data collected to date on track to illustrate influence of CEW on species diversity. |
| Mortality, reduced establishment and spread of xeric taxa |  | Measured and observed outcomes refer to exotic rather than xeric – probably okay – but just need to clarify this. |
| Greater vegetation diversity | Increased richness and productivity of wetland vegetation communities | What did CEW contribute to vegetation community diversity? |  | Species richness of vegetation communities exhibited mixed responses to wetting both within and between Selected Areas (Capon and Campbell 2017). |
| Shifts in composition of floodplain and wetland vegetation communities | How did CEW affect the composition and structure of particular vegetation communities? |  | No CEW on western floodplain and limited overbank flows in other Selected Areas. Where inundation of wetlands and floodplains did occur CEW contributed substantially to landscape-scale vegetation diversity (Capon and Campbell 2017). |
| Increased heterogeneity of vegetation communities at landscape scales | How did CEW affect the composition and structure of particular vegscapes? |  | Consistently promoted the diversity and heterogeneity of vegetation communities at landscape scales at each Selected Area and across the Basin (Capon and Campbell 2017). |
| Greater resilience of plant species to drought | Enhanced resilience to drought among plant taxa benefiting from Commonwealth environmental water | No specified KEQ |  | Species influenced by CEW are predicted to have greater resilience to drought over next 1–5 years and should exhibit greater responses to further wetting (Capon and Campbell 2017). |
| Greater vegetation resilience to drought | Enhanced resilience to drought among vegetation assemblages benefiting from Commonwealth environmental water | No specified KEQ |  | Watering in 2014-15 influenced vegetation responses in 2015-16 (Capon and Campbell 2017). |

### Fish

The LTIM evaluation questions for fish are (Stoffels et al. 2017):

* What did Commonwealth environmental water contribute to sustaining native fish populations?
* What did Commonwealth environmental water contribute to sustaining native fish reproduction?
* What did Commonwealth environmental water contribute to sustaining native fish survival?

**Findings:** Very good report, quite technical. Stoffels et al. (21070 make a clear distinction between flows and regimes, and the emphasis of the fish Basin Matter evaluation being on long term outcomes pertaining to population dynamics. Fish Basin Matter outputs are planned to increase each year (Stoffels et al. 2107). Excellent synthesis of fish outcomes across the seven Selected Areas, which includes consideration of influences, other than CEW, on the outcomes (Table 3, Stoffels et al. 2017).

Concern has been expressed by some LTIM team members that the intended expected outcomes will not be achieved by Cat 1 methods not likely to achieve outcome.

Table 14. Assessment of progress for Basin-scale evaluation of fish.

|  |  |  |
| --- | --- | --- |
| Basin-scale KEQ (Stoffels et al. 2017) | Rating | Justification |
| What did CEW contribute to sustaining native fish populations? |  | The Fish Basin Matter is not yet in a position to provide robust reporting on the contribution of Commonwealth environmental water to the Basin Plan objectives of recruitment and survival (Stoffels et al. 2017, p51).  There was no significant change in the species richness, evenness or nativeness of the fish community in any of the Selected Areas. |
| What did CEW contribute to sustaining native fish reproduction? |  | “Note that we have not extended this modelling to undertake a full evaluation of Commonwealth environmental water’s contribution to fish spawning across all Selected Areas. The primary reason for not doing this at this stage is that the models are not quite ready for a robust evaluation” …“We will undertake a full evaluation of the contribution of Commonwealth environmental water to fish spawning in 2016-17” Stoffels et al. (2017), p 35. |
| What did CEW contribute to sustaining native fish survival? |  | No single, within-year watering action (i.e. timing, rate of increase, mean discharge, etc. of a managed flow) will be optimal if our objective is to maintain diversity of native fishes |

### Generic diversity

Not assessed at the Selected Area-scale – general data collated by BM Lead and additional data sourced from other sources such as TLM and Ramsar site monitoring data.

The LTIM evaluation questions for generic diversity are (Hale 2017):

* What did Commonwealth environmental water contribute to species diversity?
  + How did Commonwealth environmental water affect the presence, distribution and abundance of plant, fish, waterbird, frog, turtle and aquatic ecosystem dependent mammal species?
  + What listed threatened species and ecological communities benefited from Commonwealth environmental water?
  + What migratory species listed under international agreements (Bonn Convention, CAMBA, JAMBA or ROKAMBA) benefited from Commonwealth environmental water?

“The main output of the Generic Diversity evaluation is an aggregated list of species and communities that potentially benefited from Commonwealth environmental water each year” Hale (2017), p

The Basin Evaluation Plan stats that the following Basin-scale evaluation questions will be addressed in the Generic Diversity Basin Matter reports:

* Long-term (five-year) question:
  + What did Commonwealth environmental water contribute to other vertebrate populations?
* Short-term (one-year) and long-term (five-year) question:
  + What did Commonwealth environmental water contribute to other vertebrate species diversity?

According to Gawne et al. (2013) this Basin Matter is intended to focus on species not addressed in the other Basin Matter reports – i.e. birds, frogs, turtles, bats etc.

**Findings:** Very useful report on genetic diversity for both LTIM sites and non-measured sites. The mismatch between the KEQ from the Basin Evaluation Plan and those listed in Hale (2017) shown above may have been due to revisions that we are not privy too. The KEQ from Hale (2017) are much more similar to the specific objectives for water-dependent ecosystems (see Appendix E this report), but we expect populations KEQ to also be relevant as a long term outcome. The Basin Matter blurs the distinction between biodiversity and generic diversity in some spots in the report. Limited evaluation due to only two years data, but considered on track. Inclusion of more data from the Northern basin – in particular Queensland sites would be useful to provide a more balanced picture.

Table 15. Assessment of progress for Basin-scale evaluation of generic diversity.

|  |  |  |
| --- | --- | --- |
| Basin-scale KEQ (Hale 2017) | Rating | Justification |
| What did CEW contribute to species diversity? |  | There is a lack of information on the outcomes of environmental water in the Northern Basin and this may be limiting the list of species and communities that potentially benefited in that part of the Basin. The majority of the report focuses on sites within the Southern Connected Basin, but with a fair bit from the Gwydir. Inclusion of data for the Narran or the Paroo Ramsar sites may improve this balance. |

### Integrated Basin-scale evaluation – Synthesis report

“This analysis will take the form of a procedural and reporting integration of information from Basin Matter outputs and other information sources. Reported outcomes and modelled predictions from the Basin Evaluation of ecosystem diversity, vegetation diversity, fish populations and generic diversity will be integrated to provide an overall evaluation of the influence of Commonwealth environmental water in protecting or restoring the Basin’s biodiversity” Gawne et al. (2013), p27.

Procedural integration is typically based on an agreed set of protocols with all the information accessible in a standard or known format. However, evaluation and reporting may not occur in an integrated manner. Reporting integration is where the various elements of a monitoring program are summarised, analyzed and reported by an appointed group or unit that integrates the various aspects, in this case the Basin Matter team. It does not include standard methods for data collection used in reporting. Data is not necessarily collected for the objectives of integrated reporting – this approach uses what is available from multiple sources (Butcher et al. 2014).

“Due to limitations associated with identifying suitable reference sites, the Basin evaluation will, over the next 5 years, develop quantitative models that predict the outcomes of Commonwealth environmental watering based on the characteristics of the event and the condition prior to watering” Gawne et al. (2017), p5 (This should probably read as over the 5 years of the project).

“Evaluation at the Basin scale requires both an estimation of the overall outcomes across the Basin and then a judgement of their significance and contribution to Basin Plan objectives” Gawne et al. (2017).

“..Basin evaluation is cumulative for 2014–16 and is provided in three parts:

1. integrated Basin-scale evaluation – a summary of the achievements of Commonwealth environmental water under three broad themes of the Basin Plan (biodiversity, ecological function and resilience)
2. contributions to Basin Plan environmental objectives – a tabulation of progress toward these long-term goals in the first 2 years
3. adaptive management – a summary of key ‘lessons learned’ for both improved environmental water outcomes and the LTIM Project.” Gawne et al. (2017),

**Findings:** A good report; but would be improved by adding more references to the sources of evidence (mostly in the Appendices) and paying more attention to terms used, and consistency between foundation and Basin Matter reports.

1. **Reference to BEWS**

Currently there is limited reference to the BEWS in the integrated Basin-scale evaluation. The BEWS provides detail on the environmental objectives and targets, with ‘quantified expected outcomes’ identified for four components: river flows and connectivity; native vegetation; waterbirds; and native fish. Gawne et al. (2017) state that the MBDA has the responsibility to evaluate the contribution of Basin Plan reforms to achieving the targets set in the BEWS, however this is incorrect, or at best misleading (see Section 2.1 for discussion on CEWH obligations under the Water Act).

1. **Water Quality as a Basin Objective and/or Basin Matter**

The Synthesis Report focuses on three broad *environmental objectives* of the Basin Plan: biodiversity, ecosystem function and resilience (Gawne et al. 2014). It’s not apparent why water quality has not been included as it’s included in both the Outcomes Framework and the Evaluation Plan as being part of the LTIM Project. We feel Water Quality should be included as a theme for integrated Basin-scale evaluation.

“*This process synthesises the evaluations from the Selected Areas and then uses the CEWO Outcomes Framework to link these to Basin Plan objectives, by translating local or site-scale outcomes into the four high-level environmental objectives under the Basin Plan generically described as Biodiversity, Ecosystem Function, Resilience and* ***Water Quality***” Gawne et al. (2017), p6. The problem is the distinction (or lack of) between the *environmental objectives*, *objectives of the MDBA EWP*, and the *Basin Plan objectives*. These are interchangeably used in the foundation documents and Synthesis report and have led to a lack of clarity, especially around how water quality is reported in the LTIM Project.

**When introducing the stream metabolism and water quality** Basin Matter in the Synthesis report (dot point 3, page 5) instream primary productivity and decomposition, salinity and pH are listed (Gawne et al. 2017, p 5), but not the other indicators for which there are long and short expected outcomes and Basin-scale KEQ. There is limited discussion of water quality throughout the Synthesis report and it is unclear as to why this is the case. There is a need to improve the clarity around the intended evaluation of Water Quality and Stream metabolism across the LTIM Project. It may be that these would be better suited as separate Basin Matters to avoid this confusion; noting that doing so would require the Outcomes Framework, Evaluation Plan and treatment in Basin Matter reporting to be updated. For example within the Outcomes Framework there are no expected outcomes for water quality.

1. **Integrated Basin-scale evaluation**

There is a need to improve the description of *integrated Basin-scale evaluation* in the Synthesis report. Gawne et al. (2014) states that integrated evaluation at the Basin-scale will be undertaken in as procedural and reporting integration (see above for definitions). This is reflected in the Synthesis report which provides a summary of findings by Basin Matter as they relate to the three themes of biodiversity, ecosystem function and resilience. The nature of the evaluation may change after the third year of data collection, and this could be spelt out more clearly.

1. **Consistency between documents**

A minor, but frustrating issue is the inconsistency in the order and description of elements between the foundation documents, Basin Matter reports and the Synthesis report. The inconsistency with regard to water quality is a prime example, but there are others. The logic and rational should carry through all documents in a consistent manner, particularly in the Synthesis document as this makes it easier for the reader to, firstly find, and then follow conceptual linkages and discussions.

For example, vegetation diversity has been added as a key evaluation question in the Synthesis report under the biodiversity theme, but it’s not in the Basin Evaluation Plan and there is no explanation why it, and not fish outcomes, were included. Another example of inconsistency is…. “*Watering by Commonwealth environmental water in 2015–16 contributed significantly to the biodiversity objectives of the Basin Plan associated with vegetation diversity and is likely to have increased species diversity at the Basin scale over the 2 years*” there are no biodiversity objectives for vegetation per se. Closer peer review of the Synthesis report and related Basin Matter Reports would help capture, and fix these issues.

1. **Contribution to Basin Plan objectives – Section 5**

This is a very brief summary addressing the main objective of the LTIM Project. It mentions data limitations for 2014-16, but it’s not clear how that relates to the objective hierarchy. Statements on the likelihood of achieving the objectives would be useful. There is a need to make a distinction in the summary table as to what is an outcome and what is a prediction.

1. **Adaptive management**

Gawne et al. (2017) provides a good summary of the adaptive management lessons gained to date in the LTIM Project. The recommendations on how to improve the LTIM outputs largely match our findings.

Table 16. Assessment of progress for Basin-scale integrate evaluation of Biodiversity, Resilience, and Ecosystem Function.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Basin Plan objective | Theme (Gawne et al. 2017) | Contributing Basin Matters | Basin-scale KEQ (Gawne et al. 2017) | Rating | Justification |
| to protect and restore water-dependent ecosystems of the Murray-Darling Basin (Basin Plan, Chapter 8, Part 2, 8.04(a)) | Biodiversity | * Ecosystem diversity * Vegetation * Fish * Generic diversity | What did CEW contribute to ecosystem diversity? |  | A lack of expected outcomes for ecosystem diversity has been discussed elsewhere in this review. |
| What did CEW contribute to species diversity? |  | Gawne et al. (2017 state that in 2014-16 protecting threatened species through environmental water management was a priority – this needs citation.  Assigned yellow as it’s not clear why fish weren’t included. |
| What did CEW contribute to vegetation community diversity? |  | Not clear why this is included in the Synthesis report and fish are not. Assumed to have made a significant contribution. |
| to protect and restore the ecosystem functions of water-dependent ecosystems (Basin Plan, Chapter 8, Part 2, 8.04(b)) | Ecosystem function | Hydrology | What did CEW contribute to restoration of the hydrological regime? |  | Assessed base flow and fresh components of the water regime in 2014–16 and what would have occurred in the absence of water resource development and extraction. Not sure if this is justified as a restoration of the hydrological regime, but concludes CEW contributed significantly to maintaining base flows and freshes in the southern Basin. |
| What did CEW contribute to hydrological connectivity? |  |  |
| Stream metabolism | What did CEW contribute to   * patterns and rates of decomposition? * patterns and rates of primary productivity? |  | More complete quantitative evaluations will be undertaken in future years once additional hydraulic data and modelled predictions of what would have happened in the absence of environmental flows become available |
| to ensure that water-dependent ecosystems are resilient to climate change and other risks and threats (Basin Plan, Chapter 8, Part 2, 8.04(c)) | Resilience | * Hydrology * Ecosystem diversity | None specified in Gawne et al. (2017), but they are in Gawne et al. (2014):  What did CEW contribute to ecosystem resilience?  What did CEW contribute to population resilience? |  | This section of the report is presented differently to biodiversity and ecosystem function. It cross references the discussions for connectivity and ecosystem diversity; however these sections do not address outcomes for resilience per se. The KEQ listed in the Basin Evaluation Plan are not included in the Synthesis report. |
| to ensure water quality is sufficient to achieve the above objectives for water-dependent ecosystems, and for Ramsar wetlands, sufficient to maintain ecological character (Basin Plan, Chapter 9, Part 3, 9.04 (1) & (2)) | Water quality – not addressed |  |  |  | Not addressed adequately. |

# Appendix G: Assessment of progress of Area-scale evaluation

|  |  |  |
| --- | --- | --- |
| **Green – Evaluation on track and likely to be achieved** | **Yellow – Evaluation will possibly be achieved but dependent on watering conditions or other constraint** | **Red – Evaluation questions not adequately addressed, or not on track to be achieved.** |

**This assessment of the Selected Area reports is very high level and does not constitute a detailed evaluation of the conceptual premise, methods or evaluation techniques. The ratings are based on only two years of LTIM and conditions/results may change in the final years of the program. Whilst some of the expected outcomes set at the Area-scale may not be achieved, this in itself is not necessarily a failure, since the knowledge gained from this project will be significant – even if the outcome isn’t what was originally hypothesised.**

**In most cases, identification of some aspect not being on track, reflects one or more of the following:**

* **no measurable objectives/expected outcomes given (e.g. ecosystem diversity);**
* **outcome unlikely to be achieved due to constraints;**
* **and/or ecological response not observed as expected.**

**In these cases, there may be a need to refine objectives and or manage expectations.**

The following is an extract from the contracts with the Selected Area teams that relate to the objectives and requirements for reporting – these have been used as guides to assess the progress of the Selected Area teams in meeting objectives, evaluation and reporting requirements. Bolded text are areas in which there is inconsistency between the Selected Areas, and or, requirements have not been met.

*The Services in priority order aim to:*

1. evaluate ecological outcomes of CEW at each Selected Area;
2. evaluate the contribution of CEW to the objectives of the Murray Darling Basin Authority’s Environmental Watering Plan;
3. infer ecological outcomes of CEW in areas of the Murray-Darling Basin not monitored;
4. support the Adaptive Management of CEW; and
5. monitor the ecological response to CEW at each Selected Area.

*Annual reports are to include:*

*Evaluation*

*a) evaluate the extent to which the* ***expected outcomes******identified in the Monitoring and Evaluation Plan, and identified for environmental watering in the years 2014-15 to 2018—19, have been achieved;***

*b) evaluate the outcomes of environmental water use based on available information using one or more of the following approaches:*

*i. monitored results;*

*ii. observations;*

*iii. quantitative evaluation;*

*iv. qualitative evaluation;*

*v. inferred using scientific opinion and the outcomes framework; or*

*vi. inferred using expert scientific opinion and other evidence.*

*c) clearly identify which of the above approaches was used for the evaluated outcome;*

*d) for the expected outcomes identified in the Monitoring and Evaluation Plan,* ***provide clear answers to each relevant evaluation question****;*

*e) quantify to the fullest extent possible* ***the marginal benefit*** *of Commonwealth environmental water and other held environmental water delivered in conjunction with Commonwealth environmental water;*

*f)* ***the evaluation of expected outcomes (both less than one year and one to five years) after the first year will need to be cumulative by considering the evaluation of results from the previous years***

*g)* ***provide area evaluation of both Basin and area matters****;*

*h)* ***include, where possible, preliminary findings in relation to one to five year expected outcomes*** *(if necessary these may be supported by qualitative results in the earlier years leading to quantitative evaluation in the later years);*

*Adaptive management*

*i) use monitoring and evaluation outcomes and expert scientific opinion to* ***provide implications for future management*** *of Commonwealth environmental water and how to* ***improve for the future****;*

*Context*

*j)* ***provide context of the environmental condition of the Selected Area for watering actions****;*

*k)* ***provide brief context to the watering actions and links to the expected outcomes from the watering action and previously evaluated outcomes****;*

In addition, a progress status rating is provided for each of the Area-scale indicators (see tables below). **Note** that none of the latest progress reports for each of the Selected Area indicate any risks to the achievement of the intended project outcomes.

**General findings for Selected Areas reports:** Overall the Selected Area evaluation reports address Area-scale evaluation questions (predominantly short term) but don’t necessarily address the LTIM objectives. Only the Gwydir and Warrego-Darling evaluation reports make reference to the Basin Plan EWP objectives. The Goulburn team report on Basin and Area-scale matters, with most other Selected Area evaluation reports stating this will be done by MDFRC.

The way in which expected outcomes are documented in the evaluation reports varies considerably. Expected outcomes should be either from the MEP or annual watering objectives/acquittal reports for each Selected Area, but need to be restated in the main text of the evaluation reports. Some of the issues lie not with the Selected Area teams, but with the expected outcomes articulated in the water planning documents (e.g. Warrego-Darling and others, where they are not SMART); however all MEP had expected outcomes stated against which the Area-scale evaluation is expected to report against. Having a clear, SMART, objective/expected outcome is fundamental to assessing if and what the CEW contributed to achieving the Basin Plan environmental Watering Plan objectives.

Many of the evaluation reports did not mention the long term outcomes, or they were included but not clearly labeled as being long term outcomes/KEQ. Discussion on the marginal extent to which CEW contributed to outcomes was also variably dealt with across the Selected Area teams.

For reporting on the expected outcomes as per the MEP (Evaluation column d in Table 17) a quick cross check was made between the evaluation reports and the MEPs; a yellow rating indicates one or more KEQ (either long or short, but usually long term) were not addressed in the evaluation reports. For some Selected Areas this may be due to an agreement with CEWO that we haven’t been privy too, e.g. was ecosystem diversity still expected to be assessed by the area teams?; was fish condition dropped in the Edward-Wakool?

Overall there is a need for greater consistency in the content of the evaluation reports. The reports should summarise the planning and delivery of CEW, and the associated expected outcomes upfront. These should then be clearly linked to the evaluation questions and indicators, a summary of findings, and recommendations for changes/adaptive management of the monitoring. A key requirement is a statement on whether the flows were appropriate to achieve the expected outcomes. Every KEQ should be answered – even if it is to say no data/no response. A distinction between short and long term outcomes/KEQ is required.

Whilst the Area-scale evaluation as part of the LTIM project as a whole is largely on track, there are definitely some areas in which improvements can be made.

An assessment of risks to achieving outcomes should be clearly stated in each Selected Area annual report.

Adaptive management recommendations were generally well done.

Table 17. Progress status for each reporting requirement for Selected Areas – based on 2015-16 evaluation reports.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Selected Area | Evaluation | | | | | | | | Adaptive management | Context | |
| a | b | c | d | e | f | g | h | i | j | k |
| Edward-Wakool |  |  |  |  |  |  |  |  |  |  |  |
| Goulburn |  |  |  |  |  |  |  |  |  |  |  |
| Gwydir |  |  |  |  |  |  |  |  |  |  |  |
| Lower Lachlan |  |  |  |  |  |  |  |  |  |  |  |
| Lower Murray |  |  |  |  |  |  |  |  |  |  |  |
| Murrumbidgee |  |  |  |  |  |  |  |  |  |  |  |
| Warrego-Darling |  |  |  |  |  |  |  |  |  |  |  |

### Edward-Wakool

The overall ‘purpose’ for managing the Commonwealth’s water portfolio in the Mid Murray for 2015–16 was to **protect** the floodplain forest areas where demands are high, while **maintaining** ecological health and resilience of other key sites in the system (Watts et al. 2016, p14). The objective of these two watering events was: *‘to compare the spawning response of cod by applying e-flows into the upper Wakool and Yallakool at the same time and to support the on-going recovery/re-establishment of in-stream aquatic vegetation’* (Watts et al. 2016, p15). Four environmental watering actions occurred, with two actions monitored by the project - upper Wakool River and Yallakool Creek (11 November to 30 January) (see Watts et al. 2016, p 19, Table 2.2). Eight watering events were planned.

**Findings:** Constraints (that is floodplain inundation) are the main issue affecting the ability to achieve the expected outcomes with the watering reported on having little to no effect on the indicators assessed. The way in which the outcomes are presented (e.g. in Table 12.2) is misleading and seems to contradict earlier statements. Most are shaded green but this only indicates a positive response – not necessarily that the objectives of the watering action were achieved.

No selected area evaluation for the fish community was undertaken in 2015-16 only occurring in years 1 and 5 (Watts et al. 2016).

Overall Watts et al. (2016) is a very good, informative report. The project objectives (evaluation questions) are well identified, and adequate details provided on the monitoring, results and their analysis. In particular, the summary evaluation tables for each indicator were very useful. These tables were split into two sections: (a) the CEWO planning and delivery (i.e. what was planned, what outcomes were expected), and (b) Edwards-Wakool monitoring and evaluation questions and outcomes (i.e. LTIM question, observed outcome, evidence, were the flows appropriate to achieve expected outcomes).

It is obvious that a number of the desired ecological outcomes for this system are constrained by either operational or landholder constraints. **Recommend** that a short report be prepared to specifically identify these constraints and what changes would be needed to achieve the ecological outcomes sought.

Table 18. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Edward-Wakool.

| Indicator | Expected outcome as per Water Use Minute 10038 and/or CEWO Acquittal report (from Watts et al. 2016). | Area-scale LTIM KEQ | Rating | Justification |
| --- | --- | --- | --- | --- |
| River hydrology | Support mobilisation, transport and dispersal of biotic and abiotic material (e.g. sediment, nutrients and organic matter) through longitudinal and lateral hydrological connectivity  Support inundation of low-lying wetlands/floodplains habitats within the system  Maintain ecosystem and population resilience through supporting ecological recovery and maintaining aquatic habitat. | What did CEW contribute to:   * hydrology of the four zones in the Edward-Wakool system that were monitored for the LTIM project? * longitudinal hydrological connectivity? * longitudinal hydrological connectivity? * in-channel wetted benthic area? * area of slackwater, slow flowing water and fast water? * lateral connectivity? |  | Flows in the upper Wakool River were not large enough to achieve expected outcomes due to flow constraints. It did not increase lateral connectivity or connect low-lying habitats within the system. Note this contradicts assessment of outcome in Table 12.2, p63  Flows in Yallakool creek resulted in an increase longitudinal connectivity and in lateral connectivity in some, but not all reaches (Watts et al. 2016). |
| Water quality and carbon | To support mobilisation, transport and dispersal of biotic and abiotic material (e.g. sediment, nutrients and organic matter) through longitudinal and lateral hydrological connectivity    To maintain/improve water quality within the system, particularly dissolved oxygen, salinity and pH | What did CEW contribute to:   * temperature regimes? * dissolved oxygen concentrations? * nutrient concentrations? * modification of the type and amount of dissolved organic matter through reconnection with previously dry or disconnected channel habitat? * reducing the impact of blackwater in the system? |  | CEW did not influence temperature or nutrient concentrations in 2015-16, but DO was higher in Yallakool Ck. CEW introduced only small amounts of floodplain carbon from upstream in the Barmah-Millewa forest. Flow management achieved C inputs without a blackwater event. Dilution flows from the canal were not required (Watts et al. 2016). |
| Stream metabolism | To support mobilisation, transport and dispersal of biotic and abiotic material (e.g. sediment, nutrients and organic matter) through longitudinal and lateral hydrological connectivity (Water Use Minute 10038) This is related to metabolism but not specifically addressing it.  No specific targeted outcomes for metabolism (Watering action acquittal report) | What did CEW contribute to:   * patterns and rates of decomposition? * patterns and rates of primary productivity * affect rates of gross primary productivity and ecosystem respiration in the Edward- Wakool River system? |  | Flows were considered too small to have any impact on these variables – responses observed were not attributed to changes in flow (Watts et al. 2016). |
| Riverbank and aquatic vegetation | To maintain health of riparian and in-channel aquatic native vegetation communities (Water Use Minute 10038)  To support the ongoing recovery/re-establishment of in stream aquatic vegetation (Watering action acquittal report) | What did CEW contribute to:   * recovery (measured through species richness, cover and recruitment) of riverbank and aquatic vegetation in Yallakool Creek and the mid and upper Wakool River that have been impacted by operational flows and drought and how do those responses vary over time? * How do vegetation responses to CEW delivery vary among hydrological zones? * percent cover of riverbank and aquatic vegetation in Yallakool Creek and the upper and mid Wakool River? * taxonomic richness of riverbank and aquatic vegetation taxa in Yallakool Creek and the upper and mid Wakool River? |  | CEW contributed to recovery in the mid Wakool and Yallakoll Creek, but not in the upper Wakool. Recruitment and cover varied among zones, but were generally higher in those that received environmental flows. Submergent vegetation richness was also higher in those zones that had a history of eflows (Watts et al. 2017). |
| Fish movement | To maintain the diversity and condition of native fish and other native species including frogs and invertebrates through maintaining suitable habitat and providing/supporting opportunities to move, breed and recruit (Water Use Minute 10038) | * Were periodic species (golden and silver perch) present in the target reaches during CEW delivery? * Did periodic species remain within the target reaches during CEW delivery? * Did CEW stimulate periodic fish species to exhibit movement consistent with reproductive behaviour? * Does CEW enable periodic species to disperse from and return to refuge habitat? * Does CEW protect periodic species from adverse water quality? |  | Summarised result of CEW as facilitating fish movement from zone 3 over very small distances, with most staying within zone 3 (Watts et al. 2016).  no evidence from our larval fish monitoring to confirm a spawning response of either species (or bony herring) to water delivery  CEW not delivered to deal with adverse water quality issues – not relevant. |
| Fish reproduction | To provide areas of habitat for Murray cod to move into and spawn, especially where the flows will cover snags that are the preferred spawning and nesting sites of Murray cod.  To maintain the diversity and condition of native fish and other native species including frogs and invertebrates through maintaining suitable habitat and providing/supporting opportunities to move, breed and recruit | * Did CEW contribute to increased spawning activity of Murray cod? |  | “Irrespective of differences in hydrology and environmental flows in 2015-16 and in all previous years, Murray cod spawning started in mid-October, peaked in November and ended by mid- to late December.” Watts et al. (2016), 170 |
| What did CEW contribute to:   * spawning in ‘flow-dependent’ spawning species (e.g. golden and silver perch? * the spawning of 'Opportunistic' (e.g. Small bodied fish) species? |  | Golden perch didn’t spawn in 2015-16; localised spawning has not occurred in this system over the past 5+ years and contributed to recruitment (Watts et al. 2016).  Constraints may be limiting response for perch species. |
| Fish recruitment (Murray cod, golden and silver perch | To provide areas of habitat for Murray cod to move into and spawn, especially where the flows will cover snags that are the preferred spawning and nesting sites of Murray cod.  To maintain the diversity and condition of native fish and other native species including frogs and invertebrates through maintaining suitable habitat and providing/supporting opportunities to move, breed and recruit | Did CEW affect the growth rate of Murray cod, golden perch and silver perch during the first year of life? |  | No discernible pattern or relationship with environmental watering in regards to growth in different zones for Murray cod (Watts et al. 2016).  No recruit growth reported for golden perch.  Not able to assess silver perch as too few specimens taken. |
| Did CEW contribute to the recruitment of Murray cod, golden perch and silver perch? |  | Murray cod YOY and 1+ individuals suggest annual recruitment in the EW or in nearby systems. No change in Murray cod due to changes in hydrology over the past few years.  Not for golden perch.  Silver perch results not as clear cut – no eggs or larvae collected, but 0+ and 1+ individuals were collected – most likely immigrants from nearby and not responding to CEW per se. |

### Goulburn

River flows in the Lower Goulburn River were lower in 2015–16 than in the first year of the Goulburn LTIM Project – 2014-15. A dry winter and spring led to low volumes of water in storage and reduced environmental allocations. Commonwealth environmental water during 2015–16 contributed to (Webb et al. 2017):

* baseflows, to ensure adequate habitat provision;
* one major spring fresh, delivered in October targeting continued recovery of riverbank vegetation; and
* a smaller autumn fresh delivered in March, to support new lower bank vegetation and improve macroinvertebrate and fish habitat and water quality.

Note: there are no overbank environmental flows allowed in the Goulburn River system.

**Findings:** A very solid report. It would be helpful to have the expected outcomes (Table 19 below; p8 of Webb et al. 2017) for the Goulburn directly aligned with the indicators and KEQ rather than being presented in a separate section of the report. Having the logic of ‘this is the water we have, here is what we expected to happen, this is indicator we are using, this is the evaluation question and this is what we saw’ in the one spot would be ideal. Having said that, the overall presentation of evaluation questions, results and methods are very well done. In particular the inclusion of the Basin-scale matters alongside the area-scale evaluation is very good – clearly shows both the spatial and temporal scale of the evaluation questions.

Clear advice is given in regards to managing future watering for desired outcomes, or in the case of bank erosion, avoiding issues.

Table 19. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Goulburn.

| Expected outcome (linked to flow type/delivery) (Webb et al. 2017, p8) | Indicator | Area-scale KEQ | Rating | Justification |
| --- | --- | --- | --- | --- |
| * maintain water quality * support native fish condition & macroinvertebrate abundance/diversity * longitudinal connectivity - fish passage * support ecosystem function (e.g. connectivity, dispersal, primary production) * improved condition and cover of native in-channel vegetation (especially on banks) * discourage terrestrial vegetation encroachment on lower bank * support ecosystem function * breeding and movement of native fish | Physical habitat and bank condition | What did CEW contribute to:   * provision of productive habitat (e.g. slackwaters) for the recruitment, growth and survival of larval and juvenile fish? * provision of diverse and productive macroinvertebrate habitats? * inundating specific riparian vegetation zones and creating hydraulic habitats that favour the dispersal and deposition of plant seeds and propagules? * How does CEW affect bank erosion and deposition? * How does the amount of river bank erosion affect vegetation responses to environmental water delivery? |  | Likely to be on track – based modelling with links being a bit tenuous with only a couple of years data.  Strategic ewatering does not appear to have contributed to bank erosion (Webb et al. 2017). |
| Stream metabolism | How does the timing and magnitude of CEW delivery affect rates of Gross Primary Productivity and Ecosystem Respiration in the lower Goulburn River? |  | There was no consistent immediate effect of flow increases (including those from CEW delivery) across the 4 sites on rates of either GPP or ER. However, there was a positive effect of flow rate on total amounts of GPP and ER (Webb et al. 2017). |
| How do stream metabolism responses to CEW in the lower Goulburn River differ from CEW responses in the Edward Wakool system where the likelihood of overbank flows is higher and nutrient concentrations are generally much lower? |  | Goulburn River compared to the Edward-Wakool. The actual CEW and natural flows in the Edward Wakool prevented determination of flow metabolism relationships. In neither system did flows get out of the river channel. Both systems had very low bioavailable nutrient concentrations (Webb et al. 2017). |
| Macroinvertebrates | What did CEW contribute to:   * macroinvertebrate diversity in the lower Goulburn River? * macroinvertebrate abundance and biomass in the lower Goulburn River? * macroinvertebrate emergence (and hence recruitment) in the lower Goulburn River? |  | Diversity was not affected by CEW in 2014-15 or 2015-16. Biomass might be affected, but varied in each year, with a decrease in the Goulburn in 2015-16 compared to the Broken. Abundance varied by taxa, and emergence differed between years (Webb et al. 2017).  Considered too early to establish contribution of CEW. |
| Vegetation diversity | What did CEW contribute to:   * the recovery (measured through species richness, plant cover and recruitment) of riparian vegetation communities on the banks of the lower Goulburn River that have been impacted by drought and flood and how do those responses vary over time? |  | The spring fresh flows are expected to be of benefit to species diversity. Short term responses to freshes were limited; the cover of vegetation along the elevation gradient reflects the longer term influence of spring freshes (Webb et al. 2017). |
| * How do vegetation responses to CEW delivery vary between sites with different channel features and different bank conditions? |  | Differences observed in 2014-15 were not seen in 2015. Need longer data set (Webb et al. 2017). |
| * Does the CEW contribution to spring freshes and high flows trigger germination and new growth of native riparian vegetation on the banks of the lower Goulburn River? |  | Increases in cover on banks inundated by freshes in 2014-15 were not observed in 2015-16 – attributed to drier conditions pre sampling (Webb et al. 2017). |
| * How does CEW delivered as low flows and freshes at other times of the year contribute to maintaining new growth and recruitment on the banks of the lower Goulburn River? |  | Conditions are not discussed in terms of CEW – just other conditions (local climate, antecedent conditions) in between flows (Webb et al. 2017). |
| Fish | What did CEW contribute to:   * the recruitment of golden perch in the adult population in the lower Goulburn River? * golden perch spawning and in particular what magnitude, timing and duration of flow is required to trigger spawning? * survival of golden perch larvae in the lower Goulburn River? |  | Spawning event associated with CEW in 2014-15, but no eggs, larvae or evidence of recruitment in 2015-16.  No flows delivered for golden perch spawning in 2015-16 (Webb et al. 2017). |
| What did CEW contribute to:   * the movement of golden perch in the lower Goulburn River and where did those fish move to? |  | Movement downstream associated with CEW (Webb et al. 2017). |

### Gwydir

Five environmental watering actions occurred during 2015-16, with combined CEW and NSW ECA water (Southwell et al. 2016). Environmental water was used to provide small flow pulses and longitudinal connection with the Gwydir system at critical times during the dry summer/autumn period. A total of 13,250 ML was delivered (63% CEW, 37% NSW) – this was ca. 10% of the total flow in the system.

“The overall aim of Commonwealth environmental water in the Gwydir catchment during 2015-16 was to consolidate and protect the ongoing environmental recovery achieved over the last three years in anticipation of a potentially low rainfall and inflow period. This was to be achieved by following natural flow cues, and activating access to supplementary water to offset a component of the consumptive extraction up to an approved volume withheld environmental water from Copeton Dam” (Commonwealth of Australia 2015b).

**Findings:** There was no clear summary of what monitoring was undertaken in 2015-16 in the main report – only in the appendices. The concluding statements made for each indicator in the technical appendices are very useful, but these should have been included in the main report. Still not all KEQ listed are explicitly addresses. It would have been helpful to have the expected outcomes for the watering year linked to the KEQs and outcomes. Would be good to distinguish between short and long term outcomes – stated in a few of the appendices but not consistently. Having said that – most of the matters are on track or likely to be achieved.

This and the Warrego-Darling are the only SA evaluation reports that address the contribution to meeting the objectives of the MDBA Environmental Watering Plan. Currently there is no reference to the BEWS, which is probably the more relevant as targets have been set for catchments, but none of the other SA reports do this either.

The content and presentation in this and the Warrego-Darling Reports are significantly different to the other SA evaluation reports (see BH comments re Warrego-Darling report also). Discussion of several of the indicators are spread over different Appendices and this is a little hard to follow at times – would like to see an overall evaluation of water quality and small bodied fish (as least) at the whole of SA scale. Overall both this and the Warrego-Darling are good reports – just different.

Table 20. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Gwydir.

| Expected outcomes | Indicator | Area-scale KEQ | Rating | Justification |
| --- | --- | --- | --- | --- |
| Gwydir and Gingham wetlands   * Maintain vegetation condition and reproduction * Provide refuge habitat for waterbirds, fish and other aquatic species * Maintain ecosystem resilience by supporting individual survival and condition * Provide baseflows and freshes to increase lateral and longitudinal hydrological connectivity * Allow for sediment transport, nutrient and carbon cycling.   Mallowa wetlands   * Support hydrological connectivity between wetlands * Support further recovery of vegetation extent and condition * Provide habitat for waterbirds and native aquatic species * Contribute to improved habitat quality and increased within ecosystem diversity to support survival of native birds fish and other fauna   Mehi River   * To support in-stream ecological function and nutrient cycling, contributing to the health of in-stream habitat and maintaining water quality.   Carole Creek, Mehi River, Gwydir River, Lower Gwydir River, Gigham Watercourse   * During dry conditions, provide base flows to protect refugial in-stream habitat and mitigate declining water quality | Hydrology (river) | * What did CEW contribute to hydrological connectivity? * What did CEW contribute to hydrological connectivity of the Gwydir Selected Area channels? |  | Contributed to connectivity in the Gwydir, lower Gwydir and Mehi River channels and was responsible for all significant flow in Mallowa Creek during 2015-16. Full connectivity in the Gingham watercourse and Moomin Creek was due to non-eflows. Overall, but expected, connectivity in 2015-16 was markedly reduced compared to 2014-15 (Southwell et al. 2016). |
| Hydrology (watercourse) | * What did CEW contribute to hydrological connectivity of the Gingham, lower Gwydir and Mallowa wetlands? |  | Played a key role in inundating the Mallowa wetlands. 2015-16 CEW contributed less to connectivity in the lower Gwydir and Gingham wetlands than in the 2014-15 (Southwell et al. 2016). |
| Ecosystem diversity | * What did CEW contribute to sustainable ecosystem diversity? * Were ecosystems to which CEW was allocated sustained? * Was CEW delivered to a representative suite of ecosystem types? |  | Only SA with an expected outcome for ecosystem diversity.  Not sure what is meant by sustainable ecosystem diversity in KEQ.  No conclusion in the Appendix.  “Within the Selected Area, a total of 122 sites, accounting for 82% of all sites were inundated during the 2015-16 water year. All ecosystem types except F1.11: River cooba woodland floodplain and Lt2.2: Temporary floodplain lake were inundated.” Southwell et al. (2016). This indicate that CEW was delivered to a representative suite of the 149 sites that were sampled – and probably also of all ecosystem types in the Gywdir SA, but the whole of the area-scale evaluation is not included – easy to address. |
| Water quality (Cat II) | What did CEW contribute to:   * temperature regimes? * pH levels? * turbidity regimes? * salinity regimes? * dissolved oxygen levels? |  | Expected outcomes for carbon and nutrient cycling are given but not for the parameters with KEQ for water quality per se.  Describes how CEW affected the various water quality indicators in Appendix C, sampled at one location in the Gwydir. The argument made is that “this single station has permanent surface water connectivity in a defined channel and all environmental water delivered to the lower Gwydir must pass through this reach” Southwell et al. (2016).  Don’t understand why there are separate treatments of water quality and stream metabolism spread over three Appendices – can these be combined into a whole of SA evaluation?  (see comment below re Mehi results) |
| Stream metabolism (Cat III) | What did CEW contribute to:   * patterns and rates of primary productivity? * patterns and rates of decomposition? |  | Rates peaked in association with ewater.  Statements presented in Appendix D regarding water quality in the Mehi would appear to relate to stream metabolism (nutrients) but it’s not clear. No Cat I stream metabolism data collected. Cat III indicators for stream metabolism were sampled. Method is supposed to be in the MEP but it’s not.  (From Appendix on microinverts) “The increase in rates of GPP and ER correspond to higher carbon and phosphorus availability in the ‘wet’ phase, which are either transported along with the environmental water or released in situ from freshly inundated sediments. This pattern is consistent among sites and suggests the management of carbon or phosphorus concentrations will regulate metabolism in these systems” Southwell et al. (2016).  May want to consider reporting metabolism in a separate section rather than in with the microinvertebrates. |
| Microinvertebrates | What did CEW contribute to:   * microinvertebrate productivity? * microinvertebrate community composition? * connectivity of microinvertebrate and vegetation communities in floodplain watercourse? |  | Water quality Cat III methods also reported on in Appendix D (Southwell et al. 2016). Exceptionally high N and P concentrations in 2014-15 and 2015-16.  KEQ re vegetation and microinverts not addressed. Diversity and density of microinvertebrates were influenced by ewater. |
| Macroinvertebrates | What did CEW contribute to:   * macroinvertebrate diversity? |  | No statistically significant effect of ewater on density, richness or diversity, but there was a significant effect on family level community composition (Southwell et al. 2016). |
| Vegetation diversity | What did CEW contribute to:   * vegetation species diversity? * vegetation community diversity? |  | Watering action insufficient to inundate substantial areas of wetland vegetation (Southwell et al. 2016).  Summary statement that the cover of the weed species lippia decreased with native species cover increasing (from Table 4.1) is only part of the story – the result section of Appendix G states overall cover has been consistent over the two years. Cover varies in response to wetting and drying but no overall gains.  CEW influenced vegetation – not a clear answer to the KEQs, but likely to be achieved. |
| Small bodied fish and frogs | What did CEW contribute to:   * frog and small-bodied fish populations? * frog and small-bodied fish species diversity? |  | Too early to state contribution to populations, but Olive perchlet may be sustained at Gingham waterhole if managed for this species. Only location in the Gwydir its  been recorded.  Been assigned yellow due to comments re SBNF in Appendix I |
| Fish (river) | What did CEW contribute to:   * native fish community resilience? * native fish survival? * native fish populations? * native fish diversity? |  | Sets context by reference to previous monitoring – not just LTIM – i.e. refers to SRA and STIM data.  SBNF results are reported separately – but would be good to see area-scale evaluation of small bodied fish data - combining findings from the two Appendices. For example in Appendix l the small-bodied species are reported as declining in numbers and all were in low abundance compared with 2014-15 (attributed to dry conditions in the the lower Gwydir catchment 2015-16) (Southwell et al. 2016).  Significant difference between years in fish abundances between years, no difference in biomass between channels, but a sig difference between years in biomass. Overall fish community in lower Gwydir is relatively stable but in poor condition.  Conclude by stating “any significant and measurable improvement in the fish community is likely to take some considerable time” |
| Fish (movement) | What did CEW contribute to:   * native fish dispersal? * Did environmental water stimulate target species to exhibit movement consistent with breeding behaviour? * Did environmental water facilitate target species to move/return to refuge habitat?   What did CEW contribute to:   * to native fish populations? |  | Included reference to short and long term KEQ, but data not yet available – being process in 2016-17. |
| Waterbird diversity | What did CEW contribute to:   * waterbird populations? * waterbird species diversity? * waterbird survival |  | Waterbird results support findings from previous monitoring and are responding as expected. |

### Lower Lachlan

Three environmental watering actions were delivered to the Lower Lachlan river system during 2015-16.

The primary expected outcomes of the watering actions were to (catchment scale) (Dyer et al. 2016):

• Provide habitat to support survival, maintain condition of, and provide reproduction opportunities for native fish;

• Maintain the extent and diversity of aquatic and riparian vegetation;

• Support waterbird habitat, and breeding and recruitment opportunities; and

• Maintain hydrological connectivity including end of system flows.

The secondary expected outcomes were to:

• Contribute to ecosystem function; and

• Deliver landscape vegetation diversity and resilience.

Individually, the watering actions were expected to maintain hydrological connectivity, contribute to vegetation condition and diversity, provide habitat and access to habitat for frogs, fish and birds, trigger breeding and recruitment in frogs and generate movement and spawning of golden perch

**Findings**: This is a very good, informative report. The project objectives (evaluation questions) are well identified, and adequate details provided on the monitoring, and outcomes. However, in the main report there was little detailed information provided on the results and how they were analysed, but this is available in the Appendices. The distinction between action-specific and area-scale questions was well done. Dyer et al. (2016) included reference to 2014-15 as representing baseline conditions. The summary table of evaluation questions and responses clearly indicate which were short and long term questions.

In a few places reference is made to change at the catchment scale but it’s not clear if this is distinct from area-scale. For example, “…indicates that the vegetation community within the catchment is responsive to watering” Dyer et al. (2016), p47.

A separate report on waterbirds was provided (Brandis & Lyons (2016), but this information was not incorporated into the Lower Lachlan Area report

Table 21. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Lower Lachlan.

| Indicator | Expected outcomes – from Dyer et al. (2016) – (note source of outcomes not attributed in LTIM report) | Area-scale LTIM KEQ | Rating | Justification |
| --- | --- | --- | --- | --- |
| Hydrology | * Improve hydrological connectivity including end of system flows. * Contribute to hydrological connectivity in the Booligal Wetlands. * Provide habitat to support, maintain condition of, and provide reproduction opportunities for native fish, waterbirds and other aquatic vertebrate species. * Contribute to hydrological connectivity. | What did CEW contribute to:   * maintaining hydrological connectivity including end of system flows? * hydrological connectivity?   What was the effect of Commonwealth environmental water on:   * hydrological connectivity to Murrumbidgil Swamp? * providing access to habitat for fish? |  | CEW raised water levels by up to 1.5 m connecting in-channel habitats and providing additional habitat for fish. Increased water levels of more than 0.5 m were achieved and considered optimal for golden perch migration and spawning (Dyer et al. 2016).  Connectivity to the Great Cumbung Swamp and Murrumbidgil Swamp was achieved and duration extended by about 55 days in Great Cuumbung Swamp (Dyer et al. 2016) |
| Stream metabolism and water quality | None at catchment scale. | What did CEW contribute to:   * patterns and rates of decomposition? * patterns and rates of primary productivity.   There were no LTIM KEQ listed relating to water quality, however results were presented. It is assumed that the same Cat I water quality KEQ apply in the Lower Lachlan. |  | Environmental flows did not result in any consistent responses in either GPP or ER (Dyer et al. 2016)  There were no clear patterns in water chemistry associated with delivery of environmental flows. |
| Fish community | * Provide habitat to support, maintain condition of, and provide reproduction opportunities for native fish, * Trial the augmentation of flow to generate a golden and/or silver perch movement and spawning response. | What did Commonwealth environmental water contribute to:   * native fish community resilience? * native fish survival? * native fish populations? * native fish diversity? |  | Both long and short term KEQ listed in Appendix, but only short term in the summary report.  Overall, the fish community still in very poor condition. Results similar to previous year. Focus in dry years should be on maintaining not improving. |
| Spawning and larval fish | Watering Action 3 had specific objectives concerning native fish with 9378 ML of CEW delivered to:   * Provide habitat to support, maintain condition of, and provide reproduction opportunities for native fish, * Trial the augmentation of flow to generate a golden and/or silver perch movement and spawning response. | What did CEW contribute to:   * native fish reproduction in the Lower Lachlan river system? * native larval fish growth in the Lower Lachlan river system? * native fish populations in the Lower Lachlan river system? * native fish species diversity in the Lower Lachlan river system? |  | No eggs, larvae or new recruits, and only stocked juveniles of golden perch were collected. It is unlikely that spawning of golden perch occurred in response to the 2015-16 water delivery (Dyer et al. 2016).  Expected outcomes only partially met in 2015-16.  Non-flow cued spawning evident for Murray cod, flat headed gudgeon, Australian smelt and carp gudgeon (Dyer et al. 2016).  Overall evidence of 6 species reproducing attributed to CEW.  Not able to assess growth KEQ. |
| Frogs | * Trigger breeding and recruitment in frogs | What did CEW contribute to:   * frog diversity and populations? * breeding and recruitment of frog species? * What was the effect of Commonwealth environmental water on refuge for frogs in the Great Cumbung Swamp and Booligal Wetlands? |  | Results suggest that frog diversity has been maintained to pre LTIM levels, except for one species which had been recorded in prior surveys. Calling increased during periods peak flow for both ewater and translucent flows (Dyer et al. 2016).  Short and long term KEQ addressed.  Some indication of breeding at Cumbung Swamp but further data required to say Booligal has potential to act as a refuge – dependent on watering conditions/duration (Dyer et al. 2016) |
| Vegetation | * Maintain the extent and diversity of aquatic and riparian vegetation * Contribute to vegetation condition and diversity | What did Commonwealth environmental water contribute to:   * vegetation species diversity? * vegetation community diversity? * the condition of floodplain and riparian trees? * populations of long-lived organisms? |  | Unable to ‘disentangle’ effects of CEW and translucent flows.  Changes in ground cover species between year 1 and 2 suggest vegetation community within the catchment is responsive to watering (Dyer et al. 2016).  Tree condition improved in 2015-16 compared to the previous year and responded to CEW (Dyer et al. 2016). |

### Lower Murray

During 2015-16, approximately 814 GL of CEW was delivered to the LMR from 1 July to 30 November 2015, and from 2 January to 30 June 2016. This included 15.8 GL of CEW used for wetlands and weir pool raising (WPR) within South Australia, with the remaining ~798 GL flowing through the main channel. Note that in July and August 2015, the CEW consisted largely of return flows from the Barmah–Millewa Forest and flow pulse events in the Goulburn River.

**Findings**: This was the only evaluation report that included objectives, KEQ and associated hypothesis – well defined/presented. No consideration of Basin-scale evaluation – states MDFRC to address Basin-scale evaluation. Included results for DEWNR objectives for the LTWP. No reference to Basin Plan Environmental Watering Plan objectives or expected outcomes from watering actions (this is the reason some of the ratings are yellow – can’t say if achieved). Only short term 1 year outcomes were evaluated, but each KEQ addressed/answered in terms of contribution by CEW.

Ye et al. (2017) is a useful report that provides a good discussion and summary of the 2015-16 monitoring program and key findings. The report would be improved with the inclusion of a clear summary of what monitoring was undertaken in 2015-16, covering which of the environmental flow events were monitored, why and what indicators in the overview/summary report.

Table 22. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Lower Murray.

| Indicator | Expected outcomes | Area-scale LTIM KEQ | Rating | Justification |
| --- | --- | --- | --- | --- |
| Hydrology (channel) (Cat I) | Not specified | None specified |  | Doesn’t directly address any specific KEQ, but provides fundamental information for analysis and evaluation of all other indicators (Ye et al. 2017). Expectation that Cat I indicators are evaluated at the Basin-scale by MDFRC. |
| Stream Metabolism(Cat I) | What did CEW contribute to:   * patterns and rates of decomposition? * patterns and rates of primary productivity? * dissolved oxygen levels? |  | There were enhanced gross primary production and respiration rates associated with WPR in Weir Pool 5 and return flows from Chowilla, both of which were supported by CEW. Integrated ecosystem net production was near zero, indicating that organic material was derived from aquatic production with little enhancement from external supplies that could have further increased food supplies. Oxygen concentrations did not fall below acceptable levels (>50% saturation) (Ye et al. 2017, Table 1) |
| Fish (channel) (Cat I) | None specified |  | There are no KEQ for this indicator at the SA scale; however, fish monitoring data are consolidated to evaluate a number of fish targets of DEWNR’s LTWP (Ye et al. 2017). |
| Hydrological Regime (Cat III) | What did CEW contribute to:   * Hydraulic diversity within weir pools? * Variability in water levels within weir pools? |  | Some increase in velocities in winter and spring with CEW. Some variability achieved in weir pools – can’t really state if on track as no expected outcomes stated, but suspect this indicator is probably okay. |
| Matter Transport(Cat III) | What did CEW contribute to:   * salinity levels and transport? * nutrient concentrations and transport? |  | Increased salt transport through and out of system, only minor changes in concentrations. Also some transport of nutrients. |
| * concentrations and transport of phytoplankton? |  | No impact on concentrations, but transport did occur |
| * ecosystem function? |  | Increased exchange of nutrients and phytoplankton between critical habitats possibly influenced ecosystem function – but early days. |
| * water quality to support aquatic biota and normal biogeochemical processes? |  | Reduced salinity concentrations in particular may have improved conditions in the Lower Lakes and Murray Mouth (Ye et al. 2017). |
| Microinvertebrates (Cat III) | What did CEW contribute:   * to microinvertebrate diversity? |  | Peak diversity matched peaks in river discharge and CEW. Most taxa were transported taxa from floodplain or riparian sources (e.g. Chowilla) Ye et al. (2017). |
| * via upstream connectivity to microinvertebrate communities of the LMR Selected Area? |  | Likely to be achieved – some indication of taxa being transported from upstream, but could also be from lateral connections (Ye et al. 2017). |
| * to the timing and presence of key species in relation to diet of large-bodied native fish larvae (e.g. golden perch)? |  | Relationship could not be determined. |
| * to microinvertebrate abundance (density)? |  | Flow including CEW contributed to changes in density of microinvertebrates. Reduced flows had reduced densities (Ye et al. 2017) |
| Fish Spawning and Recruitment (Cat III) | What did CEW contribute to:   * reproduction of golden perch and silver perch? |  | Limited spawning and negligible recruitment (to YOY, age 0+) of golden perch and silver perch (Ye et al. 2017). |

### Murrumbidgee

In 2015-16, sixteen actions delivering a total of 108,328 ML of environmental water to the Murrumbidgee river system, targeting floodplain and wetland habitats and floodplain anabranches and creeks. Four of these events were monitored (Wassens et al. 2016, pp. 7-11). There was no environmental water targeted specifically for the Murrumbidgee river channel (although the channel did get e water through the delivery to the floodplain and wetland sites).

**Findings**: Adaptive management was well addressed with useful information on possible future changes provided. This is a very good, informative report. The project objectives (evaluation questions) are well identified, and adequate details provided on the monitoring, and outcomes. There was little information provided on the results and how they were analysed. The outcomes were adequately linked back to the evaluations questions. However, there were no clear statements re what CEW contributed – distinction not made. Emphasis in report is on outcomes and future planning for delivery. No extrapolation of findings to whole of SA.

A number of indicators are of questionable value - wetland and riverine water quality do not appear to be responding to CEW – a counterfactual comparison would be useful to determine if this is an indicator worth continuing. Also riverine microinvertebrates do not appear to be linked to peaks in larval fish – or at least there is no obvious pattern – may be a limitation of only a couple of years data and lack of in channel ewater flows. The inclusion of wetland microinvertebrates is also of concern – see comments in the table.

Table 23. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Murrumbidgee (MMEP = Murrumbidgee Monitoring and Evaluation Plan).

| Indicator | MMEP and 2015-16 Acquittal Report Expected outcomes (Wassens et al. 2016) | Area-scale LTIM KEQ/predicted outcomes | Rating | Justification |
| --- | --- | --- | --- | --- |
| River water quality | Support primary productivity, nutrient and carbon cycling, biotic dispersal and movement;  Provide refuge habitat from adverse water quality events. | * Physicochemical variables remain within range tolerated by aquatic species * Nutrient, carbon and chlorophyll-a concentrations within range tolerated by aquatic species * Nutrient concentrations sufficient to support ecosystem functions |  | Results were described as consistent with prior records and within water quality criteria.  Not known if primary production in the Murrumbidgee River is resource-supply limited (Wassens et al. 2016, p15). |
| Stream metabolism | Provide flows, including restoring natural flow events that are affected by river regulation and/or extraction, to support habitat and food sources and promote increased movement, recruitment and survival of native fish. | What did CEW contribute to:   * patterns and rates of decomposition? * patterns and rates of primary productivity? |  | Preliminary findings show weak relationships between metabolism (GPP and ER) with both flow and temperature. Unknown if expected outcome from watering action was achieved (Wassens et al. 2016, p17). A lack of high scouring flows and lateral connecting flows are likely to limit assessment of this indicator. |
| Riverine microinvertebrates | Provide flows, including restoring natural flow events that are affected by river regulation and/or extraction, to support habitat, food sources and breeding requirements of waterbirds, native fish and other vertebrates. | What did CEW contribute to breeding and recruitment of riverine native fish by supporting prey? |  | Differing results in different zones, but findings suggest there may be a mismatch of peak microinvertebrate density and timing of target larval fish (Wassens et al. 2016).  No in channel watering (Wassens et al. 2016), so the main element of the expected outcome was not met. The observed responses were from freshes from passing flows – not a dedicated release.  Only addresses one aspect of expected outcome, but states that the outcome was met. |
| Riverine and larval fish | Provide flows, including restoring natural flow events that are affected by river regulation and/or extraction, to support habitat and food sources and promote increased movement, recruitment and survival of native fish. | What did CEW contribute to native fish reproduction? |  | Found little association between golden perch spawning and hydrology metrics; a positive association between silver perch spawning and water level was found (Wassens et al. 2016). Should get a better handle on relationships with more data.  No in channel watering (Wassens et al. 2016), so the main element of the expected outcome was not met. The observed responses were from freshes from passing flows – not a dedicated release. |
| Wetland hydrology | None specified – water was delivered to “inundate wetland and refuge habitat” in the Murrumbidgee Catchment Wassens et al. (2106), p29 | What did CEW contribute to inundated area:   * in Yarradda Lagoon? * in core wetland habitats across North Redbank? * in maintaining inundation extents in Tarwillie Swamp of Yanga National Park? * in refuge habitat through the Nimmie-Caira floodways to Waugorah Lagoon and Monkem Creek system? * of the Juanbung Swamp floodplain wetland habitat? * in Hobblers Lake and Penarie Creek? |  | Almost half of the inundated area in the Redbank zone can be attributed to CEW. ~85% of the 2015-2016 inundated area in the Nimmie-Caira was combined CEW and NSW environmental water (Wassens et al. 2016).  “All Commonwealth water actions achieved the expected inundation objectives for targeted wetland assets” Wassens et al. 2016, p121.  Note that inundation objectives were not stated in the section on wetland hydrology – no expected outcome provided. |
| Wetland water quality | Improve aquatic habitat, water quality and riparian vegetation  Support the habitat and breeding requirements of native vegetation, waterbirds and fish | What did CEW contribute to:   * suitable physicochemical conditions for wetland fauna? * wetland nutrient and carbon concentrations? |  | Supported adequate water quality for colonisation by aquatic biota. “There is no evidence that water quality is changing among years in response to repeated watering” Wassens et al. (2016), p128  Wetland nutrient and carbon concentrations also within ranges of historical data.  Reconsider inclusion of indicator? |
| Wetland microinvertebrates | Improve aquatic habitat, water quality and riparian vegetation  Support the habitat and breeding requirements of native vegetation, waterbirds and fish | What did CEW contribute to wetland productivity nutrients and carbon fluxes, primary productivity (CHL a) and secondary productivity (Microinvertebrates)? |  | No idea how microinvertebrates relate to the first expected outcome listed – mistake in the report?  The KEQ is somewhat questionable as well.  Would prefer to see indicators directly related to the expected outcome rather than as assumed surrogates. There is no apparent linkage between the microinvertebrate data and the fish and bird data as evidenced by the statement made on p135 “It will be valuable to examine the relationship between the high densities of microinvertebrates and the fish and waterbird species that prey upon them.”  “Required microinvertebrate densities for waterbirds and tadpoles are not known.”  Question the value of this indicator – in particular as there is a very tenuous link to the expected outcome and the KEQ. |
| Vegetation diversity | Protect and maintain the health of existing extent of riparian, floodplain and wetland native vegetation communities | * Did CEW contribute to vegetation species diversity? * Did CEW contribute to vegetation community diversity? * Did environmental watering influence the types of species present in wetlands? * Did the percentage cover of plant functional groups change in response to environmental watering? |  | The KEQ for this indicator reported in the summary Table on page 44 are different to those given in the technical appendices and MEP – just need to be consistent (being a bit picky here).  “Overall species richness has remained stable across the monitoring locations, the exception being Yarradda Lagoon where species richness has increased following environmental watering” - attributed to the Nimmie-Caira wetlands having had a history of watering and being unlikely to change diversity or abundance greatly in response to watering.  No clear statement as to what/if CEW contributed to community diversity – patterns in community diversity reflected geomorphic zones.  Add water to dry wetlands and aquatic plants grow – so yes, functional groups are different in wet and dry wetlands. |
| Wetland fish | Support the habitat and breeding requirements of native vegetation, waterbirds and fish. | What did CEW contribute to:   * native fish populations and native fish diversity? * native fish community resilience and native fish survival? |  | Native fish diversity maintained, or increased via overbank natural flows. Evidence of dominant spp – bony herring, Aust. smelt and carp gudgeon – breeding. Breeding may have occurred post watering or that smaller fish were washed into the system post natural overbank flows. |
| Wetland frogs and turtles | Support the habitat and breeding requirements of native fish and other vertebrates. | What did CEW contribute to:   * other aquatic vertebrates (frog and turtle) diversity and populations? * the provision of habitat to support breeding and recruitment of other vertebrates? * the maintenance of refuge habitats? |  | Frog outcomes were achieved, with diversity maintained and populations of southern bell frog persisting in wetlands that were watered. |
| Waterbird diversity | Support the habitat requirements of waterbirds | What did CEW contribute to:   * waterbird species diversity? * waterbird species of conservation significance? * waterbird breeding\*? |  | Waterbird breeding was assessed via complementary NSW OEH waterbird diversity and breeding.  Wetlands that received water had more waterbirds than wetlands that were dry – not surprising.  Good adaptive management recommendations re future watering options for waterbird outcomes. |

### Warrego-Darling

Four small to moderate flow events containing environmental water flowed down the Darling River during the 2015-16 water year. These occurred in July-October 2015, November 2015, January-March 2016 and June 2016. No environmental water was accounted for in the Warrego River or on the Western Floodplain in the Selected Area. However, a small flow event containing around 4% Commonwealth environmental water from the upper Warrego catchment flowed into the Selected Area during February-March 2016.

A moderate pulse in the Darling River began in June 2016 reaching 4,818 ML/d at the Bourke Town gauge (NSW425003) by 30 June 2016, peaking at 8,542 ML/d on 7 July 2016. Flow events of this size occur less than 20% of the time.

Use of Commonwealth Toorale entitlements is expected to contribute to the following on-park outcomes at Toorale and/or in the Darling River downstream (Frazier et al. 2016):

• support periods of high primary productivity triggered by unregulated flow events and carbon and nutrient cycling

• support wetland and aquatic vegetation condition and diversity

• support waterbird survival and condition and diversity

• inundate and connect in-channel habitat associated with riffles, pools, bars and anabranches to support movement and biotic dispersal

• maintain water quality and carbon/nutrient cycling processes

• provide hydrological connectivity and improve end-of-system flows

**Findings:** The expected outcomes listed in the Warrego-Darling Evaluation report are, in theory linked to both longer-term and broader objectives set out in the Murray-Darling Basin Plan; however these are not presented as SMART outcomes and are not measurable in their current form. This is a problem with how they are presented in the Annual watering Priorities – Commonwealth of Australia (2014). The annual watering priorities for the Northern unregulated rivers for 2014-15 and 2015-16 were for maintenance of native fish and waterbird refuges. Only one option (option 6) was relevant to the SA and it focused on waterbird refuges on the western floodplain which didn’t receive water in 2015-16 (Commonwealth of Australia 2014, p31). Stating that most, if not all, expected outcomes were achieved and that CEW made a contribution to these is in a strict sense not accurate, as there is no indication of what the actual outcome was expected to be. For this reason we have assigned red to a number of indicators. The expected outcomes for this SA need to be written as SMART – for example stating *salinity* or *individual survival and condition (individual refuges and ecosystem resistance)* as expected outcomes, gives no insight at all to what is the expectation of response to watering – they do not meet any of the SMART criteria.

The evaluation questions are not provided in the main report. Frazier et al. (2016) is really a synthesis report that is set at a very high level with little detail provided in the main report. Presumably, the detail is in the Appendices. However, without spending excessive time in reviewing the Appendices, I could not assess the quality of this work (DN: RB did review the appendices to assess progress on objectives – see table below).

I recommend that CEWO require the Gwydir/Warrego-Darling team in future years to provide more detail on: what the evaluation questions for that year are; the monitoring program (i.e. what was measured, when and where); how the results were analysed; what the outcomes were (in terms of the evaluation questions); what adaptive management occurred (if any); and recommendations for future years (i.e. what did we learn and what do we want to do differently).

Appendices could be reduced in size by removing repeated text.

Table 24. Assessment of progress towards expected outcomes and Area-scale LTIM KEQ for the Warrego-Darling.

| Expected outcomes for 2014–15 and 2015-16 (Frazier et al. 2016, Table 5.1) | Indicator | Area-scale KEQ | Rating | Justification |
| --- | --- | --- | --- | --- |
| * Individual survival and condition (individual refuges and ecosystem resistance) * Salinity * Dissolved oxygen * pH * Dissolved organic carbon * Nutrient and carbon cycling * Fish reproduction * Fish condition * Vegetation reproduction * Vegetation condition * Waterbird survival and condition * Waterbird chicks * Waterbird fledglings * Hydrological connectivity including end of system flows * Biotic dispersal and movement * Primary productivity (of aquatic ecosystems) | Hydrology (river) | What did CEW contribute to hydrological connectivity? |  | Good outcome in Darling River, but less so in Warrego. Achieving connectivity is more dependent on upstream conditions than other SA. Likely to be achieved with relatively small flows. |
| Hydrology (northern tributaries) | What did Commonwealth environmental water from upstream tributaries contribute to hydrological connectivity within the Selected Area? |  | CEW estimated to be around 5%, 4% and 30% in the 2015-16 flows, enhancing in-channel longitudinal connection. Similar to 2014-15, where two CEW events contributed 4% and 25% of flows at the SA. Overall CEW played a small role in promoting the transmission of natural flow events downstream towards the SA (Frazier et al. 2016) |
| Hydrology (channel) | What did Commonwealth environmental water contribute to hydrological connectivity? |  | “Work in coming years will further elucidate the implications of this complexity in channel character for hydrological connectivity, the ecology and ecosystem processes along the lower Warrego River within the Selected Area” Frazier et al. (2016), pC-9.  The results presented are about geomorphology – not what CEW has achieved – not clear if this should be considered a separate hydrological indicator – depends on what will be monitored into the future. |
| Hydrology (habitat) | What did Commonwealth environmental water contribute to in-channel habitat availability along the Darling River? |  | CEW contributed to around 30% of benches and anabranch channels being inundated in low flow events. Inundated habitat was considered likely to contribute a small amount of dissolved carbon and nutrients to the river system. Forty two percent of snags were also inundated throughout the year providing additional habitat for fish and other aquatic biota (Frazier et al. 2016). |
| Hydrology (floodplain) | What did Commonwealth environmental water and management contribute to hydrological connectivity of the Western Floodplain? |  | No CEW reached the Western Floodplain. |
| Water quality | What did CEW contribute to:   * temperature regimes? * pH levels? * turbidity regimes? * salinity regimes? * dissolved oxygen levels? * algal suppression? |  | Exec summary states lowering of pH and conductivity – but results in appendix state highest conductivities were associated with the peak flows which had about 30% CEW. Water column pH also rose in the peak flows, whilst other variables showed effects of dilution. Seems to be a mismatch in the interpretation. The other smaller flows only had up to 4.5% CEW.  Probably too early in the project to make clear statements re contribution of CEW to water quality.  Need to update/specify expected outcomes.  Also there are water quality data reported in the microinvertebrate section which are different to those presented under the water quality indicator – on a superficial review it would seem these should be combined??? |
| Stream metabolism | What did CEW contribute to:   * patterns and rates of decomposition? * patterns and rates of primary productivity? |  | Positive relationships between rates of GPP, ER, NPP and nutrient concentrations, and relatively minor changes in hydrology. Increased rates of GPP and ER were associated with higher discharge, suggesting ewater in the Darling River contributes to improved water clarity and/or increase inorganic nutrients that promote pelagic primary production (Frazier et al 2016). |
| Microinvertebrates | What did CEW contribute to:   * microinvertebrate productivity? * microinvertebrate community composition? * microinvertebrate and vegetation communities in floodplain watercourse? |  | Don’t understand why vegetation is in the KEQ to do with microinvertebrates?  Don’t understand why there are separate treatments of water quality and stream metabolism in this section of the Appendices.  There was no significant temporal pattern in Shannon diversity during the sampling period. The two rivers had different communities and successional turnover was observed – however the conclusion that this is attributable to connectivity and CEW is questionable. Further technical review is required and links to expected outcomes (when drafted as SMART) should be made clearer. |
| Macroinvertebrates | What did CEW contribute to macroinvertebrate diversity? |  | First year of data – not monitored in 2014-15. Too early to make conclusions re contribution of CEW. |
| Ecosystem type | * What did Commonwealth environmental water contribute to sustainable ecosystem diversity? * Were ecosystems to which Commonwealth environmental water was allocated sustained? * Was Commonwealth environmental water delivered to a representative suite of Ecosystem types? |  | No watering on the Western floodplain only in channel, so limited number of ecosystem types influenced. |
| Vegetation diversity | What did CEW contribute to:   * vegetation species diversity? * vegetation community diversity? |  | No watering of the western floodplain, so not able to attribute vegetation response to ewater. Heavy rainfall prior to sampling had an effect on results. No discussion of constraints but if CEW doesn’t make it onto the floodplain then this indicator is not going to be achieved. |
|  | Fish (river) | What did CEW contribute to:   * native fish community resilience? * native fish survival? * native fish populations? * native fish diversity? |  | Provides baseline data on fish in the Warrego. No planned CEW, only a small amount derived from an upstream contribution made its way to the SA – 4% contribution. This likely contributed to increased recruitment and abundance in fish post the connecting flow. |
| Frogs | What did CEW contribute to:   * frog populations? * frog species diversity? * frog survival? |  | Diversity and abundance post rainfall on floodplain highest. Too early to address KEQ. |
| Waterbird diversity | What did CEW contribute to:   * waterbird populations? * waterbird species diversity? * waterbird survival? |  | Abundance and species richness corresponded to habitat and resource availability. No difference between year 1 and 2, and no difference between channel and floodplain sites except in March 2015. Good floodplain results in year 1 attributable to CEW. |

1. SMART objectives are:  **Specific** – clear and unambiguous; **Measurable** –quantified, contain a measurable element that can be readily monitored to determine success or failure; **Achievable** – realistic and attainable; **Relevant** – considerate of temporal scale of response, resources available; and **Time** bound – specify a time scale in which the outcome is met/assessed. [↑](#footnote-ref-1)
2. http://www.environment.gov.au/water/cewo/about-commonwealth-environmental-water [↑](#footnote-ref-2)
3. Management of: LTIM finances; LTIM contractual issues; the LTIM Monitoring Data Management System; and management of advice, coordination of issues, cross project coordination and consistency. [↑](#footnote-ref-3)
4. SMART objectives are:  **Specific** – clear and unambiguous; **Measurable** –quantified, contain a measurable element that can be readily monitored to determine success or failure; **Achievable** – realistic and attainable; **Relevant** – considerate of temporal scale of response, resources available; and **Time** bound – specify a time scale in which the outcome is met/assessed. [↑](#footnote-ref-4)
5. R. Stoffels, personal communication, 2 Nov 2017 [↑](#footnote-ref-5)
6. R. Stoffels, personal communication, January 2018. [↑](#footnote-ref-6)
7. B. Stewart-Koster, personal communication, February 2018. [↑](#footnote-ref-7)
8. M. Grace, personal communication, February 2018. [↑](#footnote-ref-8)
9. S Brooks, Personal Communication, 19 January 2018 [↑](#footnote-ref-9)
10. Prof Nick Bond, MDFRC, Personal communication, 1 March 2018 [↑](#footnote-ref-10)
11. Personal communication, Sam Roseby, CEWO, 23 January 2018 [↑](#footnote-ref-11)
12. Note that several of the Selected Area teams have key evaluation questions regarding ecosystem diversity in their MEP. [↑](#footnote-ref-12)
13. https://www.mdba.gov.au/publications/mdba-reports/2017-basin-plan-evaluation-reports [↑](#footnote-ref-13)