

STAGE 1 REPORT: APPENDIX F

INDEPENDENT EXPERT EVALUATORS' ASSESSMENT OF THE OUTPUTS AND OUTCOMES OF THE LONG TERM INTERVENTION MONITORING (LTIM) PROJECT

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We acknowledge the traditional owners of the lands and waterways of the Murray-Darling Basin, and pay our respect to Elders past, present and emerging.

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Acronyms

BEWS	Basin-wide Environmental Watering Strategy
EWP	Environmental Water Plan
CEW	Commonwealth Environmental Water
CEWO	Commonwealth Environmental Water Office

environmental water	Environmental water
KEQ	Key Evaluation Question
LTIM	Long Term Intervention Monitoring
MDBA	Murray-Darling Basin Authority
MEP	Monitoring and Evaluation Plan
MERI	Monitoring, Evaluation, Reporting, Improvement

1 INTRODUCTION

This report is part of an independent evaluation for the Commonwealth Environmental Water Office (CEWO) of the outputs and outcomes of the Commonwealth's Long Term Intervention Monitoring (LTIM) project. The LTIM project is the main program for addressing the CEWO's requirements under the *Water Act 2007 (Cwlth)* and Murray-Darling Basin Plan. After an initial two-year scoping and development phase, the LTIM project commenced on-ground monitoring in June 2014 and ended in June 2019, a period of five-years.

The LTIM project is world-leading in its scope, both spatially (the entire Murray-Darling Basin) and temporally (5 years), objectives and budget (over \$32 million over 5 years). It sought to achieve an outcome – assessment of the effectiveness of Commonwealth environmental water (CEW) delivery in achieving local and Basin-scale ecological outcomes – that has never been attempted before anywhere in the world. It was a highly ambitious project.

This report provides an outcome evaluation of the LTIM project against 14 Key Evaluation Questions (KEQs). Details of the LTIM project, its objectives and expected outcomes, and the evaluation strategy used are presented in Butcher and Schreiber (2020). This Evaluation report highlights important achievements, but also identifies areas where there is potential for better outcomes and lessons for the next round of monitoring and evaluation activities.

The report first outlines the approach adopted, second provides a summary of the results for the 14 KEQs (more detailed comments are in Appendix A), third discusses possible improvements to guide the CEWO's future monitoring and evaluation activities, and finally provides a series of recommendation for the CEWO's consideration.

2 APPROACH

The evaluation was structured around assessing the merit, worth and significance of the LTIM project across five focal areas:

1. The extent to which the project's objectives were achieved
2. The extent to which the project supported the CEWO's legislative reporting requirements
3. How well the project demonstrated environmental outcomes
4. How well findings were communicated to all stakeholders
5. The extent to which the project was fit for purpose.

A sixth focal area was to identify opportunities for improvements that could be incorporated into the CEWO's future monitoring, evaluation and research activities (addressed below). For the first 5 focal areas, 14 Key Evaluations Questions were answered by the evaluators. Merit, worth and significance were captured with evaluation criteria prescribed in the CEWO's Monitoring, Evaluation, Reporting and Improvement (MERI) Framework (CEWO, 2013). Multiple lines of evidence were used by each evaluator (BTH, AL and WR) independently to answer the 14 KEQs as well as numerous subsidiary KEQs (sub-KEQs: lower-level and more-specific evaluation questions whose answers informed assessment of their respective high-level KEQs). Complete details are provided in Appendix A. The relationship between focal areas and KEQs is shown in Table 1.

The evidence for this evaluation was obtained from two sources: first, from approximately 250 relevant reports¹ (Appendix B) and second, the results of an on-line survey (Butcher and Fenton, 2020) and 312 pages of transcripts of open-ended interviews of project participants ('service providers'), the client and end users. A similar evaluation of the MDB Environmental Water Knowledge and Research (EWKR) project evaluation was completed prior to this project (Boulton and Davies, 2020). Lessons learned helped streamline this evaluation and where appropriate, some of the same processes were adopted.

There were four evaluation criteria: effectiveness, appropriateness, impact and efficiency. Each evaluator used rubrics (presented in Butcher and Schreiber, 2020) that set out three levels of performance standards (e.g., 'Minimally effective', 'Moderately effective' and 'Effective') to address and rate each high-level KEQ and mid- and micro-level KEQ. During the evaluation, two further performance standards were added. 'Insufficient evidence'

¹ Program Logic documents; Selected Area Monitoring and Evaluation Plans (MEP); Basin-Matter evaluation plans; Selected Area quarterly reports; Selected Area annual reports; Basin Matter annual evaluation reports; Synthesis reports; Annual Forum and workshop reports. See Appendix B.

was used when the evaluators agreed that there was too little evidence from the available material and transcripts to evaluate a sub-KEQ, and 'Not attempted' was used when a KEQ referred to an activity or review that did not occur.








Ratings were supplemented with specific comments by each evaluator independently documenting relevant evidence from the written material, survey responses and interview transcripts. On completion of the task, the two (or three for some KEQs) evaluators compared their summative ratings and, where differences occurred, discussed and reached a consensus on a single score. These discussions were fully documented, along with each evaluator's initial evaluation comments and ratings (Appendix A). Consensus on the fourteen KEQs was not based on simply averaging ratings of subsidiary KEQs. Instead, the evaluators used their collective professional experience to weigh up the multiple lines of evidence, contextual factors, such as financial and other logistic constraints, and the needs of the client to mutually agree on a summative rating that was as robust as possible given the varying availability and credibility of evidence.









Where disparate initial ratings arose from different interpretations of a KEQ, the evaluators consulted with the core team who supplied additional evidence where it existed. In a few cases the KEQ was slightly modified for greater clarity.

3 RESULTS FOR KEY EVALUATION QUESTIONS (KEQ)

The results of this evaluation of 14 KEQs, grouped by focal areas are summarised in Table 1 and Appendix C. A brief rationale behind the rating for each KEQ is presented in the following text. For further details of each evaluator's initial ratings and comments and the documentation of the discussion for consensus, see Appendix A and presented as report cards in Appendix C.

Table 1. Performance ratings of effectiveness, appropriateness, impact and efficiency for fourteen KEQs assessing merit, worth and significance of the LTIM project. Rating are also portrayed in a 'traffic light' format to indicate whether they were low (red), moderate (yellow) or high (green).

KEQ	Question	Rating	Rating
Focal Area 1: To what extent has the LTIM project achieved its objectives			
1	How effective was the LTIM project in planning, reporting and collaborating to support adaptive management?	Moderately effective	
1A	How effectively has the LTIM project been in monitoring the ecological responses to CEW at the each of the seven Selected Areas?	Effective	
2	How effectively did the LTIM project evaluate the contribution of CEW to the Basin Plan objectives (includes Chapter 8 and 9 objectives)?	Moderately effective	
3	How effectively did the LTIM project evaluate the ecological outcomes of CEW at the seven Selected Areas?	Moderately effective	
4	To what extent did the LTIM project infer ecological outcomes of CEW to areas in the Basin not monitored?	Minimally effective	
Focal Area 2: To what extent has the project supported the CEWO's legislative reporting requirements			
7	How well has the LTIM project contributed to the CEWO's ability to meet their legislative reporting requirements?	Moderately appropriate	
Focal Area 3: How well has the LTIM project demonstrated environmental outcomes			
6	How effectively has the LTIM project demonstrated outcomes?	Moderately effective	
Focal Area 4: How well were findings communicated to stakeholders			

KEQ	Question	Rating	Rating
5	How effective was the LTIM project at communicating key findings?	Moderately effective	
Focal Area 5: To what extent was the LTIM project fit for purpose			
8	To what extent was the LTIM project design fit for purpose in meeting the CEWO's strategic requirements?	Moderately appropriate	
Additional KEQ relating to Impact and Efficiency			
9	To what extent has the LTIM project had an impact in terms of improving water management practices?	Moderate impact	
10	How impactful have the LTIM project been in fostering improved collaboration?	Moderate impact	
11	How efficiently has the LTIM project achieved its objectives and outcomes?	Moderately efficient	
12	How efficient was the collaborative process within the LTIM project?	Moderately efficient	
13	How efficient was the LTIM project in managing and sharing data?	Inefficient	
14	How efficient was the LTIM project in generating the agreed outputs?	Moderately efficient	

3.1 FOCAL AREA 1: TO WHAT EXTENT HAS THE LTIM PROJECT ACHIEVED ITS OBJECTIVES?

The first focal area is addressed by the first 4 of the high-level KEQs which assess the extent to which LTIM project met its objectives. The overarching objective of LTIM is:

- To evaluate the contribution of Commonwealth environmental water to Basin Plan environmental objectives.

This is assessed by 4 KEQs:

- How effective as the LTIM project in planning, reporting and collaborating to support adaptive management
- How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at each of the 7 Selected Areas
- How effectively did the LTIM project evaluate the contribution of Commonwealth environmental water to the Basin Plan objectives (specified in Chapter 8 and 9).
- How effectively did the LTIM project evaluate the ecological outcomes of Commonwealth environmental water at each of the seven Selected Areas.

Further details of the objectives of the LTIM project are provided in Butcher and Schreiber (2020).

3.1.1 KEQ 1 – HOW EFFECTIVE WAS THE LTIM PROJECT IN PLANNING, REPORTING, AND COLLABORATING TO SUPPORT ADAPTIVE MANAGEMENT?

Supporting the adaptive management of CEW evolved to become the major focus of LTIM project. However, despite this, the project had no well-coordinated and systematic approach to the planning, capturing and disseminating adaptive management lessons. There were a variety of formal reports that addressed adaptive management learnings. These all contain useful intelligence, but there appears to have been no process for consolidating this information.

Clearly, there was good collaboration at the local Selected Area scale, which led to effective and adaptive management of CEW in these areas. One issue highlighted in the interviews with end users was the timing and frequency of reporting, which did not always meet the needs of water managers because reports on one year's watering came after decisions were made for the next year. However, in many cases this shortcoming was overcome by personal contact between managers and scientists particularly during planning for the years environmental watering. Collaboration and adaptive management was less effective at the Basin-scale.

This evaluation suggests that there would be value in improving knowledge management in relation to adaptive management. This could include a 'knowledge broker' to collaborate with the Selected Area and Basin Matter teams and environmental water managers, to identify, collect, synthesise and collate adaptive management learnings on a continuous basis.

The stakeholder interviews suggest that the original intent of LTIM was that the adaptive management learnings would be captured by the CEWO staff and consolidated. Obviously, this did not happen and an excellent opportunity was lost. However, some aspects of the adaptive management outcomes from the LTIM project have been captured in two peer-reviewed publications by LTIM researchers (Webb et al., 2018; Watts et al., 2020).

The Evaluators assessed the Pilot Evaluation undertaken in 2014-15, which was intended to test the proposed Basin-scale evaluation process and the use of the CEWOs Outcomes Framework (CEWO, 2013). Our assessment was that although there was limited data, the pilot met many of its objectives and provided valuable lessons. However, there is no evidence that these were fed back to the Basin Matter and Selected Areas teams. It appears that learnings from the pilot did not influence the future LTIM project.

Our assessment of the Annual Forum was that it was planned, run and reported on in an effective way that provided support for collaboration and adaptive management. Organisation of the forum and contributions by participants, improved over the 5-years of the LTIM project. In general, we found there were shortcomings related to collaboration within LTIM, particularly between Selected Area and Basin Matter teams, but in contrast to this, the Annual Forum, was an effective means of bringing the various teams together.

The Evaluators found that there were issues with technical review and consultation. There seems to have been a lack of consultation in relation to the development of Basin Matter foundation reports and the development of the Basin Evaluation Plan. There were also issues with the technical review of the Selected Area evaluation reports.

A major barrier to adaptive management was the effectiveness of the data management system. Issues with getting data into and out of the system, version control and QA/QC caused confusion and delay.

3.1.2 KEQ 1A - HOW EFFECTIVE HAS THE LTIM PROJECT BEEN IN MONITORING THE ECOLOGICAL RESPONSE TO COMMONWEALTH ENVIRONMENTAL WATERING AT EACH OF THE SEVEN SELECTED AREAS?

Overall, the ecological response to CEW was effectively monitored at the Selected Areas. Monitoring was supported by thorough planning with the documentation of standard methods, monitoring requirements and development of Monitoring and Evaluation Plans (MEPs) for each Selected Area. MEPs were subject to technical review by the M&E Advisers. There was also a comprehensive stakeholder consultation process. The service providers undertaking monitoring generally had high levels of expertise and undertook their activities in a way that was consistent with planning.

There were issues at some Selected Areas. In particular, at the Warrego-Darling, suffered instrument failure and loss of data in the first year and again in the high flow year of 2016-2017. In the Lachlan, vegetation sites appear to have not been well selected with limited monitoring at sites that received CEW in multiple years.

Each of the Selected Areas have provided annual technical reports in which the details of their monitoring methods and the response(s) to CEW are provided. We understand that these technical reports are reviewed internally by each Selected Area team. In 2017 it appears they were also reviewed by the Basin Matter team, but this external review was apparently only undertaken in one year. We are unaware of the reasons why this external technical review was discontinued but believe the lack of independent peer review is unfortunate and has reduced the credibility of the monitoring programs.

Two relevant comments from the survey and interviews were: the monitoring design, indicators and methods were focussed on collecting data to inform Basin-scale evaluation, which compromised evaluations in some Selected Areas; and over time other useful indicators were identified and in some cases introduced as special sub-projects, an adaptive response that has contributed to improvements in evaluating ecological responses.

3.1.3 KEQ 2 - HOW EFFECTIVELY DID THE LTIM PROJECT EVALUATE THE CONTRIBUTION OF CEW TO THE BASIN PLAN (CHAPTER 8 AND 9) OBJECTIVES?

The Basin Plan has three overall environmental objectives (S8.04) - to protect and restore water-dependent ecosystems (S8.05)²; to protect and restore the ecosystem functions of water-dependent ecosystems (S8.06)³; and to ensure water-dependent ecosystems are resilient to climate change and other risks and threats (S8.07)⁴ – and further objectives related to water quality and salinity (S9.04).

At a broad level, the LTIM project is well aligned with the Basin Plan objectives seeking to evaluate the contribution of CEW at a Basin-scale in four areas: biodiversity, ecosystem processes, resilience and water quality. Details of the rationale for this alignment is provided in the CEWO Outcomes Framework (CEWO, 2013), the LTIM Logic and Rationale Document (Gawne et al., 2013) and the LTIM Basin Evaluation Plan (Gawne et al, 2014b).

However, there are some shortcomings. LTIM was not closely aligned with biodiversity objectives related to threatened species or with international conventions related to protection of migratory birds or internationally significant ecosystems. There does not seem to have been consideration of threatened or representative species or communities during selection of areas to be monitored, except perhaps the Southern Bell Frog in the Murrumbidgee.

The Evaluators found that there were issues in relation to the water quality and salinity Basin Plan objectives. The LTIM and Basin Plan objectives were only moderately well aligned, and the evaluation of CEW to meeting these objectives was minimally effective. There was a lack of regular monitoring of water quality constituents and there was no attempt to use data collected by others. These issues were acknowledged early in the project but were not addressed, possibly for budgetary reasons.

A major issue, noted by the Evaluators, was reporting at the Basin-scale. This required inferring outcomes from measurements in Selected Areas, to the whole of the Selected Areas then thence to the Basin as a whole. This was not achieved in any quantitative way. The deficiency was caused by problems with data and lack of a comprehensive approach to predictive model building, and a lack of clarity around the role of Selected Area teams in inferring results to areas not monitored. This issue was addressed in planning but never taken on during the project.

Evaluation of the six specified Basin Matters was rated as moderately effective. The key issues we wish to highlight are:

- Hydrology – this was generally effective except for inundation modelling. Lack of inundation modelling was noted as a major project risk during initial planning and unfortunately, this was never adequately addressed.
- Ecosystem diversity – this was addressed effectively at the Basin-scale.
- Vegetation – the challenge was the delay in developing predictive models.
- Fish – evaluation was effective in the final year of the program once data and modelling issues were beginning to be addressed.
- Stream metabolism and Water quality – the stream metabolism component was done effectively for the southern Basin, but minimally effectively for the northern Basin, and the Basin-scale evaluation of the effect of CEW on water quality was rated as minimally effective
- Biodiversity – provided a useful summary of the contribution of CEW to biodiversity-related objectives of the basin plan, but offered few adaptive management lessons.

Stakeholder comments (survey, interviews) were somewhat mixed regarding the effectiveness of the Basin-scale evaluations with some of the main points being: the hydrologic contribution has been well demonstrated; approaches to other themes (e.g. fish and vegetation) continued to develop through the program; the degree to which cumulative analysis was undertaken was poor; it has been challenging to convert a series of annual

² This objective is focused on protecting and restoring a subset of water dependent ecosystems, including Ramsar sites and other ecosystems which support species listed under international treaties, and biodiversity (representative native biota; threatened species).

³ This objective is focused on connectivity within and between water-dependent ecosystems, including the Lower Lakes and Murray Mouth; habitat diversity; biological populations; and ecological community structure and, species interactions and food webs. A minor point is that LTIM did not address the Basin Plan requirement relating to hydrologic connectivity 'vertically between surface and subsurface' (S8.06, 3(b)(iii)) as groundwater monitoring was not undertaken in any Selected Area and is not mentioned in the MEPs.

⁴ This objective is focused on resilience, protecting refugia and minimising habitat fragmentation; and providing wetting and drying cycles and inundation intervals that do not exceed ecosystem tolerances.

outcomes into a cumulative outcome; there is need to question the concept of a Basin-scale response compared to regional or local-scale response; and there is still confusion about what Basin-scale evaluation means.

The current relevance of the CEWO Outcomes Framework that guided the design of the LTIM project has also been questioned. This framework was developed so that ecological outcomes at local-scales and in annual timeframes could be mapped to the Basin Plan objectives, because it was thought that this information would be needed for the CEWO's legislative reporting obligations. However, it has been suggested that much of this information was not needed, and yet the LTIM objectives have remained unaltered as have the Selected Area contracts.

3.1.4 KEQ 3 - HOW EFFECTIVELY DID THE LTIM PROJECT EVALUATE THE ECOLOGICAL OUTCOMES OF COMMONWEALTH ENVIRONMENTAL WATER AT THE SEVEN SELECTED AREAS?

The initial evaluation plan for LTIM identified that both qualitative and quantitative analysis methods could be used to evaluate the ecological, outcomes (Gawne et al. 2014c):

- *Qualitative analysis methods* - where predictions of outcomes are descriptive or based on conceptual models that only enable qualitative predictions (increase, decrease or no response) – these approaches would be used to provide a better understanding of the relationships between the indicators and to assist in making predictions about the influence of CEW on trends through time and responses to particular environmental watering events
- *Quantitative analysis methods* - where model-based approaches (e.g. statistical hierarchical models) and sometimes 'counterfactual' analysis (i.e. observations or inferences about conditions with and without CEW) are used to provide more quantitative information to evaluate the ecological outcomes of CEW at either local or Basin-scale.

The Selected Areas provided primarily qualitative evaluations of the ecological outcomes of CEW, although towards the end of LTIM more quantitative analysis methods were being trialled by some teams. The Goulburn Selected Area was a standout in the use of Bayesian hierarchical models for their evaluations.

The survey and interview responses from service providers noted the considerable difficulty in meeting the CEWOs requirements to separate the outcomes that could be attributed to CEW from those caused by environmental water from other sources. This was identified as a particular problem with some floodplain wetlands, where there were water sources and events occurring at the same time. This requirement to evaluate the contribution of CEW, while understandable, is nevertheless artificial in that it is the total amount of environmental water available that assists in providing required flow regimes regardless of who owns the water.

A number of specific challenges were identified in the monitoring and evaluating the ecological benefits of environmental water in the Warrego-Darling Selected Area. These included: the unregulated nature of the catchment so that it was not possible to have designed deliveries from a regulated storage; the difficulty in responding to inflows; flows which are often contained a small proportion of CEW; and years where parts of the system were dry during scheduled monitoring periods. Some monitoring equipment was also lost during high flows.

An additional challenge was that results from Warrego-Darling were not considered appropriate to infer outcomes in the northern MDB, which means there was only one site in the northern Basin that could be used to infer Basin-scale evaluations.

Stakeholders also commented that evaluation of the cumulative effects of CEW (and other environmental water) over the 5-years of LTIM were not very effective, and that the lack of interaction between the Selected Area teams, and between the Selected Area teams and the Basin Matter team, made the integration of information and reports difficult because each group was largely working in isolation.

3.1.5 KEQ 4 – TO WHAT EXTENT DID THE LTIM PROJECT INFER ECOLOGICAL OUTCOMES OF COMMONWEALTH ENVIRONMENTAL WATER TO AREAS IN THE BASIN NOT MONITORED?

Inference of the ecological contribution(s) of CEW in non-monitored areas in the Basin is a very challenging task, made even more difficult by the lack of an overall strategy of how to do this, a lack of data to guide inference in non-monitored areas (particularly in the northern Basin), and a lack of robust predictive models.

The need to infer ecological outcomes in non-monitored areas was a key objective of the LTIM project and is acknowledged in planning documents, the Selected Area MEPs, and in the Basin Matter synthesis reports, but almost nothing was done about this requirement. None of the Selected Area services providers extrapolated their findings from reach to whole of Selected Area scale, while the Basin Matter synthesis reports (and some of the six Basin Matter reports) did at least make an attempt to use information from the Selected Areas and elsewhere to infer the contribution of CEW in non-monitored areas (e.g. hydrology and ecosystem diversity). The models for fish and vegetation that were built during the final year of the project have potential to assist with making inferences, but were developed too late to inform evaluation for the LTIM project and have yet to be validated.

Stakeholder comments (survey, interviews) were somewhat mixed regarding the effectiveness of attempts to infer ecological outcomes in non-monitored areas of the Basin with some of the main points being: that this was a challenging space for the LTIM scientists; this was an incredibly hard task; progressive improvement was achieved through the life of the project; we underestimated how complex these systems are in that two wetlands next to each other can be completely different for completely different reasons; hydrology did well but other indicators not so well; and extrapolation of stream metabolism and primary production knowledge made progress.

3.2 FOCAL AREA 2: THE EXTENT TO WHICH THE PROJECT SUPPORTED THE CEWO'S LEGISLATIVE REPORTING REQUIREMENTS

3.2.1 KEQ 7 - HOW WELL HAS THE LTIM PROJECT CONTRIBUTED TO THE CEWO'S ABILITY TO MEET THEIR LEGISLATIVE REPORTING REQUIREMENTS?

The CEWO reporting requirements are described in the *Water Act 2007* and the Basin Plan (S12). The LTIM project has contributed to some of these reporting requirements, but not all. Annual Basin-scale evaluation reports provide information on the contribution of CEW to protection of biodiversity, ecosystem function and resilience of the water-dependent ecosystems of the MDB. Although valuable, for most Basin Matters, these reports are focused on information collect at the Selected Areas. As noted elsewhere, there were challenges in obtaining a Basin-scale synthesis for matters such as vegetation and fish.

The LTIM project is not contributing appropriate information in a number of areas where the CEWO is required to report. For example, the water quality targets (see Basin Plan, Schedule 11), implementation of the water quality and salinity plan, and the extent to which local knowledge and solutions inform implementation of the Basin Plan. However, we note that the task of reporting on progress towards the Basin Plan Schedule 7 objectives is potentially a huge task for the CEWO.

Stakeholder feedback (survey, interviews) regarding the level of the CEWO's legislative reporting requirements was that this has not turned out to be as onerous as was originally thought when the LTIM project was being designed. With this in mind there may be scope for the design of the CEWO's future monitoring programs to be less constrained by perceptions of Basin-scale legislative reporting requirements.

3.3 FOCAL AREA 3: HOW WELL HAS THE LTIM PROJECT DEMONSTRATED ENVIRONMENTAL OUTCOMES

3.3.1 KEQ 6 - HOW EFFECTIVELY HAS THE LTIM PROJECT DEMONSTRATED OUTCOMES?

The LTIM project has been moderately effective at demonstrating outcomes.

For the Selected Areas, results varied from relatively good quantitative assessments (developing statistical models) to qualitative assessment, which in the case of the qualitative assessments essentially reduced to assessments that because CEW was delivered and because a particular ecological indicator improved, therefore CEW was beneficial. There is considerable scope for most of the Selected Areas to increase use of statistical models to better demonstrate the contributions of CEW (and other environmental water) to achieving particular ecological outcomes.

In terms of the Basin Matters, there is tension between the design of the project around Selected Areas and the need to report at the Basin-scale. This has created a mismatch of scales for monitoring and reporting that particularly applies to vegetation, fish, biodiversity, and stream metabolism and water quality. This is less of an issue for hydrology and ecosystem diversity as these are based on Basin-scale evaluations. Similar to comments

related to Selected Areas, there is substantial scope to increase the quantitative rigour of the demonstration of outcomes through the use of predictive models to provide counterfactuals and infer outcomes to areas not monitored.

Quantitative demonstration of ecological outcomes at the Basin-scale was challenged by the lack of a method to infer outcomes to areas not monitored. Qualitative descriptions of outcomes are provided in the annual synthesis reports.

3.4 FOCAL AREA 4: HOW WELL DID THE LTIM PROJECT COMMUNICATE ITS KEY FINDINGS

3.4.1 KEQ 5 - HOW EFFECTIVE WAS THE LTIM PROJECT AT COMMUNICATING KEY FINDINGS?

The LTIM project was moderately effective at communicating key findings. A key issue was lack of an overall communications strategy from the commencement of the LTIM project. Most of the Selected Areas developed a communications plan which was included in their Monitoring and Evaluation Plan. However, implementation of these plans was patchy. In general, there was a lack of reporting on what communication activities were undertaken by Selected Area and Basin Matter teams and other project members. We were not able to find any evidence that the CEWO drew together and documented communication activities that took place within the LTIM project or coordinated overall communication activities. As stated above communication activities were not part of the original LTIM project, but should have been.

This is not to say that there was no communication of results there were a range of regular reports by Selected Area, Basin Matter teams and M&E advisors. Additionally, part way through the LTIM project the CEWO provided additional funding to encourage more collaboration within the project and to improve external communication of the key findings. The survey and interviews were silent on the success or otherwise of this additional funding.

Consistent feedback from the interviews was that neither the Selected Area nor the Basin Matter reports were particularly effective in targeting key stakeholders. Some thought these reports were more targeted at the CEWO staff rather than other water managers or community members. Additionally, the interviews made it clear that while adaptive management was reasonably effective within each Selected Area, learnings were not well captured and transferred between catchments and to areas not monitored. Additionally, the view was expressed that the cumulative effects of adaptive management over the longer term both locally and Basin-wide were not captured.

Stakeholders were very supportive of the broader community engagement activities by Selected Area teams with one interviewee suggesting the '[this type of communication] *has really helped to build relationships with community members that may not be as supportive of environmental water as we all might be*'. However, many were critical of the broadly poor communication of Basin-scale results and findings, which consisted only of annual reports and presentations at the Annual Forums. Some interviewees felt that the initial LTIM project design was flawed in that an overall communications strategy was not developed at the start. Other comments related to: a lack of clarity about who the audience was for the different components of the LTIM reports; and the communications being targeted more at the scientific community and not the broader messaging that goes out to people. There was a telling comment by one interviewee who said a consultant was engaged to go through the various reports to identify key messages. Clearly the original reports did not meet the needs of that stakeholder. Specific issues that relate communication to support adaptive management are discussed under KEQ1.

3.5 FOCAL AREA 5: TO WHAT EXTENT WAS THE LTIM PROJECT FIT FOR PURPOSE?

3.5.1 KEQ 8 - TO WHAT EXTENT WAS THE LTIM PROJECT DESIGN FIT FOR PURPOSE IN MEETING THE CEWO'S STRATEGIC REQUIREMENTS?

The evaluators assessment was that the LTIM project design was moderately appropriate in terms of being fit for purpose in meeting the CEWOs strategic requirements.

One point of assessment relates to whether objectives are SMART⁵. The program logic as specified in Gawne et al. (2013) facilitated SMART objectives however not all objectives were specified in a way that could be considered SMART. An example is the lack of 1-year and 5-year objectives for ecosystem diversity. This lack of SMART objectives was noted in earlier reviews but does not appear to have been addressed.

There were major issues with predictive modelling in LTIM which was generally either not done as expected or delivered late in the project. Problems relate to planning, data management and sample design.

The Basin-scale Evaluation Plan developed for LTIM was fit for purpose in most areas. However, an important gap was the lack of a specified process for inferring outcomes in areas that were not monitored. This required predictive modelling which has implications for site selection, measurements of covariates and the development and testing of stochastic relationships (see Section 4.5). The lack of attention to modelling at the program design stage contributed to delays and the overall poor performance of this modelling task.

Data management was a major issue for LTIM. This is discussed under a range of headings in this report but in terms of project design, many problems seem to have been recognised at planning stages but not addressed until near the end of the project. Reporting, survey response and interviews all point to data management issues. These clearly improved toward the end of LTIM but caused significant problems during the first four years.

The LTIM project design made appropriate use of existing scientific and complementary knowledge and cause and effect diagrams in developing appropriate standard methods (Category I and II methods) that were consistently applied in each Selected Area. And, best available scientific and local knowledge was appropriately used to develop the Selected Area MEPs to assess the monitoring results and to evaluate the findings regarding the contribution of CEW to the ecological outcomes. However, there was no apparent consideration of cultural knowledge.

Some stakeholders questioned the appropriateness of the current LTIM program logic, which commenced with the focus on being able to evaluate the Basin-wide contributions of CEW (and other environmental water) based largely on information provided at a Selected Area local-scale. However, the LTIM project became focused on evaluation at the seven Selected Areas with a lesser focus on integrating these local-scale findings to the Basin-scale. This increased focus on Selected Area is reflected in the CEWO's investment in LTIM, with approximately the same funding for the entire Basin Matter team as for **each** Selected Area team.

3.6 IMPACT AND EFFICIENCY KEQS

3.6.1 KEQ 9 - TO WHAT EXTENT HAS THE LTIM PROJECT HAD AN IMPACT IN TERMS OF IMPROVING WATER MANAGEMENT PRACTICES?

It seems clear from our evaluation, and from stakeholder feedback, that the LTIM project has had an impact in improving environmental water management practices in the MDB, and through this to informing and improving Basin Plan implementation. However, there is little well documented information (evidence) available for this generally agreed finding. There are very few comments in reports on exactly how environmental watering management practices have changed as a result of the new knowledge generated. One exception was the Goulburn Selected Area (Webb et al., 2020) where it was noted that new knowledge had improved the timeliness of decision making and the design of flow actions to maximise ecological outcomes.

It is known that the very good interactions between Selected Area teams and the CEWO Water Delivery teams, and the timely input of new knowledge, did result in changed environmental watering management practices, and thus improved Basin Plan implementation (Hart and Butcher, 2018). However, the impact of these 'science-practice partnerships' on Basin Plan implementation was only moderate because the outcomes were poorly communicated within the LTIM project team and with key stakeholders.

In general, decision-making processes related to water management are not transparent, a finding also noted in the mid-term review of LTIM by Hart and Butcher (2018). However, there is some additional evidence from the survey, written responses to survey questions and the interviews.

⁵ 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.

The Evaluators found that knowledge gained through the LTIM project has been moderately impactful in informing and improving Basin Plan implementation and/or outcomes. Both survey and interview responses were a mixture of positive and negative sentiments.

Similarly, the impact of the LTIM project on adaptive management of environmental water was rated as moderate. However, there was a mix of positive responses at the Selected Area scale and negative at the Basin-scale. It was thought that Selected Area scale environmental water managers needed to rely on only a few contacts for advice and that LTIM has expanded the range of advice available. However, at the Basin-scale, the LTIM project's capacity to impact environmental water management was more difficult for two reasons: first, the Basin-scale information base regarding the ecological outcomes of CEW was considerably less than that at the Selected Area scale; and second, the links between the Basin Matter team and the environmental water managers was not strong.

One end-user commented on the impact of the LTIM project in demonstrating the local benefits of managed environmental water events in the Edward-Wakool system. This region has been particularly contentious regarding environmental flows. It was noted that in-stream vegetation responses have been good, as have water quality benefits for salinity, but not for large-scale hypoxic blackwater mitigation or blue-green algae. Another key finding was that there have been limited outcomes for native fish breeding, probably because of the current limited scale of the environmental water flows allowed in this system.

3.6.2 KEQ 10 - HOW IMPACTFUL HAS THE LTIM PROJECT BEEN IN FOSTERING IMPROVED COLLABORATION?

While the LTIM project facilitated a range of collaborative activities, including: the Annual Forum; Selected Area leads workshops; workshops to refine fish monitoring methods; and Basin Matter workshops for vegetation, ecosystem diversity and biodiversity, there was still a relatively low level of collaboration in the project.

Stakeholder feedback (survey, interviews) suggests that the LTIM project has had considerable impact in fostering improved collaboration between the CEWO Delivery Team, the associated state environmental water managers, and with Selected Area scientists. It was noted that these improved relationships were primarily associated with Selected Area sites, and the CEWO water managers responsible for other areas often are 'out of the loop' in terms of information sharing and collaboration.

Also highlighted were the advantage of the consortium approach used to establish the Selected Area teams, with university scientists, water agency scientists and environmental water managers, and consultants all working together.

Stakeholder feedback regarding the LTIM project's impact in raising awareness of the CEWO's aims and approaches suggests this has been quite effective within Selected Area teams and associated environmental water managers, but there was no information available to gauge any change in awareness amongst Basin communities more generally.

3.6.3 KEQ 11 - HOW EFFICIENTLY HAS THE LTIM PROJECT ACHIEVED ITS OBJECTIVES AND OUTCOMES?

The evaluation of this KEQ has been challenging because of a lack of data. There was insufficient evidence to address the following issues:

- The efficiency of allocating funds and time to address the LTIM project objectives at the Selected Area scale, at the Basin-scale and by Basin Matter
- The extent to which the project attempted to improve over time, by finding better or lower cost ways to deliver outcomes.

Based on those questions that could be addressed, the LTIM project has been evaluated as moderately efficient in achieving its objectives and outcomes.

Implementation of the Selected Area monitoring programs appears to have been technically efficient. Interview responses suggest that some were concerned with the cost and time allocated to some indicators.

There were issues with efficiency of the Basin-scale evaluation. This relied on predictive modelling which was delayed or not carried out. Efficiency was also reduced because of problems with data management.

3.6.4 KEQ 12 - HOW EFFICIENT WAS THE COLLABORATIVE PROCESS WITHIN THE LTIM PROJECT?

The importance of collaboration appears to have been underestimated in the early stages of LTIM. It is clear from the survey and interviews that the initial LTIM project did not place much focus on the need for collaboration between the various teams. And while collaboration across the LTIM project did improve after the first two to three years, this lack of collaboration could have been addressed if there had been a consolidated LTIM project collaboration and communications plan from the start. Additionally, and related, there is essentially no documentation of the efforts to facilitate collaboration and the outcomes from these efforts.

One positive feature was the annual forums which seemed to work well, had good engagement and were well reported.

3.6.5 KEQ 13 - HOW EFFICIENT WAS THE LTIM PROJECT IN MANAGING AND SHARING DATA?

The LTIM project data management arrangements were inefficient in both systematically capturing data and in sharing this data, and this caused delays in key aspects of the project.

In particular, the issues that plagued the monitoring data management system (MDMS), were identified early but were not addressed until the later stages of LTIM (see KEQ1.7). These data management issues resulted in a series of project problems, including: a reluctance by Selected Areas to use MDMS (they generally used their own data management arrangements); difficulties for the Basin Matter team in accessing Selected Area data needed to undertake their Basin-scale evaluations; and delays in the development of predictive models.

3.6.6 KEQ 14 - HOW EFFICIENT WAS THE LTIM PROJECT IN GENERATING THE AGREED OUTPUTS?

The LTIM project was moderately efficient in using available resources to generate agreed outputs. The project had some impressive achievements but there are things that could have been done better. Particular issues that created inefficiencies were: data management, delays in quantitative modelling and inconsistencies in monitoring of some indicators across the Selected Areas.

Our evaluation is that the project was moderately efficient in producing useful new understandings at the Selected Area scale, inefficient in using this Selected Area and other knowledge in producing new understandings at the Basin-scale, and moderately efficient in improving the adaptive management of CEW and other environmental water, at least in the seven Selected Areas.

4 FOCAL AREA 6: POSSIBLE IMPROVEMENTS TO THE CEWO'S FUTURE MONITORING AND EVALUATION ACTIVITIES

This section contains a discussion of possible improvements to the CEWO's future monitoring and evaluation activities. These relate to:

- Purpose and objectives
- Project design
- Ecological indicators
- Quantitative modelling
- Data management
- Reporting and communications
- Project management
- Collaboration

4.1 PURPOSE AND OBJECTIVES

The initial planning for the LTIM project identified⁶ five objectives that can be summarised as two high level goals, namely to:

- Demonstrate the ecological outcomes from CEW actions
- Support the on-going adaptive management of CEW actions.

In pursuing these goals, the LTIM project:

- Monitored ecological indicators at 7 Selected Areas receiving CEW
- Used these data to evaluate the ecological outcomes at each Selected Area⁷
- Extrapolated this local data to provide an evaluation of the outcomes of CEW across the Murray-Darling Basin to produce an assessment of Basin-scale ecological outcomes.

The initial decision regarding LTIM's focus on Basin-scale evaluation appears to have been driven by the CEWO's interpretation of its reporting requirements. These are specified in the Basin Plan and relate to the Environmental Watering Plan (Chapter 8) and the Water Quality and Salinity Plan (Chapter 9). The objectives in the Basin Plan were interpreted in the initial LTIM Program Logic to be related to four themes: biodiversity, ecosystem function, resilience, and water quality and salinity.

The Evaluators have noted a tension between the need to evaluate ecological outcomes of CEW at the local-scale (Selected Areas) and the requirement to also produce Basin-scale evaluations. This had implications for the choice of indicators, the need to share data within the LTIM project, and the desire to infer the ecological outcomes attributable to CEW in non-monitored areas. Our evaluation is that these tensions have not been successfully resolved.

A number of stakeholders interviewed suggested that the CEWO's interpretation of legislative reporting requirements under the Basin Plan should be reviewed for two reasons. First, the reporting requirements expected by the MDBA have turned out to be not as onerous as initially thought, and second, the Basin Environmental Watering Strategy (BEWS) was published in 2014 (and was updated in 2019), after the commencement of LTIM.

The BEWS is one of the planning instruments under the Basin Plan Environmental Management Framework (Chapter 8 Part 4) which is intended to inform annual watering priorities and ultimately contribute to the achievement of the Basin Plan objectives. The current version of the BEWS focuses on four components of the Basin's water-dependent ecosystems: river flows and connectivity, native vegetation, waterbirds, and native fish. The BEWS documents the expected environmental outcomes that can be achieved beyond 2019 across these four components.

The Evaluators have assumed that the CEWO will require that any future monitoring and evaluation activities will have the same two high level objectives noted above. Clearly, the focus on adaptive management should remain to ensure the new knowledge gained from the local-scale monitoring is used to improve environmental water management at both the local- and Basin-scale.

However, the challenge for the CEWO will be to agree on the scope of the key ecological objectives to demonstrate the ecological outcomes from CEW. Clearly, the CEWO must demonstrate the contribution of CEW to Basin-scale objectives as specified in the Basin Plan, which has implications for the types of local-scale data needed and also for the prediction of ecological outcomes at non-monitored sites in the Basin.

The Evaluators recommend that in deciding upon the scope of the ecological objectives, the CEWO seek to map the objectives of any future monitoring and evaluation activities as a minimum to the four themes of the BEWS. In addition, there will need to be consideration of the Basin Plan Environmental Watering Plan objectives to identify any gaps. In particular, objectives around resilience will become increasingly important because of climate variability and change (as discussed below).

The BEWS also provides a new focus on water quality and salinity. Each Basin state as part of their regional water resource plans (WRP), has developed a water quality management plan with associated procedures for water quality (and salinity) monitoring and evaluation. We consider it appropriate for the CEWO to reconsider their requirements related to reporting on water quality and salinity and seek to collaborate with water quality

⁶ The Head Contract for the LTIM project had 10 objectives which includes the 5 identified in Gawne et al. (2013, 2014d) – see Butcher and Schreiber (2020)

⁷ Lower Gwydir; Lachlan; Murrumbidgee; Edward–Wakool; Lower Goulburn; Lower Murray River; Junction of the Warrego and Darling.

managers rather undertake their own evaluation of the interactions between environmental flows and water quality.

The Evaluators note that the MDBA and the CEWO hope to partner with Northern Basin Aboriginal Nations and the Murray Lower Darling Rivers Indigenous Network to develop methods that can incorporate First Nations' environmental watering objectives into environmental water planning (MDBA 2019). The BEWS provides a case study on achieving Ngiyampaa First Nation cultural outcomes through environmental flows. This should also inform the development of objectives for the next monitoring project.

It is also recommended that the CEWO: decide whether the primary objective of future monitoring and evaluation activities is to be focused on Basin-scale reporting or on both Basin-scale and local scale; map this objective with the four themes of the BEWS; consider the inclusion of an objective related to First Nations water needs and consider any additional activities that may be required to meet Basin Plan objectives (**Recommendation 1**).

It is recommended that the CEWO undertakes limited water quality and salinity monitoring and obtains any required water quality and salinity information from the agency responsible for implementing the appropriate water quality management plan (**Recommendation 2**). This will assist in defining clear lines of responsibility for management and reporting of water quality and overcome the problems with the ad hoc water quality monitoring that was undertaken during LTIM which provided little useful information

4.1.1 CLIMATE VARIABILITY AND CHANGE

Climatic extremes can have a major impact on the ecological condition of rivers. This is generally well recognised by environmental water managers who are always more concerned with the extremes (e.g. droughts and floods) rather than 'averages'.

Environmental water management during periods of drought is particularly difficult. These are the times when rivers, wetlands, and the biota that depend on these systems, become stressed, and there is insufficient environmental water available to meet the requirements of all waterways. Current environmental water management during periods of drought generally focusses on ecological refuges, for example, waterholes and wetlands that support threatened species or high numbers of native species and can readily receive environmental water.

But higher flows (floods) can also lead to problems as was graphically illustrated in the Edward-Wakool system in 2016-2017 when 96% of the Murray Cod population were killed because of low dissolved oxygen concentrations during a flood-induced blackwater event. This is an example where environmental watering which resulted in improved ecological outcomes in average years, can be undone during an extreme event. And in this case, if another next extreme event happened before the fish populations could recover, it is likely they would not survive (Anderson, 2019).

The frequency of extremes will increase with a warming climate and this is being considered as part of the management of environmental water. One of the Basin Plan objectives is to increase resilience of water-dependent populations of native flora and fauna. Chapter 3 of the BEWS provides water management strategies to achieve expected environmental outcomes, some of which address climate. For example, in relation to native fish communities, the BEWS proposes to: 'maintain drought refuge habitats to build population resilience and to prevent catastrophic loss of fish populations during extended dry periods'.

Planning of the ecological responses to extreme events is taking place, at least to some extent. What is lacking, as demonstrated by LTIM is the monitoring of responses to extremes and to the outcomes of actions that are intended to mitigate these extreme responses. This monitoring needs to be flexible to the extent that the timing and location of issues and actions may not be known in advance.

The Evaluators recommend that monitoring of extreme events and responses to these events be included in future monitoring programs (**Recommendation 3**).

4.2 PROJECT DESIGN

4.2.1 LOCAL-SCALE MONITORING INFORMING BASIN-SCALE EVALUATION

It is clear that the CEWO's legislative requirement - to report on the contribution of CEW to the environmental objectives of the Basin Plan – requires a Basin-scale evaluation. However, the concept of what constitutes a 'Basin-scale evaluation' or an 'integrated Basin-scale evaluation' is 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 Basin) or single catchments. These aggregations will be informed by statistical models that draw on measured data and co-variates to predict outcomes in non-monitored areas. However, even the integration of the components making up a catchment is not a simple matter.

The initial LTIM project logic was to monitor the ecological outcomes of CEW (and other environmental water) at local scales and then use this data to scale up to determine (predict) outcomes at the Basin-scale. This presents a dilemma of sorts. As noted in the original logic, intervention monitoring is well served by using a before-and-after type monitoring approach to compare conditions before and after an environmental watering event, and typically also comparing outcomes with other non-watered locations. But with dynamic and transient ecosystems as experienced in the MDB, the outcomes may vary substantially from one environmental water event (intervention) to another and from place to place within areas where interventions occur. Therefore, monitoring the outcomes of environmental watering events is best served by monitoring the same location (e.g. a Selected Area) many times, such as has occurred in the LTIM project and at many sites within that location. However, this approach focuses monitoring resources on the Selected Areas and limits the ability to also monitor other areas of interest, whether watered or not. The extension of the results from the Selected Areas to the other parts of the Basin is unknown in the current program.

If data from Selected Areas is to inform Basin-scale evaluations, then it is necessary to start with that end objective in mind. This approach will only be effective if the Selected Areas cover the full range of both environmental watering actions and biophysical conditions expected throughout the Basin, and are also capable of providing sufficient data for the development and validation of predictive models. These models could also make use of data from monitoring programs other than LTIM (e.g. TLM), which would both strengthen the modelling and influence the choice of local areas for monitoring. This is discussed further below.

If the primary objective is to report at the Basin-scale then a better monitoring design would be to sample in a manner that better represents the Basin, that is by focussing resources across more locations and sampling each location less intensively. The trade-off achieved by sampling more intensively in time and less intensively in space as in the current LTIM project, is that the results are less generalisable at the larger spatial scale, but that individual watering events and local responses are better known.

Scaling up from these multiple local areas to the whole Basin requires knowledge of how representative the monitored areas are. This was an issue for the LTIM project, because there was the lack of local sites in the northern Basin. Only two sites were monitored during LTIM, the Lower Gwydir and the junction of the Warrego and Darling, with the latter not considered appropriate to guide inference to other areas in the northern Basin. This meant that the Lower Gwydir was the only site that could be used to infer ecological condition to over half of MDB. Additional sites that have been proposed include: Macquarie Marshes, Condamine-Balonne (including vegetation and waterbirds at Narran Lakes), and the Barwon-Darling system. It would be appropriate to monitor some, or all of these, at least occasionally, including in intervention and non-intervention years. In the current program, the Lower Gwydir is in danger of being erroneously interpreted as a bellwether site for the northern Basin.

A Basin-scale evaluation will need to be informed by monitoring and evaluation of the ecological outcomes of CEW actions at multiple local-scales. However, in light of the discussion above the question of whether a Basin-scale evaluation is best supported by multiple fixed Selected Areas or multiple variable Selected Areas needs to be resolved.

It is recommended that the CEWO determine whether a Basin-scale evaluation is best supported by multiple fixed Selected Areas or multiple variable Selected Areas before designing an appropriate monitoring and evaluation approach (**Recommendation 4**).

In addition, it is recommended that monitoring and evaluation of the environmental outcomes of CEW is expanded beyond the current two sites in the Northern Basin (**Recommendation 5**)

4.3 ECOLOGICAL INDICATORS

The ecological indicators selected for the LTIM project were driven by the CEWO's Outcomes Framework that provided links to Basin Plan objectives. This resulted in the six Basin Matter - hydrology, stream metabolism and water quality, fish, vegetation, biodiversity, ecosystem diversity.

The Evaluators have recommended that improved alignment to the BEWS be considered. This will require a mapping exercise to match the existing indicators to the BEWS key components. We have also suggested that water quality would be better addressed by those responsible for implementing water quality management plans rather than the CEWO.

Indicators should only be included if they are capable of being influenced by environmental flows. For the LTIM project, hypothesised links were developed through cause and effect diagrams (CED). There is now an opportunity to revise these CEDs based on the new understanding provided by the LTIM project. We suspect that the case for including some indicators, e.g. micro- and macro-invertebrates, needs to be revisited.

It is recommended that indicators be reviewed based on their performance in LTIM project and revised to improve alignment to the BEWS (**Recommendation 6**)

4.4 STANDARD METHODS

The other area that needs review is the application of standard methods for monitoring. The LTIM program logic and rationale document states 'An important component of the LTIM design and implementation phases will be to employ standard methods for indicator measurement, site selection and data management'.

The requirement of standard methods for data management and site selection is not questioned. However, standard monitoring (measuring) methods are not necessarily a good fit for measuring transient items, such as is generally experienced with ecological outcomes across large spatial scales. For example, it is expected that many environmental variables (e.g. flow and habitat and consequently, fish or vegetation species and communities), will vary between areas in the Basin. Hence, the best methods for measuring them could also be expected to be different between the different areas. No matter what method is used for measuring vegetation or fish, there will always be some bias towards or against collecting some species or size classes. It is therefore important that the indicators reflect this to allow comparisons and reporting relevant to Basin-scale evaluations.

The Evaluators believe that the *indicator* to be measured (or derived) is more important than the method used to measure it. If the same indicators are available across areas, regardless of how they are measured, then larger scale evaluations, or comparison of responses between the Selected Areas, are simpler to perform. However, if the aim is to better understand or evaluate the ecological outcomes *within* a Selected Area, then clearly repeating the measurements within the area is far more important than repeating the measurements *across* areas.

It is recommended that standard indicators be adopted across sites with the method adopted to inform that indicator being allowed to vary between sites if necessary (**Recommendation 7**).

4.4.1 EVALUATION PROCESS

The current LTIM project requires that the Selected Area monitoring results are evaluated to:

- Identify the effect of environmental watering
- Support adaptive management of the environmental watering and
- Support adaption of the monitoring program.

Additionally, these results are used by the Basin Matter team to make Basin-scale evaluations. Currently, the focus is on the outcomes of the CEW and not on all environmental water.

This Evaluation and input from the interviews provide the following considerations regarding future evaluations.

It is recommended (**Recommendation 8**) that evaluations should focus on:

- All environmental water (e.g. 'held' water and 'planned' or 'above Cap' water) and not just on CEW
- 'Counterfactual' assessments, that is evaluations with and without environmental water
- Quantitative assessments, that is greater application of quantitative statistical models, e.g. Bayesian hierarchical modelling.

4.5 QUANTITATIVE MODELLING

4.5.1 FLOW-ECOLOGICAL OUTCOME MODELS

The availability of quantitative models relating environmental water to ecological outcomes will be essential to evaluate the environmental benefits of CEW at both the local- and Basin-scale, and for inferring outcomes at non-monitored areas.

LTIM has seen the development of some quantitative models – for example, the Goulburn Selected Area has developed a number of Bayesian hierarchical models, and at the Basin-scale hydrological models are available for

the MDB and preliminary statistical models are available for fish, vegetation and metabolism. But overall model development has fallen far short of what was expected.

Predictive modelling of the effects of environmental water on fish and vegetation relies on statistical relationships between:

- Observations of the effect of environmental water at a site on the outcome of interest
- Numerical descriptions of the environmental water at the site and at locations where predictions are required
- Numerical descriptions of covariates⁸ at the site and at the locations where predictions are required
- Building the statistical relationships from observations and then applying them to new sites
- Validating the models using observations at sites that were not used to establish the original relationships.

The Selected Areas must be chosen such that the covariates that can be measured are appropriate to guide prediction across the whole Basin. Also, the range of environmental water events at Selected Areas (as measured by appropriate indicators) must represent the range that occur in areas where predictions are required and that the full range of covariates exists in the areas that are monitored.

The Evaluators stress the importance of the validation and confirmation of predictions for any modelling project and recommend the CEWO ensure this is part of any future monitoring and evaluation activity. A concern is that the Selected Areas are monitoring only a limited proportion of the CEWO's environmental watering events and because of this there are not a large number of data points for Basin-wide evaluations.

Further, validating any models using data from outside the Selected Areas is essential to aid in understanding how generalisable the Selected Area watering events are. Given the recommendations for covariates in the previous paragraph, we expect that predictions may be possible for a wide range of watered and non-watered locations outside the Selected Areas. Model validation should therefore aim to use independent sampling to populate the test locations data set. This will need to use a random selection strategy to select additional watered and non-watered areas for sampling. Typically, the test locations would not be permanent and would be re-selected, probably annually. A less valuable but still useful strategy, may be to use data from existing programs to validate the predictive models. For example, environmental water delivered by the CEWO or other agencies has been delivered to many locations throughout TLM program. Future and retrospective TLM data may be of use when validating and calibrating LTIM models. This approach does not allow a whole of Basin-scale assessment however as TLM sites have a southern bias by definition and the sites were also not selected to represent a specific population of watering sites.

Hart and Butcher (2018) in their mid-term review of LTIM recommended the need for a comprehensive modelling development plan 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). The Evaluators agree with the need for a well-resourced and detailed modelling plan for any future monitoring and evaluation activities.

It is recommended that the CEWO establish and resource a model development plan for any future monitoring and evaluation activities (**Recommendation 9**).

4.5.2 INUNDATION MODELLING

The lack of detailed inundation modelling (mapping) has been identified as a major issue in this Evaluation and also previously by Gawne et al (2017), the Joint Steering Committee (JVSC, 2017) and Hart and Butcher (2018).

The initial planning for Basin-scale evaluation was contingent on the availability of good floodplain inundation data both with and without CEW (Gawne et al. 2014). Floodplain inundation information was recognised as a critical need in the Basin Matter hydrology foundation report (Stewardson and Guarino, 2019), and the original plan was to provide daily inundation extents for major floodplains across the Basin with and without CEW (Stewardson and Guarino, 2015). The major risk that was identified at that time was that the MDBA was not able to provide model scenarios for stream flows or link these to modelled floodplain inundation. Unfortunately, this risk seems to have been realised.

⁸ Covariates could include: physical descriptions of stream channel and floodplain; descriptions of the biota; descriptions of climate; geology; soil types; vegetation; and elevation

Stewardson and Guarino (2020) did produce inundation mapping in the final hydrology Basin Matter report. These maps (models) were developed from a range of sources and were sufficiently detailed to inform the evaluation of ecosystem diversity. However, they were not useful for the evaluation of vegetation, with the vegetation Basin Matter team reporting that: 'The greatest constraint on the development of effective predictive tools for vegetation diversity,... is the availability of robust, Basin-wide inundation data with spatial and temporal resolution appropriate to the model framework' (Capon and James, 2020). The vegetation Basin Matter team was able to make some progress using inundation data derived from the *Water Observations from Space* remote sensing product available from Geosciences Australia. Similarly, the Murrumbidgee Selected Area team derived their own inundation mapping as part of evaluating the impact of CEW on wetlands.

It is recommended that a fit-for-purpose inundation modelling (mapping) method is developed to support any future monitoring and evaluation activities (**Recommendation 10**).

4.6 DATA MANAGEMENT

Data management has been a major issue for the LTIM project. It seems the original MDMS established by the CEWO was difficult to use, and largely for this reason Selected Area teams preferred to use their own data management systems rather than entering data directly into MDMS. They then exported a copy of their data to MDMS to honour their contractual obligation to upload data onto the MDMS. This however, resulted in QA/QC issues and major delays before the Basin Matter team could access the data and commence their actual evaluations. There were also version control issues; data that was informally supplied using spreadsheets differed from that in the MDMS and in some cases, incorrect data was used by Basin Matter teams for several years before this was resolved.

Many of the problems that plagued the MDMS were identified early in the project but took years to resolve. For example, problems of alternative names for common species were mentioned in 2013 (Brooks and Wealands, 2013) but drop-down lists to address this issue were not implemented until November 2018⁹). Survey results also highlight issues, with a significant proportion of participants reporting either that data management system was either 'not at all effective' or 'not so effective'.

The Evaluators understand that many of the issues with the MDMS software were addressed in the last year of LTIM, but we are not convinced that all data management problems have been addressed. It will be important that a future LTIM has a robust MDMS, with strong data governance and a dedicated data manager to ensure compliance. It is also important that data is protected against fire, vandalism and theft (Lindenmayer and Likens 2018).

It is recommended that the CEWO ensure that an adequate data management system to capture and process relevant data from future monitoring and evaluation activities is established and properly resourced (**Recommendation 11**).

4.7 REPORTING AND COMMUNICATIONS

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

The Evaluators have noted the positive changes in the annual Selected Area, Basin Matter's and Synthesis reports over the 5-years of the LTIM project. The Selected Area teams now produce two reports annually: the first a relatively short summary report suitable for water managers and other stakeholders; and the second a science report (as an appendix to the general report) containing the detailed monitoring results and an evaluation of the ecological outcomes for the Selected Area. The Basin Matter team produce annually a Synthesis report with the six Basin Matter reports as an appendix.

A strong theme in the interviews was the need for the project's annual overview reports (Selected Area summary reports and Basin Matter synthesis reports) to be made shorter and more readable. Hart and Butcher (2018) in their mid-term review of LTIM came to a similar conclusion, and recommended that the CEWO engage an effective science communicator(s) to assist the Selected Area and Basin Matter teams in producing reports that are more readable for the target audience, and to assist the CEWO in producing better information products related to the LTIM project.

This Evaluation supports the engagement of a science communicator(s) for any future monitoring and evaluation activities.

⁹ As discussed in LTIM Data standard 2018 Nov16

Another theme from the interviews was the desire for reporting to better meet the needs and timelines of environmental water managers. It was suggested that the utility of adaptive learnings would be increased if evaluation from one round of watering actions could be provided while water managers were designing the next deliveries. There was one comment in the interviews that information was not delivered until six months too late; after 'the war was over'. This reinforces the need for a communications strategy to consider potential uses of information and to be adaptive as new needs are uncovered.

It is also important that the communications strategy is capable of dealing with surprises. For example, if routine monitoring revealed a fish kill, it would be appropriate for the CEWO to employ a media strategy to proactively address likely public concern.

It is recommended that a comprehensive communications and reporting strategy be developed for any future monitoring and evaluation activities, and that effective science communicators be engaged to assist the monitoring and evaluation teams to make their various reports more readable, and to assist the CEWO to produce more structured and targeted information products (**Recommendation 12**).

4.8 PROJECT MANAGEMENT

4.8.1 OVERALL PROJECT MANAGER

Hart and Butcher (2018) in their mid-term review found that LTIM project management was too dispersed with four of the CEWO sections involved: Aquatic Ecosystems and Science Section and the three Water Delivery teams. This does not appear to have changed.

The Evaluators recommend the appointment of an overall project manager to ensure the robust management of future monitoring and evaluation activities.

4.8.2 PROJECT STEERING COMMITTEE

Hart and Butcher (2018) in their mid-term review also recommended that a project steering committee be established to assist with management of future monitoring and evaluation activities. This recommendation was accepted by the CEWO, but was not implemented in the final years of LTIM. However, we understand that a project steering committee has been established for the current Flow-MER project.

The Evaluators recommend that the CEWO consider establishing a project steering committee to assist with management of any future monitoring and evaluation activities.

4.8.3 INDEPENDENT SCIENCE REVIEW

This Evaluation has identified a significant lack of independent peer review of the LTIM project science. Stakeholder interviews suggest that some internal review occurred within the Selected Area teams and (recently) between the Basin Matter and the Selected Area teams. However, there is little documentation of any reviews that has been undertaken. The Evaluators have been able to undertake only limited review of the detailed science of LTIM due to time constraints.

The Evaluators also believe to ensure the credibility of any future monitoring and evaluation activities that the CEWO should consider the appointment of a project *Science Leader* 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.

It is recommended that the CEWO establish robust project management arrangements for any future monitoring and evaluation activities including: (a) an overall project manager; (b) a project steering committee to assist the project manager and assist with collaboration; and (c) the establishment of an independent science review committee to ensure the quality of the science being undertaken (**Recommendation 13**).

4.9 COLLABORATION

The Evaluators have identified a lack of effective collaboration, particularly between the Selected Areas and the Basin Matter team. We also believe collaboration could have been better between the Selected Area teams. Additionally, the collaboration between the Basin Matter teams and environmental water managers appears to

have been minimal. On the other hand, collaboration between the Selected Area scientists and the CEWO Delivery Teams (and other environmental water managers) was very good and grew over the 5-years of LTIM.

It was not that collaboration between LTIM staff did not occur, but that it could have been improved and that would be a positive for the project. However, most of the improvements that have occurred over the 5-year LTIM project have emerged largely through individual actions by Selected Area team members, rather than being led centrally. The exception is the Annual Forum (and other workshops) that have been very useful in fostering collaboration. The CEWO recognised this lack of collaboration and in 2017 made additional funds available to assist various collaborative activities to occur.

It is recommended that a *project collaboration plan* be established at the start of any future monitoring and evaluation activities, that examples of collaboration be collected and documented, and reported on annually (**Recommendation 14**).

4.9.1 ADAPTIVE MANAGEMENT

Adaptive management of CEW was seen as a lower priority for the LTIM project at the outset of the project (see Gawne et al. 2014). However, the Evaluators have been impressed by the very close working relationships established between the seven Selected Area teams and the three CEWO Water Delivery Teams and other environmental water managers in particular. The practical scientific information and advice provided on the relationships between various flow components and possible ecological outcomes in a timely manner (and mostly well ahead of formal reporting) has resulted in improved decision-making regarding particular environmental watering events. But, as noted elsewhere in this report the impact of the LTIM project on the adaptive management of environmental water at the Basin-scale has been less impressive.

There are two additional aspects of adaptive management upon which we comment. The first is the adaption (or flexibility) that has occurred with the management of the LTIM project. At the highest level, the transformation from a very 'top down' project at the start, to a more collaborative project has been impressive, although the level of collaboration achieved was somewhat less than if the project had been collaborative from the start (Hart and Butcher, 2018). Additionally, there have been a number of examples where the CEWO has initiated or responded to requests to change aspects of the Selected Area projects. This need to respond to desirable changes in the project along the way is entirely expected in a new project such as LTIM and over a 5-year time period.

The second aspect is the generally poor capture and integration of the adaptive management learnings from the project. Adaptive management learnings are being reported annually by the Selected Areas and Basin Matter teams, and also in the CEWO delivery team acquittal reports; however these are not captured in any systematic way. They need to be brought together to provide an accessible illustration of how the LTIM outputs are helping to improve management of environmental water in the Basin. Improved reporting of adaptive management learnings would promote their dissemination and improve outcomes.

The Evaluators suggest there is a need to improve knowledge management and that there would be value in any future LTIM if 'knowledge brokers' were appointed to the project with the task of collaborating with the Selected Area and Basin Matter teams and environmental water managers, and identifying, collecting, synthesising and collating adaptive management learnings on a continuous basis.

It is recommended that a comprehensive *knowledge management strategy* be developed for any future monitoring and evaluation activities to support the adaptive management of Commonwealth Environmental Water. This strategy should include the appointment of knowledge brokers to assist with the capture, collation and dissemination of the lessons from management of CEW (**Recommendation 15**).

5 RECOMMENDATIONS

It is recommended that:

1. The CEWO (a) decide whether the primary objective of future monitoring and evaluation activities is to be focused on Basin-scale reporting or on both Basin-scale and local-scale; (b) map this objective to the BEWS to improve alignment; (c) consider the inclusion of an objective related to First Nations water needs; and (d) consider additional activities to meet Basin Plan objectives not adequately addressed to date
2. The CEWO undertakes limited water quality monitoring and obtains any required water quality and salinity information data from the agency responsible for implementing the appropriate water quality management plan
3. Monitoring of extreme events and responses to these events be included in future monitoring programs

4. It is determined whether a Basin-scale evaluation of the contribution of CEW to ecological outcomes is best supported by multiple fixed Selected Areas or multiple variable Selected Areas before designing an appropriate monitoring and evaluation approach
5. Monitoring and evaluation of the environmental outcomes of CEW is expanded beyond the current two sites in the Northern Basin
6. Indicators be reviewed based on their performance in during the LTIM project and revised to improve alignment to the BEWS
7. Standard indicators be adopted across sites with the method adopted to inform that indicator being allowed to vary between sites if necessary
8. That evaluations should focus on: (a) all environmental water (e.g. 'held' water and 'planned' or 'above Cap' water) and not just on CEW; (b) 'counterfactual' assessments, that is evaluations with and without environmental water; (c) quantitative assessments, that is greater application of quantitative statistical models, e.g. Bayesian hierarchical modelling
9. The CEWO establish and resource a *model development plan* for any future monitoring and evaluation activities
10. A fit-for-purpose inundation modelling (mapping) method is developed to support any future monitoring and evaluation activities
11. The CEWO ensure that an adequate data management system to capture and process relevant data from future monitoring and evaluation activities is established and properly resourced
12. A comprehensive communications and reporting strategy be developed for any future monitoring and evaluation activities, and that effective science communicators be engaged to assist the monitoring and evaluation teams to make their various reports more readable, and to assist the CEWO to produce more structured and targeted information products
13. The CEWO establish robust project management arrangements for any future monitoring and evaluation activities including: (a) an overall project manager; (b) a project steering committee to assist the project manager and assist with collaboration; and (c) the establishment of an independent science review committee to ensure the quality of the science being undertaken
14. A *project collaboration plan* be established at the start of any future monitoring and evaluation activities, that examples of collaboration be collected and documented, and reported on annually
15. A comprehensive *knowledge management strategy* be developed for any future monitoring and evaluation activities to support the adaptive management of CEW, and that knowledge brokers be appointed to assist with the capture and collation of the adaptive management learnings.

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APPENDIX A: LTIM EVALUATOR RATIONALE AND CONSENSUS JUDGEMENT

EFFECTIVENESS – ACHIEVED OBJECTIVES

- 5 high-level KEQs
- 28 mid-level KEQs
- 30 micro-level KEQs

High KEQ 1	How effective was the LTIM project in planning, reporting, and collaborating to support adaptive management?
<p>Evaluator 1</p>	<p>Moderately Effective</p> <p>The LTIM project was moderately effective in planning, reporting, and collaborating to support adaptive management. Supporting the adaptive management of CEW was a key objective of the LTIM project. However, despite the importance of the outcomes from LTIM in progressing adaptive management of CEW, the project had no well-coordinated and systematic approach to the planning, capturing and reporting of adaptive management learnings.</p> <p>The formal reporting of adaptive management learnings in LTIM was through the Selected Area annual reports, the Basin Matters reports and internal CEWO reports (annual water planning process, portfolio management plans, and acquittal reports). These all contain useful information, but there appears to have been no process for consolidating all this information; the annual Basin Matters reports did attempt to do this at the Basin-scale, but this was rather ineffective because the interviews with stakeholders showed clearly that few read these reports.</p> <p>This review, and that conducted mid-term by Hart and Butcher (2018), found that considerable collaboration has occurred between the Selected Area teams and their respective environmental water delivery teams. For example, in the interviews the three CEWO Water Delivery Teams told us that their close interaction with the relevant Selected Area teams provided 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), and that this had resulted in improved decision-making regarding particular environmental watering events. Similarly, Webb et al. (2017) identified two particular advantages in the management of environmental water that flow from these science-manager partnerships; first, that 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; and second, that practitioners see field verification of their management intentions.</p> <p>Thus, there is clearly good collaboration at the local level which has led to effective and adaptive management of CEW. This is less so at the Basin-scale. But these adaptive management learnings are not being effectively captured and consolidated.</p> <p>Hart and Butcher (2018) in their mid-term review of LTIM recommended ‘that the capture of adaptive management learning’s be improved and done more systematically, in particular with the development of an accessible and searchable database to contain the learning’s, and the production of an</p>

	<p>annual report that synthesises how this increased knowledge is changing the way in which environmental water is being delivered.’ We have no evidence that CEWO ever acted upon this recommendation.</p> <p>We understand from the interviews that the original intent was that the capture of adaptive management learnings would be captured by CEWO staff and consolidated. Obviously, this did not happen and an excellent opportunity was lost. However, some aspects of the adaptive management outcomes from the LTIM project have been captured in two peer-reviewed publications by LTIM researchers (Webb et al., 2018; Watts et al., 2020).</p> <p>We believe there would be value in any future LTIM if a ‘knowledge broker’ was appointed to the project with the task of collaborating with the Selected Area and Basin Matters teams and environmental water managers, and identifying, collecting, synthesising and collating adaptive management learning on a continuous basis.</p>
Evaluator 2	<p>Moderately Effective</p> <p>LTIM was moderately effective in planning, reporting, and collaborating to support adaptive management. The pilot basin evaluation was undertaken effectively but the evaluation was reduced to moderately effective because lessons from the pilot did not generally inform the next stage of the project. Consultation with monitoring and evaluation providers was rated as moderately effective based on evidence from interviews. Collaboration and participation was moderately effective because it was hampered by the lack of an overall consultation plan. There were many issues with data management which delayed model building and hampered adaptive management. Support for adaptive management was rated as moderately effective at the Selected Area scale and minimally effective at the Basin-scale. Improvements in knowledge management could lead to better adaptive management outcomes. On a positive note, the relationships between Selected Area teams and water delivery managers seemed to be positive and this facilitated adaptive management at the Selected Area scale. Interview responses were positive about the role of LTIM in adaptive management at this scale. One theme from the interviews was that the timing of reports did not fit in to cycles of water delivery planning.</p>
Consensus final rating	Moderately Effective

Mid KEQ 1.1	How effectively did the LTIM project undertake and report on the Pilot Basin Evaluation in 2014-15 to test the proposed Basin-scale evaluation process and methodology as described in Gawne et al. (2014c, Section5)? (from Head contract B2.1 (a))
Evaluator 1	<p>Moderately Effective</p> <p>A Pilot Basin Evaluation was undertaken in 2014-15 to test the proposed Basin-scale evaluation process and methodology. The objectives of the Pilot Evaluation were to: test some of the ideas and methods proposed for Basin Evaluation; identify information needs for future Basin Evaluation; and refine Basin Evaluation methods and analyses.</p> <p>The suitability of the (limited) information available from some of the Selected Areas for the Basin-scale integrated evaluation approach was assessed, but there was insufficient data or information to be able to refine the integrated evaluation approach.</p>

	<p>The Pilot Evaluation developed a method (table) for consolidating data on monitoring outcomes and CEW actions, which was subsequently used by the Basin Matters team in their reporting (and also by some of the Selected Area teams). Additionally, the Pilot Evaluation also identified five information requirements for the Selected Area monitoring, and four information requirements for the CEW actions, necessary for the Basin -scale evaluation.</p> <p>However, it appears this Pilot Evaluation report (Gawne et al., 2015) was never publicly released, and this Evaluator was not able to assess whether the advice relating to the Selected Areas and the CEWO Delivery Teams was fed back, or whether the advice resulted in any changes.</p>
Evaluator 2	<p>Moderately Effective</p> <p>The Pilot evaluation generally met the objectives of testing evaluation processes and methods. Unfortunately, its effectiveness was limited because many of the learnings from the project do not seem to have been carried forward. The report does not appear to have been publicly released nor was it as influential as it should have been.</p>
Consensus final rating	Moderately Effective

Micro 1.1.1	KEQ	To what extent were the objectives of the Pilot Basin Evaluation achieved (from Basin Evaluation Plan Part B, Section 5): to synthesise the outcomes of past Commonwealth environmental watering actions using the Outcomes Framework and, to the extent possible, the Basin Matter evaluation methods?
Evaluator 1	Moderately Effective	<p>The Pilot Evaluation tested the suitability of the (limited) information available from some of the Selected Areas for the Basin-scale evaluation, and identified a number of important additional information requirements needed from the Selected Areas and the CEWO necessary for the Basin Evaluation to be undertaken successfully.</p> <p>This Evaluator is not able to assess whether these additional requirements were fed back to the Selected Area teams and the CEWO Delivery teams, or whether they resulted in any changes.</p>
Evaluator 2	Effective	<p>Although the Pilot evaluation has based on limited data, it was carried out thoroughly and there are many insights in reporting. In general these objectives were met.</p>
Revision comments – Evaluator 1		

Revision comments – Evaluator 2	Agree that the main issue about effectiveness is that the learnings from the Pilot Evaluation do not seem to have been carried forward to inform the work of the Selected Area and Basin Matter teams. The Technical review planned for the end of the project was not undertaken.
Consensus final rating	Moderately Effective

Micro 1.1.2	KEQ	To what extent were the objectives of the Pilot Basin Evaluation achieved (from Basin Evaluation Plan Part B, Section 5): 2. where possible, to assess the information available in the context of the Basin Matter evaluation methods, which would include testing the likelihood of being able to successfully implement the Basin Evaluation methods as described in this plan?
Evaluator 1		<p>Moderately Effective</p> <p>The Pilot Evaluation tested the integrated evaluation approach using the limited data available at the time (after 2 years of Selected Area monitoring) but did not have the data or information necessary to be able to refine the integrated evaluation approach. However, the Pilot Evaluation did identify a number of important additional information requirements needed from the Selected Areas and the CEWO necessary for the Basin Evaluation to be undertaken successfully.</p>
Evaluator 2		<p>Effective</p> <p>My impression is that this was an excellent piece of work that highlighted many issues that the SA teams needed to overcome. It highlighted, for example:</p> <ul style="list-style-type: none"> • The need to have clear information about a watering i.e. location, volume, depth, timing. • The need to be clear about expectations of a watering • Categorization of systems watered to support extrapolation of results from monitoring to similar systems that were not monitored. • The need to understand ecosystem condition prior to watering as this will affect outcomes • The importance of understanding non-flow stressors • The importance of having hypotheses for outcomes associated with watering. <p>Many of these issues were not picked up in the MEPs for the Selected Areas.</p> <p>The report also highlights factors that underpin successful outcomes. It is not clear to what extent these were incorporated into SA planning and activities.</p> <p>I think this was helpful, or could have been helpful, in advancing the MEPs because it contains clear thinking about what was required.</p>
Revision comments – Evaluator 1		Not happy to go to effective. Report was reasonable, did some good work at both Selected Area and Basin Matter scale – but it was never acted on. Only part of the job was done. I think the report was quite reasonable and somewhere evaluator 2 has said the same, that yes, they did some good working in pulling out some of the things that both Selected Areas and the CEWO people needed to do. But the trouble is, it wasn't ever acted upon.

Revision comments – Evaluator 2	Agree with Barry to some extent; I suppose I've reached the same conclusion that my last sentence indicted the report was okay and helpful, but agree with evaluator 1 it wasn't used – agree to down grade to Moderately effective
Consensus final rating	Moderately Effective

Micro 1.1.3	KEQ	To what extent were the objectives of the Pilot Basin Evaluation achieved (from Basin Evaluation Plan Part B, Section 5): 3. to test and refine the integrated evaluation approach based on existing data?
Evaluator 1	Effective	<p>The LTIM project Annual Forums were rated by this evaluator and a majority of the stakeholder interviewed as effective.</p> <p>These Forums were convened each year (2015-2019), the proceedings were well reported, and they assisted in facilitating increased communication and collaboration across project teams and with water managers. The Forums were attended by researchers (Selected Areas and Basin Matters teams), water managers (CEWO, MDBA state agencies, NRM bodies) and community members. The early Forums focused on discussing on-ground monitoring, standard methods for monitoring, and issues being experienced by the monitoring teams. In subsequent years, the content of evaluation reports from Selected Areas and Basin Matters teams were discussed, together with a focus on how LTIM monitoring was supporting adaptive environmental water management, assessing similarities and differences in adaptive management among Selected Areas, and better understanding the needs of environmental water managers.</p> <p>We were told that over the course of the 5-years the presentations from LTIM teams became clearer and more accessible, with less technical jargon, and because of this communication improved.</p> <p>Most of the views from both the survey and interviews were that the Annual Forums were very successful in providing information on the progress of LTIM at both the Selected Area scale and Basin-scale, and hence in improving communications, and in facilitating collaborating between the researchers and water managers. However, there were other views that the Annual Forums, while useful for communicating progress, did little to assist with fostering collaboration – the view being that ‘true collaboration is actually working together towards a common goal’ and not just telling each other what you have done.</p> <p>So but having those forums, should have been a biannual, because it was the only time that people actually had to ask questions of the scientists and try and get them to put it into language that could be understood and the scientists themselves that they hated having to do that sort of adaptive management side.</p>
Evaluator 2	Effective	<p>This was a thorough and thoughtful piece of work. It highlights issue of evaluation in areas not monitored in clearer way that most of the annual SA plans do not. It appears that the SA teams would have benefitted if this report was an input to the MEPS.</p>

Consensus final rating	Effective
Mid KEQ 1.2	How effectively has the LTIM project Annual Forum been organised, convened and reported on each year of the project as described in Gawne et al. (2014a, Section 6.1) (from Head contract B2.1 (e))?
Evaluator 1	<p>Effective</p> <p>The LTIM project Annual Forums were rated by this evaluator and a majority of the stakeholder interviewed as effective.</p> <p>These Forums were convened each year (2015-2019), the proceedings were well reported, and they assisted in facilitating increased communication and collaboration across project teams and with water managers. The Forums were attended by researchers (Selected Areas and Basin Matters teams), water managers (CEWO, MDBA state agencies, NRM bodies) and community members. The early Forums focused on discussing on-ground monitoring, standard methods for monitoring, and issues being experienced by the monitoring teams. In subsequent years, the content of evaluation reports from Selected Areas and Basin Matters teams were discussed, together with a focus on how LTIM monitoring was supporting adaptive environmental water management, assessing similarities and differences in adaptive management among Selected Areas, and better understanding the needs of environmental water managers.</p> <p>We were told that over the course of the 5-years the presentations from LTIM teams became clearer and more accessible, with less technical jargon, and because of this communication improved.</p> <p>Most of the views from both the survey and interviews were that the Annual Forums were very successful in providing information on the progress of LTIM at both the Selected Area scale and Basin-scale, and hence in improving communications, and in facilitating collaborating between the researchers and water managers. However, there were other views that the Annual Forums, while useful for communicating progress, did little to assist with fostering collaboration – the view being that ‘true collaboration is actually working together towards a common goal’ and not just telling each other what you have done.</p> <p>So but having those forums, should have been a biannual, because it was the only time that people actually had to ask questions of the scientists and try and get them to put it into language that could be understood and the scientists themselves that they hated having to do that sort of adaptive management side.</p>
Evaluator 2	<p>Effective</p> <p>From reviewing reporting, the annual forums seem to have been effective. The forum reports are well written and informative. At the end of each forum participants were surveyed and feedback was acted on for the next forum. There is evidence of continuous improvement. The final forum report (2019) provides less detail than earlier reports.</p> <p>The interviews provide positive responses about the annual forums in that they encouraged collaboration and a chance for face-to-face meetings, but there were also criticisms:</p> <ul style="list-style-type: none"> • Excess focus on individual Selected Areas, lack of focus on adaptive management and Basin-scale

	<ul style="list-style-type: none"> • Good to meet people and find out what was going on. Some of the structure programs were less valuable. • Concern about the cost, length and required time commitment • Some of the early ones were hostile towards some of the Basin Matter teams.
Consensus final rating	Effective

Mid KEQ 1.3	How effective was the technical review at the final year of the project, as described in Gawne et al. (2014a, Section 6.2) (from Head contract B2.1 (f))?
Evaluator 1	<p>Not Attempted</p> <p>At the commencement of the LTIM project the M&E Advisers recommended that a technical review be undertaken towards the end of the final year of the project (i.e. year five) (Gawne et al., 2014b). It was anticipated that the technical review would be at two scales: (a) the Basin Matter team leaders would review the outputs of their individual matters against terms of reference relating to adaptive management, and (b) the Basin Evaluation process as a whole would be reviewed, drawing on the Basin Matters outputs, integration components and assessing the higher level, overall impact aspects of the project. This was not done. It appears that funds for this technical review were redirected to other activities and that the review is now being undertaken as part of this current LTIM and EWKR evaluation.</p>
Evaluator 2	<p>Not Attempted</p> <p>It is understood that this evolved into the CEWO review of LTIM and EWKR and that monies allocated to this in the CEWO budget were redirected to other activities.</p>
Consensus final rating	Not Attempted

Mid KEQ 1.4	How effective was consultation with monitoring and evaluation providers prior to the finalisation of the Basin Evaluation Plan and Basin Matter Foundation Reports? (from Head contract B2.1 (g))?
Evaluator 1	<p>Moderately Effective</p> <p>There was good collaboration with a wide range of stakeholders in the development of the Selected Area M&E Plans (Cottingham et al., 2013; M&E Plans, 2013). However, there appears to have been minimal subsequent collaboration with Selected Area (M&E Providers) if the development of the LTIM Evaluation Plan (Gawne et al., 2014c; Gawne et al., 2014d). The Evaluation plan was developed by the M&E Advisers at the MDFRC, although obviously they would have considered the ecological indicators being monitored by the Selected Areas, since this data was to form the basis of several of the Basin-scale Basin Matters evaluations.</p>

	<p>Additionally, there is also little indication of collaboration with Selected Areas in finalising the Basin Matters Foundation reports. The exception is the fish Foundation Report where there obviously was collaboration given that the Selected Area fish experts are joint authors of this report and are also listed as members of the Basin Matters (fish) team (Stoffels et al., 2016). An update of the Fish Foundation Report was prepared by King (2019). Presumably, this was prepared in collaboration with the Selected Area fish experts, but this is not explicitly indicated in the report.</p>
<p>Evaluator 2</p>	<p>Insufficient Evidence</p> <p>There is insufficient information to evaluate this KEQ.</p> <p>There is no direct evidence about consultations that occurred with the M&E providers about the Basin Evaluation Plan or the Basin Matter Foundation Reports.</p> <p>There may have been some consultation but it was not well documented.</p> <p>The Basin Evaluation Plan was finalised in Dec 2014 (Gawne et al., 2014d). The Basin Matter Foundation reports were finalised in 2015.</p> <p>For each SA, requirements documents were produced in mid 2013 with first drafts produced in early 2013. These requirements documents do include consultation with: “service providers undertaking environmental water monitoring and evaluation activities on behalf of CEWO and jurisdictions”.</p> <p>So, consultation did occur and the reporting in the requirements reports suggest it was good.</p> <p>The Basin Evaluation Plan does not mention consultation nor do most of the Basin Matters foundation reports.</p> <p>The fish BM report provides an indication that consultation with the Selected Areas did occur – the fish team members of the SAs are joint authors of the foundation report and are also listed as members of the Basin Matters (fish) team - but collaboration is not explicitly stated.</p>
<p>Revision comments – Evaluator 1</p>	<p>No evidence that Selected Area groups were involved in the discussion on the Basin Evaluation Plan and the Foundations reports. Lack of documentation on consultation activities makes it hard to make a call.</p> <p>I focused on consultation. Prior to finalization of the evaluation plan. I mean sure there was good consultation in the monitoring and evaluation plans, but I couldn't find anything from there on, I think, evaluator 2, you found some other things didn't you? Definitely not well done.</p> <p>I'd be happy enough with minimally effective because I reckon that there was some consultation. I have no evidence of that, in fact we might have the opposite, that the Selected Area group were involved in discussions on the evaluation plan and foundation reports? Yes, there is some evidence, but it was a sort of all about resolving issues. I mean, the stuff that that we've put up about fish was about resolving problems, wasn't about resolving the foundation report. They were just arguing among themselves.</p>

	<p>This brings up another problem all the way through. That if they were supposed to be consultation and it did occur, it's got to be documented somewhere and they just don't document most of it. That's what makes it so hard to do sensible evidence based evaluations because it's not documented. I'd be prepared to go minimal.</p> <p>In a number of cases, I have put down Hart and Butcher in the mid-term review, said this. So it was more about using that to confirm what I'd evaluated from this particular case.</p>
Revision comments – Evaluator 2	<p>I struggled to find evidence that it occurred, interviews indicated that Selected Area service providers didn't feel they were engaged. I'd be prepared to go to minimum</p> <p>Agree there was only minimal engagement. Agree to change my assessment to minimally effective.</p>
Consensus final rating	Minimally Effective

Mid KEQ 1.5	How effective was the technical review processes undertaken by the technical advisors (MDFRC/LaTrobe) of the draft Selected Area Evaluation Reports? (from Head contract B2.1 (h))
Evaluator 1	<p>Insufficient Evidence</p> <p>We understand that some technical reviewing of the draft Selected Area annual evaluation reports was undertaken by the Basin Matters technical advisors (MDFRC/LaTrobe) in the early days of the LTIM project, but this did not continue. We have no information on how effective these earlier reviews were or indeed why the reviewing process did not continue.</p>
Evaluator 2	<p>Insufficient Evidence</p> <p>It is not clear if there was technical review and there is no information available to evaluate its effectiveness.</p>
Revision comments – Evaluator 1	<p>There is no evidence to support being able to make an evaluation of the effectiveness of this process – it would appear it only happened in one year and there is no documentation to review.</p> <p>I interpreted this to be about did they look at their evaluation reports. That's not the MEPs. Yes, they did, but my understanding was, and again, there's no body evidence. Nick indicated they did a bit of it, but everyone was sledging both ways, so some terms of reference were establish.</p> <p>I think technical review is really important. And yes, because of the bad relationship, I think they should have got something outside, but anyway they did not</p>

Revision comments – Evaluator 2	Agree there is insufficient evidence to evaluate this KEQ.
Consensus final rating	Insufficient Evidence

Mid KEQ 1.6 How effectively did the LTIM project staff collaborate and/or participate in collaboration with other parties? (from Head contract B2.1 (i))?	
Evaluator 1	<p>Moderately Effective</p> <p>The collaboration of LTIM project staff (Selected Area teams and Basin Matters team) with each other and with other parties (CEWO staff, including the three Water Delivery teams; MDBA; state water managers; others stakeholders) was moderately effective.</p> <p>This collaboration occurred through both formal channels (e.g. Annual Forum; advisory groups) and less formal channels (workshops, <i>ad hoc</i> discussions), and varied from moderately to minimally effective.</p> <p>The stakeholder interviews revealed that interactions and collaborations within Selected Area teams, and between the Selected Area teams and the CEWO Water Delivery team (and other -environmental water managers) ranged between very effective to moderately effective. On the other hand, stakeholders suggested that collaboration between the Selected Area teams and between Basin Matters team and Selected Area teams ranged between moderately and minimally effective. The view was also expressed that there was minimal collaboration between Basin Matters team members.</p>
Evaluator 2	<p>Effective</p> <p>There are many examples of collaboration as noted in KEQ 12.1.2. Examples include, the Fish Basin Matter report (Stoffels et al., 2018) includes data from NSW Department of Primary Industries and Qld Dept of Ag and Fish (2017); Bloink and Robinson (2016); Davis et al. (2017) as well as from Selected Area reporting). The appendix to the Lower Murray requirements document (Gawne et al., 2013h) provides a detailed listing of communication activities, a stakeholder contact list, stakeholder meeting notes, stakeholder workshop notes.</p>
Revision comments – Evaluator 1	Stay with moderate to be consistent with my overall perspective on consultation. Communication not a fundamental of the project – very much a top down approach. Wasn’t seen as needing collaboration per se.
Revision comments – Evaluator 2	Agree with evaluator 1 that collaboration and participation was hampered by lack of an overall communications strategy.
Consensus final rating	Moderately Effective

Mid KEQ 1.7	How effective were the data management tasks as specified in Gawne et al. (2014d), to support the evaluation and reporting on outcomes as per B.2.1 (from Head contract B2.1 (j))?
<p>Evaluator 1</p>	<p>Minimally Effective</p> <p>The data management process established for the LTIM project to aid the evaluation and reporting on outcomes, particularly at the Basin-scale, was minimally effective.</p> <p>A Monitoring Data Management System (MDMS) was established for the LTIM project, with the broad requirements provided in Gawne et al. (2014d, Section 10.1). The purpose of the MDMS was threefold: first, to provide a repository for data from Selected Area monitoring; second, to provide access to this data to evaluate local outcomes from CEW actions and also contribute to the Basin-scale evaluations; and third, to enable data to be shared by multiple organisations and used in combination with other complementary data sets to support an array of research, reporting and environmental management activities.</p> <p>Considerable effort went into 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), and a set of data standards were developed to ensure that data collection was done in a structured and consistent manner (Brooks and Wealands (2014/2017).</p> <p>Hart and Butcher (2018) in their mid-term review found that at that time the MDMS had a multitude of problems and was not being effectively used; it was overly complex and not user friendly, and many of the Selected Area teams were using their own data management systems (e.g. Excel files) and exporting a copy in the required formats to the MDMS when required, making QA/QC checking difficult. These MDMS and QA/QC issues had a major impact on the Basin Matters reporting, entailing literally weeks to months in delays each year sorting out data problems before the actual evaluations could commence.</p> <p>As a result of these issues, we understand that the CEWO established a ‘data wrangler’ role in the Basin Matter team, which they suggest has allowed data management to be handled much more smoothly. This Evaluator has little evidence that the MDMS in its current form is fit-for-purpose as most of the survey responses focused on the problems with the MDMS and not on whether these had been solved.</p> <p>Additionally, Gawne et al. (2014d) recommended that there be training in use of MDMS provided to all users in year one, and that ongoing technical support related to the MDMS would be provided throughout the duration of the LTIM. We have no information as to whether training in the use of the MDMS occurred. We were told that there was ongoing technical support for MDMS, but it appears that this was rather ineffective until the last two years when Dr Shane Brooks was contracted by CEWO to modify the MDMS so it was more user-friendly and more effective.</p> <p>The stakeholder survey and interviews provided clear evidence of the problems with the MDMS, particularly those with service providers. It is also clear that most (if not all) of the Selected Area teams did not use the MDMS in their area-scale evaluations and used their own system (often Excel spreadsheets). The poorly performing MDMS made it particularly difficult for the Basin Matters team, who either sourced their data directly from the Selected Areas or spent considerable time trying to access the MDMS system, often to experience difficulties in interpreting that data. It was generally agreed that the MDMS was much more user-friendly towards the end of LTIM after Dr Shane Brooks was contracted to get the system in order.</p> <p>Perhaps the lessons from this MDMS experience is that the Selected Area and Basin Matters teams should have been more involved in the planning and operationalising of the MDMS, and there should have been a dedicated data manager from the start who interacted closely with the Selected Area teams.</p>

<p>Evaluator 2</p>	<p>Moderately Effective</p> <p>Cross-reference: KEQ 1.7, 8.9, 13.11, 13.22</p> <p>The relevant section from Gawne et al. (2014d) is:</p> <p>“10.1 Data storage and management</p> <p>Data inputs for Basin Evaluation will be sourced from the Monitoring Data Management System (MDMS) using only data that has been subject to QA/QC and is flagged "final". Models and data outputs generated during the Basin Evaluation will be stored in the MDMS, attached to the appropriate spatial units (sites, area, Basin) with compliant metadata. Management of the data will be assisted through MDMS training provided to all users in Year One. Ongoing technical support related to the MDMS is provided throughout the duration of the Project.”</p> <p>Data management in the LTIM project did have some major issues, particularly in the first 3 years of the project. I have rated this as ‘moderate’ rather than ‘minimal’ because these issues do seem to have been resolved in year 5, at least to a large extent.</p>
<p>Revision comments – Evaluator 1</p>	<p>Not prepared to change – it really only got fixed in last year. This is a key point that the data management was a significant issue for the project.</p>
<p>Revision comments – Evaluator 2</p>	<p>Focused on the end year that it became functional. Agree with evaluator 1 that overall, the data management was generally poorly done but did improve.</p>
<p>Consensus final rating</p>	<p>Minimally Effective</p>

<p>Mid KEQ 1.8</p>	<p>How effective was the LTIM project in supporting the adaptive management of Commonwealth environmental water? (objective 4 Gawne et al. 2014)?</p>
<p>Evaluator 1</p>	<p>Minimally to Moderately Effective</p> <p>Adaptive management of environmental water is a key component of both the Basin Plan and the LTIM project. The LTIM project was established to support the CEWO in meeting its obligations for reporting on the outcomes of CEW actions, and to support the adaptive management of CEW through the monitoring of CEW actions and the development the new knowledge to support environmental water delivery in the future. The initial logic and rationale for the LTIM project (Gawne et al., 2013a) indicated that effective adaptive management requires ‘<i>processes to generate, communicate, assimilate and apply new knowledge to improve monitoring, evaluation, system understanding and future interventions</i>’. To this end it was anticipated that the LTIM project would include the development of statistical predictive models to facilitate the generation, assimilation and application knowledge to future management decisions. In the latter stages of LTIM, some predictive models have been developed by some Selected Areas and for some of the Basin Matters (see KEQ8.6.4).</p>

	<p>As noted below (KEQ1.8.1, 1.8.2 and 1.8.3) the effectiveness of the LTIM project in supporting the adaptive management of CEW was rated on two aspects:</p> <p><i>Adaption of the LTIM project</i> – is discussed in KEQ1.8.1 below, where it was noted that despite some modifications to the Selected Area programs during the -year LTIM project, there appears to be little flexibility for the CEWO to modify project agreements and for this reason the capacity to adapt the operation of the Selected Area programs is limited and rated minimally effective. It does appear from the interviews that this issue of lack of flexibility has to some extent been addressed in the new MER project.</p> <p><i>Development and use of new knowledge</i> - LTIM has developed a new knowledge-base that has contributed to improving environmental water management through the detailed monitoring of CEW actions in the seven Selected Area (and other non-monitored areas), and through close collaboration with water managers. Information relating to the relevant learning’s that are contributing to adaptive management of the CEW is reported at two levels: first, the individual Selected Area teams are required to provide an assessment of adaptive management learnings in their annual evaluation report (and quarterly reports), which has been rated as moderately effective, with a note that this process could have been improved if these interactions had been formalised with an annual plan of approach, and more resources had been available to better capture the learnings; and second, the Basin Matters team also has a requirement to provide an assessment of adaptive management learnings at the Basin-scale, and generally report these in their annual Synthesis Reports, with these rated as minimally effective.</p> <p>The other source of information relevant to the adaptive management of CEW is held by the three Water Delivery teams at CEWO. They produce annual water plans, portfolio management plans and acquittal reports for the CEW they deliver each year, and obviously act on new knowledge generated by the Selected Areas. The finding by Hart and Butcher (2018) in their mid-term review was that the interactions between the Selected Area teams and the CEWO Water Delivery teams was significant and effective in leading to adaptive management. One interviewee suggested that while these interactions were working well, there was ‘a lack of cross fertilization between the Selected Areas’.</p> <p>The interviews provided considerable comment on how effective the LTIM project had been in supporting the adaptive management of CEW. Some of the comments include: adaptive management worked well at Selected Area scale but not so well at Basin-scale; adaptive management learnings are easier in the short-terms and for upstream rive reaches; poor capture of active management lessons is more a failure to communicate, rather than a failure to achieve; having water managers as part of the Selected Area team is a great help; the evaluation questions were not always the right ones, particularly the Basin-scale to support active adaptive management; it is very hard to take information on adaptive management from the local-scale and scale up to the Basin; the context needs to be taken into account (e.g. the adaptive management information was obtain over a period where there was three years of drought and a major flood).</p> <p>There was also comment in the interviews about more effective ways to capture the adaptive management learnings. One suggestion was to appoint an LTIM ‘knowledge broker’ whose task it would be to capture the adaptive management learnings from all Selected Areas (and others) and to share between the researchers and environmental water managers. This approach could assist some of the Selected Area researchers who expressed difficulty in capturing the adaptive management messages each year.</p>
<p>Evaluator 2</p>	<p>Moderately Effective</p> <p>The LTIM project was moderately effective at supporting adaptive management of Commonwealth environmental water at the Selected Area scale but was less effective at the Basin-scale. This was both because basin-scale evaluations were challenging and because of weaker links between the Basin Matters team and the water delivery teams. An addition issue was the need to better manage the knowledge gained in the LTIM project.</p>

Revision comments – Evaluator 1	Happy to upgrade to moderately effective.
Revision comments – Evaluator 2	Agree
Consensus final rating	Moderately Effective

Micro 1.8.1	KEQ	How effectively did the LTIM project support adaptive management of CEW in each Selected Area?
Evaluator 1		<p>Moderately Effective</p> <p>All Selected Areas were required to report on adaptive management outcomes in their annual reports (see KEQ1.1.3). In assessing the effectiveness of the LTIM project in supporting adaptive management within the Selected Areas two aspects have been considered:</p> <p><i>Development of a knowledge-base that can contribute to improving environmental water management through the detailed monitoring of CEW actions in the seven Selected Areas, and through close collaboration with water managers</i> - The Selected Area teams appear to capture adaptive management learnings through two activities: (a) within each Selected Area through project team meetings, formal and informal meetings with environmental water managers (e.g. CEWO Delivery Teams), and in some Selected Areas meetings with advisory committees that involved community members; and (b) between the Selected Areas through the Annual Forum (see KEQ1.2) and <i>ad hoc</i> discussions. The capture and reporting of adaptive management learnings by Selected Area teams is rated as moderately effective; it appears that many of the learnings were not formally captured.</p> <p><i>Adapting the operation of the LTIM project as needed to ensure it is kept relevant and captures the benefits of key knowledge generated by the Selected Area teams</i> - the 5-year LTIM project has shown clearly that adaptive management of environmental water is not easy. It requires the development of trusted partnerships between the monitoring teams (researchers) and the water delivery teams, and the flexibility to change both watering actions (e.g. three freshes rather than one fresh in previous years) and the associated monitoring program. Such flexibility is difficult to build into a program such as LTIM, which is based on CEWO contracting research groups to undertake rather fixed monitoring programs. However, to their credit both CEWO and the research groups have been able to achieve some flexibility within the rather rigid contracts. Two examples where changes to the environmental watering actions and the associated monitoring program occurred on the basis of new knowledge or seeking new knowledge are: (a) <i>Lower Goulburn Selected Area</i> where the existing contract with The University of Melbourne was amended in 2018 to enable a new approach to winter environmental watering to be trialled; and (b) <i>Murrumbidgee Selected Area</i> where the existing contract with Charles Sturt University was amended to allow additional monitoring of a CEW action to delivered 90 GL to Yanga National Park in winter-spring 2018 to achieve a north-south overland flow aimed at fish and waterbird outcomes. It appears there was little flexibility for the CEWO to modify project agreements and for this reason the capacity to adapt the operation of the Selected Area programs is limited and rated minimally effective.</p>

<p>Evaluator 2</p>	<p>Moderately Effective</p> <p>Warrego-Darling: Effective</p> <p>Adaptive management is included in the MEP and each of the annual reports. The final report (Southwell et al., 2019a) has a section “Implications for future management of Commonwealth Environmental Water” that provides advice to water managers.</p> <p>Lachlan: Effective</p> <p>There are “Adaptive Management” section in annual reports. In the final SA report there is a section on “Implications for future management of Environmental Water”.</p> <p>Lower Murray: Moderately effective There seems very little information that could support adaptive management. Both the final SA summary document and technical report have a section on ‘General Management Recommendations’ but there is little information that a manager could use. The impression is that CEW did not have much influence on this SA so there were few Adaptive Management lessons. In the 2017 annual forum report (Gawne et al., 2017) there is recognition that: “Indicators may not be particularly informative at this stage...”, this seems to be born out in later reporting.</p> <p>The other Selected Areas were generally effective in reporting, the challenge is in the application. There were issues capturing Adaptive management lessons across all the Selected Areas.</p> <p>Interviews:</p> <p>Strong positive statements about AM at the Selected Area scale in the interviews. For example: ‘Huge impact at SA scale...biggest success of the project’ (3.1) ‘LTIM has revolutionized the way that the CEWO designs and plans for the water use’ (3.13).</p> <p>Survey results suggest that support of AM was reasonably effective at the Selected Area scale. There was only 1 of 37 response of “not at all effectively”. The others were where either “Somewhat effectively” or better with 50% to 65% “Don’t know”.</p> <p>Issues with the Lower Murray are noted:” ... in the lower Murray, I would say outcomes have been fairly muted. It's been a challenging period to try and get really strong outcomes that we can demonstrate...”</p>
<p>Consensus final rating</p>	<p>Moderately Effective</p>

<p>Micro 1.8.2</p>	<p>KEQ How effectively did the LTIM project support adaptive management of CEW at the Basin-scale?</p>
<p>Evaluator 1</p>	<p>Minimally Effective</p> <p>Annually, the Basin Matters team produce a Basin-scale evaluation report for each of six ecological indicators (ecosystem diversity; hydrology; stream metabolism and water quality; vegetation diversity; fish; biodiversity) and also the Synthesis Report (Evaluation Report). All reports contain a consideration of adaptive management lessons at the Basin-scale. The final Synthesis Report (Hale et al., 2020) draws together the results of each Basin-</p>

	<p>scale ecological indicators to provide an integrated assessment of the key adaptive management ‘lessons learned’ for improving environmental water outcomes and future evaluation from a Basin-scale perspective over the 5-years of the LTIM project.</p> <p>The Basin Matters team are largely dependent upon the Selected Area reports for the basic information required to determine the adaptive management outcomes at the Basin-scale. The rather untimely production of some of the Selected Area annual reports has made it difficult for the Basin Matters team to capture adaptive management outcomes at a Basin-wide scale in a timely manner. This issue has been heightened by the less than effective interactions between the Selected Area teams and the Basin Matters team. As a result of this rather tenuous arrangement, it seems inevitable that some important lessons regarding the adaptive management of CEW were lost, or at least not adequately captured through the LTIM project.</p> <p>Many interviewees expressed the view that adaptive management learnings were largely determined at the Selected Area scale. Additionally, there was some scepticism about the usefulness of adaptive management recommendations at the Basin-scale, particularly give the Basin Matters teams appear to be somewhat divorced from the environmental water managers.</p>
<p>Evaluator 2</p>	<p>Minimally Effective.</p> <p>The reporting of adaptive management seems good, but the interviews suggest that, unlike the Selected Area scale, AM at the Basin-scale was challenging. There were also limits to possible AM advice because of the lack of response to CEW at some Selected Areas.</p> <p>Reporting:</p> <ul style="list-style-type: none"> • Each of the annual basin-scale synthesis reports includes a section on Adaptive Management. • Each of the Basin Matters reports includes a section on adaptive management. • Each of the Selected Area annual reports includes a section on adaptive management or future management. <p>There is a comment in the 2019 annual forum report (Thurgate and Bond, 2019): “The provision of slides [from the annual forum] to the CEWO has allowed early adoption of adaptive management outcomes.”</p> <p>The final fish report highlights some issues with the influence of CEW and hence the ability to provide AM advice (King et al., 2020): “There was no significant predicted response in spawning probability for any species with the use of CEW. The limited range of flow conditions experienced during LTIM project and the range of CEW flow delivery types that occurred during LTIM is a likely cause for the limited evidence of a spawning response to CEW at the Basin-scale.”</p> <p>And</p> <p>“This suggests that there may be only limited adaptive management lessons that can be generalised across all Selected Areas or outside of these Selected Areas within the Basin. Therefore, the adaptive management lessons provided here are given in the context of limited flow variability and the dominance of southern Basin Selected Areas in our findings. There remains a need for further refinement and testing of these modelled relationships in future years capturing a greater range of flow variability and if possible sampling locations in the Northern Basin” (King et al., 2020).</p> <p>This suggests that a broader range of experimental conditions were necessary to learn about the system. There was a similar effect in the lower Murray with little response to CEW (see KEQ 0197).</p>

	<p>For biodiversity AM learnings are limited (Hale et al., 2020):</p> <p>“The biodiversity Basin Matter has largely been a consolidation of monitoring outcomes across the Basin from a variety of sources to develop a list of species and communities that potentially benefited from Commonwealth environmental water. The summary nature of the evaluation has not lent itself to providing adaptive management messages.”</p> <p>The interviews suggest the end users acknowledge the strong input of AM at the Selected Area scale but not so much at the Basin-scale.</p>
Consensus final rating	Minimally Effective

Micro 1.8.3	KEQ	How effective has the reporting of adaptive management by Selected Areas been? (i.e. annual evaluation report and Quarterly reports)?
Evaluator 1	Moderately Effective	<p>All Selected Areas are required to report on adaptive management activities in their annual evaluation reports and quarterly reports. They are providing information and knowledge that leads to adaptive management of CEW (and other environmental water) in a number of ways, including: project team meetings; meetings (ad hoc and formal) with environmental watering managers; meetings with environmental water advisory committees; annual environmental water planning meetings; and special workshops to develop long-term environmental water plans.</p> <p>However, a review of these Annual Reports shows that not all the activities that eventually feed into changed management practices appear to be captured, or at least reported. Additionally, review of the Selected Area 2018-19 Annual Reports (their final reports) revealed a lost opportunity to consolidate the adaptive management activities undertaken by each Selected Area over the 5-years of the LTIM project, and to document the changes in CEW actions that resulted.</p> <p>Given that much of the adaptive management of CEW at the Selected Area scale occurs through interactions between researchers and environmental water managers much before the annual reports are written, it is questionable whether a section in an annual report is the most effective way to capture the learnings. It was suggested (interviews) that adaptive management learnings could be better capture and shared between Selected Areas, Basin Matters and environmental water managers by the appointment of an LTIM ‘knowledge broker’.</p>
Evaluator 2	Moderately Effective	<p>Adaptive management is recognised in the Monitoring and Evaluation Plans for each of the Selected Areas. Most Selected Area report include a section on Adaptive Management. The reporting template for the final Selected Area reports specified that there was to be a section on “Implications for future management of Commonwealth Environmental Water”, not all Selected Areas followed this template but most did (see KEQ 5.1.1).</p> <p>Some specific examples are:</p>

	<p>Warrego-Darling: Effective</p> <p>Adaptive management is included in the MEP and each of the annual reports. The final report (Southwell et al., 2019a) has a section “Implications for future management of Commonwealth Environmental Water” that provides advice to water managers.</p> <p>Lachlan: Effective</p> <p>There are “Adaptive Management” section in annual reports. In the final SA report there is a section on “Implications for future management of Environmental Water”. (Dyer et al., 2019a).</p> <p>Lower Murray: Not effective</p> <p>The reporting is reasonable, however that there is little to report (see KEQ1.8.1).</p> <p>A theme in the interviews was that the timing of reporting did not meet the needs of water managers. Ideally, outcomes from one watering would be available to water managers as they were designing the next. The Selected Area reports did not meet this need with information not being available until too late.</p>
Consensus final rating	Moderately Effective

High KEQ 1A	How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at each of the seven Selected Areas. (objective 5 Gawne et al. 2014)
Evaluator 1	<p>Effective</p> <p>Monitoring of the ecological response(s) to CEW at most of the seven Selected Areas was effectively undertaken. The question of the relevance or appropriateness of the indicators monitored is covered in in KEQ8, and the value for money in KEQ11.</p> <p>Monitoring and Evaluation Plans (MEP) were developed for each of the Selected Areas. Each MEP involved extensive consultation with key stakeholders and were subjected to peer review by the M&E Advisers. Each Selected Area was contracted to carry out the agreed monitoring program, which focused on monitoring ecological indicators (and other associated indicators) and then evaluate the response(s) to CEW actions.</p> <p>Each of the Selected Areas have provided annual technical reports in which the details of their monitoring methods and the response(s) to CEW are provided. We understand that these technical reports are reviewed internally by each Selected Area team. Early in the LTIM project it appears they were also reviewed by the Basin Matters team (M&E Advisers), but this external review was not undertaken in the latter stages of LTIM. We are unaware</p>

	<p>of the reasons why this external technical review was discontinued but believe the lack of external peer review is unfortunate and has reduced the credibility of the monitoring programs.</p> <p>This evaluator has not reviewed the monitoring methods in any detail and has assumed the expertise necessary to ensure these methods were best practice was used in developing the Standards Methods document (Hale et al., 2014).</p> <p>Two relevant comments from the survey and interviews were: the monitoring design, indicators and methods were focussed on collecting data to inform Basin-scale evaluation, which compromised evaluations in some Selected Areas; and over time other useful indicators have been identified and in some cases introduced as special sub-projects, an adaptive response has helping contributed to improvements in evaluating ecological responses.</p>
Evaluator 2	<p>Effective</p> <p>Monitoring was generally effective with issues at some Selected Areas. The processes were that a requirements document was prepared for each Selected Area that summarised consultation and priority indicators. Each Selected Area developed a Monitoring and Evaluation Plan that included indicators selected from a standard set (Hale et al., 2014). All the Selected Areas undertook the monitoring as agreed in their MEPS. Reporting was generally thorough and appropriate.</p> <p>Survey: Other than “Don’t know” responses, responses were generally positive with a large proportion rating this as “Very effectively” or “Extremely effectively”.</p>
Consensus final rating	Effective

Mid KEQ 1A.1	How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Warrego Darling Selected Area?
Evaluator 1	<p>Moderately Effective</p> <p>Monitoring was very dependent upon the presence of water; Darling more permanent; Warrego ephemeral</p> <p>Little flow in the Warrego system except for 2016, and very little CEW</p>
Evaluator 2	<p>Moderately Effective</p> <p>There were issues with monitoring water quality and stream metabolism because of instrument failure and data quality issues. Other indicators were monitored effectively and seem to be consistent with the MEP.</p> <p>Issues with Water quality data. In 2014-2015, there was less than 1 month data (Southwell et al., 2015d). In 2016-2016 there were instrument failures (no algal suspension data), and permanent loss of the Darling upstream station during a high flow event on 27th Sep, therefore data are discontinuous. The upstream site was telemetered but the downstream site required visits to download data.</p>

	<p>Issues with stream metabolism data for the two Darling River Sites: instrument failure (turbidity and biofouling) permanent loss of the Darling upstream station. BASE modelling rejected 80% of the dataset due to poor modelling. This was possibly because the method required flowing water and there were periods with little flow.</p> <p>All the indicators planned for monitoring, as noted in the MEP, are reported on in the final Selected Area report.</p> <p>There was no Cat I fish indicator monitoring in the Warrego-Darling, which meant fish data from this SA could not be reported in the fish Basin Matter reports. However, this was not included in the MEP so the decision to exclude this indicator was made early in the project.</p>
Consensus final rating	Moderately Effective

Mid KEQ 1A.2	How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Gwydir Selected Area?
Evaluator 1	<p>Effective</p> <p>The ecological responses to CEW in the Gwydir Selected Area were effectively monitored in both river and wetlands sites over the 5-years of the LTIM project. Ecological indicators monitored included: stream metabolism; ecosystem diversity; microinvertebrates; macroinvertebrates; vegetation diversity; native fish; fish movement; and waterbirds.*</p> <p>The Gwydir Selected Area consists of the system downstream of Moree where the Gwydir fans out into a broad alluvial near-terminal floodplain - numerous anabranches and distributary channels characterise the lower half of the Gwydir catchment, with the Mehi River and Moomin Creek to the south, and the Lower Gwydir River, Gingham Watercourse and Carole Creek to the north.</p> <p>CEW actions are targeting the channel, wetland and floodplain assets, including the Lower Gwydir, Gingham and Mallowa wetlands and also the Gwydir River downstream (west) of Tareelaro Weir (this weir is on the Gwydir at confluence with the Mehi River).</p> <p>The draft MEP was reviewed by the M&E Service Providers (MDFRC) in 2014 and most review comments appear to have been address in the final MEP agreed by CEWO (Frasier et al., 2015)*.</p> <p>Five river sites are monitored** and eight wetland sites***. A brief summary of the indicators monitored and the findings is provided below.</p> <p>-----</p> <p>Hydrology (rivers and wetlands)</p> <p>During period 2014-2019, 301 GL of environmental water (ca 180 GL CEW; ca 118 GL NSW) was delivered through the Gwydir River system, making up 23% of the total water that flowed down the Gwydir River channel</p> <p>Focused on establishing flow thresholds measured at upstream gauging stations that would ensure flow through the length of channel in each zone including three wetland systems (Gingham, Lower Gwydir and Mallowa wetlands)</p>

Established the extent of inundation and volume in these 3 wetlands and also extent of inundation of vegetation communities

The data analysis provided information on the % of time the various assets (Gwydir, Mehi, Mallowa rivers) were connected in each year – the relative contribution of environmental water (CEW and NSW) to this connectivity was also assessed

However, there was no attempt to develop a model (or models) that would relate flows in the Gwydir for example at Pallamallama with connectivity in the other channels and inundation in the 3 wetland areas – this model would need to include consideration of environmental water flows, unregulated flows, rainfall and antecedent conditions

Water quality

Monitoring at long-term station at Pallamallawa in the Gwydir River between Copeton Dam and Tareelaroi Weir

In situ continuous monitored of EC, pH, DO and turbidity - no information provided on calibration of field instruments

Compared EC, pH, DO, turbidity with ANZECC guidelines, but did not analysed further – and did not answer the question relating to influence of CEW on WQ

WQ indicators were also measured on 20 occasions 2014-2019 at 6 river sites and 4 wetland sites - measured: EC, pH, DO, turbidity in situ and took samples for DOC, Chl-a, FRP and NOx – no details provided on QC/QA protocols for laboratory analytical methods

Analysed data using multivariate analysis and found some trends WQ vs ecosystem type, hydrology and season (temperature) – but not link to CEW

Stream metabolism

Continuous measurement of DO and temp at 5 sites (4 in Gwydir, 1 in Mehi) at 10-minute intervals – calculated GPP, ER and NPP – why 4 sites when these are all basically linked?

Use a Category 3 method (why?) and because of this the data was not used in the Basin-scale Evaluation (Grace, 2020)

Gwydir river is a net sink for carbon (i.e. ER>GPP) and is a net heterotrophic system

Concluded that rates of metabolism respond to threshold changes in discharge rather than following a linear trend – but provide no analysis

Also, no attempt to relate metabolism to CEW

Lower Gwydir also found to be heterotrophic – suggests dominance of the microbial loop and decomposer pathways either through pelagic decomposition of DOC or benthic decomposition of organic matter deposited from wetland plants

Microinvertebrates

Sampling on 20 occasions at 5 sites: 3 channel sites (Gwydir River, Mehi River, Moomin Creek) and 2 wetland sites (Gingham and Lower Gwydir wetlands)

Found that hydrology is the primary driver of microinvertebrate patterns at both types of sites, but no quantitative relationships developed

Macroinvertebrates

Sampled at same sites and occasions as for macroinvertebrates – analysed data for density, diversity, richness, SIGNAL score, salinity sensitivity index and community abundance

Some statistical analysis undertaken to relate macroinvertebrate indices to explanatory factors

Macroinvertebrate taxonomic composition showed strong spatial and seasonal patterns; spatial differences in macroinvertebrate composition between channel and wetland ecosystems; seasonal factors related to hydrology, temperature and Chl-a concentration

Again, broad relationships between macroinvertebrate abundance and composition and various factors, but no predictive model(s) that would assist in quantifying the importance of environmental watering actions

Ecosystem diversity

A total of 16 mapped ANAE ecosystem types were influenced by environmental water over the duration of this LTIM project, included six floodplain types, two lacustrine types, five riverine types and three palustrine types

No analysis that quantified contribution of particular environmental water (CEW & NSW) to ecosystem types inundated

Vegetation diversity

The 3 wetlands were surveyed bi-annually (spring, autumn) – vegetation diversity and condition estimated

Found that Vegetation community condition and plant diversity of the Gwydir wetlands is driven by patterns of inundation, e.g. the highest species richness and cover recorded in the Gingham and Lower Gwydir wetlands was after a large release of environmental water

Annual flooding is key for supporting native/exotic species competition, e.g. inundation benefitted native wetland species, such as water couch, helping them to outcompete lippie and reducing its cover

Broad links were established between environmental watering and wetland vegetation communities – but no quantitative models

Native fish

Fish sampling (Category 1 and 3 – electrofishing, bait trapping) occurred each year (between late Feb and mid-May) at 23 sites – measured abundance, biomass, length frequency, health indices,

Analysis – ‘boom and bust’ system, relative low abundance of most native species, study occurred in a period of extreme and unprecedented low rainfall and drought, which in effect limited the opportunities for native fish to move, reproduce and grow – without e-flows would have been worse, multivariate analysis of fish assemblages across hydrological zones and between and within years – lots of general comments but no quantitative linking of native fish abundance, condition and reproduction to environmental watering actions

Fish movement

Fish tracked with acoustic trackers

	<p>Analysis: total daily movement was correlated with daily total river discharge, spawning period, environmental flow period and average daily river temperature and fish morphology data – statistical modelling related fish movement in periods with and without e-flows – found that river discharge, river type, and target species life history are all important when assess the effect of e-flow releases on fish movement in Gwydir system</p> <p>Waterbirds</p> <p>29 sites monitored biannually (autumn and spring) – 94 species recorded - waterbird abundance data was converted into density (abundance per hectare) for each site</p> <p>Found evidence of waterbird breeding on 77 individual occasions across 29 species and 22 sites</p> <p>Analysis: multivariate analysis showed community composition was related to wetland system type and inundation status</p> <p>Found waterbird species richness, density and diversity all varied significantly over time, between wetland systems and site types, and with varying levels of inundation</p> <p>Unsurprisingly it was found that highest average species richness, waterbird density and Shannon Diversity occurred during spring 2018, which coincided with the largest environmental water delivery</p> <p>-----</p> <p>* The final report did not provide a conceptual model of the linkages (known and hypothesised) between flow and the ecological indicators monitored and between the various indicators, which made evaluation of the ecological outcomes difficult (see also KEQ3.2).</p> <p>**Gwydir @ Pallamallawa; Gwydir d/sTareelaroi; Gwydir @ Yarraman Bridge; Gwydir @ Allambie Bridge; Mehi d/s Tareelaroi</p> <p>*** 4 in the Gingham wetland and 4 in the Lower Gwydir wetland</p>												
<p>Evaluator 2</p>	<p>Effective</p> <p>The monitoring undertaken was generally consistent with the MEP.</p> <p>Selected indicators in the MEP are shown below.</p> <table border="1"> <thead> <tr> <th>Monitoring indicator</th> <th>Category</th> </tr> </thead> <tbody> <tr> <td>Ecosystem type</td> <td>I</td> </tr> <tr> <td>Hydrology (River)</td> <td>I</td> </tr> <tr> <td>Fish (River)</td> <td>I+III</td> </tr> <tr> <td>Waterbird breeding</td> <td>I</td> </tr> <tr> <td>Vegetation diversity</td> <td>II</td> </tr> </tbody> </table>	Monitoring indicator	Category	Ecosystem type	I	Hydrology (River)	I	Fish (River)	I+III	Waterbird breeding	I	Vegetation diversity	II
Monitoring indicator	Category												
Ecosystem type	I												
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Waterbird breeding	I												
Vegetation diversity	II												

	Waterbird diversity	II	<p>A category 1 waterbird breeding indicator is shown, but this is not included the standard methods document (Hale et al., 2014). Conversely, there is no category1 stream metabolism indicator selected for the Gwydir but is it measured everywhere else. The lack of a category 1 stream metabolism indicator is acknowledged in Hale et al. (2014) so this decision was made early. This meant stream metabolism for the Gwydir was not included in the Basin-scale reporting (Grace, 2020).</p> <p>The indicators reported in the 5-yearly evaluation report are:</p> <ul style="list-style-type: none"> • Hydrology (River) • Hydrology (Watercourse) • Water quality – Cat II • Water quality – Cat III • Microinvertebrates • Macroinvertebrates • Ecosystem type • Vegetation Diversity • Fish – Cat III (River) • Fish movement • Waterbird diversity. <p>So, Waterbird diversity, macroinvertebrates, and more hydrology and water quality indicators were added, waterbird breeding were dropped.</p>
	Water quality	II	
	Hydrology (Watercourse)	III	
	Fish (Movement)	II	
	Microcrustaceans	III	
Consensus final rating	Effective		

Mid KEQ 1A.3 How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Murrumbidgee Selected Area?

<p>Evaluator 1</p>	<p>Effective</p> <p>The ecological responses to CEW in the Murrumbidgee Selected Area were effectively monitored in both river and wetlands sites over the 5-years of the LTIM project. Ecological indicators monitored included: (a) river sites - stream metabolism, macroinvertebrates, fish communities, and larval fish; (b) wetland inundation, fish, vegetation diversity, macroinvertebrates, waterbirds, frogs and turtles.*</p> <p>River monitoring covered around 790 km from Wagga Wagga to Balranald, almost half of the 1,600 km length of the Murrumbidgee River, with wetland monitoring occurring in three - the mid-Murrumbidgee, Redbank and Gayini Nimmie-Caira – of the six wetland zones in lower Murrumbidgee River.</p> <p>The draft MEP was reviewed by the M&E Service Providers (MDFRC) in 2014 and most review comments appear to have been address in the final MEP agreed by CEWO (Wassens et al., 2014). The MEP was amended in 2018 to include additional monitoring associated with a 90 GL CEW action aimed at fish and waterbirds in Yanga (Kopf et al., 2018).</p> <p>A brief summary of the indicators monitored and the main findings is provided below.</p> <p>-----</p> <p><i>River monitoring: two main sites - Narrandera, Carrathool:</i></p> <ul style="list-style-type: none"> • <i>Water quality - monitored six times between October and December in each monitoring year at 2 sites (Narrandera, Carrathool) - in situ - EC, pH, DO and turbidity; samples for DOC, Chl-a, FRP and NOx – No information provided on (a) calibration of field instruments, and (b) QC/QA protocols for laboratory analytical methods - analysed data using general linear model relating water year and site – did not answer the question relating to influence of CEW on WQ (Wassens et al, 2020a, p142)</i> • <i>Metabolism – daily rates of DO measured at Narrandera and Carrathool – some attempt to relate NPP to flow and time of year but not very quantitative analysis</i> • <i>Microinvertebrates – hypothesis that environmental flows in spring and summer would inundate previously dry sediments in rivers (i.e. backwaters, in-channel benches), releasing and transporting nutrients that along with rising temperatures, stimulates productivity and diversity of microinvertebrate communities, and that peaks in microinvertebrates density would match the timing of peak numbers of fish larvae – benthic and pelagic samples collected fortnightly at six larval fish sampling sites (3 in each Carrathool and Narrandera zones) from mid spring to early summer – qualitative analysis only of CEW vs microinvertebrate density</i> • <i>Fish communities – fish (10 native, 3 exotics) collected at sites in 2015 and 2019 within 3 riverine zones using Category 3 methods (MEP says Category 1 methods) – abundance and biomass data analyse using multivariate method – compared between the two years – but no analysis of CEW contribution to fish populations</i> • <i>Larval fish – collected fortnightly at above 6 river sites in period between October and December – multivariate analysis of larval fish CPUE to compare between 2 zones; also generalised linear mixed-effect model developed relating probability of periodic species spawning (golden perch and silver perch) in response to abiotic factors (hydrology and temperature) – some DNA testing of samples – CEW not specifically delivered to support in-channel fish, but evidence that spawning of golden perch and silver perch mostly stimulated by temperature and not flow -</i> <p><i>Wetland monitoring: 12 wetlands in three of the zones - the mid-Murrumbidgee, Redbank and Gayini Nimmie-Caira</i></p> <ul style="list-style-type: none"> • <i>Wetland inundation – floodplain wetland inundation mapped using satellite data – areas of wetlands in 3 classes (open water, water mixed with vegetation, and dense vegetation cover that was inundated) calculated – used the area inundated to assess the contribution of CEW to extent of inundation</i> • <i>WQ – sampled 4 times per year (Sept, Nov, Jan, Mar) at 12 sites - in situ EC, pH, DO and turbidity – samples also analysed for DOC, Chl-a, FRP and NOx – evaluation rather ineffective</i>
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	<ul style="list-style-type: none"> • <i>Microinvertebrates - benthic and pelagic samples collected 4 times per year (Sept, Nov, Jan, Mar) at 12 wetland sites – qualitative analysis only of CEW vs microinvertebrate density – CEW shown to result in high density of microinvertebrates in all zones thus producing feeding habitats for filter-feeding waterbirds, fish, larval fish and tadpoles</i> • <i>Vegetation diversity - sampled 4 times per year (Sept, Nov, Jan, Mar) at 12 sites using standard methods (Category 1 – data collected along fixed transects – measure percentage cover of each species, open water, bare ground, leaf litter, and logs >10 cm, tree canopy crown cover, water depth (cm) and soil moisture – compared community structure and species diversity, and community composition between wetlands, water years and wet-dry phases – statistical analysis showed CEW contributed to a significant increase in the number of water dependent and native vegetation species, and to a decrease in the species richness of exotic and terrestrial species</i> • <i>Fish - sampled 4 times per year (Sept, Nov, Jan, Mar) at 12 sites using Category 1 methods – CPUE recorded – analysed for differences in fish community composition – also analysed for recruitment – 9 native and 6 exotics collected - diversity of native species was positively correlated with increasing water permanence (but composition varied between years) – contribution of CEW to wetland fish communities seems to be largely related to the provision of water (i.e. inundation) – not clear (to me) what the key finding (outcomes were regarding fish composition, abundance, recruitment etc</i> • <i>Frogs and turtles – frogs and tadpoles sampled 4 times per year (Sept, Nov, Jan, Mar) at 12 sites – measured adult frog abundance, calling activity and tadpole CPUE - Generalised Linear Models used to examine frog presence and absence relationships with water depth, survey month, wetland zone and water year – seems CEW is contributing to frog breeding (many tadpoles sampled) – very broad findings, e.g. more water more frog and tadpoles</i> • <i>Waterbirds - ground surveys assessed waterbird species richness, maximum abundance and breeding activity at the 12 wetland sites 4 times per year - multivariate analyses used to investigate differences in waterbird guild assemblages among the survey sites – regarding the contribution of CEW unsurprisingly it was found that waterbird species richness and total abundance was higher in wetland sites that were inundated cf dry sites – waterbird breeding activity related to extent of inundation (e.g. in 2016-17 there were 32 species breeding cf 8-19 species in other years – the more water there is the greater the waterbird species richness, abundance and breeding</i> <p>-----</p> <p>* The final report did not provide a conceptual model of the linkages (known and hypothesised) between flow and the ecological indicators monitored and between the various indicators, which made evaluation of the ecological outcomes difficult (see also KEQ3.3).</p>
Evaluator 2	<p>Effective</p> <p>Monitoring was effective. The monitoring activities undertaken were consistent with planned activities in the Monitoring and Evaluation Plan. Reporting was thorough and appropriate.</p>
Consensus final rating	<p>Effective</p>

Mid KEQ 1A.4	How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Lachlan Selected Area?
Evaluator 1	<p>Moderately Effective</p> <p>Very good annual reports both summary and technical</p>

	<p>Did modify program in 2018-19 to include studies in mid-Lachlan (and received special funding)</p> <p>Focused on golden perch – fortnightly sampling but no spawning detected – then tried weekly sampling in 2015-16 to see if they missed spawning, but still no spawning</p>
Evaluator 2	<p>Moderately Effective</p> <p>All the indicators that were planned to be measured in the MEP were reported on in the final Selected Area report. Most of these indicators seem to have been monitored effectively. However, there were issues with vegetation monitoring:</p> <p>“A number of the vegetation monitoring sites, which have been monitored in the lower Lachlan River Catchment over the past five years of the LTIM have not, and it is very unlikely that they will, receive environmental water. In contrast, very few sites that have received environmental water more than once in the five year period have been monitored.” (Dyer et al., 2019a).</p>
Consensus final rating	Moderately Effective

Mid KEQ 1A.5	How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Goulburn River Selected Area?
Evaluator 1	<p>Effective</p> <p>The ecological responses to CEW in the Lower Goulburn Selected Area were effectively monitored in river sites over the 5-years of the LTIM project. Ecological indicators monitored included: physical habitat, stream metabolism, macroinvertebrates, algal biofilms, native fish, and bank vegetation.*</p> <p>The Goulburn Selected Area focused only on in-channel responses. There were no overbank flows as the Victorian government policy does not permit this. Two zones of the lower Goulburn sampled: Zone 1 - Goulburn Weir to Broken Creek (sites Darcey’s Track (plus others)); Zone 2 - Broken Creek to Murray (sites Lock Gary, McCoys Bridge (plus others)).</p> <p>The draft MEP was reviewed by the M&E Service Providers (MDFRC and WEC) in 2014 and all review comments appear to have been address in the final MEP agreed by CEWO (Webb et al., 2014). The MEP was amended in 2018 to focus environmental water delivery in the winter period – the original MEP had little winter monitoring included (Webb et al., 2018).</p> <p>A brief summary of the indicators monitored and the main findings is provided below.</p> <p>-----</p> <p><i>Physical habitat (hydraulic conditions; bed & bank condition)</i></p> <ul style="list-style-type: none"> • <i>Hydraulic conditions from field surveys and hydraulic modelling</i> • <i>Bank condition – field studies at different flow rates using erosion pins – develop a probabilistic model of erosion/deposition vs inundation – tested IVT flow situation</i> • <i>Sediment and seed deposition using artificial turf mats placed on banks – seed recovered and germinated – hierarchical model developed to test hypothesis that the transport and deposition of seeds/sediments in waterways is driven by streamflow, and differs by habitat type (bank, bar, bench or ledge) and time of the year</i>

Stream metabolism

- *Stream metabolism and water quality measurements were performed in accordance with the LTIM Standard Operating Procedure (Category 1)*
- *Water temperature and dissolved oxygen were logged every ten minutes at four sites*
- *Water quality parameters (temp, EC, pH, DO turbidity) measured fortnightly. Samples also taken at 4 sites and analysed for TOC, DOC, POC, TN, NH4, NOx, TP, FRP approx. monthly – no details on calibration of field instruments, or QC/QA protocols for laboratory analytical methods*
- *DO data used to calculate GPP, ER, NPP (NPP calculated using Bayesian model)*
- *Modelled: relationship between flow and GPP and ER; temp and light as drivers of GPP and ER; hierarchical Bayesian linear regression model used to test GPP and NEP against daily discharge, temperature and light*
- *Net Org-C (NOC) production and load also calculated*

Macroinvertebrates/algal biofilms

- *Previous results from LTIM monitoring showed that crustaceans, notably the freshwater shrimp (*Paratya australiensis*) and the freshwater prawn (*Macrobrachium australiense*), are particularly sensitive to flows in the Goulburn River - additional monitoring occurred over winter (2018-19 monitoring period to help answer whether flows are directly beneficial to crustaceans*
- *Macroinvertebrate sampling undertaken – artificial substrates; edge sampling; crustacean sampling*
- *Statistical analysis of data using a Bayesian model to assess the effect of the spring fresh on macroinvertebrate biomass and abundance - Results see Webb et al, 2020b -Table Section 5.2*
- *Work also undertaken (2018-19) on algal biofilms to provide initial insight into how flows may impact on biofilms on hard structures (used artificial substrates) – tested the effects of season and environmental flows on biofilm biomass, community composition & photosynthetic performance*

Bank vegetation

- *Vegetation sampled before and after spring freshes at different elevations on the bank (Lock Gary and McCoys Bridge)*
- *Analysis qualitative and quantitative (statistical models of relationships between hydraulic variables and vegetation)*

Native fish

- *Annual fish surveys in the river channel undertaken – now 15 years of data – eggs and larvae (drift nets), golden perch movement (Category 1 methods used)*
- *Statistical models developed for larval fish surveys and fish movement*
- *Six native and two exotic species surveyed in the annual adult fish electrofishing and netting studies, e.g. Murray cod, trout cod, silver perch, Murray River rainbowfish, Australian smelt, carp*
- *Statistical model developed to predict probability of spawning of golden perch as a function of instantaneous flow or velocity with spawning becoming possible when both temperature and antecedent flow exceed certain threshold levels*
- *Golden perch movement – used tagged fish*
- *Statistical modelling of fish movement indicated significant positive relationships between temperature and fish movement; the effects of either flow or velocity not significant*

 * The final report provided a very useful a conceptual model (see below) of the linkages (known and hypothesised) between flow and the ecological indicators monitored and between the various indicators, which made contributed to the successful evaluation of the ecological outcomes (see also KEQ3.5).

Evaluator 2	Effective LTIM has been effective in monitoring ecological responses in the Goulburn. The monitoring that was undertaken was consistent with the Monitoring and Evaluation Plan. Reporting was of high quality.
Consensus final rating	Effective

Mid KEQ 1A.6	How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Edward-Wakool Selected Area?
Evaluator 1	<p>Effective</p> <p>The ecological responses to CEW in the Edwards-Wakool Selected Area were effectively monitored in river sites over the 5-years of the LTIM project. Ecological indicators monitored included: stream metabolism, native fish (movement, spawning, recruitment, adults), and vegetation (aquatic, bank).*</p> <p>During the 5-years of the LTIM project, monitoring focussed on permanent flowing rivers in four hydrological zones: Yallakool Creek (zone 1), upper Wakool River (zone 2) and mid reaches of the Wakool River (zones 3 and 4). The Niemur and Werai Forests were to be part of this Selected Area, but were not sampled because there have not been CEW actions large enough to get water overbank. The main source of CEW for the Edward-Wakool system is from the Murray River through the Edward River and Gulpa Creek – Stevens Weir is the main flow regulating structure within the Edward-Wakool system.</p> <p>The draft MEP was reviewed by the M&E Service Providers (MDFRC and WEC) in 2014 and all review comments appear to have been address in the final MEP agreed by CEWO (Watts et al., 2014).</p> <p>A brief summary of the indicators monitored and the main findings is provided below.</p> <p>-----</p> <p><i>Hydrology</i></p> <ul style="list-style-type: none"> • <i>Daily discharge obtained from gauges – CEW volumes also estimated</i> • <i>Extent of riverbank inundation calculated using 2-DI hydraulic modelling a</i> • <i>Volume of CEW delivered over the 5-year period was small in comparison to the large unregulated flow in 2016 – however when no unregulated flows environmental water has been important</i> • <i>Provide information on a particular CEW action (800 ML/d) in 2018 on flow in 4-zones, longitudinal and lateral (bank height, overbank) connectivity, and hydraulic diversity – need to look at other reports to assess other CEW actions</i> <p><i>Water quality and Carbon</i></p> <ul style="list-style-type: none"> • <i>Water temperature and dissolved oxygen were logged every ten minutes with two loggers located in each of zones 1, 3 and 4 and one logger in zone 2</i> • <i>Light and depth loggers were also deployed and data were downloaded on a monthly basis</i>

	<ul style="list-style-type: none"> • Monthly water samples collect at Steven Weir and Mulwala Cannal and analysed for: DOC; NH4, FRP, NOx, TN, TP, and absorbance and fluorescence spectroscopy for organic matter characterisation (provide details of methods in Watts et al, 2014a) – compared data with ANZECC guidelines • Also comment on WQ data collected by Water NSW (e.g. in Niemur River on the Barham Moulamein Rd) • Assessed the influence of CEW on DO, nutrients and type of DOC – this assessment was qualitative – no quantitative relationships of flow vs indicator <p><i>Stream metabolism</i></p> <ul style="list-style-type: none"> • Temperature and DO were logged every ten minutes with two loggers located in each of zones 1, 3 and 4 and one logger in zone 2 • DO data used to calculate GPP, ER, NPP • Established several hypotheses to test • Modelled: relationship between flow and GPP and ER (regression model) – E-W system strongly heterotrophic • Net Org-C (NOC) production and load also calculated • Some assessment of influence of CEW on GPP& ER – found from 2018-19 actions that increased flows due to CEW enhanced the organic carbon load – but low FRP concentrations probably limiting factor – also little overbank flow <p><i>Vegetation (aquatic and bank)</i></p> <ul style="list-style-type: none"> • Monitored 4 sites in each of 4 hydrological zones (Yallakool Creek, Wakool River zone 2, 3 and 4) once per month – at each site 6 x 20 m long transects established up the bank (no floodplain sampling) • Vegetation classified: submerged taxa, amphibious taxa, and terrestrial taxa – total species richness and cover calculated • Analysis qualitative observations – no statistical models of relationships between CEW actions, hydraulic variables and vegetation <p><i>Native fish (movement, reproduction, recruitment, community)</i></p> <ul style="list-style-type: none"> • Movement – acoustic tags - 79 golden perch, 21 Murray cod and 43 silver perch • Spawning & reproduction – larvae sampled fortnightly Sept 2018 to Feb 2019 (several methods used) • Recruitment – 4 zones sampled between Feb & Mar – electrofishing & bait lines used - • Adult fish communities – 18 sites sampled between April & June in 2015 and 2019 - electrofishing and unbaited bait traps - • Considerable good information on fish behaviour in E-W system – fish community probably still recovering after flood-induced hypoxic blackwater and associated fish kills in 2016 – • Evaluation of influence of CEW actions – qualitative using observational data – no statistical statistical modelling <p><i>Special study</i></p> <ul style="list-style-type: none"> • Undertaken Aug-Sept 2018, flow of 800 ML/d in Yallakool creek and Wakool River system (see Fig 4) • Lots learned about operational constraints, flows in different locations, river bank inundation, infrastructure inundations – little on the ecological outcomes <p>-----</p> <p>* The final report did not provide a conceptual model of the linkages (known and hypothesised) between flow and the ecological indicators monitored and between the various indicators, which made evaluation of the ecological outcomes difficult (see also KEQ3.1).</p>
<p>Evaluator 2</p>	<p>Effective</p> <p>The LTIM project was effective in monitoring the ecological response to CEW in the Edward-Wakool.</p>

	There were problems with the vegetation indicator: “It should be noted that vegetation diversity data collected from the Edward-Wakool river system is limited to Category 3 and does not, therefore, have the same taxonomic resolution or range of observations as that from the other Selected Areas.” (Capon and James, 2020). However, this was agreed in the Edward-Wakool Monitoring and Evaluation Plan.
Consensus final rating	Effective

Mid KEQ 1A.7	How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Lower Murray Selected Area?
Evaluator 1	<p>Effective</p> <p>All the indicators mentioned in the MEP were monitored and reported on – focus was on fish spawning, recruitment and populations</p> <p>Monitoring was effective</p> <p>Also reporting on the Coorong and Lower Lakes salinity – presumably obtained information from Basin Matters hydrology report</p>
Evaluator 2	<p>Effective</p> <p>All the indicators mentioned in the MEP were monitored and reported on. There is also additional reporting. For example, Banrock station is a case study in the final Basin Matters biodiversity report even though it is not mentioned in any of the Lower Murray Selected Area reports. There is also reporting on the Coorong and Lower Lakes.</p>
Consensus final rating	Effective

High KEQ 2	How effectively did the LTIM project evaluate Basin-scale contribution of CEW to the Basin Plan objectives using the CEWO Outcomes Framework and following the process and methodology outlined in Gawne et al. (2014a, Section 2.4)? (from Head contract B2.1 (b)) (objective 1 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)
Evaluator 1	<p>Moderately Effective</p> <p>The annual and cumulative evaluation of the Basin-scale contribution of CEW to the Basin Plan objectives, achieved through the Basin Matters team reports, has been moderately effective. The Basin Matters team evaluated annually the contribution of CEW (and other environmental water) to six ecological indicators: hydrology, ecosystem diversity, vegetation diversity, fish populations, biodiversity, and stream metabolism and water quality. The main findings from these reports were then integrated into a Synthesis report which mapped the contributions of CEW to the four Basin Plan objectives</p>

	<p>– biodiversity, ecosystem processes, sustainability and water quality and salinity. This type of evaluation is new and challenging, and to our knowledge has never been done before at this scale.</p> <p>These evaluations became more effective over the 5-years of LTIM, but as noted elsewhere in this assessment, the lack of effective collaboration between the Basin Matters and Selected Area teams contributed to these evaluations being less effective that they could have been.</p> <p>The annual and cumulative evaluations of the contribution of CEW were well reported, although as noted elsewhere in this report, these Basin Matters reports have not been widely read and appear to have had little impact on environmental water management in the MDB.</p> <p>Stakeholder comments (survey, interviews) were somewhat mixed regarding the effectiveness of the Basin-scale evaluations with some of the main points being: the hydrologic contribution has been well demonstrated; approaches to other themes (e.g. fish and vegetation) continued to develop through the program; the degree to which cumulative analysis was undertaken was poor; it has been challenging to convert a series of annual outcomes into a cumulative outcome; there is need to question the concept of a Basin-scale response compared to regional or local-scale response; and there is still confusion about what Basin-scale means.</p> <p>The current relevance of the CEWO outcomes framework that guided the design of the LTIM project has also been questioned. It was suggested that this framework was developed so that ecological outcomes at local-scales and in annual timeframes could be mapped to the Basin Plan objectives, because it was thought that this information would be needed for CEWO’s legislative reporting obligations. However, it has been suggested that much of this information was not all needed, and yet the LTIM objectives have remained unaltered as have the Selected Area contracts.</p>
Evaluator 2	<p>Moderately Effective</p> <p>The overall assessment of KEQ 2 is that the LTIM project was moderately effective in evaluating the basin-scale contribution of CEW using the outcomes framework. This is based on an aggregation of meso- and micro-scale KEQs. The outcomes framework was moderately effective in aligning to the objectives in the Basin Plan Environmental Watering Plan and the Water Quality and Salinity Management Plan (KEQ 2.1). The LTIM project was moderately effective in evaluating the contribution of CEW to the Basin Plan objectives. The project was minimally effective at reporting on the cumulative evaluation of CEW at the Basin-scale (KEQ 2.3). And the project was moderately effective in undertaking an annual evaluation of the influence of CEW on the six Basin Matters (KEQ 2.4)</p>
Revision comments – Evaluator 1	
Revision comments – Evaluator 2	
Consensus final rating	Moderately Effective

Mid KEQ 2.1	How effectively did the CEWO Outcome Framework align to the Basin Plan Environmental Water Plan (EWP) and Water Quality and Salinity Plan objectives?
Evaluator 1	<p>Moderately Effective</p> <p>The LTIM project is moderately aligned to the Basin Plan Environmental Water Plan (EWP) objective and minimally aligned to the Basin Plan Water Quality and Salinity Plan objectives</p> <p>The Basin Plan has three overall environmental objectives (S8.04) - to protect and restore water-dependent ecosystem (S8.05)*; to protect and restore the ecosystem functions of water-dependent ecosystems (S8.06)**; and to ensure water-dependent ecosystems are resilient to climate change and other risks and threats (S8.07)*** – and further objectives related to water quality and salinity (S9.04).</p> <p>At a broad level, the LTIM project is well alignment with these Basin Plan objectives seeking to evaluate the contribution of CEW at a Basin-scale in four area: biodiversity, ecosystem processes, resilience and water quality. Details of the rationale for this alignment is provided in the CEWO Outcomes Framework (CEWO, 2013), the LTIM Logic and Rationale Document (Gawne et al., 2013) and the LTIM Basin Evaluation Plan (Gawne et al, 2014b).</p> <p>Alignment of the LTIM project with the Basin Plan biodiversity objectives is moderately effective. Ecosystem diversity and species diversity (fish, vegetation, other species) are evaluated at the Basin-scale by the Basin Matters team, using monitoring information on vegetation, macroinvertebrates, fish, waterbirds and other vertebrates provided by the Selected Areas. The LTIM project, however, has done little on bird species listed under the various international conventions, and on threatened species and threatened ecological communities.</p> <p>Alignment of the LTIM project with the Basin Plan ecosystem function objectives is moderately effective. Annual Basin Matters reports containing information relevant to ecosystem processes include: hydrology (hydrological connectedness; metabolism (primary production and respiration; biodiversity (maintaining populations; and ecosystem diversity (supporting habitat diversity). The LTIM project is not (or poorly) addressing Basin Plan ecosystem function objectives related to: in-stream or floodplain processes that shape landforms; habitat extent, condition and connectiveness; and energy, carbon and nutrient dynamics.</p> <p>Alignment of the LTIM project with the Basin Plan resilience objectives is minimally effective. The Basin Matters synthesis report attempted to address outcomes from CEW actions in 2018-19 (dry conditions) that contributed to wetland resilience. However, the LTIM project is not (or poorly) addressing resilience objectives related to: resilience to climate change, variability and disturbances; minimisation of habitat fragmentation; and provide wetting and drying cycles and inundation intervals that do not exceed ecosystem tolerances.</p> <p>Alignment of the LTIM project with the Basin Plan water quality objectives is minimally effective. The objective related to maintaining the ecological character of declared Ramsar wetlands in the MDB received scant attention in the Basin Matters synthesis reports. The other Basin Plan water quality objective related to water-dependent ecosystems (other than declared Ramsar wetlands) is a particularly high-level (and rather vague) objective. The LTIM project has made little attempt to interpret this objective, although some information on oxygen-depleted blackwater and the export of salt and nutrients from the system is provided in Basin Matters reports.</p> <p>-----</p> <p>* This objective is focused on maintaining the ecological character of Ramsar wetlands and supporting the life cycle of waterbirds; and protecting and restoring biodiversity (representative native biota; threatened species).</p>

	<p>** This objective is focused on connectivity within and between water-dependent ecosystems, including the Lower Lakes and Murray Mouth; habitat diversity; biological populations; and ecological community structure and, species interactions and food webs.</p> <p>*** This objective is focused on protecting refugia and minimising habitat fragmentation; and providing wetting and drying cycles and inundation intervals that do not exceed ecosystem tolerances.</p>
Evaluator 2	<p>Effective</p> <p>I have assumed “The Outcomes Framework” is as specified in the document, CEWO (2013) “The Environmental Outcomes Framework” December 2013 Version 1.1. This includes reference to both Basin Plan Chapter 8 Environmental Water Plan and Chapter 9 Water quality and salinity management plan objectives.</p> <p>This rating of effective was based on an aggregation of ratings for the KEQs. I initially regarded alignment with Basin Plan objectives as generally effective as noted below.</p> <p>Survey: The results from the survey strongly support at least partial alignment with over 92% responding that the framework was “Somewhat effectively” or “Effectively” aligned.</p>
Revision comments – Evaluator 1	Do not wish to change – LTIM was only moderately aligned with Water quality and salinity plan at best.
Revision comments – Evaluator 2	Agree that a change to moderately effective is appropriate given the revised ratings of the micro-level KEQs
Consensus final rating	Moderately Effective

Micro 2.1.1	KEQ	How effectively did the LTIM project align to the Basin Plan EWP objectives in S8.05 (labelled 'biodiversity')?
Evaluator 1		<p>Moderately Effective</p> <p>The LTIM project is moderately well aligned with the Basin Plan objectives in S8.05.</p> <p>The Basin Plan objectives listed in S8.05 relate to: protecting and restoring biodiversity of representative populations and communities of native biota (S8.05, 3 (b)) and protecting the lifecycles of listed threatened species (S8.05, 3 (a)); and protecting and restoring a subset of all water-dependent ecosystems (e.g. Ramsar wetlands (S8.05, 2 (a)), and wetlands that support species listed under international conventions (Bonn Convention, CAMBA, JAMBA or ROKAMBA) (S8.05, 2 (b))).</p>

	<p>The LTIM project is addressing biodiversity at the Selected Area scale by monitoring vegetation, macroinvertebrates, fish, waterbirds and other vertebrates in most Areas, and evaluating ecosystem diversity and species diversity (fish, vegetation, other species) at the Basin-scale (Gawne et al., 2014b).</p> <p>However, the LTIM project has done little bird species listed under the various international conventions, and on threatened species (except for the vulnerable southern bell frog in the Murrumbidgee) and threatened ecological communities.</p>
<p>Evaluator 2</p>	<p>Moderately Effective.</p> <p>There is little data available to evaluate this KEQ.</p> <p>Basin Plan EWP objective related to biodiversity:</p> <p>S8.05 (3)</p> <p>An objective is to protect and restore biodiversity that is dependent on Basin water resources by ensuring that:</p> <ol style="list-style-type: none"> a) 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 b) representative populations and communities of native biota are protected and, if necessary, restored. <p>The outcomes framework links these objectives to things that can be measured by LTIM.</p> <p>The Biodiversity objectives have a focus on 1) water-dependent ecosystems that support threatened species or communities and 2) representative populations and communities.</p> <p>There is some ambiguity around how the LTIM project deals with threatened species. Threatened species do not seem to have been specifically monitored in Selected Areas.</p> <ul style="list-style-type: none"> • Only one threatened species is mentioned in the Lower Murray SA MEP (the Southern Bell Frog) • There is some limited mention of threatened species in the Lachlan and the Warrego-Darling SA MEP • There is no mention of threatened species in the Murrumbidgee MEP (although I understand, the location of this SA was partly because of threatened frogs). • The impact of watering on threatened species is mentioned in the Basin-scale synthesis reports. • There is focus on representative ecosystem types in the Ecosystem Diversity Basin Matter. <p>It is not clear that SAs were selected because they contained “water-dependent ecosystems that support threatened species or communities” or “representative populations and communities”. But I have not been able to find anything on how the Selected Areas were chosen. There is little information in the Logic and Rationale document (Gawne et al., 2013a).</p>

	In contrast, the biodiversity Basin Matter reports are all about threatened species. The link between the SA annual reports and the biodiversity annual reports is not clear. There was aerial surveillance to determine water bird information so perhaps this was done independently of the SA monitoring.
Consensus final rating	Moderately Effective.

Micro 2.1.2	KEQ	How effectively did the LTIM project align to the Basin Plan EWP objectives in S8.06 (labelled 'ecosystem function')?
Evaluator 1	Moderately Effective	<p>The LTIM project is reasonably well aligned with the Basin Plan objectives in S8.06.</p> <p>The Basin Plan list thirteen objectives related to ecosystem function (S8.06, 3 (a,f)); S8.06,5; S8.06, 6 (a,b); connectiveness (longitudinal, lateral, vertical) within and between water-dependent ecosystems, including Lower Lakes and Murray Mouth; landscape shaping processes; habitat diversity; ecosystem functions that maintain biological populations (recruitment, regeneration, dispersal, immigration, emigration) by ensuring flow sequences, inundation and recession events, and habitat diversity, extent, condition and connectivity that support life cycles of biota.</p> <p>The LTIM project is addressing ecosystem function largely at the Basin-scale through annual Basin Matters reports on hydrology (hydrological connectedness (S8.06, 3 (b-f)), metabolism (primary production and respiration (S8.05, 7)), biodiversity (maintaining populations, e.g. cues for migration, germination and breeding) (S8.06, 6a)) and ecosystem diversity (supporting habitat diversity (S8.06, 5)).</p> <p>The LTIM project is not (or poorly) addressing Basin Plan ecosystem function objectives related to: in-stream or floodplain processes that shape landforms (S8.06, 4); habitat extent, condition and connectiveness (S8.06, 6 (b)); and energy, carbon and nutrient dynamics (S8.06, 7).</p>
Evaluator 2	Effective	<p>8.06 Protection and restoration of ecosystem functions of water-dependent ecosystems</p> <p>(1) This section sets out particular objectives relating to the protection and restoration of the ecosystem functions of water-dependent ecosystems.</p> <p>(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.</p> <p>(3) An objective is to protect and restore connectivity within and between water dependent ecosystems, including by ensuring that:</p> <p>(a) the diversity and dynamics of geomorphic structures, habitats, species and genes are protected and restored; and</p> <p>(b) ecological processes dependent on hydrologic connectivity:</p> <p>(i) longitudinally along watercourses; and</p> <p>(ii) laterally between watercourses and their floodplains (and associated wetlands); and</p>

<p>(iii) vertically between the surface and subsurface; are protected and restored; and</p> <p>(c) 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</p> <p>(d) 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</p> <p>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.</p> <p>(e) 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:</p> <p>(i) maintaining levels above 0.4 metres Australian Height Datum for 95% of the time, as far as practicable; and</p> <p>(ii) maintaining levels above 0.0 metres Australian Height Datum all of the time; and</p> <p>(f) barriers to the passage of biological resources (including biota, carbon and nutrients) through the Murray-Darling Basin are overcome or mitigated.</p> <p>(4) 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.</p> <p>(5) 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).</p> <p>(6) 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:</p> <p>(a) flow sequences, and inundation and recession events, meet ecological requirements (for example, cues for migration, germination and breeding); and</p> <p>(b) 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.</p> <p>(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.</p> <p>In summary, the relevant objectives are:</p> <ul style="list-style-type: none"> • (2) Water quality...consistent with the water quality and salinity management plan • (6) (a) flow sequences etc; (b) habitat diversity, condition, connectivity
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	<ul style="list-style-type: none"> (7) ecological community structure, species interactions and food webs...primary production and respiration. <p>Relevant objectives from the water quality and salinity management plan are that the quality of water is sufficient to:</p> <ul style="list-style-type: none"> Protect and restore the ecosystems Protect and restore the ecosystem functions of the ecosystems Ensure that the ecosystems are resilient to climate change and other risks and threats. <p>LTIM seems to be closely aligned with these objectives.</p> <p>A minor point...It doesn't appear that LTIM was concerned with 3(b)(iii) hydrologic connectivity vertically between surface and subsurface. Groundwater monitoring was not undertaken in the SAs and is not mentioned in the MEPS. For example, in the Lower Murray, sites within the SA were selected so they did not have significant groundwater inflows.</p>
Revision comments – Evaluator 1	Mostly it's good, but there's a few of the objectives under Ecosystem function that weren't addressed (see above)
Revision comments – Evaluator 2	I'm certainly happy to go with moderate.
Consensus final rating	Moderately Effective

Micro 2.1.3	KEQ	How effectively did the LTIM project align to the Basin Plan EWP objectives in S8.07 (labelled 'resilience')?
Evaluator 1	Minimally Effective	<p>The LTIM project is poorly aligned with the Basin Plan objectives in S8.07.</p> <p>The Basin Plan lists six objectives related to ecosystem resilience; resilience to climate change, variability and disturbances (S8.07, 2); protecting refugia (S8.07, 3); providing wetting and drying cycles and inundation intervals that do not exceed ecosystem tolerances (S8.07, 4); minimising human-induced threats (alien species, water management, water quality) (S8.07, 5); and minimising habitat fragmentation (S8.07, 6).</p> <p>The LTIM project has made an attempt to address this outcome in the Basin Matters synthesis reports. For example, Hale et al. (2020) lists three outcomes from CEW actions in 2018-19 (dry conditions) that contributed to wetland resilience: sustaining species and communities in the Gwydir system through maintaining vegetation condition, provision of habitat for waterbirds, prevention of no flow conditions and improved connectivity for native</p>

	<p>fish; provision of wetland refuge habitat in the Murrumbidgee, benefitting waterbirds, turtles, frogs and native fish; and using CEW to maintain the ecological character (particularly biodiversity) of 10 of the Basin’s 16 Ramsar wetlands that would otherwise have remained largely dry.</p> <p>The LTIM project is not (or poorly) addressing Basin Plan resilience objectives related to: resilience to climate change, variability and disturbances; minimisation of habitat fragmentation; and provide wetting and drying cycles and inundation intervals that do not exceed ecosystem tolerances (although is partially addressed through the hydrology Basin Matters reports).</p>
Evaluator 2	<p>Effective</p> <p>The Basin Plan EWP objectives in S8.07 are:</p> <p>(1) This section sets out particular objectives relating to ensuring that water dependent ecosystems are resilient to climate change and other risks and threats.</p> <p>(2) An objective is that water-dependent ecosystems are resilient to climate change, climate variability and disturbances (for example, drought and fire).</p> <p>(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.</p> <p>(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.</p> <p>(5) An objective is to mitigate human-induced threats (for example, the impact of alien species, water management activities and degraded water quality).</p> <p>(6) An objective is to minimise habitat fragmentation.</p> <p>It’s clearly hard to monitor these things. However, LTIM was concerned with (3) and (4). The links in the outcomes framework seem reasonable. The concept of resilience is clearly important but is not well defined in the basin plan or elsewhere. Much of the discussion around resilience relates to the ability for organisms to survive extended drought. This implies a role for CEW to provide long lasting refuges. However, LTIM showed the risks associated with high flows when 96% of Murray Cod were killed in the Edward-Wakool because of a blackwater event. Resilience needs to consider all types of extreme events and their consequences. It may be necessary to keep water in reserve to mitigate extremes but this would mean less water available in normal years. For some reaches, it may be impossible for extremes to be mitigated by environmental water. Perhaps these should be afforded a lower priority.</p>
Revision comments – Evaluator 1	<p>Well, the problem is that resilience wasn't really very well defined in the Basin Plan. Again, I think that's where the Gawne et al. (2020) paper explained their thinking a bit better. Now I'd agree to upgrade to moderate.</p>
Revision comments – Evaluator 2	<p>I think I was way too high – so let’s compromise – moderately.</p>

Consensus final rating	Moderately Effective
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Micro 2.1.4	KEQ	How effectively did the LTIM project align to the Basin Plan objectives in S9.04 (labelled 'water quality')?
Evaluator 1	Minimally Effective	<p>The LTIM project is poorly aligned with the Basin Plan water quality and salinity outcomes.</p> <p>The Basin Plan EWP list six objectives related to water quality and salinity (S9.04, 1 & 2). These relate to ensuring that: water quality does not adversely affect water-dependent ecosystems and is consistent with the water quality and salinity management plan S8.06, 2); the quality of water is sufficient to maintain the ecological character of declared Ramsar wetlands (S9.04, 1); and that the quality of water is sufficient to protect and restore other water-related ecosystems and their functions (S9.04, 2 (a,b)), and to ensure that the ecosystems are resilient to climate change and other risks and threats (S9.04, 2 (c)).</p> <p>Water quality is poorly assessed by the Selected Areas. Salinity, DO, pH and DOC are monitored in each of the Selected Areas, and there is some monitoring of bioavailable nutrient concentrations (FRP, NOx; NH4-N). However, in most cases the frequency and extent of sampling of these water quality indicators is insufficient to be able to confidently address the Basin Plan objectives.</p> <p>Additionally, the LTIM project does not specifically address the Basin Plan objective (S9.04, 1) related to the ecological character of declared Ramsar wetlands. The Lower Gwydir and Gingham wetlands located within the Gwydir Selected Area is a Ramsar declared wetland, but there is no evidence of any evaluation of either CEW actions or water quality in maintaining the ecological character of this Ramsar wetland. The Basin Matters synthesis report (Hale et al., 2020?) did provide some comment on maintenance of the ecological character of other Ramsar wetlands in the MDB.</p> <p>The other Basin Plan water quality objective (S9.04 (2)) related to water-dependent ecosystems (other than declared Ramsar wetlands) is a particularly high-level (and rather vague) objective, which provides little guidance on the actual indicators that need to be monitored and evaluated to assess whether these objectives are being met. Perhaps this objective assumes water quality is a basic element of aquatic ecosystems, and has an influence on: biodiversity, ecosystem function and resilience; acute events such as cyanobacterial blooms, oxygen-depleted blackwater and acidification; and the export of salt and nutrient from the system. Whatever the interpretation, the LTIM project has not addressed this objective well.</p>
Evaluator 2	Effective	<p>Basin plan water quality objectives S9.04.</p> <p>(2) The water quality objective for water-dependent ecosystems other than declared Ramsar wetlands is that the quality of water is sufficient:</p> <p>(a) to protect and restore the ecosystems;</p> <p>(b) and to protect and restore the ecosystem functions of the ecosystems; and</p>

	<p>(c) to ensure that the ecosystems are resilient to climate change and other risks and threats.</p> <p>The objectives at S9.04 are very general. The outcome framework links these to measurements of:</p> <ul style="list-style-type: none"> • Salinity • Dissolved Oxygen • pH • Dissolved Organic Carbon • Algal Blooms. <p>The logic and rationale (Gawne et al., 2013a) document states that CEW delivery will focus on four characteristics of water quality where the relationship to flow and the impacts on biodiversity and ecosystem function are relatively well understood: salinity, DO, pH, DOC. The logic and rationale document also includes a comprehensive review of these relationships. Although the logic and rationale was good, the monitoring work undertaken on salinity and water quality was generally poor. There was only sporadic monitoring of key water quality parameters. Reporting suggest that this was because of lack of budget but there was appears to be no attempt to use water quality data collected by others.</p>
Revision comments – Evaluator 1	<p>As noted above LTIM not very well aligned with Basin Plan S9.04</p> <p>Consensus from discussions is that minimal is too low and effective too generous, therefore compromised on to moderately effective.</p>
Revision comments – Evaluator 2	<p>The reason this is difficult is because the Basin plan water quality objective 9.04 could be anything, so the outcome framework did a good job in linking these vague objectives to things that could be measured: salinity, dissolved oxygen, pH., etc.. I thought that was argued well in Gawne et al. 2013. I thought that they had a comprehensive review of those relationships and was convinced by their argument That's why I gave it effective.</p> <p>So why do you think it's minimal? Because they should have done more, tackled the vague thing a bit better?</p> <p>I agree that there are certainly issues with alignment when we consider the water quality monitoring and evaluation. This was poorly done. There were budgetary constraints but there was also no attempt to use data collected by others.</p>
Consensus final rating	Moderately Effective

Mid KEQ 2.2	How effectively did the LTIM project evaluate the contribution of CEW to the Basin Plan objectives? (includes Chapter 8 and 9 objectives)
Evaluator 1	<p>Moderately Effective</p> <p>The LTIM project evaluated the contribution of CEW to Basin Plan objectives under four generic groups: biodiversity, ecosystem function, resilience and water quality. The evaluation was mainly done at the Basin-scale, and reported in the Basin Matters reports, with some Selected Area teams providing relevant information. A general finding was that while the LTIM project provided a consolidated evaluation of the contribution of CEW to some of the Basin Plan EWP objectives, a number were not reported on.</p>

	<p>Evaluation of the Basin-scale contribution of CEW to the Basin Plan biodiversity objectives (S8.05) was quite effective for some objectives (e.g. ecosystem diversity, fish and vegetation) and minimally effective for others (e.g. threatened species, Ramsar wetlands, waterbird species listed under international conventions).</p> <p>Evaluation of the Basin-scale contribution of CEW to the Basin Plan ecosystem processes objectives (S8.06) was quite effective for hydrological connectivity, maintaining biological populations for fish and vegetation, and metabolism. Nutrient and carbon cycling, sediment transport and habitat diversity, extent, condition and connectivity were not evaluated.</p> <p>Evaluation of the Basin-scale contribution of CEW to the Basin Plan resilience objectives (S8.07) was minimally effective. No consolidated evaluation is provided with relevant information spread over several Basin Matters reports.</p> <p>Evaluation of the Basin-scale contribution of CEW to the Basin Plan water quality objectives (S8.09) was minimally effective at both the Selected Area scale and Basin-scale.</p> <p>The interviews revealed that the collaboration within the Basin Matters team was less than optimal and resulted in considerable difficulties in producing the annual and final synthesis reports.</p>
Evaluator 2	<p>Moderately Effective</p> <p>The evaluation of CEW to basin plan objectives was moderately effective. A major challenge was aggregating contributions to provide a consolidated assessment at the Basin-scale. Evaluation of the contribution of CEW to biodiversity and ecosystem function objectives was rated as moderately effective while evaluation of the contribution of CEW to resilience and water quality was rated as minimally effective.</p> <p>Survey:</p> <p>The survey suggests that there were some issues with some responses of “Not at all effectively” and “Not so effectively”. In the comments, there concerns about the time scale of LTIM (reasonably short term) in contrast with that of the basin plan.</p>
Consensus final rating	Moderately Effective

Micro 2.2.1	KEQ	How effectively did the LTIM project evaluate Basin-scale contribution of CEW to Basin Plan EWP objectives S8.05 - 'biodiversity'?
Evaluator 1	Moderately Effective	<p>Evaluation of the Basin-scale contribution of CEW to the Basin Plan objectives in S8.05 was quite effective for some objectives (e.g. ecosystem, fish, vegetation and waterbird diversity) and minimally effective for others (e.g. threatened species, Ramsar wetlands, waterbird species listed under international conventions). The LTIM project did not provide any consolidated evaluation of the contribution of CEW to Basin-wide biodiversity (S8.05), with relevant information spread over several of the Basin Matters reports.</p> <p>The Basin Matters report on ecosystem diversity, which presumably addresses Basin Plan objective S8.05, 2 – to protect and restore a subset of all water-dependent ecosystems in the MDB - provides a very detailed evaluation of the cumulative Basin-scale contribution of CEW to ecosystem diversity</p>

	<p>over the 5-year LTIM project (Brooks, 2020), reporting that 57 of the 68 ANAE ecosystem types in the MDB were supported by CEW at least once in the 5-year of the LTIM project.</p> <p>However, evaluation of Basin Plan objective S8.05, 2 – ecological character of Ramsar wetlands and support for waterbird species listed under international conventions – is poorly done, with scant information provided in the Basin Matters synthesis report (Hale et al., 2020b) and biodiversity report (Hale et al., 2020a).</p> <p>Evaluation of the Basin-scale contribution of CEW to biodiversity (S8.05) was well done. This is reported in Basin Matters on fish (King et al., 2020), vegetation (Capon and James, 2020), and biodiversity (waterbirds, frogs and turtles, Hale et al., 2020a). There was minimal evaluation of the contribution of CEW in supporting threatened species, the focus being on improvements to two threatened bird species (the Australasian bittern, Australian painted snipe), to Murray cod populations and to the southern bell frog (Hale et al., 2020b).</p>
Evaluator 2	<p>Moderately Effective.</p> <p>Cross-reference: KEQ 2.1.1.</p> <p>The LTIM project was not closely aligned with the biodiversity objectives. These was monitoring and evaluation of biodiversity at the Selected Areas but threatened and representative species and ecosystems were not a key focus of monitoring. However, these were a key focus of the S8.05 objectives. Therefore, this is judged as moderately effective.</p>
Consensus final rating	Moderately Effective

Micro	KEQ	How effectively did the LTIM project evaluate Basin-scale contribution of CEW to Basin Plan EWP objectives in S8.06 - 'ecosystem function'?
2.2.2		
Evaluator 1		<p>Moderately Effective</p> <p>The LTIM project did not provide any consolidated evaluation of the contribution of CEW to Basin-wide ecosystem processes (S8.06). Evaluation of the Basin-scale contribution of CEW to the Basin Plan ecosystem processes objectives was quite effective for hydrological connectivity (Stewardson and Guarino, 2020), maintaining biological populations for fish (King et al., 2020) and vegetation (Capon and James, 2020), and metabolism (Grace et al., 2020). Nutrient and carbon cycling, sediment transport and habitat diversity, extent, condition and connectivity were not evaluated.</p>
Evaluator 2		<p>Moderately Effective</p> <p>Cross-reference: KEQ 2.1.2</p> <p>The key question relates to the determining CEW contribution at the basin-scale. The main evidence is provided by the synthesis reports. Basin-scale evaluations were challenging to undertake. For some Basin Matters, such as hydrology, Basin-scale evaluations were successful. This addressed some of the S8.06 objectives such as those associated with hydrologic connectivity (except for connectivity between surface and subsurface). For others, that depended on measurements at sites, planning at the start of LTIM, was for predictive models to be developed based on monitored data with outcomes</p>

	to be inferred at areas not monitored. This was not delivered as expected as discussed in other KEQs. There were also issues meeting the S8.06 objectives related to water quality and salinity. The synthesis report does a good job of providing a qualitative assessment using the limited information available.
Consensus final rating	Moderately Effective

Micro 2.2.3	KEQ	How effectively did the LTIM project evaluate Basin-scale contribution of CEW to Basin Plan EWP objectives in S8.07 - 'resilience'?
Evaluator 1		<p>Minimally Effective</p> <p>The LTIM project did not provide any consolidated evaluation of the contribution of CEW to Basin-wide ecological resilience (S8.07). Two of the Basin Plan objectives were evaluated – metabolism (primary production and respiration) (Grace et al., 2020), and ecological community structure (fish (King et al., 2020) and vegetation (Capon and James, 2020)). The Basin Matters biodiversity report (Hale et al., 2020a) comments on Ramsar wetlands noting that over the five years of the LTIM project there have been several examples of multi-year wetting and drying strategies aimed at maintaining the ecological character of Ramsar sites, and that matching the delivery of environmental water with the needs of critical components, processes and services at wetland in the context of the current and antecedent climatic conditions has been successful. And in particular, during the dry year 2018-19 CEW was used to maintain the ecological character (particularly biodiversity) of 10 of the Basin’s 16 Ramsar wetlands that would otherwise have remained largely dry.</p> <p>Basin Plan objectives related to energy, carbon and nutrient dynamics, protecting refugia and minimising habitat fragmentation were not evaluated.</p>
Evaluator 2		<p>Effective</p> <p>Cross-reference: KEQ 2.1.3</p> <p>As discussed in KEQ 2.2.2, basin-scale evaluation was problematic for many Basin Matters. This objective is particularly challenging because resilience is difficult to define and measure. Resilience to climate variability and disturbance was tested during LTIM with extreme events in 2016-2017 resulting in the loss of 96% of Murray Cod in the Edward-Wakool reach of the Murray and severe effects on other Selected Areas. The annual Basin-scale synthesis reports provide a brief summary of the role of CEW in providing resilience.</p>
Revision comments – Evaluator 1		
Revision comments – Evaluator 2		Agree that this was generally not well done with major issues extrapolating to the Basin-scale.

Consensus final rating	Minimally Effective
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Micro 2.2.4	KEQ	How effectively did the LTIM project evaluate Basin-scale contribution of CEW to Basin Plan objectives relating to water quality?
Evaluator 1	Minimally Effective	The evaluation of the contribution of CEW to water quality objectives was minimally effective at both the Selected Area scale and Basin-scale. There were however, two exceptions: first, during a major flood in October-December 2016 when anoxic conditions were recorded in the Murrumbidgee, Lower Murray, Goulburn, Edwards-Wakool and Lachlan rivers, CEW was effectively used to reduce the effects of this low DO water (Grace et al., 2020, p93); and the export of salt from the system via the Murray Mouth was also well related to CEW actions (Ye et al., 2019; Stewardson and Guarino (2020).
Evaluator 2	Minimally Effective	<p>Cross-reference: KEQ 2.1.4</p> <p>There is extensive discussion of the derivation of LTIM water quality objectives in the Logic and Rationale document (Gawne et al., 2013a). It is possible to set SMART objectives for these water quality parameters.</p> <p>The main shortcoming is that there was inadequate monitoring of these parameters. At most Selected Areas, water quality was only sampled infrequently (apart from DO). There was also no attempt to use data collected by others. This contrasts to the hydrology Basin Matter where gauged data was used extensively.</p> <p>The deficiency of water quality monitoring was recognised in the first Basin Matter report (Grace, 2017): “Collection of water quality data to address both the short- and long-term questions was typically performed when accessing the sites for other purposes (e.g. dissolved oxygen (DO) logger downloading and maintenance). Hence, 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.”</p> <p>To be fair, a basin-scale assessment of water quality would have had a focus on all the water quality gauges in the basin rather than a focus on Selected Areas. It would have needed to be much broader than the stream metabolism project which was focused as a few sites. This would have been a project somewhat similar to the hydrology Basin Matter. This is certainly possible but perhaps was not budgeted for.</p>
Consensus final rating	Minimally Effective	

Mid KEQ 2.3	How effectively did the LTIM project document and report annually on the cumulative evaluation of the contribution of CEW at a Basin-scale as described in Gawne et al. (2014b, Section 6.3)?
Evaluator 1	<p>Minimally/Moderately Effective</p> <p>The LTIM project, through the Basin Matters team, was moderately effective in documenting and report annually on the cumulative evaluation of the contribution of CEW at the Basin-scale. However, these reports were minimally effective in evaluating, annually and cumulatively, the contributions of CEW at the Basin-scale.</p> <p>The reporting requirements for the LTIM project at the Basin-scale are outlined in Gawne et al. (2024a – Part C, Section 6.3). The Basin-scale evaluation was to occur at two levels (Gawne et al. (2024b – Part C Implementation):</p> <ul style="list-style-type: none"> • Evaluation of each of the Basin Matters: hydrology (flow regimes, hydrological connectivity; ecosystem diversity; fish populations, vegetation diversity; water quality and stream metabolism; and biodiversity (initially called genetic diversity) • Integration of the Basin Matters evaluation to produces combined Evaluation Report (also called a Synthesis Report). <p>The Synthesis Report was the major mechanism for reporting on the annual and cumulative evaluation of the contribution of CEW to the environmental objectives of the Basin Plan across the MDB. The structure of the Basin Synthesis Report* was to be: an <i>executive summary</i>; the <i>main report</i> containing the context (environmental condition across the Basin, CEW actions and expected outcomes), evaluation, and adaptive management components of the evaluation; and <i>appendices</i> containing the six detailed Basin Matters reports.</p> <p>The Basin Matters hydrology and ecosystem diversity reports covered the whole of the MDB, while the others were largely restricted to using knowledge gained from the Selected Areas. It was only toward the last year of LTIM that statistical predictive models relating flow with some indicators (fish, vegetation, metabolism) were developed, which allowed some extension of these evaluations to other parts of the Basin. The general paucity of data made this less effective in the northern Basin.</p> <p>The effectiveness and impact of these reports in improving environmental watering management practices is covered in KEQ5.1.4 and KEQ9 respectively. It appears from the interviews that few read these Basin-scale reports and they had minimal impact on environmental watering management practices.</p> <p>* These are published on the CEWO web site. (https://www.environment.gov.au/water/cewo/publications/2018-19-basin-scale-evaluation-cew-report-and-appendices)</p>
Evaluator 2	<p>Moderately Effective</p> <p>The LTIM project was moderately effective in documenting and reporting annual on the cumulative evaluation of the contribution of CEW at the Basin-scale. The annual basin evaluation report was moderately effective in meeting the specified reporting requirements. Reporting on the annual contribution of CEW at the Basin-scale was minimally effective as was reporting on the cumulative contribution. A major challenge was the inference of the role of CEW to areas that were not monitored.</p> <p>Survey:</p>

	<p>Survey results are somewhat muted. Most responses are “Somewhat effectively”. There were some criticisms in the comments:</p> <ul style="list-style-type: none"> • “...collation and interpretation [of Selected Area data] for reporting at the Basin-scale has fallen short • “The degree to which cumulative analysis was undertaken was poor...I refer to the final hydrology report – which [was] not a cumulative hydrological analysis but yet another annual report, rendering it largely useless and putting question to the value of that component of the project”. • “I so not think these documents are effective engagement resources. Has any of this information helped to inform decisions for water recovery and proposed works and measures...? These documents are generally too high level (academic) and/or too large for non-scientific stakeholders to read or completely understand...” <p>There were also concerns about the lack of monitoring in the northern basin with only 2 Selected Areas and one, Warrego-Darling not appropriate for extrapolation to other areas.</p>
Revision comments – Evaluator 1	<p>Based on the micro KEQs of this question we have got two minimal and one moderate, so this judgement should be minimal?</p> <p>It is sort of harsh in some respects when you know, for example, that the trouble Jenny Hale went to try to synthesize that stuff together. And you're saying, well, look, you worked your butt off, Jenny, but you didn't do a very good job. It's a harsh judgment. But, you know, you've got to do what you see. Actually, it's quite interesting, that a few comments in the interviews, a couple of people must've known about how little time was allocated to that, I think that might have been in the user group comments. And I did make those sorts of comments on the synthesis report - they did a terrific job under trying situations. You decide.</p>
Revision comments – Evaluator 2	<p>The way that I've done this is if I only had information at a higher KEQ, like from the survey, then I could only tackle that particular question, not the micro ones. In this case that's where I was summarizing the survey data. But then I haven't brought my arguments up from below. So we agree on the subsequent micro KEQs below. I will aggregate from these to confirm a judgement of minimally effective.</p> <p>Agree to down grade to minimally effective</p>
Consensus final rating	Minimally Effective

Micro KEQ 2.3.1	How well did the annual Basin Evaluation Report meet the reporting requirements as specified in Gawne et al. (2014b, Section 6.3)?
Evaluator 1	Moderately Effective

	<p>The LTIM project annual Basin Evaluation Reports (Synthesis Reports) were moderately effective in meeting the specified reporting requirements at the Basin-scale as outlined in Gawne et al. (2024a – Part C, Section 6.3).</p> <p>An Evaluation Report was seen as the major mechanism for reporting on the annual and cumulative evaluation of the contribution of CEW to the environmental objectives of the Basin Plan across the MDB. The Basin-scale evaluation used the evaluation of each of the Basin Matters (ecosystem diversity, fish populations, vegetation diversity, water quality and stream metabolism, biodiversity and hydrology) as the basis for the integrated Basin Matters evaluation.</p> <p>The Basin-scale Evaluation Reports improved over the course of the 5-year LTIM project as more information became available from the Selected Areas. Additionally, processes were developed over time to access other information relevant to evaluating the contribution of CEW in areas that were not monitored as part of LTIM (e.g. Barmah, Hattah, Macquarie Marshes).</p> <p>Basin Evaluation Reports were prepared each year between 2014 and 2019 and are published on the CEWO web site¹. These all followed the prescribed reporting requirements, with the exception that only the final report contain an executive summary (Hale et al., 2020b).</p> <p>There were mixed perceptions across all stakeholder groups in relation to the effectiveness with which the LTIM project documented and reported on the evaluation of the contribution of CEW at the Basin-scale, both annually and cumulatively, with most participants indicating it was somewhat effective.</p>
<p>Evaluator 2</p>	<p>Moderately Effective</p> <p>The reference here is to Section 6.3 in the document: Gawne, B., Everingham, P and Hale, J. (2014) Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Revised Basin Evaluation Plan – Part C: Project Management and Governance.</p> <p>The reporting requirements are:</p> <ul style="list-style-type: none"> • Timing <ul style="list-style-type: none"> ○ Draft in August ○ Final in October • Intended for three audiences <ul style="list-style-type: none"> ○ Environmental water managers ○ Interested stakeholders ○ Scientists • Structure <ul style="list-style-type: none"> ○ An executive summary – plain English, public audience ○ Main report – plain English, water manager, interested audience ○ Appendices – detailed results and methods • Format <ul style="list-style-type: none"> ○ Common language provided by the outcomes framework, CEDs • Content

- Evaluation
 - Extent to which expected outcomes have been achieved
 - What the outcomes were
 - Quantify marginal benefit of CEW
 - Evaluate cumulative outcomes
- Adaptive management
 - Implications for future management of CEW
- Context
 - Broad context of environmental conditions
 - Context to watering actions and expected outcomes

It is not clear completely clear what the “Basin Evaluation Report” is, or became. I am assuming it is the annual Basin-scale synthesis reports which had the six Basin Matters reports as Appendices.

Timing:

The timing varied from that indicated but not in a major way. The final versions of the reports were generally produced by the end of the next year. Sometimes a bit later than October.

Intended audience:

The lack of an executive summary in most reports means the general reader was not well catered for.

Structure:

The first 4 reports did not include an executive summary. The final report included summary of the annual basin-scale evaluation and of multi-year outcomes for project from 2014-2019. All reports included a main section and appendices which were the individual Basin Matter reports.

Format:

Ok

Content:

Evaluation, Ok.

A section on adaptive management was included in each report.

Contextual information was provided on climate and water availability

The areas where the reports do not follow meet requirements are:

- The lack of an executive summary in the first 4 reports and

	<ul style="list-style-type: none"> there are some figures in the main report that are too complex for non-scientists e.g. the GPP boxplot and notched boxplot for Murray cod condition in Gawne et al. (2017). <p>Some end users expressed concerns at interview:</p> <p>“The Basin Matter reports are close to impenetrable” I couldn’t understand a word of them sometimes”.</p> <p>“I found at the Basin-scale, the reports were very complex, even for someone like me who does have a freshwater ecology background and wetland floodplain management background. I think the fact that even I was having to use control-F to find phrases made it really difficult, and so then trying to work out whether they had answered the questions in the foundation report and inferred at the Basin-scale was extremely difficult for me.”</p> <p>One end user paid a consultant to go through all the SA reports and summarise the information because the Basin Matter reports did not provide what they needed.</p>
Consensus final rating	Moderately Effective

Micro 2.3.2	KEQ How effectively did the LTIM project report on annual evaluation of the contribution of CEW at the Basin-scale?
Evaluator 1	<p>Minimally Effective</p> <p>The annual Basin Matters reports, and the Synthesis Report, were minimally effective in evaluating the contribution of CEW at the Basin-scale.</p> <p>These annual reports improved over the time of the LTIM project as more information became available from the Selected Areas, but were still very general in relating the contributions of CEW to the particular Basin Matter. It was only in the final years of the project that statistical models were developed for fish, vegetation and metabolism that provided some predictive capacity regarding outcomes of CEW in non-monitored areas.</p> <p>We are aware of the considerable difficulties the Basin Matters teams had in obtaining relevant information for areas that received CEW, but were not monitored as part of the LTIM project.</p>
Evaluator 2	<p>Minimally Effective</p> <p>There are several different reports that include information on the contribution of CEW at the Basin-scale:</p> <ul style="list-style-type: none"> The various Basin Matters reports The annual synthesis reports.

	<p>These reports provide an annual evaluation of the contribution of the CEW. For example, the annual synthesis report provides a tabulated summary of the contribution of CEW including measured and predicted outcomes at various time scales.</p> <p>The challenge is that proposed modelling was not undertaken as proposed. This was intended to:</p> <ul style="list-style-type: none"> • provide a counter factual (i.e. what would have happened in the absence of CEW) • infer outcomes to areas not monitored within Selected Areas • infer outcomes at the Basin-scale. <p>The lack of modelling means that the evaluation of the CEW was not as effective as intended in the planning documents such as MEPs and Basin Matter foundation reports.</p>
Consensus final rating	Minimally Effective

Micro 2.3.3	KEQ	How effectively did the LTIM project report on the cumulative evaluation of the contribution of CEW at the Basin-scale?
Evaluator 1	Minimally Effective	<p>At the Basin-scale, the annual Basin Matters reports, and the Synthesis report, were minimally effective in evaluating the cumulative contribution of CEW.</p> <p>Obviously, this was a difficult task. Until the latter years of LTIM there was insufficient information from the Selected Areas to enable any cumulative evaluation, and even then, 4-5 years of data is hardly enough given the time for many of the ecological outcomes sought to become apparent. Certainly, these annual reports improved over the time of the LTIM project, but the evaluations were still very general in relating the contributions of CEW to each particular Basin Matter. It was only in the final years of the project that statistical models were developed for fish, vegetation and metabolism that provided some predictive capacity regarding outcomes of CEW in non-monitored areas.</p>
Evaluator 2	Moderately Effective	<p>Annual evaluations are included in the Basin Matters reports for each Basin Matter for each year. They are also summarised in the basin-scale synthesis reports. The lack modelling which limited the ability to extrapolate to areas not monitored means this was only moderately effective.</p> <p>Survey:</p> <p>The survey responses are not glowing with many “Somewhat effectively”.</p>

Revision comments – Evaluator 1	
Revision comments – Evaluator 2	Agree that the challenge of extrapolating to the Basin-scale mean that this should be rated as minimally effective.
Consensus final rating	Minimally Effective

Mid KEQ 2.4	How effectively did the LTIM project undertake annual evaluation of CEW on the six specified Basin Matters as described in Gawne et al. (2014a, Section 3 and 2014b Section 2.2)?
Evaluator 1	<p>Moderately Effective</p> <p>The annual and cumulative evaluation of the Basin-scale contribution of CEW (and other environmental water) to hydrology, ecosystem diversity, vegetation diversity, fish populations, biodiversity, and stream metabolism and water quality is new and challenging, and to our knowledge has never been done before at this scale.</p> <p>There is evidence that these evaluations became more effective over the 5-years of LTIM, but as noted elsewhere in this assessment, the lack of effective collaboration between the Basin Matters and Selected Area teams contributed to these evaluations being less effective than they could have been. This loss of opportunity was well reflected in one comment in the stakeholder survey: <i>‘in my view the separation of the Selected Area and Basin teams made integration of the reports more difficult as each Selected Area and each Basin Matter group tended to work in isolation’</i>.</p> <p>The stakeholder comments (survey, interviews) were mixed regarding the effectiveness of these Basin-scale evaluations. Many had obviously not read the relevant reports, which is revealing in itself. A number found the hydrology reports ‘very effective’ to ‘extremely effective’. There were also comments relating to the difficulties in addressing the Basin Plan objectives (Environmental Watering Plan and Water Quality and Salinity Plan) because of their vagueness.</p>
Evaluator 2	<p>Moderately Effective</p> <p>Annual evaluations are included in the Basin Matters reports for each Basin Matter for each year. They are also summarised in the basin-scale synthesis reports. The lack of modelling which limited the ability to extrapolate to areas not monitored means this was only moderately effective.</p> <p>Survey:</p> <p>The survey responses are not glowing with many “Somewhat effectively”.</p>
Evaluator 3	Overall assessment Moderately Effective

	<p>My individual Basin Matter evaluations are merely whether they addressed the evaluation, not whether they were able to assess CEW contribution – which is covered in KEQ 6.1.</p> <p>Essentially however, there is a lack of modelling/reporting in not monitored areas which therefore limits the effectiveness relative to the Gawne et al. (2014) document.</p>
Consensus final rating	Moderately Effective

Micro 2.4.1	KEQ	How effective was the annual evaluation of hydrology?
Evaluator 1	Moderately Effective	<p>The annual and cumulative evaluation of the contributions of CEW (and other environmental water) to flow regimes and longitudinal connectivity was effective, but was only moderately effective in providing an evaluation of lateral connectivity between the rivers and their floodplains. Some information was provided on the method employed to calculate floodplain inundation*, but this has not been documented and we are not able to assess its accuracy.</p> <p>The annual and cumulative evaluations of the Basin’s hydrology provide crucial information relating to both flow regimes and hydrological connectivity (longitudinal, lateral). This hydrological information underpins the Basin Matters evaluations, the Selected Area evaluations, and also supports the evaluation of un-monitored areas.</p> <p>The objective of the Basin Matters hydrology reports was to evaluate whether there is loss or degradation in: (a) flow regimes, which include relevant flow components set out in the Basin Plan (S8.51(1)(b)); and (b) hydrological connectivity between the river and floodplain and between hydrologically connected river valleys. Hydrological information was provided for 19 of the 25-river valley’s in the MDB.</p> <p>These Basin Matters hydrology reports provided contextual information for both the year of the report and cumulatively since the commencement of LTIM (e.g. rainfall for most of the MDB was below average or very much below average during 2018-19; surface inflows in both the northern and southern Basin from 2014 were also low, particularly in the north) and a summary of the environmental water (CEW and other) delivered in the Basin.</p> <p>The streamflow volumes in each major river system over the period 2014-2019 were calculated and compared with pre-development flows. The percentage of those flows that was provided by all environmental water and from only CEW, and the contributions of all e-flows and CEW to baseflows and freshes were also calculated. Relatively easily understandable graphics were used to present this flow information.</p> <p>The Basin Matters hydrology reports also provide broad estimates of the extent of lateral connectivity, that is inundation of wetland and floodplain, for each year of LTIM. Waterways, wetlands and floodplains in all major river valleys were included, not just those in Selected Areas.</p> <p>The method used to obtain the inundation extent maps is not fully documented and we have no assessment of its accuracy. An outline of this method was obtained from Dr Enzo Guarino (email 3.9.20) and is briefly summarised below*. The method is somewhat different to that outlined in Stewardson and Guarino (2019, p10; Revised Foundation hydrology report).</p>

	<p>The Basin Matters hydrology reports linked the hydrology to Basin Plan Environmental Watering Plan hydrological objectives. These included: longitudinal connectivity targets to increase baseflows and increase flow volumes; lateral connectivity targets to increase freshes, bank-full and lowland floodplain flows; and Coorong, Lower Lakes and Murray Mouth targets relating to barrage flow, lower lakes water levels, and salinity in Coorong.</p> <p>For 2018-19, the hydrology Basin Matters team produced a set of very informative hydrological Report Cards for each river valley, in which water delivery context, environmental conditions and resource availability, watering actions, and the contribution of CEW to flow regimes was reported (Stewardson and Guarino, 2020b).</p> <p>The survey of stakeholders revealed that the service providers regarded the Basin Matters hydrology reports ‘very effective’ to ‘extremely effective’.</p> <p>* A combination of remote sensing, MIKE flood models and GIS tools were used to map inundation and attribute CEW. A before and after approach was used to determine impact (e.g. map water before, during and after the watering action). The inundation areas reported represent cumulative inundation over the course of the year. Attribution of environmental water (or other water) was undertaken using a combination of : remote sensing mapping of water (satellite or drone); known instream environmental water contributions, routing models; air borne imagery (obliques taken from the air); MIKE FLOOD models; DEM-Combined with water level sensors; GIS tools; basic spatial explicit models linking flow/inundation extent; and local expert knowledge.</p>
<p>Evaluator 2</p>	<p>Effective</p> <p>Annual hydrology reports underpin the assessment of CEW contributions to meeting Basin Plan outcomes. Importantly, the hydrology reports contain graphic (as well as other supporting information) that demonstrate progress to meeting hydrology targets in the Selected Areas in each of the water years covered by LTIM. Hydrology reporting also includes report cards that cover most of the valleys in the MDB.</p>
<p>Evaluator 3</p>	<p>Effective</p> <p>The data used and the methods applied are best practice. The gauges essentially cover basin wide strategy and therefore allow a basin wide reporting framework for in channel flows at least. The inundation mapping is as good as can be done with current knowledge and capacity, but certainly open for improvement, however that is a research question associated with advancing knowledge and methods, not really anything the reporters or CEW can do.</p> <p>The other small constraint is that whilst the gauges do cover most of the basin quite well, they are not placed in a manner ideal to environmental water monitoring. This gives a lack of resolution sometimes. For example, an environmental watering event may not apply to a whole reach as monitored by a single gauge.</p>
<p>Revision comments – Evaluator 1</p>	<p>The only sticking point was the inundation work: the rest of the hydrology was well done. In terms of getting consensus, I think my only sticking point is the inundation modelling. I think the rest of the hydrology was extremely well done. It did all the things and more and those last lot of report cards were great. Inundation was needed as a covariate for a few Basin Matters – e.g. Samantha Capon didn't use inundation modelling provided as it wasn't sensitive enough, it was too coarse.</p> <p>Agree to change to effective but with a caveat that the problem of inundation mapping and it being a covariate for other Basin Matters is important to capture in the summary report.</p>

Revision comments – Evaluator 2	Agree to keep it at effective. Question to evaluator 3 - What do you think about the inundation material that you looked at that? They promised to do inundation modelling and they never really did. Well, they promised MDBA would do it and they didn't. There was follow up with the Basin Matter team on this – see email corro shared by evaluator 1.
Revision comments – Evaluator 3	Agree but I think we certainly have got to mention the issues with inundation. I believe they did the best possible with the available tools, even for inundation modelling
Consensus final rating	Effective -caveat that inundation modelling was problematic

Micro 2.4.2	KEQ	How effective was the annual evaluation of ecosystem diversity?
Evaluator 1	Effective	<p>The annual and cumulative evaluations of the contributions of CEW (and other environmental water) to ecosystem diversity were effective.</p> <p>The Basin Matters ecosystem diversity (or ecosystem type) evaluation addressed Basin Plan objective S8.05 (3b). These evaluations provided a comparison of the extent (area) of ecosystem-types (lakes, wetlands, floodplains and rivers) in the overall MDB and in a subset - the 'managed' floodplain* - that received CEW over the 5-year period of LTIM. The Australian National Aquatic Ecosystem (ANAE) classification was used to map floodplain ecosystems.</p> <p>The MDB contains a total of 68 ANAE ecosystem types and 57 of these were supported** by CEW at least once during the 5-year period of LTIM. Over the 5-year period of LTIM, environmental water supported 12% of the area of the Basins wetland ecosystems (26% managed floodplain), but only 2% of the Basins floodplain ecosystems (7% of managed floodplain).</p> <p>The method used to obtain the inundation extent of the various ecosystem types involved constructing watering extent maps in GIS where the inundation information provided by the Basin Matter hydrology team was combined with the ANAE maps. The inundation extent was estimated for all environmental water and not just CEW. As anticipated in the ecosystem diversity foundation report (Brooks, 2015), the ANAE classification system was improved over the 5-year period of LTIM. There are still questions about the accuracy and effectiveness of the inundation mapping, because the method used by the Basin Matter hydrology team has not been documented and its accuracy verified.</p> <p>*The managed floodplain is the area where floodplain vegetation can be influenced with CEW under the Basin Plan (MDBA, 2014, 2019). It includes both actively managed areas that can receive environmental water via large headwater storages or via The Living Murray 'environmental works' sites on the River Murray floodplain, and passively managed areas that receive environmental water via flow rules in water resource plans or via natural events</p>

	** The area of different ecosystem types that received CEW were classified as either ‘inundated’ - the sum of only the inundated areas of each wetland type, excluding the areas of wetlands that were not inundated – or ‘influenced’ - the sum of the all wetland areas that received water even if the inundation mapping showed that only a portion of the wetland was inundated
Evaluator 2	<p>Effective</p> <p>Each annual Basin Matter report includes outcomes for the current year as well as cumulative results and adaptive management implications. There is also a summary of annual and cumulative results in the basin-scale synthesis reports.</p> <p>My slight concern is that the main focus of these reports is on presenting the numbers – the areas of different ecosystems that are influenced by CEW. There is comparatively little <u>evaluation</u>. This is partly related to the lack of objectives for this Basin Matter. However, there is a reasonable attempt to support adaptive management which does require evaluation (see the final ecosystem diversity Basin Matter report).</p>
Evaluator 3	<p>Effective</p> <p>What did Commonwealth environmental water contribute to ecosystem diversity? See Brooks (2020) who addressed this matter in the context of a basin wide assessment. Which is far more effective than the matters based in Selected Areas could ever achieve.</p>
Consensus final rating	Effective

Micro 2.4.3	KEQ	How effective was the annual evaluation of vegetation?
Evaluator 1		<p>Moderately Effective</p> <p>The Basin Matters annual and cumulative evaluation of the contributions of CEW to plant species diversity and vegetation community diversity at the Basin-scale was moderately effective.</p> <p>For plant species diversity over the 5-years of LTIM it was found: over 640 plant taxa were recorded across five of the Selected Areas; 27% of the plant taxa were recorded in every year from at least one Selected Area; and annual numbers of total recorded plant taxa declined overall over the 5-year. For vegetation community diversity over the 5-years of LTIM it was found: total cover and species richness of groundcover vegetation varied considerably over the 5-year period; five annual vegetation community types (AVTC) were identified and these clusters explained 69% of the total variance in the data set and were relatively distinct from each other;</p> <p>Twenty-eight ecosystem types have received CEW every year, with vegetation communities that were inundated over a significant proportion of their area (> 10 %) in most years being: temporary river red gum swamp, permanent tall emergent marsh, permanent wetlands, temporary sedge/grass/forb marsh and freshwater meadows.</p> <p>The overall conclusion of the Basin-wide contribution of CEW to vegetation diversity over the 5-years of LTIM, was that it was ‘<i>very likely to have increased the diversity of wetland plant species present in the Basin as well as the diversity of vegetation communities present</i>’, no doubt reflected the</p>

	<p>short term of the project and the rather dry conditions experienced over this period. The application of the predictive models being developed by the Basin Matters team* will potentially allow more definitive conclusions to be made in the future</p> <p>The Basin Matters annual and cumulative evaluation of vegetation diversity used data and information obtained from six Selected Areas (not Lower Murray). Only groundcover vegetation was assessed, and not understory and overstory vegetation, as it was assumed that this groundcover would be more responsive to CEW in the short term). Apparently, over the 5-years of LTIM there were some difficulties with the Selected Area vegetation sampling and vegetation identifications.</p> <p>*Two models are being developed to predict likely vegetation diversity responses based on hydrological** and climate (temp, rainfall) predictors for which data is available at a Basin-scale - a plant species response model and a vegetation community response model (Capon and James (2020, Appendix E). The model development used data available from the Selected Areas, and these models should eventually be applicable for predicting vegetation diversity outcomes in unmonitored areas. Capon and James (2020) commented that the greatest constraint on the development of effective predictive tools for vegetation diversity is the availability of robust, Basin-wide inundation data with spatial and temporal resolution appropriate to the model framework.</p> <p>** Hydrological predictor variables were calculated from the Geoscience Australia Water Observations from Space (WoFS) Fractional Cover product and not the information on inundation calculate by the Basin Matters hydrological team.</p>
Evaluator 2	<p>Moderately Effective</p> <p>Each annual vegetation report included results for the watering year, as well as cumulative findings and implications for adaptive management. Monitoring is as stated in the foundation documents and the evaluation of monitoring results is reasonable. Predictive and explanatory modelling really only happened in the final year of the project.</p>
Evaluator 3	<p><i>Effective</i></p> <p><i>What did Commonwealth environmental water contribute to vegetation species diversity?</i></p> <p><i>What did Commonwealth environmental water contribute to vegetation community diversity?</i></p> <p>Capon and James (2020). <i>Effective on both</i> points in the sense that the <i>evaluation</i> addressed both points. However, the evaluation itself doesn't address unwatered areas that well and generally relies on positive reinforcement of preconceived ideas rather than independent analyses of all outcomes.</p>
Revision comments – Evaluator 1	
Revision comments – Evaluator 2	

Revision comments – Evaluator 3	The evaluation itself was effective, but happy to go to moderately based on evaluator 1 justification.
Consensus final rating	Moderately Effective

Micro 2.4.4	KEQ	How effective was the annual evaluation of fish?
Evaluator 1		<p>Moderately Effective</p> <p>The Basin Matters annual and cumulative evaluation of the contribution of CEW to fish communities at the Basin-scale was moderately effective.</p> <p>The key objective of the Basin Matters fish evaluation was to assess the CEW water contribution to sustaining native fish at the Basin-scale; this required the evaluation of native fish diversity, condition, reproduction and recruitment as a function of flow in order to understanding the benefit of environmental water.</p> <p>The evaluation used monitoring data from five of the Selected Areas (data from Warrego-Darling was not used); abundance and diversity of riverine fish was monitored annually; spawning of both native and introduced species was measured during know spawning periods*. Generic and species-specific statistical models linking fish response to flows were developed; the focused on seven species** and allowed calculation of the response with and without CEW. Predictive models were developed to allow separation of the effects of CEW actions from the effects of the background (non-environmental water) hydrological variability. No information was provided on the actual mathematical form of these models, or on their levels of uncertainty in their predictive capacity.</p> <p>The influence of flow events and flow regimes across all Selected Areas were assessed on: spawning success of native flow-cued species; recruitment strength of all native fish species; population composition (structure and condition) of abundant native species; and native fish community structure and persistence.</p> <p>In their cumulative evaluation of flow on fish, King et al. (2020) reported:</p> <ul style="list-style-type: none"> • A total of 13 native and 4 introduced fish species were collected with the abundance of each species varying across Selected Areas and a decline in the abundance of some large-bodied native species following the occurrence of hypoxic blackwater events and associated fish kills in late 2016 • Spawning was observed for 15 native and 4 introduced species, but this did not result in recruitment of golden perch • A number of general broad findings specifically related to flow: Murray cod, golden perch, carp gudgeons and common carp were detected annually in all Selected Areas; golden perch and Murray cod populations both decreased after the incidence of hypoxia events and fish kills with populations increasing with time since these events; higher abundances of Murray cod and bony herring occurred in years with drier than average conditions; and higher numbers of carp gudgeon and common carp occurred in years with wetter than average conditions

	<ul style="list-style-type: none"> • Specific findings related to the effects of CEW were: an increased abundance of only one species (Australian smelt); a reduction in abundance of carp gudgeon and common carp; and only one species (bony herring) increased larval abundance as a result of CEW. <p>* Abundance and diversity of riverine fish populations was monitored annually at fixed sites within the Selected Areas using a standardised sampling regime (Category 1 sampling). Spawning of both native and introduced species was measured by collecting eggs and fish larvae using drift nets and light traps during the known spawning period at five Selected Areas. Additional sampling (Category 2 and 3 sampling) of fish movement and fish occurrence on floodplain habitats also occurred at various Selected Areas. These data are not included in this Basin-scale analysis of fish response to CEW, but can be found within relevant Selected Area reports.</p> <p>** Table 3 in King et al. 2020) provides an excellent summary of the known or hypothesised fish response-flow relationship for these species.</p>
Evaluator 2	<p>Moderately Effective</p> <p>Each annual Basin Matter report includes outcomes for the current year as well as cumulative results and adaptive management implications. There is also a summary of annual and cumulative results in the basin-scale synthesis reports. Monitoring is generally as specified in the MEP and there is evaluation of monitoring results.</p> <p>There were issues with data transfer from SAs to the Fish Basin Matter team mentioned in the Stoffels et al., (2018) and King et al. (2019; 2020). This is discussed in KEQs related to data management. These were overcome by the final Fish Basin Matter report but limited modelling approaches which challenged the annual evaluation of fish in all years.</p>
Evaluator 3	<p>Effective</p> <p>3.2.2 Long-term (five-year) question</p> <ul style="list-style-type: none"> • What did Commonwealth environmental water contribute to sustaining native fish populations? <p>Short-term (one-year) questions:</p> <ul style="list-style-type: none"> • What did Commonwealth environmental water contribute to sustaining native fish reproduction? • What did Commonwealth environmental water contribute to sustaining native larval fish growth and survival? • What did Commonwealth environmental water contribute to sustaining native fish survival? <p>King et al, (2020) Effective on all points</p>
Revision comments – Evaluator 1	<p>All agree that year 5 report was good – but up til then the outputs were not as strong.</p> <p>Agree on caveat</p>
Revision comments – Evaluator 2	<p>I did the same – focus on the final year report, but up until then, they had a lot of trouble because they couldn't get the data out of the database; couldn't run or build a model.</p>

	Agree on caveat
Revision comments – Evaluator 3	Agree to Moderately effective. My assessment was the same as previous micro KEQ – that they did the evaluation, but not about the contribution of CEW. I only looked at King et al. 2020 and I thought it was reasonable. Can we add a caveat to that effect? That is, the earlier reports were not as effective.
Consensus final rating	Moderately Effective – caveat noting that the final year report was effective

Micro 2.4.5	KEQ	How effective was the annual evaluation of stream metabolism and water quality?
Evaluator 1		<p>Moderately Effective/Minimally Effective</p> <p>The annual and cumulative evaluation of the contributions of CEW to stream metabolism was moderately effective, but was minimally effective in the evaluation of the contributions of CEW to water quality</p> <p>Stream metabolism</p> <p>The Basin Matters stream metabolism team sought to evaluate the influence of CEW on metabolism, which is a key ecosystem process that relates to the transformation of organic matter through the balance between two processes: gross primary production (GPP) which is the rate of biomass creation through photosynthesis, and decomposition or respiration (ER), which relates to the decomposed of organic matter. If $GPP > ER$ the system is ‘autotrophic’ and is producing organic matter, generally phytoplankton or algae, and if $GPP < ER$ the system is ‘heterotrophic’, generally a sign that bacterial decomposition of dissolve organic carbon is dominate.</p> <p>The objective of this evaluation was to identify the influence of CEW on the rates of stream metabolism using the rates per unit volume, the rates per unit area, and the mass of organic carbon created or consumed per day.</p> <p>A key finding from this evaluation is that in-channel flows, initially thought unlikely to boost rates of GPP and ER, is not true, and that even small increases in in-change flows - from very low (nominally base) flow to moderately low flow - can see substantial amounts of organic carbon (‘fish food’) being produced. In addition to flow, stream metabolism is also influenced by temperature and light, with GPP expected to be greatest in summer and lowest in winter. The first fresh following winter to inundate dry sediment has the greatest potential to enhance metabolic rates, but this is also dependent upon timing as freshes in winter-early spring will result in lower primary production due to colder temperatures and shorter hours of lower intensity sunlight than freshes that are delayed until late spring-summer. It is expected that watering actions that reconnect backwaters, flood runners and the floodplain will result in a major increase in both primary production and ER (beyond in-channel increases), but there were few over-bank watering actions delivered over the 5-years of LTIM.</p> <p>Metabolism data was available for 6 of the 7 Selected Areas: data from the Gwydir Selected Areas was collected using a non-standard method and was not used in the Basin-scale evaluation. Estimates of river metabolism were derived from daily measurements of the changes in dissolved oxygen, temperature and light in open water using <i>in situ</i> loggers*.</p>

	<p>Water Quality</p> <p>The Basin Matters water quality team sought to evaluate the influence of CEW on water quality. This was restricted to salinity, DO, pH and turbidity monitoring by the Selected Areas. Some data was also available on nutrients (TP, TN, FRP, NH₄-N, NO_x-N), Chl-a and DOC, although the frequency of sampling as insufficient to allow robust relationships between these indicators and environmental watering actions to be obtained. The water quality data was however used to help explain patterns of metabolism at catchment and Basin-scales.</p> <p>The Basin Matters evaluation showed that CEW contributed to: maintaining base flows thus avoiding adverse water quality outcomes and protecting important refugia; helping to avoid low DO concentrations and possible fish deaths in black water situations; exporting salt and nutrients through the Murray Mouth.</p> <p>*Three derived metabolism units were calculated: areal metabolism units (g O₂/m²/day), which expresses GPP and ER as oxygen produced/consumed per m² of stream (or sediment) surface per day; the mass of organic carbon created/consumed each day in a one km stream reach (kg org C/km/day), which relates to the amount of organic carbon required by the food web in that stream reach each day and eventually to the sustainable stocking capacity for native fish in that reach on the assumption that this capacity is resource (food) limited; the mass of oxygen (or organic carbon) produced per day in the passing flow. This is calculated by multiplying the GPP or ER in mg O₂/L/Day by the number of litres discharged that day. This method of data collection and analysis using the BASEv2 model is <i>only</i> appropriate for flowing waters, not wetlands, lagoons, lakes or other standing water bodies.</p>
<p>Evaluator 2</p>	<p>Moderately Effective.</p> <p>Stream metabolism was well addressed. Water quality was poorly addressed</p> <p>There was little focus on water quality: “Water quality data to address both the short- and long-term questions was typically collected when accessing the sites for other purposes (e.g. dissolved oxygen (DO) logger downloading and maintenance). Hence, 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, 2020).</p> <p>The stream metabolism and water quality foundation document (the 2018 version), is explicit in excluding much on water quality (Grace, 2018). See KEQ 062 and 063.</p> <p>There were issues with water quality data at some Selected Areas. There were extensive data gaps at Warrego-Darling. There was less than one month of data recorded in the first year. In year 3 the upstream station on the Darling was lost during the floods of 2016-2017.</p> <p>There were also problems in the Lachlan during 2016-2017. Data availability [DO and temperature] for the Lachlan Selected Area was sparse, limited to one river metabolism monitoring site that operated through the flood event, and with no permanent continuous DO data at any stream gauge for this Selected Area. There were also important gaps in the Murrumbidgee record.</p>
<p>Evaluator 3</p>	<p><i>Effective on all points</i></p>

	<p><i>What did Commonwealth environmental water contribute to patterns and rates of decomposition? Increases in rates of decomposition that do not also cause adverse water quality outcomes are beneficial by making organic matter and nutrients available to the ecosystem.</i></p> <p><i>What did Commonwealth environmental water contribute to patterns and rates of primary productivity? Increases in rates of primary production that do not lead to algal blooms or adverse water quality outcomes are beneficial by increasing the amount of organic matter available to the food web.</i></p> <p><i>What did Commonwealth environmental water contribute to pH levels? The management of environmental water has the capacity to reduce the frequency or severity of acidification events. This evaluation will report on the outcomes of water actions for which this is an objective.</i></p> <p><i>What did Commonwealth environmental water contribute to turbidity regimes? The management of environmental water has the capacity to reduce the severity of highly turbid flow events. This evaluation will report on the outcomes of water actions for which this is an objective.</i></p> <p><i>What did Commonwealth environmental water contribute to salinity regimes? The management of environmental water has the capacity to reduce the severity of periods of high salinity, mix refuge pools in which salinity has led to stratification or ensure a period of low salinity occurs to support recruitment. This evaluation will report on the outcomes of water actions for which this is an objective.</i></p> <p><i>What did Commonwealth environmental water contribute to dissolved oxygen levels? The management of environmental water has the capacity to reduce the severity of anoxic events such as those associated with blackwater. It is feasible that environmental water could also be used to reduce oxygen levels in instances where water is super-saturated with oxygen, as may occur during algal blooms. This evaluation will report on the outcomes of water actions for which these were objectives.</i></p> <p>Grace (2020).</p>
<p>Revision comments – Evaluator 1</p>	<p>Basically I thought it was moderately effective for the metabolism. I thought it was totally ineffective, minimally effective for water quality.</p> <p>Lots of water quality monitoring data around – but its mostly monthly condition monitoring, not intervention monitoring. Happy to go to moderately effective. Salinity was reported in the hydrology report.</p>
<p>Revision comments – Evaluator 2</p>	<p>Went moderate as stream metabolism was okay but the water quality wasn't done at all well. It seems to me that the water quality, almost is a whole different project and needed a different kind of personality to run it. It's more like hydrology in that you'd use data from all the gauges. Water quality is important as it's a big issue at the management level i.e. dead fish due to low oxygen levels.</p>
<p>Revision comments – Evaluator 3</p>	<p>Agree with comments from other evaluators.</p>
<p>Consensus final rating</p>	<p>Moderately Effective</p>

Micro 2.4.6	KEQ How effective was the annual evaluation of generic diversity?
<p>Evaluator 1</p>	<p>Moderately Effective</p> <p>The annual and cumulative evaluation of the contributions of CEW to biodiversity was moderately effective. There was also evidence that this Basin-wide evaluation experienced considerable problems in accessing data from other monitoring programs outside LTIM.</p> <p>The Basin Matters biodiversity (previously called genetic diversity) report sought to evaluate the contribution of CEW to achieving diversity-related objectives of the Basin Plan (S 8.05 (2) and (3)). This involved generally evaluating the contribution of CEW to species diversity, considering specifically: the presence, distribution and abundance of plant, fish, bird, frog, turtle and water-dependent mammals; listed threatened species and ecological communities; migratory species listed under international agreements.</p> <p>The main output of the biodiversity evaluation is an aggregated list of species and communities that potentially benefitted from CEW each year. Information was derived from a number of sources, including other Basin Matter reports, Selected Area reports, and monitoring programs external to LTIM, e.g. TLM. The biodiversity evaluation covered the entire MDB and not just the LTIM Selected Areas. In a final year trial, data from multiple sources was used to evaluate the potential linkages between water, aquatic ecosystem type and some aspects of biodiversity not covered by other Basin Matters specifically for: waterbirds at Ramsar sites* and threatened species**.</p> <p>A cumulative evaluation of the contribution of CEW to waterbird diversity and breeding across the MDB was undertaken; this also included consideration of the Coorong. A similar evaluation was done for threatened species. An evaluation was also made of the contribution of CEW to maintaining the ecological character of these five Ramsar wetlands: Banrock Station, Barmah-Millewa, Gunbower, Macquarie Marshes, and Hattah-Kullkyne National Park.</p> <p>*Done by integrating the Wetland Insight Tool from Geoscience Australia, ANAE mapping, and MDBA aerial waterbird survey data</p> <p>** Done by intersecting records for four threatened species from the Atlas of Living Australia with the ANAE and inundation with CEW</p>
<p>Evaluator 2</p>	<p>Moderately Effective</p> <p>There is extensive reporting and evaluation of CEW at Selected Areas as well as at important wetlands: Banrock Station, Barmah Forest, Gunbower Forest and The Macquarie Marshes.</p> <p>However, there seems less evaluation of this Basin Matter, with reporting largely being a catalogue of what happened rather than the implications. A comment in the final report sums up this issue: “The biodiversity Basin Matter has largely been a consolidation of monitoring outcomes across the Basin from a variety of sources to develop a list of species and communities that potentially benefitted from Commonwealth environmental water. The summary nature of the evaluation has not lent itself to providing adaptive management messages.” Although the report does go on to list “lessons learned”.</p> <p>Reporting would be strengthened by considering the counter factual, that is, what would have happened if CEW was not delivered?</p> <p>Monitoring of Frogs and Turtles was restricted to a single Selected Area, Murrumbidgee</p>
<p>Evaluator 3</p>	<p>Moderately Effective</p>

	Hale et al (2020). Moderately effective. Was off on a few tangents and didn't specifically target the Gawne et al. questions. But value added using an adaptive monitoring and reporting framework that was admirable as well.
Consensus final rating	Moderately Effective

High KEQ 3	How effectively did the LTIM project evaluate the ecological outcomes of Commonwealth environmental water at the seven Selected Areas? (objective 2 Gawne et al. 2013)
Evaluator 1	<p>Moderately Effective</p> <p>Gawne et al. (2014c) identified both qualitative analysis methods (where predictions of outcomes are descriptive or based on conceptual models that only enable qualitative predictions (increase, decrease or no response) - this approach will be to use the understanding of the relationship between the indicators to make predictions about the influence of CEW on: trends through time; responses to events; number of adverse events), and quantitative analysis methods (where model-based approaches (e.g. statistical hierarchical models) and sometimes using 'counterfactual' analysis (i.e. observations with and without CEW) are used to provide more quantitative information) to evaluate the ecological outcomes of CEW at either local or Basin-scale.</p> <p>The Selected Areas provided primarily qualitative evaluations of the ecological outcomes of CEW, although towards the end of LTIM more quantitative analysis methods were being trialled by some. The Goulburn Selected Area was standout in the use of Bayesian hierarchical models in their evaluations.</p> <p>The survey and interview responses from Selected Area team members noted the considerable difficulty in evaluating the ecological outcomes due to CEW (required by the CEWO) separate from other environmental water. This was identified as a particular problem with floodplain wetlands, where there are often multiple water sources and events occurring at the same time. This requirement to evaluate the contribution for CEW, while understandable is nevertheless artificial in that it is the total amount of environmental water available assists in reinstating the required flow regimes regardless of who owns the water.</p> <p>A number of specific challenges were identified in the monitoring and evaluating the ecological benefits of environmental water in the Warrego-Darling Selected Area, namely: the unregulated nature of the catchment and difficulty in responding to inflows; flows which are often contain a small proportion of CEW rather than having designed deliveries from regulated storage; and years where parts of the system were dry during scheduled monitoring periods.</p> <p>Stakeholders also commented that evaluation of the cumulative effects of CEW (and other environmental water) over the 5-years of LTIM were not very effective, and that the lack of interaction between the Selected Area, and between the Selected Area teams and the Basin Matters team, made the integration of information and reports difficult because each group was largely working in isolation.</p>
Evaluator 2	<p>Moderately Effective</p> <p>Most Selected Area teams were effective in evaluating ecological outcomes in the areas where they had data. The challenge for some indicators was the need to infer outcomes where there was no monitoring. There are two sides to this. The requirements for counterfactuals – what would have happened in the absence of CEW. The need for predictive models – what were the outcomes in areas that had CEW but which were not monitored. These issues</p>

	were mentioned in all the MEPS but were generally not addressed in Selected Area reporting. Overall the Selected Areas provided good quantitative analysis of their data and usually only qualitative extrapolation to areas not monitored.
Consensus final rating	Moderately Effective

Mid KEQ 3.1	How effectively did the Warrego Darling Selected Area evaluate the ecological outcomes of CEW?
Evaluator 1	<p>Moderately Effective</p> <p>Few ecological indicators – fish, metabolism (not very effective because of turbidity), vegetation in western floodplain)</p> <p>Very qualitative, no models</p> <p>No counterfactual; studies</p>
Evaluator 2	<p>Moderately Effective.</p> <p>Determination of the outcomes from monitoring was generally good. However:</p> <ul style="list-style-type: none"> • A lot was made from data obtained at two sites, Upper Darling and Darling below Warrego, with little consideration of areas not monitored. • There was no real assessment of whether the CEW water is adequate to protect/maintain/enhance this ecosystem (perhaps this is out of scope) <p>As noted in KEQ0191 there were major issues with water quality and stream metabolism and much missing data. There were also problems interpreting stream metabolism information possibly because of high turbidity and/or lack of flow.</p>
Consensus final rating	Moderately Effective

Mid KEQ 3.2	How effectively did the Gwydir Selected Area evaluate the ecological outcomes of CEW?
Evaluator 1	<p>Moderately Effective for both river and wetland sites</p> <p>The Gwydir Selected Area was moderately effective in evaluating the ecological outcomes of CEW in both river and wetland sites in the Lower Gwydir.</p>

	<p>Ecological outcomes in rivers and downstream wetlands are being targeted in the Lower Gwydir (see KEQ1A.2). CEW is mostly held in Copeton Dam and is delivered (together with NSW environmental water and unregulated tributary inflows) to achieve ecological outcomes. Sites in both these system-types have been monitored for a range of hydrological, water quality and ecological indicators.</p> <p>The evaluation of the CEW contribution to the ecological condition (microinvertebrates, macroinvertebrates, fish, vegetation and metabolism) at both channel and wetland sites is broad, largely non-quantitative and has little predictive power. The Gwydir reports provided very few conceptual models showing the (hypothesised) links between the measured ecological indicators and possible controlling variables. There has been some attempt to develop multivariate statistical models relating ecological variables to possible controlling variables (e.g. fish movement with river discharge, river type, and target species life history).</p> <p>On a broader scale, the Gwydir Selected Area team has developed very useful ecological information through the 5-year period from 2014 to 2019, and this has contributed to the increased scientific knowledge of the lower Gwydir ecosystem.</p> <p>However, the Gwydir study produced few quantitative predictive models that would assist environmental water holders in planning annual and long-term environmental watering actions. As an example, a quantitative model that predicted the following would be extremely useful - inundation of X ha (to mean depth of Y m) of wetland Z for ZZ months would result in N waterbirds breeding, a high abundance of M native fish species and recruitment of P fish species, and this would require flows of XX ML/d for 15 days.</p>
Evaluator 2	<p>Moderately Effective</p> <p>Evaluation of the ecological outcomes of CEW was moderately effective in the Gwydir. The multi-channel nature of the Gwydir provided opportunities to assess the contribution of different amounts of CEW that were provided in different areas. This provided useful knowledge about ecological outcomes. As with most of the Selected Areas, the main challenge in evaluating outcomes were: 1) the development of counterfactuals i.e. what would have happened in area that were provided with CEW if CEW hadn't been delivered, 2) the development of predictive models i.e. what was the response to CEW in areas that were not monitored. The MEP for the Gwydir highlights the need to predict outcomes in areas not monitored but this was not addressed in a quantitative way during LTIM.</p>
Consensus final rating	Moderately Effective

Mid KEQ 3.3	How effectively did the Murrumbidgee Selected Area evaluate the ecological outcomes of CEW?
Evaluator 1	<p>Moderately Effective for both river and wetland sites</p> <p>The Murrumbidgee Selected Area was moderately effective in evaluating the ecological outcomes of CEW in both river and wetland sites in the Lower Murrumbidgee.</p> <p>The target in the Murrumbidgee has mostly been to deliver CEW to achieve ecological outcomes in downstream wetland, but also to provide for in-channel ecological outcomes along the way.</p>

	<p>Evaluation of the CEW contribution to the ecological condition (microinvertebrates, fish and metabolism) in the Murrumbidgee channel (at Narrandera and Carrathool) is broad, largely non-quantitative with little predictive power. The focus of the analyses undertaken seems to have been largely on showing difference between the two sample locations and not the influence of CEW.</p> <p>Equally, evaluation of the CEW contribution to the ecological condition (microinvertebrates, fish, vegetation, frog and turtles, and waterbirds) in the twelve Murrumbidgee wetlands studied is also broad and largely non-quantitative. The unsurprising result that comes through is that when the wetlands are inundated microinvertebrates, fish, vegetation, frog and turtles, and waterbirds all do better. And the results for the very wet year 2016-17, when a greater area of all wetlands were inundated, showed even better ecological outcomes, particularly for waterbirds.</p> <p>This is all good ecological information and is contributing to the scientific knowledge, but it would be useful to have more quantitative information relating environmental water to the monitored ecological indicators.</p> <p>While some hypotheses (or expectations) are provided in the 2020 report, covering both the 2018-19 and 2014-2019 periods, it would have been useful to have also provided the conceptual models supporting these hypotheses.</p>
Evaluator 2	<p>Moderately Effective</p> <p>Ecological outcomes were evaluated in a moderately effective way in the Murrumbidgee Selected Area. The Murrumbidgee differed from other Selected Areas in that the focus was on the influence of CEW on wetlands and also in-channel responses. As with other Selected Areas the inference of outcomes to areas that received CEW but were not monitored was not well addressed. Qualitative discussion of ecological outcomes was thorough and useful.</p>
Consensus final rating	<p>Moderately Effective</p>

Mid KEQ 3.4	How effectively did the Lachlan Selected Area evaluate the ecological outcomes of CEW?
Evaluator 1	<p>Moderately Effective</p> <p>Largely qualitative evaluation, no models, but addressed sensible evaluation questions</p> <p>No counterfactual studies</p> <p>Value add – with 1 honours and 2 PhDs</p>
Evaluator 2	<p>Moderately Effective</p> <p>Cross-reference: KEQ 1.9.4.</p> <p>There seems to have been some issues in the Lachlan associated with:</p> <ul style="list-style-type: none"> • Sites within the SA not being located appropriately

	<ul style="list-style-type: none"> The Selected Area, being downstream of Lake Brewster, did not include outcomes between Wyangala Dam and Lake Brewster, when this reach was a target for CEW to enhance fish. <p>Dyer suggests there were problems inferring vegetation response because of the placement of monitoring sites (Dyer et al., 2019a): “A number of the vegetation monitoring sites, which have been monitored in the lower Lachlan River Catchment over the past five years of the LTIM have not, and it is very unlikely that they will, receive environmental water. In contrast, very few sites that have received environmental water more than once in the five year period have been monitored. It is recommended that as part of the MER program, the sites are revised to include those which are likely to be more frequently watered and thus will provide more useful data on the response of the vegetation to watering. Choosing sites which have some level of environmental protection and away from sites heavily influenced by sheep and cattle grazing may also improve our ability to detect a response to watering. However, one must be mindful of the ability to infer responses at a greater scale in doing so.”</p> <p>In the final year of LTIM, monitoring of some indicators was expanded into the Lachlan between Wyangala Dam and Lake Brewster. This followed recommendations by the SA team (Dyer et al., 2019). This is a good example of an adaptive response to monitoring needs.</p>
Consensus final rating	Moderately Effective

Mid KEQ 3.5	How effectively did the Goulburn River Selected Area evaluate the ecological outcomes of CEW?
Evaluator 1	<p>Effective</p> <p>The Lower Goulburn Selected Area was effective in evaluating the ecological outcomes of CEW in riverine sites in the Goulburn.</p> <p>The Goulburn Selected Area program was guided by a very useful conceptual model (see below), which made it relatively easy to see the (hypothesised) relationships between CEW (and other e-flows) and the various ecological indicators being monitored.</p> <p>They also developed quantitative statistical models to evaluate the influence of CEW (and other environmental water) on the selected ecological indicators (e.g. bank condition (erosion), bank vegetation, fish and metabolism). These models have also incorporated other variable where hypothesised (e.g. season, temperature, light).</p> <p>The findings of the relationships between CEW and the monitored ecological indicators are very well summarised (Table 4, Webb et al., 2020a) and also well linked to the conceptual model of the relationships between the indicators and environmental water.</p> <p>These quantitative predictive models relating flow to the selected ecological indicators provide confidence in the Selected Area team’s ability to assess the effectiveness of CEW actions in influencing the ecological condition of the Goulburn River.</p>

	<p>Figure 15. Updated conceptual model of the linkages among the different monitoring matters in the lower Goulburn River Long-Term Intervention Monitoring Project (modified from Webb et al. 2018). The blue 'hydrology' box is the ultimate cause – low enhancement with Commonwealth environmental water, plus with the addition now of unregulated tributary inflows as an additional major hydrologic driver; orange boxes are physical effects of this, with flow on effects to intermediate (green) and ultimate (aqua) environmental variables. Arrows are hypothesized causal linkages posed at the start of the LTIM Project (with several added since as well). Ticks are linkages that we believe have been demonstrated by the monitoring data, or at least strongly suggested. Question marks are linkages that are yet to be demonstrated. The linkage between bank condition and vegetation diversity, with both symbols, is strongly suggested. No linkages have been disproved throughout the program.</p>
<p>Evaluator 2</p>	<p>Effective</p> <p>The Goulburn Selected Area reports present a sophisticated approach to evaluating the ecological outcomes of CEW. There are both qualitative and quantitative descriptions of outcomes. A clearly articulated conceptual model is used to establish questions of monitoring and summarise new understandings. Evaluations are supported with statistical reasoning.</p>
<p>Consensus final rating</p>	<p>Effective</p>

<p>Mid KEQ 3.6</p>	<p>How effectively did the Edward-Wakool Selected Area evaluate the ecological outcomes of CEW?</p>
<p>Evaluator 1</p>	<p>Moderately Effective</p> <p>The Edwards-Wakool Selected Area was moderately effective in evaluating the ecological outcomes of CEW in riverine sites in the system.</p> <p>This Selected Area focused on four hydrological zones of the Yallakool Creek and upper and mid reaches of the Wakool River – the anticipated inclusion of the Niemur and Werai forest ecosystems were not monitored (and hence not evaluated) because no CEW actions were of sufficient volume to overtop the bank and inundate these assets. The contribution of CEW to the hydrology, water quality, metabolism, bank vegetation and fish was evaluated.</p>

	<p>A useful conceptual model of the relationship between hydrology (low flows, freshes, overbank flows) and fish communities, underpinned the work on fish movement, reproduction, recruitment and finally adult fish communities. No conceptual model was presented in the final report relating flow and to other ecological indicators (metabolism, bank vegetation).</p> <p>Considerable additional knowledge has been gained on the water quality, metabolism, bank vegetation and particularly the fish biology of this system over the 5-years of the LTIM study. Additionally, useful broad (but qualitative) knowledge has also been gained regarding the influence of CEW on the hydrology, water quality and ecological indicators. This information has assisted the CEWO Delivery Team in its planning for e-flows in this system.</p> <p>The development of quantitative predictive models, of the type developed for the Goulburn, relating flow to the selected ecological indicators would have provided greater confidence in the predicted influence of CEW actions on the ecological condition of the Edwards-Wakool system.</p>
Evaluator 2	<p>Moderately Effective</p> <p>Much useful knowledge on ecological outcomes of CEW has been provided in the Edward-Wakool. One key piece of information was the inability of CEW to mitigate the blackwater event that occurred in 2016-2017. This has implications for understanding the role of CEW in enhancing the resilience of this reach to extreme events.</p> <p>Ecological outcomes of CEW were effectively evaluated where information was available. As with most of the other Selected Areas, the challenge was to move beyond qualitative descriptions. Inferring outcomes in areas not monitored was highlighted in the MEP but does not seem to have been further developed during the LTIM project.</p>
Consensus final rating	Moderately Effective

Mid KEQ 3.7	How effectively did the Lower Murray Selected Area evaluate the ecological outcomes of CEW?
Evaluator 1	<p>Moderately Effective</p> <p>Again largely qualitative evaluation, no models</p>
Evaluator 2	<p>Effective</p> <p>The outcomes were evaluated effectively where there are data, the challenge was that there were few ecological outcomes. The section on “Implications for future management of environmental water” Ye et al., (2020a) presents few concrete results. The key recommendation is that higher flows are required to achieve desired outcomes. This seems to present a similar state of knowledge to that available at the start of LTIM. As with other Selected Areas, there were challenges around inferring results to areas not monitored.</p>
Revision comments – Evaluator 1	

Revision comments – Evaluator 2	The evaluation should be moderately effective given the challenges inferring results to areas not monitored. There were similar issues in most Selected Areas.
Consensus final rating	Moderately Effective

Mid KEQ 3.8 How effectively were the Selected Area outcomes incorporated into the Basin-scale synthesis reports?	
Evaluator 1	<p>Moderately Effective</p> <p>The outcomes of the Selected Area evaluations appear to have been moderately effectively incorporated into the Basin-scale Synthesis reports.</p> <p>The design of the LTIM project was based on the assumption that the knowledge gained from the Selected Area monitoring programs would be used, together with other relevant information, by the Basin Matters team to evaluate the ecological outcomes of CEW at the Basin-scale. This is a very challenging task, made more difficult by the issues experienced in accessing this Selected Area data from the MDMS, which was less than effective, and the less than effective collaboration between the Basin Matters and Selected Area teams.</p> <p>My assessment is that given the above issues, the Selected Area data was moderately effectively used by the Basin Matters team. However, given other evidence that suggests the Basin Matters and Synthesis reports were not widely read, I question the impact of these Basin-scale evaluations.</p>
Evaluator 2	<p>Minimally Effective</p> <p>There do not appear to be particularly strong links between the annual SA reports and the basin-scale synthesis reports. The synthesis reports are closely linked to the Basin Matters reports rather than the SA reports. The Basin Matters reports are appendices to the synthesis reports.</p> <p>There is a comment in the 2020 synthesis report: “This basin-scale evaluation report draws together the results of each Basin Matter to provide an integrated assessment of outcomes of CEW” (Hale et al., 2020).</p> <p>The SA outcomes are incorporated into the synthesis reports to the extent that the SA outcomes are incorporated into the Basin Matters reports and from there to the synthesis reports.</p> <p>There are particular issues upscaling from SA to Basin-scale reporting:</p> <ul style="list-style-type: none"> • No Stream metabolism data was collected in the Gwydir • Problems with stream metabolism in the Warrego-Darling • The vegetation data collected in the Edward-Wakool was of a lower standard than other SAs: “It should be noted that vegetation diversity data collected from the Edward-Wakool river system is limited to Category 3 and does not, therefore, have the same taxonomic resolution or range of observations as that from the other Selected Areas.” (Capon and James, 2020) • Fish data was not available from Warrego-Darling • Turtles were only monitored in one SA, Murrumbidgee.

	<ul style="list-style-type: none"> Frogs were monitored in 3 of the seven SAs; the Murrumbidgee in all five LTIM areas and for fewer years in the Warrego-Darling, the Gwydir and Lachlan. Waterbird monitoring was based on aerial survey which was not restricted to SAs.
Revision comments – Evaluator 1	<p>Would go either way – interactions between SA and Basin Matters were not very effective, and there was minimal interaction between the two groups. There should have been workshops which would have helped both groups to improve collaboration.</p> <p>I agree with Evaluator 2 in that the Basin Matters use of Selected Area outcomes was overall minimally effective</p>
Revision comments – Evaluator 2	<p>Agree with evaluator 1 comments. I said minimal just because it was that extra step further away. So we had a synthesis report, below that we had the Basin Matters reports. And then below that, we had the Selected Area reports to some extent. I didn't feel like the synthesis report drew on the Selected Area reports. It drew on the Basin Matter reports. But I can see the other argument as well, the Basin Matter reports drew, on the Selected Area report. So there is a link. Also there was some problems with the SA data.</p>
Consensus final rating	Minimally Effective

High KEQ 4	To what extent did the LTIM project infer ecological outcomes of Commonwealth environmental water to areas in the Basin not monitored? (objective 3 Gawne et al. 2013)
Evaluator 1	<p>Minimally Effective</p> <p>None of the Selected Area services providers extrapolated their findings from reach to whole of Selected Area scale (KEQ4.1), while the Basin Matters Synthesis reports (and some of the six Basin Matters reports) did attempt to use information from the Selected Areas and elsewhere to infer the contribution of CEW in non-monitored areas (KEQ4.2).</p> <p>Inference of the ecological contribution(s) of CEW in non-monitored areas in the Basin is a very challenging task, made even more difficult by the lack of an overall strategy of how to do this, a lack of data for non-monitored area (particularly in the northern Basin), and a lack of robust predictive models.</p> <p>Interestingly, the survey results indicated that a significant number of participants did not know how effectively the Selected Area data was extrapolated to whole of Selected Area scale or to the Basin-scale.</p>
Evaluator 2	<p>Minimally Effective</p> <p>The need to infer outcomes not monitored is acknowledged in the introduction to all the basin-scale synthesis reports and the Selected Area MEPS. However, there is almost no mention of this in the body of the reports.</p> <p>In the final synthesis report, there is a suggestion that it will be possible for waterbirds in the future:</p> <p>“The trial in the final LTIM year of matching waterbird survey data with inundation from the Wetland Insight Tool and aquatic ecosystem mapping of the ANAE has yielded promising results. While there were significant issues with respect to matching the scale of data collected, the available</p>

data products are likely to improve over time. As our understanding of the strength of biodiversity-water regime relationships is improved, the predictive capacity of inferring biodiversity outcomes at sites that receive environmental water but are not monitored will become more certain.”

There is also almost no discussion of this issue in the annual SA reports.

This issue is addressed in some of the Basin Matter reports, (Fish and Vegetation) but only in the final year.

Survey: The survey response (Question 15) suggest that most respondents thought there was at least some inference to areas not monitored (n = 37):

- Not at all 8%
- A little 35%
- A moderate amount 30%
- Don't know 27%

Issues are highlighted in survey responses:

- “This was a challenging space for the LTIM scientists and progressive improvement was achieved through the life of the project”
- “Major shortfall”
- “LTIM failed in this objective”
- “I think this is a big issue. I'd be interested in examples where this has happened”
- “Speaking from fish, the findings have been applied fairly broadly”

Interviews:

- “I don't think what we've been able to achieve within five years is appropriate for answering questions like things that are outside of the Selected Areas that aren't being monitored.”
- “...as a scientist, I would be uncomfortable about extrapolating very far beyond ... the areas where the work was actually done”
- “So our project didn't do that at all”. “[We did] not so much infer outcomes in areas not monitored, but infer outcomes for flows not monitored.”
- “Well, I think that's absolutely difficult... there were challenges just with monitoring in monitored sites as opposed to unmonitored.”
- “I think for hydrology, it did really well. I think for the other indicators, not so well, particularly at Basin-scale. And I think it's an incredibly hard task.”
- “I think we came a long way with that in the last year. So I think up until, say, the 2017-18 report, we hadn't done that particularly well.”
- “I don't think it was quite as successful in terms of inferring ecological response in areas outside of where we were doing the monitoring.”
- “Well, I think that probably had as good a crack as we could have. Noting that, you know, there is lots of challenges to that.”
- “Not very well at all, I'd say. I think, it was getting towards there may be at the end of the five years”

	<ul style="list-style-type: none"> • “Not to the extent we first thought it might be able to in those early stages” • “So I think it's not necessarily a failure of the objective or that the design was wrong. I think we just underestimated how complex these systems are that two wetlands next to each other can be completely different for completely different reasons.” <p>However, there were positive comments about stream metabolism in the Southern basin:</p> <p>“I think we've got a very, very good handle on how metabolism, primary production, all that sort of stuff, nutrient cycling would occur under most flow conditions in the southern basin. And that's extrapolated beyond monitoring sites”.</p>
Consensus final rating	Minimally Effective

Mid KEQ 4.1	How effectively did Selected Area services providers extrapolate their findings from reach to whole of Selected Area scale?
Evaluator 1	<p>Minimally Effective</p> <p>None of the Selected Area teams attempted to infer possible ecological response to CEW in other non-monitored areas of the Selected Area</p>
Evaluator 2	<p>Minimally Effective</p> <p>There were similar issues to those discussed above and in KEQ 4.2. Ecological response was found to be complex. Extrapolation was difficult. Modelling building was not generally attempted by Selected Area teams and counter factual cases were difficult to establish. Wrangling data was a challenge. The skill set for monitoring was different to that required to build statistical models and extrapolate – although many of the SA teams had considerable expertise.</p> <p>Survey (Question 16):</p> <p>Other than the large portion of “Don’t know” responses (57% - 73% across the 6 Selected Areas), there was a large portion of “Not at all effectively” and “Not so effectively”. 29% in Lower Murray to 57% in the Murrumbidgee.</p> <p>This is confirmed in the survey responses:</p> <ul style="list-style-type: none"> • “Extrapolation of findings to area and basin-scale...still is a difficult challenge”. “Only a modest amount of progress in developing counter factual models slowed progress in this regard”. • “I think this was a bit of a shortfall from the SA data I was familiar with”. • “In my experience, Selected Areas just didn’t think this was their job”.
Consensus final rating	Minimally Effective

Micro 4.1.1	KEQ	How well did the Warrego Darling Selected Area infer ecological outcomes of CEW to areas not monitored?
Evaluator 1	Minimally Effective	No consideration of this in the annual reports.
Evaluator 2	Minimally Effective	No consideration of this in the annual reports.
Consensus final rating	Minimally Effective	

Micro 4.1.2	KEQ	How well did the Gwydir Selected Area infer ecological outcomes of CEW to areas not monitored?
Evaluator 1	Minimally Effective	The Gwydir Selected Area team did not infer the possible ecological response to CEW in non-monitored areas of the Gwydir system.
Evaluator 2	Minimally Effective	No consideration of this in the annual reports.
Consensus final rating	Minimally Effective	

Micro 4.1.4	KEQ	How well did the Lachlan Selected Area infer ecological outcomes of CEW to areas not monitored?
Evaluator 1	Minimally Effective	Addressed in part but overall still considered minimally effective due to some logistic constraints.
Evaluator 2	Minimally Effective	The Lachlan SA did consider this issue.

	<p>CEW was delivered to the Great Cumbung Swamp however this was not monitored because of issues of access and cost. Drones were tried but were found not to be effective (Dyer et al, 2019a).</p> <p>Dyer suggests there were problems inferring vegetation response because of the placement of monitoring sites (Dyer et al., 2019a):</p> <p>“A number of the vegetation monitoring sites, which have been monitored in the lower Lachlan River Catchment over the past five years of the LTIM have not, and it is very unlikely that they will, receive environmental water. In contrast, very few sites that have received environmental water more than once in the five year period have been monitored. It is recommended that as part of the MER program, the sites are revised to include those which are likely to be more frequently watered and thus will provide more useful data on the response of the vegetation to watering. Choosing sites which have some level of environmental protection and away from sites heavily influenced by sheep and cattle grazing may also improve our ability to detect a response to watering. However, one must be mindful of the ability to infer responses at a greater scale in doing so.”</p>
Consensus final rating	Minimally Effective

Micro 4.1.5	KEQ	How well did the Goulburn River Selected Area infer ecological outcomes of CEW to areas not monitored?
Evaluator 1	Minimally Effective	The Goulburn Selected Area team did not infer the possible ecological response to CEW in non-monitored areas of the Goulburn system. It is noted that the region between Eildon and Goulburn Weir must receive CEW on its way down to the Lower Goulburn and the possible ecological response(s) to CEW in this region could have been inferred.
Evaluator 2	Minimally Effective	No consideration of this in the annual reports.
Consensus final rating	Minimally Effective	

Micro 4.1.6	KEQ	How well did the Edward-Wakool Selected Area infer ecological outcomes of CEW to areas not monitored?
Evaluator 1	Minimally Effective	The Edwards-Wakool Selected Area team did not infer the possible ecological response to CEW in non-monitored areas of the Edwards-Wakool system.
Evaluator 2	Minimally Effective	

	No consideration of this in the annual reports.
Consensus final rating	Minimally Effective

Micro 4.1.7	KEQ	How well did the Lower Murray Selected Area infer ecological outcomes of CEW to areas not monitored?
Evaluator 1	Minimally Effective	As with the other Selected Areas this was not undertaken there was no consideration of this in the annual reports.
Evaluator 2	Minimally Effective	The need to infer ecological outcomes of CEW in areas of the MDB not monitored is listed as a high-level outcome in the MEP but is not mentioned in any of the SA annual reports. Therefore, this KEQ was not met.
Consensus final rating	Minimally Effective	

Mid KEQ 4.2	How effectively did the LTIM project infer ecological outcome of CEW from Selected Area to areas in the basin not monitored?
Evaluator 1	<p>Moderately Effective</p> <p>None of the Selected Areas attempted to infer the ecological outcome of CEW in non-monitored areas of the Basin using the knowledge gained from their Selected Area.</p> <p>However, a number of the Basin Matters reports did use information from the Selected Areas and elsewhere to infer the contribution of environmental water in non-monitored areas. For example, both the hydrology and ecosystem diversity evaluations considered the whole Basin, including both monitored and non-monitored areas. Also, the biodiversity Basin Matters evaluation was able to use non-LTIM monitoring data to assess the contribution of environmental water on waterbirds and threatened species in Ramsar wetlands (Banrock Station, Barmah Forest, Macquarie Marshes, Hattah-Kulkyne NP).</p> <p>Additionally, the fish and vegetation Basin Matters evaluations were able to use knowledge gained from the Selected Areas to make inferences regarding the effect of environmental water in other areas; for fish, flow effects on the abundance, spawning and recruitment of focal species; and for vegetation, because of the strong relationship between ANAE ecosystem type and vegetation community composition at monitored Selected Areas, it is expected that there would be a greater diversity of vegetation at a Basin-scale in any water year were CEW inundated a greater diversity of ecosystem types. The</p>

	<p>Basin Matters metabolism team was able to predict on the basis of knowledge gained from the Selected Areas that: in-channel rates of carbon production and consumption in southern Basin streams will be similar to those found in the monitored sites, and to some extent will be controlled by the low levels of bioavailable phosphorus; in northern Basin streams metabolism rates are likely to be low because of their higher turbidity; and inundation of floodplains is likely to increase in-channel metabolism when the water flows back into the river.</p>
<p>Evaluator 2</p>	<p>Minimally Effective</p> <p>See the discussion under KEQ4 and KEQ4.1</p> <p>The need to infer ecological outcomes from Commonwealth environmental watering in areas of the Murray-Darling Basin not monitored is recognised in all the Selected Area Monitoring and Evaluation Plans but is not explicitly addressed in any of the annual SA reports. Inference from Selected Area to basin is mainly the responsibility of the Basin Matter teams as it would be out of scope for each individual SA team. This was expressed at interview: “I don't think it was the role of selecting areas to look at evaluation outside of the Selected Areas.”</p> <p>The need to be able to extrapolate to unmonitored areas and unmonitored flows is recognised in the Basin Matter foundation documents, where it is dependent on model building. However, In most cases, model building was not undertaken, or was delayed.</p> <p>There were also issues at particular Selected Areas. For the Warrego-Darling, Gawne et al. (2013f) comment: “...monitoring the effects of Commonwealth environmental water at this location...cannot be used to infer outcomes in the wider norther Murray-Darling Basin”. This means there was only one site in the northern basin that could be used to infer results to areas not monitored.</p> <p>For the Lachlan, the challenge was the many watering events were focused on reach between Wyangala Dam and Lake Brewster which was not monitored:</p> <p>“The current LTIM program for the Lower Lachlan river system only monitors the river system below Lake Brewster. This means we do not have data to evaluate watering actions upstream. The fish community between Wyangala Dam and Lake Brewster is in much better condition and has a greater probability of responding to environmental water than the reach downstream of Lake Brewster (Sam Davis, DPI Fisheries pers comm.). Thus the response observed downstream of Lake Brewster is unlikely to be representative of the upstream reaches. The watering action delivered was targeted at the mid-Lachlan River system below Wyangala Dam. Past watering actions have also targeted this reach. Future monitoring programs should consider monitoring the target reach (Wyangala to Lake Brewster) so that the outcomes might better be evaluated” (Dyer et al., 2017)</p>
<p>Revision comments – Evaluator 1</p>	<p>Until year 4 they didn't have methods, that is, no models – happy to go to minimal</p>
<p>Revision comments – Evaluator 2</p>	
<p>Consensus final rating</p>	<p>Minimally Effective</p>

EFFECTIVENESS – COMMUNICATED FINDINGS

- 1 high-level KEQ
- 2 mid-level KEQs
- 9 micro-level KEQs

High KEQ 5	How effective was the LTIM project at communicating key findings?
<p>Evaluator 1</p>	<p>Minimally to Moderately Effective</p> <p>The LTIM project was minimally to moderately effective in communicating outputs and key findings to end users (CEWO, MDBA, other collaborators) for the purpose of better understanding the ecological responses of CEW and to use this information to adaptively management CEW.</p> <p>It is clear that the annual Selective Area and Basin Matters reports were a moderately effective means for communicating key findings, but they were minimally effective in informing adaptive management of environmental water.</p> <p>While the Selected Area annual reports were regarded by end users as moderately effective in providing relevant information on what environmental watering actions had occurred and what the outcomes were, the more-timely information needed in planning the environmental watering actions for a particular year occurred in direct meetings between the researchers and the water managers.</p> <p>The Basin Matters reports (including the Synthesis report) appear not to have been used by end users and were regarded as minimally effective for both improving the understanding of the Basin-wide ecological responses of CEW and using this information to adaptively manage CEW.</p> <p>An opinion expressed in the interviews was that while adaptive management was reasonably effective within each Selected Area, particularly during annual planning, these learnings were not well captured and transferred between catchments including those not monitored. Additionally, the view was expressed that the cumulative effects of adaptive management over the longer term both locally and Basin-wide were not captured.</p> <p>It was suggested (survey, interviews) that external communication of LTIM findings was not emphasised in the project design, and no overall communications strategy was developed for the LTIM project to guide the Selected Area and Basin Matters teams. The CEWO added a collaboration funding component part way thought the LTIM project to encourage more collaboration within the project and to improve external communication of the key findings. There appears to be no consolidated report of what activities were funded or how successful they were, and the survey and interviews are silent on the success or otherwise of this additional funding.</p>
<p>Evaluator 2</p>	<p>Moderately Effective</p> <p>LTIM was moderately effective at communicating key findings.</p> <p>Most findings were communicated using a series of reports: Annual Selected Area reports, Basin Matter reports and a basin-scale synthesis report. Generally these reports where well written and presented and contained a thorough review of the monitoring and analysis that had been undertaken.</p>

	Issues are discussed in the KEQs below. These include the lack of communication plan for the LTIM project as a whole and for the Basin Matters component. Selected Areas did develop communication plans and survey responses were generally positive about the information provided by Selected Areas teams. Selected Area teams were able to provide information to facilitate adaptive management at the Selected Area scale. Survey and interview responses are less positive at the Basin-scale.
Revision comments – Evaluator 1	Happy to go to moderate
Revision comments – Evaluator 2	
Consensus final rating	Moderately Effective

Mid KEQ 5.1	How effectively were the outputs and key findings of the LTIM project communicated to end users such as the MDBA, CEWO water delivery teams, other collaborators in the LTIM project?
Evaluator 1	<p>Moderately Effective</p> <p>It is clear from that evaluations below (KEQ5.1.1-5.1.7) that communication of the outputs and key findings of the LTIM project to end users (CEWO, MDBA, other collaborators) were minimally to moderately effective.</p> <p>One reason for this relatively poor effectiveness was the lack of an overall communications strategy for the LTIM project to guide the Selected Area and Basin Matters teams. The Selected Area annual reports were regarded by end users as moderately effective in providing relevant information on what environmental watering actions had occurred and what the outcomes were. However, the more-timely information needed in planning the environmental watering actions for a particular year occurred in direct meetings between the researchers and the water managers.</p> <p>The Basin Matters reports (including the Synthesis report) appear not to have been used by end users and were regarded by end users (interviews) as minimally effective.</p> <p>There was general agreement by end users that the CED (or conceptual models) developed at the start of the LTIM project (with some modified along the way) were useful for understanding the linkages between e-flows (and other causal indicators) and ecological indicators, and to underpin decisions regarding expected outcomes from particular environmental watering events. However, they were considered by many as too scientific as a general communication tool.</p>
Evaluator 2	<p>Moderately Effective</p> <p>Survey:</p>

	<p>There are survey results for the question (Q17): “How effective was the LTIM project at communicating key findings to stakeholders (DEWO, MDBA, other members of the LTIM project, etc.), including to inform adaptive management”.</p> <p>Results suggest there are issues at the Basin-scale, 33% of respondents selected “Not at all effectively” or “Not so effectively”.</p> <p>Extracts from extended answers to Q17:</p> <ul style="list-style-type: none"> • “The question reflects the core problem: a very poor understanding of who stakeholders are. LTIM had very little science communication.” • “External communication of LTIM findings was not emphasised in the project design”. • “I think it was a real shortfall early on in the program, which seemed very insular and purely academic”. It improved. • “What didn’t work was the timelines for formal reporting which were often 6-12 months behind results in the field” • “I thought this was one of the strong pints of our work in the northern basin” • “Warrego-Darling and Gwydir Selected Areas...has done an excellent job in informing management” • “Warrego-Darling and Gwydir did the best, the basin-scale teams did the worst”. • “LTIM providers were NOT contracted to do this. They were contracted to summarise their findings in a way that would allow CEWO communications to communicate the findings” <p>There does seem to be a range of views around who was responsible for this communication. All the Selected Area MEPs had communications plans but there is little mention of communication and no plans in the Basin Matter foundation documentations. This suggests communication was not a key responsibility of the Basin Matter teams but they were the ones with knowledge at the Basin-scale.</p> <p>This suggests a gap in project structure. The SA had the main communication responsibilities but would not have had the basin-scale information to communicate.</p> <p>Interview:</p> <p>How well did the LTIM project communicate findings:</p> <ul style="list-style-type: none"> • “Initially, I don't think it did it very well at all. It wasn't contracted to communicate to key stakeholders. It was contracted to communicate to the CEWH through reports...” • “So LTIM products where designed, I guess, to work within a certain audience - that audience is very, very limited”
<p>Consensus final rating</p>	<p>Moderately Effective</p>

Micro KEQ To what extent did planned outputs (reports) meet CEWO reporting requirements (see reporting template) and timelines?
5.1.1

<p>Evaluator 1</p>	<p>Moderately Effective</p> <p>The LTIM reports (Selected Area, Basin Matters) essentially met the CEWO (2015) reporting requirements, although the timelines appear to have been rarely met.</p> <p>The Basin Matters team were required to organise and report on the Annual Forum each year and to provide six Basin Matters reports and a Synthesis report (Evaluation Report) annually. These were all provided although the timelines established by CEWO were not met.</p> <p>The Selected Areas were required to provide CEWO with verbal updates monthly, monitoring data entry monthly, a short progress report quarterly, and an annual evaluation report (summary plus technical details). These were all provided, although the CEWO timelines were not met, which cause problems for the Basin Matters team who required the evaluation reports particularly to complete their evaluation reports. There is no record that the requirement for monthly monitoring data entry was met.</p>
<p>Evaluator 2</p>	<p>Moderately Effective</p> <p>Cross-reference: KEQ 2.3.1</p> <p>The templates I found were for:</p> <ol style="list-style-type: none"> 1. Selected Area reporting - as specified in a document: 2017-18 LTIM SA Reports – Final Structure. 2. Basin Evaluation Reports – as specified in Gawne, B., Everingham, P and Hale, J. (2014) Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Revised Basin Evaluation Plan – Part C: Project Management and Governance. <p>Timelines for Basin-scale and Selected Area reporting are specified in “LTIM Timelines”</p> <p>Summary of requirements of SA reports, this applies to SA reports in the final year, following the recommendations of mid-term review:</p> <ul style="list-style-type: none"> • 20 page summary report • Detailed scientific report • Consistent structure (headings) used across all SAs. <p>The following Selected Areas followed structure: Lachlan, Lower Murray, Warrego-Darling (approximately), Goulburn, Gwydir.</p> <p>Neither the final Murrumbidgee SA Report or the draft final Edward-Wakool SA report follow the provided structure.</p> <p>Considering the Basin Evaluation Reports, these were intended for three audiences</p> <ul style="list-style-type: none"> ○ Environmental water managers who are well informed about environmental watering but who generally are not scientists; ○ Any interested stakeholders, who may have limited knowledge of environmental water management and ecological science; and

- Scientists for whom the scientific detail is important.

To meet the needs of all three audiences, the Basin Evaluation Report was to be structure as follows:

- An executive summary: This is a separate, high level communication document which clearly and concisely explains the key outcomes, observations and messages in plain English without getting into scientific detail. It will specifically focus on the ecological response to the Commonwealth environmental water for a public audience (1 to 2 pages);
- The main report: a comprehensive document, written in plain English (suitable for a water manager and interested audience) and incorporating scientific concepts and containing the context, evaluation and adaptive management components of the Basin evaluation (around 20 pages). This document will describe outcomes and meaning of the evaluation and provide information and lessons for adaptive management. This report will include an important interpretative section which clearly explains scientific opinion and makes inferences on what the observations and outcomes mean for environmental water management, including translation of monitoring observations to broad ecosystem responses to environmental watering.

This report is on the CEWO website as the: "Basin-scale evaluation of Commonwealth environmental Water - report and appendices". Click on that and you get to another page that includes the Synthesis report and the Basin Matters reports as appendices.

This suggests that the structure wasn't adhered to as there is no executive summary to the synthesis report. The Synthesis reports are informative but are probably a bit too complicated to interest "Any interested stakeholders, who may have limited knowledge of environmental water management and ecological science". Comments from interviews suggest some reporting was considered too complex (see KEQ 0231).

Timing:

Considering the annual Selected Area reports, there are $7 \times 5 = 35$ in total i.e. seven Selected Area and 5 years of the LTIM projects. Of these 35, only 1 was delivered by the due date.

Of the annual Basin Matter reports; Hydrology and Ecosystem diversity did not depend on data from the Selected Areas. Of these, all the ecosystem diversity reports were delivered on time. And 4 out of 5 of the Hydrology reports were delivered on time. For the other Basin Matters, even though they were received the final SA reports late, they were usually delivered on time. Only Stream Metabolism and Fish were late, 1 year out of 5. The annual synthesis report were delivered late 4 years in 5.

Interview:

End users were asked about the extent to which outputs met CEWO requirements:

- "[reports] were still too technical and long, quite frankly, they didn't consolidate learnings and advice in a way that was easily accessible"
- "...the beauty of the LTIM is that [reports provide detail on] each theme and indicator"

	<ul style="list-style-type: none"> • “LTIM was a big chunk of the content of [CEWOs reporting requirements] so from that perspective [they] absolutely [met requirements]”. • “...we would be completely screwed if it wasn’t for LTIM”. • “...the reports are useful and appropriate in terms of making that information accessible and the data, similarly” <p>There were concerns about timing:</p> <ul style="list-style-type: none"> • “Look, timing was an issue, especially for some of the providers. ... we wouldn't get [reports] until a year or more after the due date • “but an acknowledgment that the reporting is almost like six to nine months after the end of the ‘war’”.
Consensus final rating	Moderately Effective

Micro 5.1.2	KEQ To what extent were planned outputs targeted at key audiences (both in terms of providing relevant information and in a format useful to the end-user)?
Evaluator 1	<p>Moderately Effective</p> <p>The LTIM annual reports (Selected Area, Basin Matters) were moderately effective in providing relevant information in a form useful to end users.</p> <p>The Selected Areas produced two reports annually: a summary report and a technical report. The summary reports were aimed at the broad stakeholder group, while the technical reports were aimed at the e-flow managers. The summary reports were mostly done well. For example, the final Goulburn Selected Area summary report (Webb et al., 2020a, Section 4.4) communicated findings on winter freshes, overbank flows and Inter-Valley Transfers (IVT) to end users in an easy to understand format. Equally, they communicated findings that have led to changed water delivery, such as limits on IVTs (e.g. upper thresholds beyond which habitat for small fish and fish larvae will be lost), and have contributed to regional water management aimed at getting golden perch to move from recruitment sites further down the River Murray system. The Edward-Wakool summary report (Watts et al., 2020a) also includes a good summary of how recommendations emerging from this Selected Area monitoring program were adopted for future environmental watering actions.</p> <p>The Basin Matters teams produced six Basin Matters reports and a Synthesis report annually. Hart and Butcher (2018) in their mid-term review recommended 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. It appears that the only change was that an executive summary was added to the reports after this review.</p>

	<p>The was consistent feedback from the interviews was that neither the Selected Area nor the Basin Matters reports were particularly effective in targeting key stakeholders. Some thought these reports were more targeted at CEWO staff rather than other water managers or community members. Other mechanisms were established to ensure the key findings from each Selected Area were provided to stakeholders. For example, both Edwards-Wakool and Lachlan Selected Areas interacted closely with their respective Environmental Water Advisory Groups to ensure the important findings were passed on. The other Selected Areas also had similar arrangements to ensure the exchange of information occurred in more effective and timely ways than through annual reports. One stakeholder suggested that this type of communication <i>‘has really helped to build relationships with community members that may not be as supportive of environmental water as we all might be’</i>. Many were critical of the broadly poor communication of Basin-scale results and findings, which consisted only of annual reports and presentations at the Annual Forums. Some interviewees felt that the initial LTIM project design was flawed in that an overall communications strategy was not developed for the start.</p>
<p>Evaluator 2</p>	<p>Moderately Effective</p> <p>Cross-reference: KEQ 0231</p> <p>There is little information on target audiences for reporting apart from the Basin Evaluation report. This is intended for three audiences</p> <ul style="list-style-type: none"> ○ Environmental water managers who are well informed about environmental watering but who generally are not scientists; ○ Any interested stakeholders, who may have limited knowledge of environmental water management and ecological science; and ○ Scientists for whom the scientific detail is important. <p>As noted above, the structure appropriate for these three audiences was not generally adhered to.</p> <p>A recommendation from the mid-term review (Recommendation 15) was that: “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”. CEWO responded that this was agreed for 2017-2018 onwards.</p> <p>That is perhaps why a summary is included in the final annual basin synthesis reports.</p> <p>There was concern about providing communication to a range of audiences. In Gawne et al., (2014a) Kathie Le Busque is mentioned as the head of the communications team, responsible for drafting communication products for a broad range of stakeholders and a non-technical audience. Michele Kavanagh is listed as having these responsibilities in later reports.</p> <p>Interview:</p> <p>As noted in KEQ0231, some people found reporting difficult, with one stakeholder contracting a consultant to pull out key messages.</p> <p>Interview:</p> <ul style="list-style-type: none"> ● “I don't think we were ever really clear on who the audience was for the different components of the LTIM reports”

	<ul style="list-style-type: none"> • “LTIM was targeted more at the scientific community and not that broader messaging that goes out to people” • “What managers almost need a reverse report [with] the snappy/key parts of the discussion upfront”
Consensus final rating	Moderately Effective

Micro 5.1.3	KEQ	To what extent did the project identify and make use of existing communication channels and networks used by key stakeholders?
Evaluator 1	Minimally Effective	<p>The LTIM project was minimally effective in identifying and using existing communication channels and networks used by key stakeholders.</p> <p>It is revealing that no overall communications strategy was developed for the LTIM project. It was left to the Selected Area and Basin Matters teams for develop their own methods for communicating with their stakeholders.</p> <p>The Selected Areas identified existing communication channels and networks quite well. Each of the Selected Areas have a section on communication and engagement in their MEPS, but only one of the Selected Areas (Goulburn) has a comprehensive stand-alone communication and engagement plan.</p> <p>However, the extent to which the Selected Areas implemented these plans is mixed. The Goulburn Selected Area is the only one that appeared to have an annual report on communication and engagement activities, while the Lachlan Selected Area provided a good summary of activities in their final evaluation report. None of the other Selected Areas provided any relevant information in their final evaluation reports, which is a missed opportunity and perhaps an indication that communication and engagement activities were not a high priority for LTIM.</p> <p>We have no documentation on what communication and engagement activities were undertaken by the Basin Matters team, with the exception of the Annual Forums.</p>
Evaluator 2	Moderately Effective	<p>There is little information available to evaluate this KEQ however it appears it was satisfied to some extent.</p> <p>The requirements report for each Selected Area include some details on consultation activities. Key stakeholder groups are identified. Each of the MEPS have a section on communication and engagement and some have comprehensive stand-alone C&E plans.</p> <p>For the Lower Murray, there is an appendix to the requirements reports that provides more detail (Gawne et al., 2013h). In this case communication was largely directed through 4 key contacts, so the intention was to access their networks. Certain individuals were approach but declined invitations to be directly involved because they would be informed through their networks.</p> <p>There is a Stakeholder Consultation Report that was written early in the project (Cottingham et al., 2013). Approx. 34 organisations were contacted.</p> <p>The section on ongoing collaboration, which offers a limited list of opportunities:</p>

- Between stakeholders in Selected Areas and M&E service providers
- Between Commonwealth and jurisdictions/CMAs in allocating CEW

This suggests the intention was that M&E providers would do the communication.

The Lachlan MEP includes a section on communication and engagement and a subheading on External stakeholder engagement. There is also a C&E plan (in an appendix) that includes mapping of stakeholder groups and a lot of detail of how groups are to be communicated with. If these plans were followed then this KEQ would be rated highly.

Communication planning by the other SAs is summarised as follows:

- Edward-Wakool. There is no separate C&E plan in an appendix. But there is a brief but reasonable plan in the main document where stakeholders are identified and activities listed.
- Goulburn: the MEP provides a comprehensive communication plan.
- Gwydir: Stand-alone communications plan
- Murrumbidgee: Brief communication plan as part of the MEP
- Warrego-Darling: Standalone communications plan.
- Lower Murray, Brief communication plan as part of the MEP

So, the impression is that communications channels and networks were identified and there were plans that they were to be used.

Reporting on activities actually undertaken is patchy. Number of mentions of communication and engagement in each of the SA annual reports is shown in Table 2.

Table 2: Number of occurrences of 'communication' and 'engagement' in each annual report from each Selected Area.

Selected Area	Communication(s)	Engagement
Edward-Wakool	1	4
Goulburn	17	8
Gwydir	0	0
Lachlan	27	17
Lower Murray	0	0
Murrumbidgee	1	5
Warrego	2	0

	<p>SA communication activities are:</p> <ul style="list-style-type: none"> • Edward-Wakool: Engagement through the Edward-Wakool Stakeholder group (Watts et al. 2017-2018b) • Goulburn: List of activities in each of the SA annual reports • Gwydir: Nothing • Lachlan. Communication and Engagement appendix in the final annual technical report. Nothing in any of the other reports. Six types of activities: <ul style="list-style-type: none"> ○ Local media products ○ Community updates ○ Social media ○ Reporting and scientific outputs ○ Community events and demonstration ○ Relationship management. • Lower Murray: There is no mention of ‘Communication’ in any of the annual summary of technical reports. • Murrumbidgee: Nothing significant • Warrego-Darling: Nothing in any of the annual reports. <p>The most comprehensive reporting is from the Goulburn.</p> <p>So, it is not clear how much these channels and networks were used. The Goulburn is the only one that has an annual report on communication and engagement activities. The Lachlan had a good discussion in the final SA report. Nothing in any other reports or for any of the other Selected Area reports. The lack of reporting suggests communication was not a focus of the SAs.</p> <p>The interview results suggest that the Gwydir and Warrego-Darling were effective at communication.</p>
<p>Revision comments – Evaluator 1</p>	<p>Each mention communications in the planning phases, but there is a lack of evidence is of actual communication taking place. Don’t think there is a lot of evidence across the board - some groups did better than others. Could go either way but still think its pretty minimal. No overall communication plan – no specific person to do this particular work; no capture of what was going on.</p>
<p>Revision comments – Evaluator 2</p>	<p>Very limited information – had to scrounge to find anything to make a judgement. Let’s go minimal.</p>
<p>Consensus final rating</p>	<p>Minimally Effective</p>

Micro 5.1.4	KEQ To what extent were end users aware of the key findings from the LTIM project relating to Basin Matters and Selected Areas?
<p>Evaluator 1</p>	<p>Moderately Effective</p> <p>The Selected Areas were moderately effective in making environmental water managers (end users) aware of their key findings, while the Basin Matters team were minimally effective in this aspect.</p> <p>A significant proportion of participants who responded to the survey indicated that they did not know how effectively the LTIM project communicated findings to stakeholders. Those that did provided responses indicated that they believed the Selected Areas communications processes were effective, some even assessing them as ‘very effective’ and ‘extremely effective’. The communications processes of the northern Basin Selected Areas (i.e. Gwydir and Warrego-Darling) were viewed very favourably, with a higher proportion of participants indicating they were ‘very effective’. The majority of the clients and end users who participated in the survey indicated that Basin-scale communication was not so effective.</p> <p>The interviews also revealed that there was considerably more awareness of the key findings within each of the Selected Areas than Basin-wide. But even this greater awareness of the local-scale findings was mostly confined to one or two Selected Areas, and not the common (or different) features between the Selected Areas. Certainly, there was a common view among stakeholders that the LTIM project communication processes were minimally effective, although it was generally agreed that these improved towards the end of the 5-years.</p>
<p>Evaluator 2</p>	<p>Moderately Effective</p> <p>This is best judged by interview responses from end users.</p> <p>In the interviews, there is a question “How well did the LTIM project communicate the key findings to stakeholders?”. The responses from end users are separated from the other participants. Some of the critical responses are:</p> <ul style="list-style-type: none"> • “I don't think the Selected Areas were really fully resource to do it...Did the best they could within the budget” • “the providers and the Basin Matter team were never resourced to communicate findings other than to the CEWO... [who would then] communicated it”. • “...there's a lot of room for improvement in communicating outcomes space. I mean, the Basin Matter reports are close to impenetrable. I couldn't understand a word of them sometimes” • “In terms of inputting into CEWO business, they were still too technical and long, quite frankly, they didn't consolidate learnings and advice in a way that was easily accessible.”
<p>Revision comments – Evaluator 1</p>	<p>Happy to change as had both minimally and moderate – it’s a too part question. The Selected Areas were moderately effective in making environmental water managers (end users) aware of their key findings, while the Basin Matters team were minimally effective in this aspect – overall agree on moderate</p>

Revision comments – Evaluator 2	Agree with evaluator 1
Consensus final rating	Moderately Effective

Micro 5.1.5	KEQ	To what extent were the communication and engagement activities captured in a Communications Plan?
Evaluator 1		<p>Minimally Effective</p> <p>There does not appear to be an overall LTIM communications plan. Each of the Selected Areas developed a communications plan as part of their MEPs, but as noted in KEQ5.1.3 the extent to which they implemented these plans is mixed.</p> <p>It is revealing that few of the Selected Area final reports provided comment on their communication achievements (exceptions Goulburn, Lachlan). The Edwards-Wakool Selective Area had an extensive communication and engagement plan as part of their MEP, extensive plan (stakeholder analysis, identified 4 groups that would be engaged empower, collaborate, involve, consult, inform nothing in the final project report.</p> <p>It seems the Selected Area teams were provided with a template for the final summary report and this did not include the requirement for a 5-year summary of either communication activities or adaptive management lessons.</p>
Evaluator 2		<p>Minimally Effective</p> <p>The Selected Area MEPs each had communication plans that reasonable standard. However, there does not seem to have been a communication plan for the Basin Matter teams or for the project. The lack of communication plan at the basin-scale increased the risk of poor communication of basin-scale results. Interview responses also confirm the lack of a plan.</p>
Consensus final rating		Minimally Effective

Micro 5.1.6	KEQ	How effective were the cause and effect diagrams (CED) in communicating key relationships between environmental watering and ecological outcomes?
Evaluator 1		<p>Moderately Effective</p> <p>The cause and effect diagrams (CED), or conceptual models, developed at the start of LTIM (Gawne et al., 2013) were regarded as moderately effective in communicating the relationships between environmental watering and ecological outcomes.</p>

	<p>These CEDS have been used effectively by the Selected Area teams to identify important processes and variables, and in identifying key links between flow, causal factors and expected outcomes. For example, the Goulburn Selected Area developed (and modified during the 5-year program) a simple conceptual model of the linkages between the different matters they monitored (see KEQ3.5). Further they used this conceptual model to structure their communications about the project so that all stakeholders had a complete picture of the project when particular components were being discussed.</p> <p>Most Survey responses on CEDs were that they were a useful tool in structuring the initial Selected Area monitoring programs and for communicating the links between environmental watering and ecological outcomes. Further, Survey participants perceived these CEDs as being appropriate in terms of including best-available knowledge.</p> <p>However, the responses during the interview was more mixed. There were those who thought they were not very effective at all; possible reasons expressed were that they were too 'scientific' and that because they were not developed collaboratively with the Selected Area experts, they did not fully represent the various process linkages.</p>
<p>Evaluator 2</p>	<p>Moderately Effective</p> <p>The CED drove the selection of indicators and the development of the MEPS. They were reviewed and revised as part of the process of development the requirements documents.</p> <p>Interview responses are mixed. Generally, they are regarded as being appropriate at the planning stage but not as a communication tool.</p> <ul style="list-style-type: none"> • “I think they're effective in helping this design and monitoring as scientists. I don't think there are effective communication tools beyond that.” • “...for a scientific starting basis for designing the project, I think they helped people with their thinking, even if they modified it from there. As a communications product – no” • “Like they know about [the CED document], but they rarely referred to it or used it to speak to the relationships between flow and ecology” • “To be perfectly honest, despite the fact I invested a large piece of my soul into those damn things, I don't think they had any impact at all.” • “Certainly, within the teams. Very effective. And to a few people outside, we've had a little bit of feedback about how good they were.” • “A complete waste of time” • “I'm not convinced [they were effective for communication]” • “..first design of the program, we heavily relied on cause effect diagrams. I think overall it worked well”

	<ul style="list-style-type: none"> • “...they were part of the process of learning and thinking...Not a communication tool” • “I don't think they were picked up and embraced... I think they were written once and largely forgotten.” • Some responses from another two participants: “no”, “Not”
Consensus final rating	Moderately Effective

Micro 5.1.7	KEQ	How effective were the Basin Matter synthesis workshops in communicating to key stakeholders (Basin Matter leaders, M&E Provider leaders, M&E Partners and other key individuals) the evaluation approach being undertaken? (Gawne et al. 2014b, p 23)
Evaluator 1	Minimally Effective	<p>The earlier expectation for the Basin Matter synthesis workshops was that <i>‘in the development of the Basin Matter work plans and the development of the Pilot Evaluation, the Basin Evaluation Synthesis Team will hold a Workshop with key stakeholders (Basin Matter leaders, M&E Provider leaders, M&E Partners and other key individuals) to review the Basin Evaluation process and how the evaluation will unfold. It is recognised that it is vital that there is a good understanding of the opportunities, challenges and expectations of the evaluation process. This workshop will be the first step in a communication and engagement process between the various teams involved in the LTIM evaluation’</i> (Gawne et al., 2014a, p23).</p> <p>There is little evidence that these workshops ever took place.</p>
Evaluator 2	Moderately Effective.	<p>Four of the 6 Basin Matter teams held workshops but all but 1 were much later in the project than envisaged by Gawne et al., 2014a.</p> <p>The relevant text from page 23 of (Gawne et al. 2014a) is:</p> <p>“Early in the development of the Basin Matter workplans and the development of the Pilot Evaluation, the Basin Evaluation Synthesis Team will hold a Workshop with key stakeholders (Basin Matter leaders, M&E Provider leaders, M&E Partners and other key individuals) to review the Basin Evaluation process and how the evaluation will unfold.</p> <p>It is recognised that it is vital that there is a good understanding of the opportunities, challenges and expectations of the evaluation process. This workshop will be the first step in a communication and engagement process between the various teams involved in the LTIM evaluation. “</p> <p>There seem to have been 4 Basin Matter workshops. Fish was held in 2015, Veg, Biodiversity and Ecosystem diversity in 2020. There is no mention of ‘Workshop’ in the hydrology or Stream metabolism Basin Matter reports.</p> <p>The fish one seems to have been effective. Meeting papers were produced and key issues appear to have been resolved. There was a follow up teleconference.</p>

	<p>The other three may have been effective but were held too late to have much influence on the project. There appears to have been no reporting on outcomes.</p> <p>Vegetation workshop in March 2020: This is from the acknowledgements section of Capon and James (2020): "In particular, we are grateful to Fiona Dyer and Cherie Campbell for their support in organising the collaborative <u>workshop</u> held in March 2020"</p> <p>Ecosystem diversity workshop, from Brooks (2020): "Thank you to the LTIM Hydrology team for compiling the annual inundation maps and to Bex Dunn (Geoscience Australia) for participating in our collaboration <u>workshop</u> and for providing background information and wetland inundation data from the Wetland Insight Tool."</p> <p>Biodiversity, from Hale et al. (2020): "We wish also to sincerely thank Heather McGuinness (CSIRO) for her significant contributions and insights. Her participation in the collaboration <u>workshop</u>, willingness to share her waterbird foraging groups and her thoughtful insights to the results of the waterbird analysis are greatly appreciated."</p>
Revision comments – Evaluator 1	We do have very vague evidence, but not sufficient to make a judgement on the effectiveness – what happened and how effective – insufficient evidence.
Revision comments – Evaluator 2	I agree. There is some evidence that some workshops took place but there are only reported outcomes for the 2015 fish workshop. It's difficult to form a reasonable evaluation based on such limited evidence.
Consensus final rating	Insufficient Evidence

Mid KEQ 5.2	How effectively were key findings conveyed to inform adaptive management?
Evaluator 1	<p>Moderately Effective at Selected Area scale; Minimally Effective at Basin-scale</p> <p>Key findings were moderately effectively communicated to inform adaptive environmental water management at the Selected Area scale, but minimally effectively communicated to inform adaptive environmental water management at the Basin-scale</p> <p>Both the Selected Area and Basin Matters annual evaluation reports all have a final section in which the key findings (outcomes) of that year are summarised and related to the adaptive management lessons. But it is clear from the interviews that these reports were minimally effective in communicating adaptive management findings.</p> <p>The final Selected Area summary reports (2018-19) all provide the key outcomes from the environmental water actions in their area over the 5-years of LTIM, and the implications of these findings for the future management of environmental water again in their area. These are generally well done. However, as noted in KEQ5.2.2 below, these annual reports appear to have had minimal impact on the use of knowledge of the key findings from past</p>

	<p>environmental watering actions to adaptively change future management actions; this occurred much more effectively during planning and other meetings between the Selected Area teams and the environmental water managers.</p> <p>The Basin-scale key findings and implications for future environmental water management are also summarised in the Basin Matters final reports, and there is certainly an attempt to draw together the adaptive management lessons from the seven Selected Areas, but it appears that the effectiveness of these reports, without more direct interaction with environmental water managers, was minimal.</p> <p>An opinion expressed in the interview was that while adaptive management was reasonably effective within each Selected Area, particularly during annual planning, learnings were not well captured and transferred between catchment including those not monitored. Additionally, the view was expressed that the cumulative effects of adaptive management over the longer term both locally and Basin-wide were not captured.</p>
Evaluator 2	<p>Moderately Effective</p> <p>As noted below, the key findings to inform adaptive management were moderately effective at the Selected Area scale and minimally effect at the Basin-scale. A rating of moderately effective as provided overall. Selected Area teams seem to have developed good relationships with water managers and were able to pass on relevant information related to the design of environmental watering. Informal channels were used to provide information in a timely way in contrast to annual reporting which was often too late to meet the needs of water managers. Interview and survey responses confirm effectiveness at the Selected Area scale.</p> <p>At the Basin-scale, evidence from survey responses where that key findings to inform adaptive management were conveyed in a way that was minimally effective.</p>
Consensus final rating	Moderately Effective

Micro 5.2.1	KEQ	How effectively were key findings conveyed to inform adaptive management at the Basin-scale?
Evaluator 1		<p>Minimally Effective</p> <p>The annual Basin Matters reports and the few (formal or informal) interactions between the Basin Matters teams and end users were minimally effective in informing adaptive environmental water management at the Basin-scale.</p> <p>Basin-scale adaptive management findings are reported annually in each of the Basin Matters and Synthesis reports. However, there is little evidence that these were effective in changing environmental watering management practice. In fact, the interviews suggest that these reports were rarely read, with perhaps the exception of the Synthesis reports.</p>
Evaluator 2		Minimally Effective

	<p>'Adaptive management' is discussed in each of the basin synthesis reports and in each of the Basin Matter reports.</p> <p>The survey included a question (Q27): "What level of impact has the LTIM project had on the adaptive management of environmental water".</p> <p>The response of end users, at the Basin-scale, was:</p> <ul style="list-style-type: none"> • No impact 6% • A little impact 29% • Somewhat impactful 17% • Very impactful 9% • Don't know 40% <p>So, 35% of respondents think there was no or little impact and 40% don't know. If we exclude the "Don't know" responses then 58% responded no or little impact.</p> <p>There are similar outcomes from the interviews:</p> <ul style="list-style-type: none"> • "[adaptive management] less-so at the Basin-scale". "LTIM didn't achieve that [AM at the Basin-scale]". • [Basin-scale teams] came up with these sort of very general adaptive management lessons for particular themes like fish...So that information was not used much by the CEWO...largely it was limited at the Basin-scale" <p>"And I think that is one of the deficiencies - that the LTIM program hasn't achieved adaptive management at the Basin-scale to the extent to which it was initially envisaged."</p>
<p>Consensus final rating</p>	<p>Minimally Effective</p>

Micro 5.2.2	KEQ How effectively were key findings conveyed to inform adaptive management at the Selected Area scale?
<p>Evaluator 1</p>	<p>Moderately Effective</p> <p>The interactions between Selected Areas and end users were moderately effective in informing adaptive environmental water management at the local-scale.</p> <p>Adaptive management findings were communicated by the Selected Areas to end users, particularly the CEWO Delivery Teams and other environmental water managers, in two ways:</p>

	<ul style="list-style-type: none"> • Through the annual reports, which had a section on adaptive management findings- these were a useful record of what had been learned from the previous year’s environmental watering, but were generally too late to inform decisions regarding the current year’s environmental watering actions • Through other less formal but more immediate forms of interactions (workshops, phone calls) that allowed more rapid (but perhaps less refined) knowledge to be used in adapting environmental watering actions. <p>However, it is clear from the stakeholder interviews that it was the other interactions between the Selected Area teams and environmental water managers that were far more effective than interactions with Basin Matters team members (KEQ5.2.1) in changing environmental watering management practice. For example, the annual planning meetings between the Selected Area researchers and the CEWO Water Delivery teams were very effective in ensuring that new knowledge was fed into the decision-making processes well before the annual reports were available.</p>
<p>Evaluator 2</p>	<p>Moderately Effective</p> <p>Cross-reference: KEQ0521</p> <p>Selected Area reports generally provided useful information about adaptive management. Examples include:</p> <p>Warrego-Darling: Key findings and management implications are provided in annual reports.</p> <p>Lachlan: Adaptive management lessons are clearly articulated in annual reports. The final summary report has a section on: “Implication for future management of Environmental Water”.</p> <p>Lower Murray: There is a section in the final annual SA report on “Implications of future management of environmental water”. However, these findings lack the required specificity to use for adaptive management.</p> <p>The end user responses to the survey question (Q27) “What level of impact has the LTIM project had on the adaptive management of environmental water” show that other than the large proportion that responded, “don’t know”, all thought there had been some impact. This included for the Lower Murray.</p> <p>There was strong support in interviews for effectiveness of LTIM informing adaptive management at the Selected Area scale:</p> <ul style="list-style-type: none"> • “[LTIM’s] strength was...it directly informed adaptive management at each of the [selected] areas.” • “...informing adaptive management...we did well” • “Starting at the Selected Area scale, I think [adaptive management has] been the biggest success of the program” • “At the Selected Area scale, that [AM] was a major achievement” • “At the Selected Area scale [the impact of LTIM was] – Huge”

	A theme in the interview responses was the timing of reports that fed into decisions about environmental water deliveries. Water managers commented that reporting on the outcomes of one watering were generally too late to provide useful input to the next watering.
Consensus final rating	Moderately Effective

EFFECTIVENESS – DEMONSTRATED OUTCOMES

- 1 high-level KEQ
- 6 mid-level KEQ
- 4 micro KEQ

High KEQ 6	How effectively has the LTIM project demonstrated outcomes?
Evaluator 1	<p>Moderately Effective</p> <p>The LTIM project was moderately effective at demonstrating environmental outcomes.</p> <p>LTIM’s demonstration of the contribution(s) of CEW to achieving the Basin Plan objectives was moderately effective, although most of the findings are quite qualitative. In the longer term, there needs to be increased development of predictive statistical models to improve the capacity to provide more quantitative information on the contribution(s) of CEW to ecological outcomes at both local and Basin-scales</p> <p>It was common practice in each Selected Area for the expected outcomes from environmental watering actions in a particular year to be agreed and then for the Selected Area team to monitor the observed outcomes and then to assess what this meant ecologically. Mostly, rather broad statements of were made regarding the outcomes (e.g. ‘the condition of wetland vegetation was maintained’), but some Selected Areas went further and provided quantitative estimates of the relative importance of CEW to the outcome. Some counterfactual assessments (i.e. outcome with and without environmental water) were undertaken by Selected Areas, these mostly focused on wetlands.</p> <p>Attempts to evaluate the potential ecological outcomes in non-monitored areas receiving CEW were minimally effective. It was only the Basin Matters team that attempted to address non-monitored areas (see also KEQ4.2).</p> <p>Currently, the environmental watering decisions are very largely based on the ecological knowledge held by the Selected Area researchers. This expert knowledge base needs to be supported by the development of predictive models to provide more quantitative information on possible environmental watering actions and the ecological outcomes.</p>
Evaluator 2	<p>Moderately Effective</p> <p>The demonstration of outcomes has been moderately effective.</p>

	This evaluation is based on the aggregation across all the meso and micro KEQs below and related KEQs (2.2 and 3). LTIM was moderately effective at demonstrating the contribution of CEW to each of the Basin Matters. At the Selected Area scale, the demonstration was effective where there was data but the inference to unmonitored areas was an issue. Aggregation to demonstrate Basin-scale outcomes was not well done for many themes. Interview and survey responses were also considered in making this evaluation with details summarised in the KEQs below.
Consensus final rating	Moderately Effective

Mid KEQ 6.1	How effectively has the LTIM project demonstrated the contribution of CEW to achieving Basin Plan objectives (note this includes Chapter 8 and 9 objectives)?
Evaluator 1	<p>Moderately Effective</p> <p>The LTIM project has been moderately effective at demonstrating the contribution of CEW to achieving the Basin Plan objectives. However, most of the findings are quite qualitative, and there needs to be increased development of predictive statistical models to improve the capacity to provide more quantitative information on the contribution(s) of CEW to ecological outcomes at both local and Basin-scales.</p> <p>The Basin Plan objectives relating to water-dependent ecosystems were listed under Biodiversity (S8.05), Ecosystem Processes (S8.06), Resilience (S8.07), and Water Quality (9.04).</p> <p>LTIM was moderately effective at demonstrating the contribution of CEW to ecosystem diversity at the Basin-scale, and species diversity (vegetation, macroinvertebrates, fish, waterbirds and other vertebrates) at the Selected Area and Basin-scales (KEQ2.2 and KEQ3). There was however, limited quantitative evaluation, although considerable new knowledge established regarding the relationships between e-flows and key biodiversity outcomes.</p> <p>LTIM project was moderately effective at demonstrating the contribution of CEW to ecosystem function at the Basin-scale, largely through hydrological connectedness, metabolism (primary production and respiration), biodiversity (maintaining populations, e.g. cues for migration, germination and breeding) and ecosystem diversity (supporting habitat diversity) (KEQ2.2.2)</p> <p>LTIM project was minimally effective at demonstrating the contribution of CEW to resilience at the Basin-scale (LEQ2.2.3).</p> <p>The LTIM project has effectively demonstrated the contributions of CEW (and other environmental water) in achieving the salinity outcomes in the Lower Lakes and Coorong. However, the project was minimally to moderately effective in demonstrating the contributions of CEW (and other environmental water) in achieving water quality outcomes in either the Selected Areas or at the Basin-scale. Two issues made this objective difficult to demonstrate; first, monitoring of water quality was far too infrequent; and second the water quality objectives for water-dependent ecosystems in the Basin Plan (S9.04) were very high level, and sufficiently quantified and measurable water quality targets were not developed in the Basin-wide Environmental Watering Strategy (MDBA, 2019).</p>
Evaluator 2	Moderately Effective

	<p>LTIM was moderately effective at demonstrating the contribution of CEW to basin plan objectives. This rating is based on the aggregation of the micro KEQs below. As noted in KEQ 6.1.1, LTIM has been moderately effective in demonstrating the contribution of CEW to each of the Basin Matters and in each of the Selected Areas.</p> <p>Other relevant KEQs: KEQ 2.2.2 and 2.2.3.</p> <p>Survey question 12 addresses this issue. The Positive responses dominate, i.e. the combination of “Somewhat effectively, Very effectively and Extremely effectively”.</p>												
<p>Evaluator 3</p>	<p>Moderately Effective</p> <p><i>I’m not assessing whether the contribution of CEW has been effective, just whether the LTIM has been effective in demonstrating the contribution. The finer scale objective in 8.05, 8.06 and 8.07 are incorporated into the overall objectives 8.04.</i></p> <table border="1"> <thead> <tr> <th><i>Overall environmental Objectives (Ch. 8)</i></th> <th>Evaluation</th> <th><i>Comment</i></th> </tr> </thead> <tbody> <tr> <td><i>to protect and restore water-dependent ecosystems of the Murray Darling Basin</i></td> <td>Effective</td> <td><i>This is well documented by the hydrological monitoring and ecosystem diversity matters. These are both at the Basin-scale and have proven modelling methodologies.</i></td> </tr> <tr> <td><i>to protect and restore the ecosystem functions of water-dependent ecosystems</i></td> <td>Moderately Effective</td> <td><i>It’s been a good attempt, but the responses are too variable/unknown and understanding these this will requires many more years. All current results are limited to Selected Areas.</i></td> </tr> <tr> <td><i>to ensure that water-dependent ecosystems are resilient to climate change and other risks and threats</i></td> <td>Moderately Effective</td> <td><i>The responses AND the pressures (CC and other threats) are extremely variable, generally unknown or difficult to predict and understanding will requires many many many more years. All current results are limited to Selected Areas and contemporary conditions (E.g. 4/5 low flow years in current period). This is actually a <u>good performance</u> (even if not effective) for such a short monitoring period.</i></td> </tr> </tbody> </table>	<i>Overall environmental Objectives (Ch. 8)</i>	Evaluation	<i>Comment</i>	<i>to protect and restore water-dependent ecosystems of the Murray Darling Basin</i>	Effective	<i>This is well documented by the hydrological monitoring and ecosystem diversity matters. These are both at the Basin-scale and have proven modelling methodologies.</i>	<i>to protect and restore the ecosystem functions of water-dependent ecosystems</i>	Moderately Effective	<i>It’s been a good attempt, but the responses are too variable/unknown and understanding these this will requires many more years. All current results are limited to Selected Areas.</i>	<i>to ensure that water-dependent ecosystems are resilient to climate change and other risks and threats</i>	Moderately Effective	<i>The responses AND the pressures (CC and other threats) are extremely variable, generally unknown or difficult to predict and understanding will requires many many many more years. All current results are limited to Selected Areas and contemporary conditions (E.g. 4/5 low flow years in current period). This is actually a <u>good performance</u> (even if not effective) for such a short monitoring period.</i>
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Consensus final rating	Moderately Effective
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Micro 6.1.1	KEQ	How effectively has the LTIM project demonstrated the contribution of CEW to each of the Basin Matters?
Evaluator 1		<p>Moderately Effective</p> <p>Evaluation of the contribution of CEW (and other environmental water) at the Basin-scale was highly dependent on the hydrology Basin Matters work, which considered the whole Basin, including both monitored (Selected Areas) and non-monitored areas that received CEW during the 5-year LTIM project. The ecosystem diversity evaluation also considered the whole Basin. The other four Basin Matters attempted to evaluate the contribution of CEW (and other environmental water) to their particular ecological indicator(s). These evaluations depended heavily on information from the Selected Areas, with these latter ranging from quantitative (e.g. statistical models) to qualitative evaluations. Certainly, over the 5-year period of LTIM these evaluations of the contribution of CEW (and other environmental water) on each of the Basin Matters (biodiversity, fish, vegetation, metabolism and water quality) improved and became more quantitative.</p> <p>However, the situation regarding demonstration of the contribution of CEW to each of the Basin Matters in non-monitored areas was less effective and at best indicative only. The biodiversity Basin Matters evaluation was able to use non-LTIM monitoring data to assess the contribution of environmental water on waterbirds and threatened species in Ramsar wetlands (Banrock Station, Barmah Forest, Macquarie Marshes, Hattah-Kulkyne NP), and the fish, vegetation and metabolism Basin Matters teams were able to use knowledge gained from the Selected Areas to make inferences regarding the effect of environmental water in other non-monitored areas that received CEW (see KEQ4.2).</p>
Evaluator 2		<p>Moderately Effective</p> <p>I'm making a distinction between the effectiveness of the demonstration and the effectiveness of CEW. In many cases, it was effectively demonstrated that CEW didn't achieve all that much.</p> <p>The main evidence are the final Basin Matter reports that include a cumulative basin-scale evaluation 2014-2019.</p> <p>Fish (King et al., 2020): Effective</p> <p>3.1.3 Effects of Commonwealth environmental water on fish</p> <ul style="list-style-type: none"> To evaluate the effects of CEW on populations of the seven focal species, statistical models were used to predict fish responses to flow regimes that included (with CEW) and excluded (without CEW) environmental flows. The comparison between these scenarios provides a counterfactual comparison for inferring the effects of CEW on fish populations. Across the Selected Areas, the use of CEW resulted in only a small increase in total abundance of one species; Australian smelt; and decline in total abundance of carp gudgeon and common carp. The response to CEW for these species also

varied considerably across Selected Areas. Increased abundances of Australian smelt were related to an increase in the proportion of flows in the freshes band due to the addition of CEW in all water years.

- Counterfactual modelling suggests common carp populations would have been larger without the delivery of CEW. This was due to an increase in the proportion of fresh flows with the use of CEW, particularly in the drier years (i.e. not the 2016–17 water year).
- Across the Selected Areas, the use of CEW during the LTIM program resulted in an increase in larval abundance of only bony herring. Counterfactual modelling also demonstrates that the abundance of carp gudgeon larvae would have been greater without the use of CEW. There was no significant predicted response in spawning probability for any species with the use of CEW. The limited range of flow conditions experienced during LTIM project and the range of CEW flow delivery types that occurred during LTIM is a likely cause for the limited evidence of a spawning response to CEW at the Basin-scale. Analysis at the Selected Area scale and with more biologically relevant hydrological periods for spawning are necessary areas for further investigation.
- The use of CEW at the Basin-scale increased the abundance of bony herring and carp gudgeon recruits relative to the counterfactual without CEW scenario, primarily due to the greater proportion of non-baseflow days. This effect was relatively small for carp gudgeon, but much larger (3-fold increase) for bony herring.

Biodiversity (Hale et al., 2020): Minimally effective

The demonstration of CEW to biodiversity is generally not effective because there is no counter-factual. There is no indication of what would have happened if there was no CEW.

“The biodiversity Basin Matter has largely been a consolidation of monitoring outcomes across the Basin from a variety of sources to develop a list of species and communities that potentially benefited from Commonwealth environmental water. The summary nature of the evaluation has not lent itself to providing adaptive management messages”

There is evidence that CEW benefited for two species: “There are, however, multiple lines of evidence to support the assertion that Commonwealth environmental water has benefitted both the Australasian bittern and southern bell frog”.

There is also evidence that CEW has contributed to maintaining the ecological character of the Banrock Station, Barmah, Gunbower, Hattah-Kulkuyne, Macquarie Marshes Ramsar site.

Vegetation (Capon and James, 2020): Minimally effective

Similar to biodiversity, the counterfactual is lacking. It is interesting to note that the Number of native plant species declined over the life of the project.

	<p>There is some evidence in the Murrumbidgee: "...suggesting that Commonwealth environmental water played a role in maintaining wetland plant communities".</p> <p>Ecosystem diversity (Brooks, 2020): Minimally effective</p> <p>The report focusses on the ecosystem types where there was CEW watering. No discussion of what would have happened to ecosystem diversity in the absence of CEW.</p> <p>Stream metabolism (Grace, 2020): Effective</p> <p>Section 3.3.7 quantifies how much additional organic carbon is being produced in the water flowing past the monitoring point each day by GPP or consumed by ER from the addition of CEW over the five-year duration of the LTIM Project.</p> <p>An approximate total contribution of CEW to TOC load, over the 5-year LTIM project, can be estimated by combining information from Table 10 (% Contribution to TOC load from CEW for each flow category), with information in Annex B (the number days in each flow category). This assumes that CEW made a similar contribution to each flow category in each year.</p> <p>Lachlan at Wheabah 6.7%, Lower Murray at Loch 6 19.2%, Darling at Louth 6.4%.</p> <p>Hydrology (Stewardson and Guarino, 2020a): Effective</p> <p>Thorough analysis of flow with and without CEW.</p> <p>One interview response is instructive:</p> <ul style="list-style-type: none"> • "But I know for lots of the Selected Area reports, not all of them, it was very difficult to say what did Commonwealth Environmental Water do? That question wasn't answered. There was a lot of stuff in there about this is what happened to fish, this is what happened to frogs, this is what happened to X, but the question was, what was the contribution of environmental water. And that was quite hard to tease out of some reports. But whether that was because of the way that it was reported or because the data wasn't collected in a way that answered the question, I don't know."
<p>Evaluator 3</p>	<p>Overall, Moderately Effective</p> <p>The major limitation is the scale mismatch of the monitoring and the reporting as a result of using Selected Areas. This really applies more so to vegetation, fish, biodiversity, and stream metabolism/water quality. In reality, if you were to design a sound program for each of those matters independently of each other, there is zero chance that you would have come up with the current design. These matters were forced to compromise in order to focus on Selected Areas rather than the overall basin.</p> <p>Biodiversity - Minimally effective.</p> <p>Biodiversity was limited to just a few species in few Selected Areas. So relevance to the basin biodiversity is poor. Almost all of the results are based on positive reinforcement with very little use of 'intervention monitoring' per se. That is, the separation of the contribution of CEW from on CEW is</p>

usually not distinguishable. The unmonitored areas that were included suffered the same issues and often had missing information on CEW anyway. The reports give the impression this is an 'add-on' Basin Matter that was unplanned and uses ad-hoc data, even though it was included in the foundation reports.

- Hale J, Bond N, Brooks S (2020) Murray–Darling Basin Long Term Intervention Monitoring Project — Biodiversity Report. Report prepared for the Department of the Environment and Energy, Commonwealth Environmental Water Office by La Trobe University, Centre for Freshwater Ecosystems, CFE Publication 252 May 2020 76pp

Ecosystem diversity – **Moderately effective.**

This one is the only matter that actually applies at the Basin-scale instead of just Selected Areas. It is clearly a true census and the standout best performer as there is no sampling error, only measurement error from GIS layers. However, the reports are based upon confirmatory analyses. That is, only looking for positive results from watered areas. There is no attempt to report on unwatered areas or non-responses in watered areas.

- Brooks S., (2020) Murray–Darling Basin Long Term Intervention Monitoring Project — 2018–19 Basin-scale evaluation of Commonwealth environmental water – Ecosystem Diversity. Report prepared for the Department of Agriculture, Water and the Environment, Commonwealth Environmental Water Office by La Trobe University, Centre for Freshwater Ecosystems, CFE Publication 248 May 2020 54p.

Vegetation - **Moderately effective.**

This one also uses positive reinforcement rather than intervention monitoring. It does make anecdotal comparisons between CEW and non CEW sites, without formal testing. Results are generally only relevant to the four Selected Areas and not the basin as a whole. There was investigation into predictive modelling but it mainly served to demonstrate the lack of available data. There was some value from the anecdotal comparison of short-term interventions.

- Capon, S.J. and James, C.S., (2020) Murray-Darling Basin Long Term Intervention Monitoring Project — Vegetation Diversity Report. Report prepared for the Department of the Agriculture, Environment and Water, Commonwealth Environmental Water Office by La Trobe University, Centre for Freshwater Ecosystems, CFE Publication 249 May 2020 129pp.

Fish – **Moderately effective.**

Regardless of the evaluation, the authors have actually done quite well considering the limitations of the data. In general, the results are based upon positive reinforcement rather than intervention monitoring. The fish matter is a very difficult one because of the dynamic nature of the response variables (e.g. fish move a lot) and separating the influence of CEW is not easy. In other words, the IM in LTIM infers a true experiment, but there is no control over the starting condition of the response variables (fish species, numbers, spawning etc) and little scope to control the independent variables (flow regime). In a fish context, the LTIM is a pseudo-experiment, giving little option except to look for positive reinforcement of concepts when reporting. I found the counterfactual modelling to be 'clutching at straws', trying to find anything to give a positive feel to the reports.

	<p>Further hindrance is from the few data points possible and a tendency for similar (flow) conditions spatially (across Selected Areas) within each year of sampling since the program started. The fairly constant low flow periods made comparison between CEW and non CEW difficult. Until there are many more years of data, and hopefully more spatial coverage of data, the fish Basin Matter should be considered as a long-term project. The first 5 years could be treated as a pilot study, or hypothesis generating period.</p> <ul style="list-style-type: none"> King A.J., McPhan L., Bond N., Thurgate, N. (2020) Murray–Darling Basin Long Term Intervention Monitoring Project — 2018–19 Basin-scale evaluation of Commonwealth environmental water – Fish Report. Report prepared for the Department of Agriculture, Water and the Environment, Commonwealth Environmental Water Office by La Trobe University, Centre for Freshwater Ecosystems, CFE Publication 250, May 2020, 82pp <p>Hydrology - Effective.</p> <p>This one is a census and the only real errors are in the modelling of natural flows and extrapolation between gauges.</p> <ul style="list-style-type: none"> Stewardson MJ, Guarino F (2020) 2018–19 Basin-scale evaluation of Commonwealth environmental water — Hydrology. Final Report prepared for the Commonwealth Environmental Water Office by La Trobe University, Publication 246/2020, 58pp, plus annex. <p>Stream metabolism and Water quality - Moderately effective.</p> <p>There is a lot of detail provided and a lot of data collected, but at the end of the day, the report is mostly effective in highlighting spatial and temporal variation in responses, explaining some of the variation by flow. However, not isolating flow from CEW well. The report uses ‘intervention analysis’, which in lay-terms is time series to compare responses before and after interventions (e.g. CEW) without a reference or control comparison. The results may be confounded by time as highlighted by the documentation of the seasonal variations. Nevertheless, the weight of repeated observations, multiple lines of evidence, lends itself well to this matter.</p> <ul style="list-style-type: none"> Grace M (2020) 2018–19 Basin-scale evaluation of Commonwealth environmental water — Stream Metabolism and Water Quality. Final Report prepared for the Commonwealth Environmental Water Office by La Trobe University, Publication 247/2020, May, 1 pp plus annexes
Consensus final rating	Moderately Effective

Micro 6.1.2	KEQ How effectively has the LTIM project demonstrated the contribution of CEW to achieving outcomes in Selected Areas?
Evaluator 1	Moderately Effective

	<p>All Selected Areas were required to demonstrate the contribution of CEW to achieving ecological outcomes in their area. All Selected Areas certainly did attempt to do this. However, the results varied from relatively good quantitative assessments (developing statistical models) to qualitative assessment, which essentially reduced to assessments that because CEW was delivered and because a particular ecological indicator improved therefore CEW was beneficial.</p> <p>There is considerable scope for some of the Selected Areas to increase use of statistical models to better quantify the contributions of CEW (and other environmental water) to achieving particular ecological outcomes. Perhaps a future LTIM should consider the engagement of an expert ecological modelled who could assist all Selected Area and Basin Matters teams with their evaluations. The development of quantitative models ‘that predict the outcomes of CEW based on the characteristics of the event and the condition of a component within the system’ was recommended by Gawne et al. (2014d).</p>
Evaluator 2	<p>Effective</p> <p>The demonstration was effective but the effect was small. So there was an effective demonstration that CEW did not achieve all that much.</p> <p>Warrego-Darling: Effective</p> <p>Summarised in Table 3-2 of Southwell et al. (2019a). Southwell provides an upbeat assessment of CEW, compared to the pessimistic assessment in the Lachlan. However, this seems at odds with the statement that there is little ability of CEW to influence outcomes since it is such a small component of the flow.</p> <p>Lachlan: Demonstration was effective. Limited contribution of CEW.</p> <ul style="list-style-type: none"> • Adult fish community remains in very poor condition. • Objectives for vegetation where not clear so difficult to tell if they have been met. • Small number of redgum seedlings generated but their survival depends on land use as they are removed by grazing • Greatest number of amphibious species occurs at one site which has received regular CEW. <p>There was a spawning response by flatheaded gudgeon.</p> <p>Lower Murray: Demonstration was effective. Few responses to CEW. Little impact on fish. No monitoring of vegetation. Some minor improvement in water quality</p>
Revision comments – Evaluator 1	
Revision comments – Evaluator 2	<p>As evaluator 1 points out, and as has been discussed in other KEQs (KEQ 3), there were issues with the evaluation so it would be fair to rate the demonstration as moderately effective.</p>

Consensus final rating	Moderately Effective
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Mid KEQ 6.2	How effectively has the LTIM project demonstrated it outcomes where the expected outcome is monitored and provides information on the condition of the system with the watering action?
Evaluator 1	<p>Moderately Effective</p> <p>In general, the LTIM project was moderately effective in demonstrating the actual outcomes of environmental watering actions compared with the expected outcome.</p> <p>It was common practice for the expected outcomes from each particular environmental watering action in each Selected Area to be documented by the water managers. These expected outcomes were informed by discussions between the Selected Area team and the CEWO Delivery Team most in annual planning meetings. These processes are not well documented.</p> <p>In their final reports, all Selected Areas provided a useful assessment of the key outcomes of environmental watering actions over the 5-year program, summarizing the links between the expected outcomes, the observed outcomes, and what this meant ecologically*. Some Selected Areas went further than just making broad statements of outcomes, such as ‘the condition of wetland vegetation was maintained’, and provided quantitative estimates of the relative importance of CEW to the outcome (e.g. in the Goulburn is was estimated that CEW produced around 25% of the organic C created by GPP over the 5-year period).</p> <p>* Murrumbidgee Selected Area final report did not follow this approach, and for this reason it was difficult to equate the expected outcomes with observed outcomes and what does this mean ecologically for this system.</p>
Evaluator 2	<p>Moderately Effective</p> <p>Fish: (King et al., 2020) Effective as noted in KEQ 611</p> <p style="padding-left: 40px;">To evaluate the effects of CEW on populations of the seven focal species, statistical models were used to predict fish responses to flow regimes that included (with CEW) and excluded (without CEW) environmental flows. The comparison between these scenarios provides a counterfactual comparison for inferring he effects of CEW on fish populations.</p> <p style="padding-left: 40px;">However, there are issues of sufficient data to drive the model structure: “...indicating that the available data at the time of analysis was depauperate for this type of structural component and greater replication is needed.” (King et al., 2020)</p> <p>Stream metabolism Effective as noted in KEQ 611</p> <p>Hydrology: Effective</p> <p>Vegetation: Effective</p> <p>Ecosystem type: Minimally effective (lack of counterfactual)</p>

	Biodiversity: Minimally effective (lack of counter fractural)
Consensus final rating	Moderately Effective

Mid KEQ 6.3	For areas where the expected outcome is not monitored, how effectively have multiple lines of evidence, including predictions based on conceptual or quantitative models, been used to demonstrate potential outcomes?
Evaluator 1	<p>Minimally Effective</p> <p>The LTIM project was minimally effective in demonstrating the potential ecological outcomes in non-monitored areas receiving CEW.</p> <p>It was only the Basin Matters team that attempted to address non-monitored areas (see KEQ4.2). They used of multiple lines of evidence to provide information on the potential ecological outcomes in these areas of the Basin, including from the Selected Areas and from other sources such as TLM and the MDBA. These assessments were however very qualitative. We were not able to assess just how much data/information from state agencies was available and used in these assessments.</p>
Evaluator 2	<p>Minimally Effective</p> <p>There is limited information that addresses this issue. Much of the assessment is qualitative which falls substantially short of the hopes of the Basin Matters foundation documents.</p> <p>Biodiversity:</p> <p style="padding-left: 40px;">No attempt to develop models. No extrapolation to unmonitored areas. Recognition that unmonitored areas may be important (Hale et al., 2020).</p> <p>Ecosystem diversity:</p> <p style="padding-left: 40px;">“The Commonwealth does not yet have 1-year or 5-year expected outcomes for ecosystem diversity (Table 14) and water is not currently delivered with explicit understanding of the contribution of Commonwealth environmental watering to ecosystem diversity at the Basin-scale”</p> <p>Fish: Effective</p> <p style="padding-left: 40px;">Models were developed that can be applied “across the Selected Areas”. There is nothing about using these outside the Selected Areas.</p> <p style="padding-left: 40px;">“To evaluate the effects of CEW on populations of the seven focal species, statistical models were used to predict fish responses to flow regimes that included (with CEW) and excluded (without CEW) environmental flows. The comparison between these scenarios provides a counterfactual comparison for inferring he effects of CEW on fish populations.” (King et al. 2020).</p> <p>Hydrology: Effective</p>

	<p>Hydrology uses gauged data throughout the basin the report on all catchments.</p> <p>Water quality: Minimally effective</p> <p>In the foundation document for stream metabolism and water quality (Grace, 2015) there is a comment: “There are no plans to further develop the capacity to predict water quality responses to flow, as the variation in response through time and across the Basin means that levels of uncertainty around the predictions would limit their value.”</p> <p>The 2018 version of the foundation document is explicit in scaling back water quality (Grace, 2018): “The continuous water quality monitoring integrated into the LTIM project was restricted to temperature and dissolved oxygen. Other water quality parameters including pH, turbidity and electrical conductivity (salinity – but see below) were typically measured during visits to sites hence that data is often single measurements at intervals of a month or more. Consequently, examining the effect of watering actions on those water quality parameters is unlikely to prove worthwhile. For this reason, it is considered outside the scope of this project. Hence, the question relating to pH has been removed and the consideration of salinity with respect the Murray-Darling Plan is restricted to the specific area targeted by that Plan – the Lower Murray River – where there is continuous monitoring in place that is reported on annually.”</p> <p>Stream metabolism: Effective</p> <p>There are models that can estimate DOC produced for flow in each flow category for each Selected Area (Section 3.3.7 Grace, 2020). If the contribution of CEW for each flow category is known then the DOC attributable to CEW can be estimated. There is an individual relationship for each SA based on measurements at two sites. There will be uncertainty, but it is possible to estimate DOC in areas not monitored in each SA. It would probably be reasonable to extrapolate outside the SA to some extent.</p> <p>It would also be necessary to extrapolate this approach when considering flows outside the range used to establish the models:</p> <p>“It is still expected that watering actions that reconnect backwaters, flood runners and the floodplain should see a major increase in both primary production and ER (beyond in-channel increases) <u>but the types of watering actions delivered over the five years did not provide the opportunity to confirm this expectation.</u>” Grace (2020) emphasis added.</p> <p>Vegetation: Moderately effective</p> <p>Qualitative assessment of likely impacts at the Basin-scale.</p>
Consensus final rating	Minimally Effective

Mid KEQ 6.4	How effectively has the LTIM project compared and contrasted the expected, observed and no flow predicted outcomes to inform an evaluation of the overall outcome of the watering action?
Evaluator 1	Moderately Effective

	<p>The LTIM project was moderately effective at comparing expected and observed outcomes of CEW management.</p> <p>The Selected Areas compared expected and observed outcomes for each CEW action. Some counterfactual assessments (i.e. outcome with and without environmental water) were undertaken by Selected Areas, mostly focused on wetland areas. The conclusions derived from these assessments were quite general since the conditions existing when the environmental watering occurred were often quite different to those existing for the no-flow situation.</p> <p>The Basin Matters hydrology team provided information on daily flows with and without CEW (and other environmental water) for each of the Basin river valleys. This information was also available for floodplain inundation, although there are questions about how good the inundation data was.</p>
Evaluator 2	<p>Minimally Effective.</p> <p>Biodiversity: minimally effective</p> <p style="padding-left: 40px;">No without CEW counterfactual</p> <p>Ecosystem diversity: minimally effective</p> <p style="padding-left: 40px;">No without CEW counterfactual</p> <p>Fish: Effective</p> <p style="padding-left: 40px;">Statistical models were developed that would allow consideration of these cases observed and no CEW across Selected Areas</p> <p>Hydrology: Effective</p> <p>Stream metabolism and water quality:</p> <p style="padding-left: 40px;">Statistical models were developed that would allow consideration of these cases observed and no CEW across Selected Areas.</p> <p>Vegetation: Not effective</p> <p style="padding-left: 40px;">No without CEW counterfactual.</p>
Revision comments – Evaluator 1	<p>Quite happy to go to minimal based on Evaluator 2 justification. Was done in hydrology and fish – but happy to go to minimal</p>
Revision comments – Evaluator 2	<p>Agree – vegetation was more about this is what happened than what was the impact.</p>
Consensus final rating	<p>Minimally Effective</p>

Mid KEQ 6.5	To what extent have critical success factors been identified to improve future management of CEW?
Evaluator 1	<p>Moderately Effective</p> <p>All Selected Area teams have been moderately effective at identifying factors that could improved future environmental water management in their area, and have captured these factors in their final reports under the heading of ‘recommendations for future management of environmental water’. One example, is the identification of issues associated with an increase in the Inter Valley Transfers (IVT) in the Goulburn Selected Area. Additionally, the Basin Matters teams have used this Selected Area information, and other information where available, to provide an integration of information relevant Basin-wide.</p>
Evaluator 2	<p>Moderately Effective</p> <p>I’ve taken this as relating to adaptive management. See KEQ 1.8, 5.2, 9.2, 12.2.2</p>
Consensus final rating	<p>Moderately Effective</p>

Mid KEQ 6.6	How effectively the LTIM project improved capacity to predict outcomes of environmental flow allocations and their management over 1–5 years?
Evaluator 1	<p>Moderately (minimally) Effective</p> <p>Assessment of the effectiveness of the LTIM project over its 5-years in improving the capacity to predict ecological outcomes from environmental water and how this has influenced environmental water management is a key component in justifying this project.</p> <p>Our assessment is that over the 5-year LTIM project there have been major increases in the understanding of the ecological benefits from environmental water and improvements in its management. These improvements in understanding are particularly apparent at the local-Selected Area scale and less so at the regional or Basin-scale. As one stakeholder noted (survey), the capacity to summarise improvements in understanding and management has to be put into the context that the 5-years of LTIM (2014-2019) has been most very dry with a short wet period in 2016.</p> <p>Given the importance of demonstrating the importance of LTIM in improving environmental water management, it is surprising that a consolidated report has not been produced. The final (2018-19) Basin Matters Synthesis report did provide some assessment of the effectiveness of the LTIM project regarding improved environmental water management over its 5-years, but this fell short of what was needed.</p> <p>The LTIM project has been moderately effective in improving the capacity of both researchers and environmental water managers to predict the outcomes of environmental flow allocations and their management at Selected Areas over the 5-years of the project. This has largely occurred largely through the close collaboration of the researchers and environmental water managers associated with each Selected Area, which has allowed the testing of predicted expected outcome(s) resulting from a particular e-flow regime (baseflow, fresh, bank full) by monitoring particular ecological indicators. The improved ecological knowledge gained these large-scale experiments has then been used subsequently to refine future environmental water management.</p>

	<p>Currently, environmental watering decisions are very largely based on the ecological knowledge held by the Selected Area researchers. There is a need to support this expert knowledge-base with the development of predictive models to provide more quantitative information on possible environmental watering actions and the ecological outcomes. This has started to happen, with some Selected Areas (e.g. Goulburn) using statistical models to support environmental watering decisions. Additionally, preliminary quantitative models have been developed for fish, vegetation, and metabolism, and these will be of use in the future for Basin-scale decision-making.</p>
<p>Evaluator 2</p>	<p>Moderately Effective</p> <p>It is reasonable to assume that predictive ability has increased as teams learn and become more efficient.</p> <p>However, most of the predictive modelling approaches, promised in the Basin Matters foundation documents, were late in being delivered or were not delivered by the end of the project.</p> <p>Ecosystem diversity: Moderately effective</p> <p style="padding-left: 40px;">The ANAE classification framework was refined which would lead to improved outcomes.</p> <p>Fish: Effective</p> <p style="padding-left: 40px;">Predictive models have been developed but were largely delayed to the final year of the project</p> <p>Hydrology:</p> <p style="padding-left: 40px;">Hydrologic assessments require:</p> <ul style="list-style-type: none"> • Compilation of operational data to characterise environmental water delivery. • Modelling by MDBA • Interpretation by MDFRC <p style="padding-left: 40px;">Presumably this has become more streamlined during the project.</p> <p>Stream metabolism and water quality:</p> <p style="padding-left: 40px;">Stream metabolism can be predicted in 6 of the Selected Areas.</p> <p style="padding-left: 40px;">No predictive ability for water quality</p> <p>Vegetation:</p> <p style="padding-left: 40px;">The veg work is more about monitoring what happened rather than predicting what will happen. So, there is only a qualitative predictive capacity with some predictive modelling in the final year report.</p> <p>Survey (Question 18):</p>

	<p>At the Basin-scale, there was a small amount of support. With, “Somewhat effectively” + “Very effectively” (35%) ahead of “Not so effectively” (27%). Amongst end users, support declines. Support is stronger at Basin Matter and Selected Area scales.</p> <p>In the comments, there are three related themes.</p> <ul style="list-style-type: none"> • More time is needed to understand responses in a variable system • Some flow types (overbank and winter flows) were not effectively monitored • Predictive models were not able to be developed as expected (but may be possible in the future) • Quotes: <ul style="list-style-type: none"> ○ “After 5-6 years of monitoring ecological responses...there is a much greater ability to build ecological response models which will improve predictive capacity” ○ “Clear progress has been made...However 5-years is not a very long time in a variable system...” ○ “The Basin-scale team’s development of predictive models did not come to fruition as expected” <p>Interview.</p> <p>From the interview questions related to KEQ 6.6, there is a general theme that capacity to predict outcomes has improved over the life LTIM particularly for vegetation and fish. However, there is currently limited available data to make predictions.</p> <p>One interesting response is that capacity to predict outcomes has improved because, at the start of LTIM there was an expectation there would be strong responses to flow, whereas through LTIM it has been learned will be limited responses. Its more about: “keeping things on life support until there is a flood”.</p> <p>Other responses:</p> <ul style="list-style-type: none"> • “five years is a very short time in the environmental space to see what longer term outcomes might be” • “I think it's too early to tell. I think it's getting there. I think the confidence in the predictive models is fairly low. And I think at the end of five years, we're right at the beginning of really having enough data to start.” • “at a Basin level, I don't think we've been in a position to be able to do that very effectively yet” • I think that's emerging now. But it's you know, it's five years, six years in, of monitoring and stumping around that catchment to get to that point. • “...it was probably the very last meeting of the Basin Matter team that some of that happened” • “Starting to, yes. But it's still a big task in its early days.”
<p>Revision comments – Evaluator 1</p>	<p>Based on reassessment of micro KEQs 6.6.1 and 6.6.2 have agreed to stay with minimally effective.</p>

Revision comments – Evaluator 2	I thought it would have had to improve; it has got better over the life of the project. They have some models which is why I went moderately effective, but based on ratings of the micro KEQ agree this is minimally effective.
Consensus final rating	Minimally Effective

Micro KEQ 6.6.1	How effectively were the outcomes related to the six specified matters incorporated into the environmental water adaptive management process (Selected Area, Basin-scale)?
Evaluator 1	<p>Minimally Effective</p> <p>There is little evidence that the documented or available in the interviews that the ecological outcomes reported in the annual Basin Matters reports had any effect on the adaptive management of CEW over the 5-years of LTIM. Although, obviously, the Basin-wide hydrology information was crucial to environmental water decision-making.</p> <p>That was not the case for the Selected Areas where there is good evidence (Hart and Butcher (2018) and interviews) that the Selected Area teams worked closely with the CEWO Delivery Teams (and others) to ensure that the outcomes and learnings from previous environmental watering actions were effectively fed into the decision-making processes for future environmental water actions.</p>
Evaluator 2	<p>Moderately Effective</p> <p>Cross-reference: KEQ091</p> <p>Each of the six specified matters: Biodiversity/Generic diversity, Ecosystem diversity, Fish, Hydrology, Stream metabolism, vegetation addressed adaptive management in annual reporting. Each of the Selected Area annual reports include a section on ‘Implications of future management of environmental water’.</p> <p>Survey comments were also mixed but there were positive comments associated with some Selected Areas.</p> <ul style="list-style-type: none"> • “...adaptive management learnings...don’t seem to have really been incorporated into adaptive management of water delivery” • “There is a lot of room for more active input into decision making...” • “There have been substantial changes in the management of water in the Lachlan because of this program...” <p>The interview comments provide positive statements about adaptive management in particular Selected Areas such as the Lachlan, Goulburn and Gwydir, but also concerns about application in other areas and at the Basin-scale:</p> <ul style="list-style-type: none"> • “I wouldn't say that there's been great uptake... it's still quite early, I think, for those for the LTIM project to have a really significant impact. • “some of the learning from that led to trying some new water delivery patterns in the Gwydir”

	<ul style="list-style-type: none"> • “I think in the Lachlan it's been very impactful” • “From a lower Murray point of view, as I discussed before, we have got a much better understanding of what we can expect with a certain amount of water [and] the way it's delivered” • “I think we've come out with some strong messages, in the end. But whether they'll actually get translated into changing the way that water is delivered, I'm not sure”
Revision comments – Evaluator 1	The focus is on the Basin Matters, and in terms of their being incorporated into adaptive management of environmental water – there is no evidence at the moment. May in the future. Some interview responses have indicated the synthesis reports haven't even been read.
Revision comments – Evaluator 2	Happy to switch to minimal as no influence on adaptive management from the Basin Matters. Survey and interview responses support minimal.
Consensus final rating	Minimally Effective

Micro 6.6.2	KEQ	How effectively have the predictive tools or processes developed or refined as part of the LTIM project informed environmental watering regimes (Selected Area and Basin- scale)?
Evaluator 1	Moderately Effective	<p>The best processes for predicting or informing the outcomes of environmental watering actions have been the researcher-manager relationships established in each Selected Area. The interviews with end users (and review by Hart and Butcher, 2018) show clearly the effectiveness of these collaborative processes (see also KEQ5.2).</p> <p>However, there have been few predictive models developed during the LTIM project to provide more quantitative information on possible environmental watering actions. Some Selected Areas (e.g. Goulburn) have develop statistical models that are supporting decisions regarding annual environmental watering actions. In the final Basin Matters reports preliminary quantitative models were developed for fish, vegetation, and metabolism and these will be of use in the future.</p>
Evaluator 2	Minimally Effective	<p>Predictive tools and processes are highlighted in project planning e.g. the requirements documents, MEPs and Basin Matter foundation plans.</p> <p>However, there was less progress than planned. No discussion of predictive tools or processes in the Warrego-Darling, Lower Murray or the Lachlan (check with BTH on other Selected Areas).</p> <p>Limited discussion of predictive tools or processes in the annual Basin Matters reports. The fish and stream metabolism matters teams were making progress by the end of the project.</p>

Revision comments – Evaluator 1	Happy to change to minimal based on discussions with evaluators – no validation, no structure and no strategy with the modelling. So therefore KEQ 6.6 should be minimal.
Revision comments – Evaluator 2	Agree.
Consensus final rating	Minimally Effective

Mid KEQ 6.7 How effectively has the LTIM project demonstrated that short term, less than 1-year outcomes, contribute to longer term outcomes?	
Evaluator 1	<p>Moderately Effective</p> <p>The Selected Area teams all used monitoring information from short-term environmental watering actions to determine the short-term outcomes, and to then to contribute that knowledge in determining longer term outcomes.</p> <p>The process of planning expected outcomes, delivering the environmental water, monitoring appropriate hydrological and ecological indicators, analysing the results, and assessing the outcomes, has been used effectively by all teams to build a knowledge base, which was then fed back to the decision-making process to modify subsequent environmental watering actions (adaptive management).</p> <p>The ecological outcomes from the short-term environmental watering actions are captured in the final Selected Area and Basin Matters reports. These were also integrated to provide a cumulative assessment of the outcomes and learnings over the 5-years of the LTIM project. Cumulative assessments were also provided in earlier Selected Area reports. We have no evidence from the survey or the interviews of how these cumulative assessments were used or whether they had any impact on environmental water management.</p>
Evaluator 2	<p>Minimally Effective.</p> <p>There is little information available to evaluate this KEQ. This issue is highlighted in the outcomes framework and in the Basin Matters reports for the early years of LTIM. However, it is not reported in final reports. There is also the issue of large flood event in year 3 which made the evaluation of this question more challenging.</p> <p>This KEQ is only appropriate for matters where conditions in one year can influence conditions in the next.</p> <p>Biodiversity:</p> <p style="padding-left: 40px;">Not addressed</p> <p>Ecosystem diversity:</p> <p style="padding-left: 40px;">No short term or long term objectives were developed.</p>

Fish:

Mentioned in the first report (Stoffels et al., 2016): “The capacity to identify expected outcomes over 1–5 years at the Selected Area scale will be underpinned by the LTIM Project’s development of quantitative models.”

Some of the models that were developed include a temporal aspect with “time since fish kill” being a predictor for increased abundance of Golden Perch and Murray Cod abundance and decreased abundance of Bony Herring and Carp. Therefore, in terms of time since fish kill, 1-year outcomes would contribute to longer term outcomes.

Hydrology:

Not relevant

Stream metabolism:

Not relevant for stream metabolism

Insufficient monitoring of water quality data to address this issue.

Vegetation:

This issue is mentioned in the first vegetation report (Capon and Campbell, 2016) but is not returned to at the end of the project (Capon and Mynott, 2018).

Survey (Question 18): Responses are generally positive with some “Very effectively” and “Extremely effectively” categories being selected.

Survey comments tended to question effectiveness, because of the limited time frame of LTIM and the response time of different indicators.

- “We still don’t have a great understanding on the cumulative impact i.e. 5+ years”
- “This is a long journey and we are only at the beginning”
- “...it was too early in the program for this to be effective”
- “Critical short term influences have been shown to affect longer term outcomes for a number of indicators...but need further assessment both through the data and with extra targeted measurements.”
- “For vegetation, different communities respond in different time frames”
- “...long-term outcomes have been a bit of an omission of the program...due to the limited timeframe...”
- “Across the project, long-term outcomes were not well demonstrated”
- “[our Selected Area] had 5 different years, making it more challenging to tease out year-on-year results...Basin-scale takes longer, but largely on the right track”
- “The providers struggled to do this, and the CEWO struggled to get them to do it.”

Interviews. There is a general theme that this hasn’t been done effectively and that more time and data is required.

	<ul style="list-style-type: none"> • “...too short, to see how short term indicators, one year targeted outcomes were really contributing to longer term outcomes beyond five years” • “You need a long period of time, multiple years of data to get a good picture.” • “[cumulative impact of] Salt export... Just having that little bit of flow to offset what would otherwise be seawater coming in and evaporating has made a massive difference over the long term for the Coorong.” • “...reports have over the last few years done evaluation of both annual and cumulative for the Basin-scale matters. So I think it's been done fairly” • “To be honest, at least from a fish perspective. I don't think we've done that very well yet, at a Basin-scale” • “Not very effectively. I think. And that's partly because we need the longer term monitoring to see if shorter term outcomes actually take place” • “Really hard to judge that...4 pretty dry years and one year where there was a lot of water. So it was very hard to then pick up any year to year behaviour”
Revision comments – Evaluator 1	Happy to down grade – yes they have tinkered with it but not very effectively – will go to minimal.
Revision comments – Evaluator 2	Not a lot of evidence – partly due to a big flood. The only one is the fish model which had a temporal component to it. Maturity of modelling is limited. The modelling didn't get that sophisticated.
Consensus final rating	Minimally Effective

APPROPRIATENESS – STRATEGIC RELEVANCE

- 1 high-level KEQ
- 2 mid-level KEQs
- 6 micro-level KEQs

High KEQ 7	How well has the LTIM project contributed to the CEWO's ability to meet their legislative reporting requirements?
Evaluator 1	Moderately Appropriate

	<p>The LTIM project has provided moderately appropriate and relevant information that has allowed the CEWO to meet some of their legislative reporting requirements, but not all.</p> <p>These reporting requirements are described in the <i>Water Act 2007</i> and the <i>Basin Plan (S12)</i>, and are summarised below in KEQ7.1. Our assessment is that the LTIM project, largely through the annual Basin Matters and Synthesis reports, is providing information of sufficient detail and quality to allow CEWO to meet most of their legislative reporting requirements, with the caveat that some of the required objectives are not being addressed at all in the LTIM project.</p> <p>We have noted the potentially huge task for CEWO to address one particular Basin Plan reporting requirement, that of on reporting progress towards the Schedule 7 objectives.</p>
<p>Evaluator 2</p>	<p>Moderately Appropriate</p> <p>The LTIM project has assisted CEWO to meet their legislative reporting requirements but only to a moderately appropriate extent. Details are provided in the KEQs below.</p> <p>Additional input is provided by the survey and interview responses</p> <p>Survey question 20 relates to this KEQ: All of the responses are positive, ranging from “A little” to “A great deal”.</p> <p>The theme of the survey comments is the LTIM helps but doesn’t provide information to meet all requirements:</p> <ul style="list-style-type: none"> • “LTIM will only every be able to contribute to a moderate amount of things like the EMF requirements” • “LTIM would help provide answers for Selected Areas for some of these but not automatically beyond to other areas of the Basin” • “LTIM is not used in any meaningful way to fulfil these reporting obligations.” • “Probably contributed a lot for catchments with a Selected Area. Didn’t help in those without.” <p>There were similar comments in the interview responses:</p> <ul style="list-style-type: none"> • Definitely [useful]. We have departmental reporting that we have to do annually, so it's used in that. Basin plan annual reporting as well.
<p>Consensus final rating</p>	<p>Moderately Appropriate</p>

Mid KEQ 7.1 To what extent has the information provided by the LTIM project contributed to the CEWH delivering on its Water Act reporting requirements?

<p>Evaluator 1</p>	<p>Moderately Appropriate</p> <p>The LTIM project has provided moderately appropriate information through the annual Basin Matters and Synthesis reports to allow the CEWO to fulfil its annually reporting requirements to the Commonwealth Water Minister, and relevant State Ministers, particularly on achievements against the objectives of the Basin Plan’s Environmental Watering Plan. Some Basin Plan objectives are not being addressed by the LTIM project.</p> <p>These reporting requirements are described in the <i>Water Act 2007</i> and the <i>Basin Plan (S12)</i>. At the highest level, the focus is on reporting whether the management of CEW has made a contribution to the protection of biodiversity, ecosystem function and resilience of the water-dependent ecosystems of the MDB. The specific reporting requirements are: annual reporting on the management of CEW to be provided to the Commonwealth Water Minister, and relevant State Ministers, particularly on contributions to the objectives of the Basin Plan’s Environmental Watering Plan; annual reporting to the MDBA on the identification of environmental water and the monitoring of its use, the implementation of the environmental management framework, and the implementation of the water quality and salinity management plan; and reporting every five years to the MDBA on the contribution of CEW to environmental outcomes at a Basin-scale.</p> <p>As noted in KEQ2.1, the LTIM project is moderately aligned to the Basin Plan Environmental Water Plan (EWP) objectives and minimally aligned to the Basin Plan Water Quality and Salinity Plan objectives. A number of objectives listed in the Basin Plan are not being addressed by the LTIM projects, particularly a number related to resilience (S8.07) and to water quality and salinity (s9.04).</p> <p>Hart and Butcher (2018) in their mid-term review, commented that the LTIM project had apparently shifted emphasis from the original intent, with more focus now on the Selected Area outcomes at the expense of the Basin-scale evaluation. They identified this as a potential concern since LTIM was established as the main program for assessing the CEWO requirements under the Murray-Darling Basin Plan, a Plan focused on ecological improvements at a Basin-scale.</p> <p>However, our assessment is that LTIM is providing information of sufficient detail and quality to allow CEWO to meet most of their legislative reporting requirements, with the caveat that some of the required objectives are not being addressed in the LTIM project.</p>
<p>Evaluator 2</p>	<p>Moderately Appropriate</p> <p>Water Act requirements are (S114):</p> <p>“Annual reports to be given to the Minister</p> <p>(1) The Commonwealth Environmental Water Holder must, as soon as practical after 30 June in each financial year, prepare and give to the Minister a report on the Commonwealth Environmental Water Holder’s operations during that year.</p> <p>Contents of the annual report</p> <p>(2) The CEWH must include in the report particulars of the following:</p> <ul style="list-style-type: none"> a. achievements against the objectives of environmental watering plans b. management of the Environmental Water Holdings Special Account c. all directions that the Secretary of the Department, or the Minister, gave to the CEWH during the year.

	The LTIM reports will assist with these requirements but do not provide all the information
Consensus final rating	Moderately Appropriate

Micro 7.1.1	KEQ	How appropriate was the information provided by the LTIM project in meeting the CEWH annually reporting requirements to the Commonwealth Water Minister, and relevant State Ministers for each of the Basin States (section 114(1)) which includes information on achievements against the objectives of the Basin Plan’s Environmental Watering Plan (section 114(2a))
Evaluator 1		Moderately Appropriate See KEQ7.1
Evaluator 2		Moderately Appropriate LTIM will assist in meeting these requirements but does not cover all the sites where environmental water was delivered. 114(1): The Commonwealth Environmental Water Holder must, as soon as practical after 30 June in each financial year, prepare and give to the Minister a report on the Commonwealth Environmental Water Holder’s operations during that year. 114(2a): achievements against the objectives of environmental watering plans
Consensus final rating		Moderately Appropriate

Mid KEQ 7.2	How appropriate was the information provided by the LTIM project for contributing to the CEWH delivering on its Basin Plan reporting requirements?	
Evaluator 1		Inappropriate The LTIM project, mainly through the annual Basin Matters and Synthesis reports, has made a minimal contribution of information to assist the CEWO in its Basin Plan reporting requirements.
Evaluator 2		Inappropriate The fact that the CEWH issued a Statement of Assurance suggests LTIM reporting was not completely adequate. However, looking at the interview responses, it seems that LTIM reporting was well regarded by the MDBA: “...we made sure that all our LTIM documents were provided to the authority (MDBA)...They were very happy with that. In fact, they specifically said to us that they didn't want us to write a separate statutory report because there's all the risk that it's not going to be saying the same things”

	<p>One of the survey written responses suggests that LTIM was structured to address MDBA requirements as specified in legislation but in the end, the actual requirements of the MDBA did not end up being as demanding as expected.</p> <p>This suggests there is a gap between when LTIM thought was required and what was actually reported</p>
Consensus final rating	Inappropriate

Micro 7.2.1	KEQ	How appropriate was the LTIM project for supporting the annual reporting requirements to the MDBA on the identification of environmental water and the monitoring of its use (Basin Plan Schedule 12, item 9)?
Evaluator 1	Appropriate	The LTIM project provides appropriate supports for CEWO’s annual reporting requirements to the MDBA on the identification of environmental water and the monitoring of its use through the annual Basin Matters hydrology reports and the annual Selected Area and Basin Matters and Synthesis reports.
Evaluator 2	Appropriate	Schedule 12, Item 9: The identification of environmental water and the monitoring of its use LTIM thoroughly addresses the issues of identifying and monitoring the use of environmental water throughout the MDB. The LTIM hydrology ‘Valley Report Cards’ list watering actions in all valleys including volumes and durations.
Consensus final rating	Appropriate	

Micro 7.2.2	KEQ	How appropriate was the LTIM project for supporting the annual reporting requirements to the MDBA on the extent to which local knowledge and solutions inform implementation of the Basin Plan (Basin Plan Schedule 12, item 6)?
Evaluator 1	Inappropriate	The LTIM project provides minimally appropriate support for CEWO’s annual reporting requirements to the MDBA on the extent to which local knowledge and solutions inform implementation of the Basin Plan. While it is clear that considerable local knowledge (e.g. from researchers, water managers, community members) goes into the annual planning of environmental watering actions in each Selected Area, these findings are not explicitly identified. We are not aware of how CEWO obtains this information.
Evaluator 2	Inappropriate	Schedule 12, Item 6: The extent to which local knowledge and solutions inform the implementation of the Basin Plan.

	<p>LTIM reporting can assist but there are no current LTIM reports that adequately address this issue.</p> <p>This is confirmed by the reporting of the CEWH for this requirement which is a 'Statement of Assurance' not an LTIM report. This includes case studies but some of these are not related to LTIM. For example, one case study is from the Macquarie catchment in 2018-2019 which was not monitored as part of LTIM. If the LTIM reports were adequate, there would be no need for a 'Statement of Assurance'.</p>
Consensus final rating	Inappropriate

Micro 7.2.3	KEQ	How appropriate was the LTIM project for supporting the annual reporting requirements to the MDBA in relation to the implementation of the Environmental Management Framework (Basin Plan Schedule 12, item 10)?
Evaluator 1	Moderately Appropriate	<p>The LTIM project provides moderately appropriate support for the CEWO's annual reporting requirements to the MDBA regarding the implementation of the Environmental Management Framework (S8.04) through the annual Basin Matters and Synthesis reports.</p>
Evaluator 2	Inappropriate.	<p>Schedule 12, Item 10: The implementation of the environmental management framework (Part 4 of Chapter 8).</p> <p>The reporting requirements are listed in Section 13.14.</p> <p style="padding-left: 40px;">For each matter listed in Schedule 12, each reporter listed for the matter must, for each reporting period and by the reporting day, produce a report (including data) on the matter as at the end of the reporting period.</p> <p>The environmental watering framework is listed in Part 4 of Chapter 8. This has the following divisions:</p> <ul style="list-style-type: none"> • Basin-side environmental watering strategy • Long term watering plans • Annual environmental watering priorities • Basin annual environmental watering priorities • Principles to be applied in environmental watering • Methods for identifying environmental assets and ecosystem functions and their environmental watering requirements. • Principles and method to determine priorities for applying environmental water

	LTIM reporting can assist with these reporting requirements. However, these requirements are much larger in scope than the LTIM project and any of the reports delivered as part of the LTIM project therefore this is rated as Inappropriate.
Revision comments – Evaluator 1	I don't believe I answered the question correctly – was focused on Schedule 12 (10). This schedule has 1 yearly and 5 yearly CEWO reporting requirement – and these are very detailed Change to inappropriate
Revision comments – Evaluator 2	
Consensus final rating	Inappropriate.

Micro 7.2.4	KEQ	How appropriate was the LTIM project for supporting the annual reporting requirements to the MDBA in relation to the implementation of the Water Quality and Salinity Plan (Basin Plan Schedule 12, item 14)?
Evaluator 1		Inappropriate The LTIM project provides minimally appropriate support for the CEWO's annual reporting requirements to the MDBA regarding the implementation of the Water Quality and Salinity Plan through two Basin Matters reports – hydrology and stream metabolism and water quality (see also KEQ2.1.4 and KEQ2.4.5).
Evaluator 2		Inappropriate Schedule 12, Item 14: The implementation of the water quality and salinity management plan, including the extent to which regard is had to the targets in Chapter 9 when making flow management decisions. Some targets from Chapter 9: <ul style="list-style-type: none"> • DO value of at least 50% saturation Chapter 9 refers to Schedule 11 which includes targets for: <ul style="list-style-type: none"> • Turbidity • Total P • Total N

	<ul style="list-style-type: none"> • DO • PH • Salinity • Temperature • Pesticides, heavy metals and other toxic contaminants. <p>LTIM does not provide any comprehensive reporting on these water quality parameters except possibly DO. There are only intermittent measurements of N, pH, temperature. Therefore this rating is inappropriate</p>
Consensus final rating	Inappropriate

Micro 7.2.5	KEQ	How appropriate were the LTIM project synthesis reports in meeting the 5 yearly reporting requirements to the MDBA on the achievement of environmental outcomes at a Basin-scale by reference to the targets to measure progress towards the environmental objectives in Schedule 7 (Basin Plan Schedule 12, item 7)?
Evaluator 1	Inappropriate	<p>The LTIM Basin Matter Synthesis reports provide minimally appropriate support for the CEWO’s reporting requirements to the MDBA regarding progress towards the achievement of Schedule 7 environmental objectives.</p> <p>This is a huge task as the Basin Plan does not specify important information, such as ‘loss or degradation’ compared with what reference (e.g. the situation pre-2012)? The final Basin Matters Synthesis report attempted to address this requirement and was able to report some of the cumulative effect of the CEW actions in achieving the environmental outcomes at a Basin-scale. However, this fell far short of what would be required to fully address progress towards achieving these Schedule 7 objectives. In fact, the MDBA is currently attempting to do this as part of its 2020 evaluation of Basin Plan implementation.</p>
Evaluator 2	Inappropriate	<p>Schedule 12, Item 7:</p> <p>“The achievement of environmental outcomes at a Basin-scale, by reference to the targets in Schedule 7.”</p> <p>Schedule 7:</p> <p>Intermediate targets up to 30 June 2019</p> <p>(1) There is no loss of, or degradation in, the following:</p>

	<p>(a) flow regimes which include relevant flow components set out in paragraph 8.51(1)(b);</p> <p>(b) hydrologic connectivity between the river and floodplain and between hydrologically connected valleys;</p> <p>(c) river, floodplain and wetland types including the condition of priority environmental assets and priority ecosystem functions; Note: Note: See section 1.07 for the meaning of the terms priority environmental asset and priority ecosystem function.</p> <p>(d) condition of the Coorong and Lower Lakes ecosystems and Murray Mouth opening regime;</p> <p>(e) condition, diversity, extent and contiguousness of native water-dependent vegetation;</p> <p>(f) recruitment and populations of native, water-dependent species including vegetation, birds, fish and macroinvertebrates.</p> <p>The Synthesis reports are based around the basin plan objectives of: biodiversity, ecosystem function and resilience. They are not specifically focussed on reporting against the targets in schedule 7. A specific gap is 1 (f); macroinvertebrates are generally not measured in the LTIM project.</p> <p>There is sufficient information in the LTIM project to report against these targets but the Synthesis is not a vehicle for such a report. If this report was provided to the MDBA in response to the Schedule 12, Item 7 requirements, they would have to do a lot of work to extract the required information</p>
Consensus final rating	Inappropriate

APPROPRIATENESS – FIT FOR PURPOSE

- 1 high-level KEQ
- 8 mid-level KEQs
- 9 micro-level KEQs

High KEQ 8	How appropriate was the LTIM project design, in terms of being fit for purpose in meeting the CEWO’s strategic requirements?
Evaluator 1	<p>Moderately Appropriate</p> <p>This KEQ is focused on evaluating whether the LTIM project design was fit-for-purpose in meeting the CEWO’s strategic requirements. The LTIM program logic, including specified objectives and outcomes, as specified in the foundation documents, was reasonably well aligned with the CEWO’s strategic requirements to address the Basin Plan objectives. However, the LTIM objectives were not sufficiently SMART* to ensure measurable evaluations could be undertaken.</p>

	<p>Additionally, the LTIM project design made appropriate use of existing scientific and complementary knowledge and cause and effect diagrams in developing appropriate standard methods (Category I and II) that were consistently applied in each Selected Area.</p> <p>Best available scientific and local knowledge was appropriately used to develop the Selected Area MEPS, to assess the monitoring results, and to evaluate the findings regarding the contribution of CEW to the ecological outcomes. However, there was no consideration of cultural knowledge.</p> <p>The Evaluation Plan was fit for purpose as originally devised, but the application and outputs from parts of this Plan were not as complete as expected. For example, project data management arrangements (largely the MDMS) were minimally effective, and were also minimally appropriate for supporting the systematic capture and making available data generated by the project.</p> <p>It was noted (survey, interviews) that much has changed since LTIM’s original design in 2012-2013. In particular, there is now a Basin Watering Strategy that provides more clarity around the Basin Plan objectives, the CEWO’s needs and requirements are now better understood, and the Basin-scale program logic as originally devised has not worked well.</p> <p>Some stakeholders questioned the appropriateness of the current LTIM program logic, which commenced with the focus on being able to evaluate the Basin-wide contributions of CEW (and other environmental water) based largely on information provided at a Selected Area local-scale. This is now however very focused on evaluation at the seven Selected Areas with a lesser focus on integrating these local-scale findings to the Basin-scale. This increased focus on Selected Area is reflected in CEWO’s investment in LTIM, with approximately the same funding for the entire Basin Matters team as for each Selected Area team.</p>
<p>Evaluator 2</p>	<p>Moderately Appropriate</p> <p>The LTIM project design was fit for purpose to a moderate extent in meeting CEWO’s strategic requirements. This evaluation is based on the meso and micro level KEQs noted below and additional consideration of data from the survey and interviews.</p> <p>Survey question 21 addresses this issue. Responses are strongly positive, with most ranging from “A little” to “A great deal”. 1 person (3%), of 37, responded “Not at all”. Responses were slightly less positive at the Basin-scale compared to the Selected Area scale.</p> <p>One issue that comes up in the survey responses is that the Basin Water Strategy was completed after the LTIM project was designed and the design is not fit for purpose in meeting BWS objectives. The BWS contains a detailed list of expected environmental outcomes for river flows and connectivity as well as targets for native vegetation, waterbirds, and native fish. LTIM did not necessarily align with these expected outcomes.</p> <p>The interview responses were generally positive.</p> <ul style="list-style-type: none"> • “It’s not black or white, yes or no. It was partially met” • “...it’s fit for some purposes...” • “But overall, I think it was fit for purpose” <p>A challenge was separating the effect of CEW from other sources of environmental water and whether an integrated monitoring approach would be better.</p> <p>There were also concerns that there should be more focus on the floodplain.</p>

	<ul style="list-style-type: none"> • “...monitoring of fish and stream metabolism has a very strong in-channel focus. And I think that blinded us a little bit to recognizing the role of the floodplain” <p>One thing to consider is the balance between getting things right on average year after year v mitigating extremes. The hypoxia in 2016-2017 killed a large proportion of Murray Cod in the Edward Wakool system (96%). So, should there be a reserve of water to mitigate such extreme event, even if achieving this reserve means that annual targets are missed? Are we seeing a Ratchet to extinction (Anderson, 1998). Also, a ‘right on average’ approach isn’t working for Golden Perch. One comment in the interviews: “We now know that Golden Perch haven't recruited in much of the basin at all for the whole of the LTIM program. The predictions are that that species without stocking isn't going to survive.”</p>
Consensus final rating	Moderately Appropriate

Mid KEQ 8.1	How appropriate was a program logic, being fit for purpose and including specifying measurable (SMART) objectives and outcomes, to be adopted by the LTIM project?
Evaluator 1	<p>Moderately Appropriate</p> <p>The program logic, including specified objectives and outcomes, adopted by the LTIM project was moderately appropriate. However, none of these objectives are sufficiently SMART* to allow measurable evaluations to be undertaken.</p> <p>The LTIM program logic and rationale is reported in Gawne et al. (2013). The Basin Plan objectives regarding CEW management are addressed in the Environmental Watering Plan and the Water Quality and Salinity Plan, with expected outcomes defined for biodiversity, ecosystem functions, resilience and water quality and salinity. More specific 1-year and 5-year outcomes were further defined for each of these higher-level outcomes (CEWO, 2013).</p> <p>The objectives of LTIM were to: monitor the ecological response to CEW at each Selected Area; evaluate ecological outcomes of CEW at each Selected Area; evaluate the contribution of CEW to the objectives of the Murray-Darling Basin Plan (at the Basin-scale); infer ecological outcomes of CEW in areas of the MDB not monitored; and support the adaptive management of CEW. However, the Basin-scale evaluation questions (e.g. what did the CEW contribute to?) were not SMART. Hart and Butcher (2018) in their mid-term review also found the Basin-scale evaluations lacked SMART evaluation questions.</p> <p>*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.</p>
Evaluator 2	<p>Moderately Appropriate</p> <p>It appears that the original intention was that SMART objectives would be specified for 1-year and 5-year outcomes. However, only some objectives and outcomes were specified in a way that could be considered SMART; many where not. An example is ecosystem diversity were there on 1-year or 5-year outcomes.</p>

Consensus final rating	Moderately Appropriate
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Micro 8.1.1	KEQ	At the Basin-scale and for Basin Matters?
Evaluator 1		<p>Moderately Appropriate</p> <p>A moderately appropriate program logic was established for LTIM at the Basin-scale and for the six Basin Matters. However, the Basin-scale evaluation questions (e.g. what did the CEW contribute to?) were not SMART. Hart and Butcher (2018) in their mid-term review also found the Basin-scale evaluations lacked SMART evaluation questions.</p>
Evaluator 2		<p>Moderately Appropriate</p> <p>There is a comment in the first basin synthesis report that objectives of water actions need to be SMART (and hadn't been so far) (Gawne et al., 2016). The Mid-term review criticised objectives as not being SMART (Hart and Butcher, 2018). This issue does not appear to have been adequately addressed in response to the mid-term review.</p>
Consensus final rating		Moderately Appropriate

Mid KEQ 8.2	How appropriate was the program logic as specified in the foundation documents, was it fit for purpose?
Evaluator 1	<p>Moderately Appropriate</p> <p>The LTIM program logic, as specified in the foundation documents, was moderately appropriately aligned with the Basin Plan objectives (see below). However, stakeholders (survey, interviews) have questioned whether the objectives outlined in the Basin Plan and particularly the Environmental Watering Plan are still appropriate. Many (e.g. water quality and salinity) are not SMART objectives. It was also noted that the Basin Watering Strategy was developed after LTIM commenced and there are some areas where there is now minimal alignment.</p>
Evaluator 2	<p>Appropriate</p> <p>The program logic as specified in Gawne et al. (2013) was fit for purpose. The Logic and Rationale document explains an objectives hierarchy and links basin plan objectives to Cause and Effect Diagrams (CEDs) and thence to indicators.</p>
Evaluator 3	Moderately Appropriate

	<p>The main reason is that the outcomes framework dictates a lot of the program logic and it is poorly set up because it is focused only on long-term objectives.</p> <p>There seems to be a strong relationship with Chapter 8, Part 2, 8.04(c) and 8.53, principle 1. Point (c); which refer to long-term resilience. I say this because there is no justification provided for the Selected Areas that are being monitored, their relevance to the rest of the basin, why they are being measured regularly instead of the monitoring focusing on annual watering, and how the proposed modelling of other areas will be evaluated. The Basin Plan Chapter 8 clearly focuses on annual EW priorities (references to ‘annual watering priorities’ are too numerous to count). That is, annual identification of different areas for watering every year, yet the project rationale and logic present a design that does not intend to monitor their responses and is clearly aimed at monitoring long-term resilience, with monitoring of annual watering inferred by the program logic and rationale as a low priority.</p> <p>The outcomes framework unmistakably focusses on the long-term by using statements like “objectives are long term, with a timeframe of greater than 10 years, and operate at the Basin-scale” and “demonstrate how individual watering actions at an area scale contribute to the long-term objectives for the Basin”.</p> <p>Commonwealth Environmental Water – The Environmental Water Outcomes Framework, Commonwealth Environmental Water, December 2013 V1.0’.</p>
Revision comments – Evaluator 1	Based on the micro KEQ, evaluator 2 should change to Moderately appropriate
Revision comments – Evaluator 2	Agree
Revision comments – Evaluator 3	Agree
Consensus final rating	Moderately Appropriate

Micro 8.2.1	KEQ	How appropriate was the program logic in terms of its alignment to the Basin Plan objectives (Chapter 8 and 9), BWS and reporting requirements?
Evaluator 1		Moderately Appropriate

	<p>The LTIM program logic was moderately appropriately aligned with the Basin Plan objectives to evaluate the contribution of CEW to biodiversity, ecosystem function, resilience and water quality and salinity. A general finding was that the LTIM project provided a consolidated evaluation of the contribution of CEW to two of the Basin Plan EWP objectives (biodiversity, ecosystem processes), but a less than adequate evaluation of resilience and water quality and salinity (see KEQ2.2).</p>
Evaluator 2	<p>Appropriate</p> <p>The program logic is as specified in:</p> <p>Gawne B, Brooks S, Butcher R, Cottingham P, Everingham P, Hale J, Nielson D, Stewardson M and Stoffels R (2013) Long Term Intervention Monitoring Logic and Rationale Document Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 01/2013, May, 109pp.</p> <p>The basin plan objectives and reporting requirements from Chapter 8 and 9, are provided as an appendix to the Logic and Rationale document. The Logic and Rationale document explains an objectives hierarchy and links basin plan objectives to Cause and Effect Diagrams (CEDs) and thence to indicators.</p> <p>The Basin Plan objectives are the basis of this process so there is clear alignment.</p>
Evaluator 3	<p>Moderately Appropriate</p> <p>Unfortunately, this is a triple barreled. I'll do the three separately.</p> <p>BP objectives. <u>Well</u>. Clearly the priority for the logic document structure.</p> <p>BWS. <u>Poorly</u>. Not even mentioned in the logic document. Even if inferred from BP objectives it should have been mentioned.</p> <p>Reporting requirements. <u>Well</u>. Not necessarily performed well, but it was there at the start.</p>
Revision comments – Evaluator 1	
Revision comments – Evaluator 2	<p>After reviewing input from the other evaluators, I support a change in rating to “moderately appropriate”.</p>
Revision comments – Evaluator 3	<p>At the time, the BWS was not around but it could have been inferred as it was still based on the EWP objectives.</p>
Consensus final rating	<p>Moderately Appropriate</p>

Mid KEQ 8.3 To what extent did the project design consider complementary recent, ongoing, or planned projects in the same area during the planning phase?	
Evaluator 1	<p>Moderately Appropriate</p> <p>Gawne et al. (2014d, Figure 14) outlined the knowledge sources that were used by MDFRC in the design of the LTIM project at both the Basin and Selected Area scales. Expert opinion, knowledge from Selected Area, and complementary information was obtained from the scientific and technical expertise at (and associated with) the MDFRC, researchers associated with the Selected Area teams, and state and federal agency scientific and water management expertise. Information on established programs was considered in the early design stages of LTIM, which is why systems such as the Macquarie Marshes, the Coorong and other TLM sites (Barmah, Hattah, etc) were not included as Selected Areas. This was also noted in the mid-term review by Hart and Butcher (2018).</p> <p>Additionally, a number of the Selected Areas (e.g. Edwards-Wakool, Goulburn) had a history of working with the CEWO in the period prior to LTIM being established, and their accumulated local knowledge was used in the original design of the Selected Area MEPS.</p>
Evaluator 2	<p>Moderately Appropriate</p> <p>Although the Selected Area foundation documents (requirements reports and monitoring and evaluation plans) do show evidence of consultation. The interview responses show that many opportunities were not taken up. Details are provided in the KEQ below.</p>
Consensus final rating	Moderately Appropriate

Micro KEQ 8.3.1	At the Basin-scale and at the Selected Area scale?
Evaluator 1	<p>Moderately Appropriate</p> <p>See above</p>
Evaluator 2	<p>Moderately Appropriate</p> <p>For each of the Selected Areas, requirements documents were produced that included consultation with all the people and organisations doing related work. The MEPS for each Selected Area included communication strategies that included a broad range of stakeholders.</p> <p>The interview responses suggest that opportunities to interact with EWKR were generally not taken up and there are some other examples of opportunities missed, e.g. a project on attraction flows that was also funded by CEWO and undertaken by SARDI. Comments include:</p> <ul style="list-style-type: none"> “From my perspective, maybe it happened elsewhere, but almost not at all. It almost required a sort of fortuitous coupling of individuals who are across multiple projects to bring those other perspectives in. We knew EWKR was happening. But EWKR information was not brought into LTIM.”

	<ul style="list-style-type: none"> • “I think the Selected Areas definitely had... good relationships, the right relationships, to allow those synergies to happen, but I don’t know if that was comprehensive, there may well have been some tricks missed.” • “So really mixed. Overall, I'd say perhaps not well” • “there was certainly consideration of EWKR, but there was no real meeting of the minds shall we say” • “Pretty much not at all, I would say. Maybe on a very ad-hoc basis. But again, that's definitely a wasted opportunity...” <p>Positive responses mention interactions with VEFMAP and IVT monitoring in the Goulburn. In the Gwydir there was close interaction with a state monitoring program that has been running for 10 years. In the lower Murray there was an effort to design monitoring that was complimentary with existing programs in the Lakes and the Coorong and in the Murrumbidgee there were links to monitoring being done by DPIE.</p>
Consensus final rating	Moderately Appropriate

Mid KEQ 8.4	To what extent did the cause and effect diagrams include best available knowledge (including scientific, local, and cultural knowledge)?
Evaluator 1	<p>Moderately Appropriate</p> <p>A suite of 27 cause and effect diagrams (CED) or conceptual models were developed linking flow to the EWP objectives and showing the way that flow influences ecological outcomes through a suite of environmental/causal factors (MDFRC, 2013). We understand that these conceptual models underwent an extensive internal review process to ensure that they were fit-for-purpose in capturing the most relevant conceptual relationships and the best available scientific knowledge. However, while they included best available ecological and local knowledge, there was no consideration of cultural knowledge.</p> <p>The feedback from the interviews was that the original CED were rarely considered by most Selected Area teams or end users. Some end users saw the value in the CED and had hoped that they would be used and updated as LTIM progressed. It was made clear that the Selected Area teams generally developed their own conceptual models; this was expected, as MDFRC (2013) noted: the CEDs are generic and provide a starting point for predicting environmental outcomes in water dependent ecosystems throughout the MDB; in many instances, the application to a specific Selected Area will require modification of the CEDs. Some Selected Areas (e.g. Goulburn) developed and used a conceptual model to guide their project and to make clear to stakeholders see the known and hypothesised relationships between CEW (and other e-flows) and the various ecological indicators being monitored (see also KEQ3.5).</p>
Evaluator 2	<p>Appropriate</p> <p>The CEDs were well argued, referenced and developed by specialists (MDFRC, 2013)¹⁰.</p>

¹⁰ MDFRC (2013) Long-term Intervention Monitoring - Generic Cause and Effect Diagrams Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 01.5/2013, May, 163pp.

	<p>Survey (Q22) responses were generally positive with 50% selecting “A lot” or “A great deal”. The survey comments suggest that the best available scientific knowledge was used but there was less use of cultural knowledge:</p> <ul style="list-style-type: none"> • “More needs to be done to include cultural and local knowledge in the future” • “I understand they were based on best available knowledge in 2012 (scientific). They were not informed by local and cultural knowledge to any major degree. • “Suspect less local and cultural knowledge may have been included” • “...they were focused on the science, rather than local or cultural knowledge” <p>“Scientific yes, local and cultural knowledge – only a little”</p>
Evaluator 3	<p>Moderately Appropriate</p> <p>From a scientific perspective they used best available. From a local and cultural perspective it is not simple to evaluate, as there is no reference to those sources.</p> <p>Referring to this document: MDFRC (2013) Long-term Intervention Monitoring - Generic Cause and Effect Diagrams Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 01.5/2013, May, 163pp.</p> <p>It is difficult to assess the input from local and cultural perspectives as there is no obvious reason why the authors would have cited such inputs. Given the report is written in a scientific format, such inputs may have been cited as pers. obs, pers. comms, or unpublished data. There are no ‘pers obs’ or ‘pers comms’ citations and 5 ‘unpublished data’ citations in the CED (2013) document. Who was the owner of the unpublished data being referred to was not made clear. Evidence of up to date scientific knowledge is evidenced by including up to date references and referring to three different scientific papers ‘in press’ (1 × Nielsen et al., 1 × King et al., 1 × Baldwin et al.).</p>
Revision comments – Evaluator 1	
Revision comments – Evaluator 2	Revise to “moderately appropriate” because there was limited use of cultural knowledge
Revision comments – Evaluator 3	
Consensus final rating	Moderately Appropriate

Mid KEQ 8.5	To what extent were the best practice scientific methods employed in the LTIM project?
<p>Evaluator 1</p>	<p>Moderately Appropriate</p> <p>The LTIM project sought to quantify the outcomes of CEW management and its contribution to achieving the objectives of the Basin Plan. Basin-scale evaluation, informed by monitoring at each of the seven Selected Areas, and employing best practice scientific methods, is pivotal to this objective.</p> <p>LTIM employed moderately appropriate scientific methods in achieving the above objective. Each of the Basin Matters reports demonstrated that high quality scientific knowledge was used to arrive at the evaluation outputs; a series of standard methods were developed at the start of LTIM for the monitoring of ecological indicators, and these were mostly used in the Selected Area, although there were examples where non-standard methods were adopted (e.g. Category 2 method for metabolism in the Gwydir Selected Area) resulting in that data not used being used for the Basin-wide evaluation; a number of scientifically robust predictive models were developed using ecological outcome data from the Selected Areas and have been shown to have application in predicting outcomes of environmental watering in areas not monitored.</p> <p>Feedback in the interviews was generally supportive that the overall approach, included the use of best practice standard methods to provide consistent Basin-wide monitoring information. However, some stakeholders questioned the lack of collaboration in the initial establishment of some of these standard methods (e.g. fish), and also the focus on indicators and methods for Basin-scale evaluation that compromised the local Selected Area evaluation.</p>
<p>Evaluator 2</p>	<p>Appropriate</p> <p>This evaluation is based on the two micro KEQs below and consideration of survey responses.</p> <p>This KEQ is addressed by survey question 23. Responses were very positive with 62% selecting “A lot” or “A great deal”. The written comments generally support this. There was some comment about whether certain methods were appropriate for each of the Selected Areas and themes.</p> <p>The interview responses also suggest that best practice scientific methods were employed.</p> <p>One interview response points out the processes used to ensure best practice. There was an open tender evaluated on the basis of the best science team.</p>
<p>Evaluator 3</p>	<p>Moderately Appropriate</p> <p>The LTIM project used contemporarily up to date methodology and scientists with local knowledge and experience where possible. I rate as moderately appropriate because of the scale mismatch between using Selected Areas and basin wide reporting (see my response to 6.1.1). I also believe that best practice scientific methods includes high quality and standardised data QA and QC before the field work begins. This was clearly not done with each Selected Area team reporting data in their own formats in the first couple of years.</p>
<p>Revision comments – Evaluator 1</p>	

Revision comments – Evaluator 2	Agree to change to moderately appropriate based on discussions with other evaluators.
Revision comments – Evaluator 3	
Consensus final rating	Moderately Appropriate

Micro KEQ 8.5.1	For each Basin Matter?
Evaluator 1	<p>Appropriate</p> <p>Review of each of the Basin Matters annual reports, and particularly the final (2018-19) reports, demonstrated that high quality scientific knowledge was used to arrive at the evaluation outputs. The Basin Matters team consists of well-regarded and highly skilled scientists, most who have very good publications records.</p> <p>The survey and interviews indicated general confidence in and support for the scientific quality of the Basin Matters team.</p>
Evaluator 2	<p>Appropriate</p> <p>In general, the LTIM project employed some of the best scientists in Australia to develop standard methods to gather data. The Basin Matters teams applied best practice scientific methods in the analysis of this data.</p>
Evaluator 3	<p>Answers are in the context of the design constraints discussed in 8.5.4 below. Ecosystem diversity and hydrology achieve basin wide outputs the other don't quite get there.</p> <p>Moderately appropriate As noted earlier, this is clearly an add-on Basin Matter with little focus and direction towards the Basin-scale, focusing on locally relevant taxa and ad-hoc data sets. Given those limitations, the data collection methods are OK. It's the sampling design and caveats on any inference from the hotch-potch of data that make it a weak component.</p> <ul style="list-style-type: none"> Hale J, Bond N, Brooks S (2020) Murray–Darling Basin Long Term Intervention Monitoring Project — Biodiversity Report. Report prepared for the Department of the Environment and Energy, Commonwealth Environmental Water Office by La Trobe University, Centre for Freshwater Ecosystems, CFE Publication 252 May 2020 76pp

	<p>Appropriate Top notch.</p> <ul style="list-style-type: none"> Brooks S., (2020) Murray–Darling Basin Long Term Intervention Monitoring Project — 2018–19 Basin-scale evaluation of Commonwealth environmental water – Ecosystem Diversity. Report prepared for the Department of Agriculture, Water and the Environment, Commonwealth Environmental Water Office by La Trobe University, Centre for Freshwater Ecosystems, CFE Publication 248 May 2020 54p. <p>Moderately appropriate Similar to fish and function, the data collection and within site methods are very good. It’s getting from there to the higher scale that has issues and again that is because of the limitations of the sampling design not the science itself.</p> <ul style="list-style-type: none"> Capon, S.J. and James, C.S., (2020) Murray–Darling Basin Long Term Intervention Monitoring Project — Vegetation Diversity Report. Report prepared for the Department of the Agriculture, Environment and Water, Commonwealth Environmental Water Office by La Trobe University, Centre for Freshwater Ecosystems, CFE Publication 249 May 2020 129pp. <p>Moderately appropriate As per vegetation.</p> <ul style="list-style-type: none"> King A.J., McPhan L., Bond N., Thurgate, N. (2020) Murray–Darling Basin Long Term Intervention Monitoring Project — 2018–19 Basin-scale evaluation of Commonwealth environmental water – Fish Report. Report prepared for the Department of Agriculture, Water and the Environment, Commonwealth Environmental Water Office by La Trobe University, Centre for Freshwater Ecosystems, CFE Publication 250, May 2020, 82pp. <p>Appropriate A census and well performed using up to date/best practice modelling.</p> <ul style="list-style-type: none"> Stewardson MJ, Guarino F (2020) 2018–19 Basin-scale evaluation of Commonwealth environmental water — Hydrology. Final Report prepared for the Commonwealth Environmental Water Office by La Trobe University, Publication 246/2020, 58pp, plus annex <p>Moderately appropriate As per vegetation and fish.</p> <p>Grace M (2020) 2018–19 Basin-scale evaluation of Commonwealth environmental water — Stream Metabolism and Water Quality. Final Report prepared for the Commonwealth Environmental Water Office by La Trobe University, Publication 247/2020, May, 1 pp plus annexes</p>
<p>Revision comments – Evaluator 1</p>	

Revision comments – Evaluator 2	
Revision comments – Evaluator 3	<p>The reason hydrology and ecosystem diversity got appropriate was because they were basin wide. The rest of the Basin Matters are attempting to do basin wide but are not doing it well. Happy to go appropriate as there were constraints on how Selected Areas were selected. A lot of the design is to get an annual response but the whole program was set up to get long term Basin-scale, but given the caveats of spatial design – happy to go with Appropriate.</p> <p>The major concerns are that the initial design was set up contrary to the ultimate aim of basin wide reporting. That is, to sample intensively in a few small areas is not an optimal design for large scale reporting, which is considerably better served by sampling more areas less intensively. The Selected Areas needed to have been selected after their relevance to the basin (plan) was known. Their relevance could be partially verified going forward by using test sites. That is by making predictions for (random and representative) responses in sites outside the current set and measuring the actual responses.</p> <p>The first step going forward is to gather enough data points to populate predictive models, which is as I understand is the current plan. When the modelling begins, and regardless of the model types, the approach could be supplemented by considering three strategies.</p> <ol style="list-style-type: none"> 1. Increasing the spatial scale of sites sampled 2. Attempting to document how the Selected Areas represent basin wide CEW 3. Including validation/test sites from outside the current Selected Areas <p>All three strategies are related and could all be implemented in a well-managed MERI framework.</p>
Consensus final rating	Appropriate

Micro 8.5.2	KEQ How appropriate were the Standard Methods, were they fit for purpose and consistently applied at the Selected Areas?
Evaluator 1	<p>Appropriate</p> <p>Category I and II standard methods were fit for purpose and generally consistently applied in the Selected Areas.</p> <p>The initial focus of LTIM was on Basin-scale evaluation of the contribution of CEW, this being informed by monitoring at each of the seven Selected Areas. For this work, it was desirable that each of the Selected Areas used as far as possible the same sampling and analysis methods. Three categories of methods were developed for LTIM:</p> <ul style="list-style-type: none"> • Category I methods: were mandatory indicators and standard protocols which were required to inform quantitative Basin evaluation, and included river hydrology, ecosystem type, riverine fish and metabolism • Category II methods; were optional indicators with mandatory standard protocols which could be used to inform quantitative Basin evaluation, and included wetland hydrology, fish movement, vegetation diversity, waterbird breeding and diversity, and water quality

	<ul style="list-style-type: none"> • Category III methods; were optional indicators with Selected Area specific protocols and reporting requirements, and included tree stand condition, wetland fish, fish larvae, and macroinvertebrate diversity. <p>A series of standard methods, based on best available scientific knowledge, were developed at the start of LTIM for the monitoring of Category I and II ecological indicators (Hale et al., 2014). Some problems were experienced early in LTIM with Selected Area teams questioning the applicability of particular standard methods in some local areas; this was particularly the case for the fish and metabolism methods. A learning from this experience is that it is best to allow time for the scientists involved in the monitoring to resolve the best way to approach standard methods, balancing local circumstances and the need for Basin-wide assessments.</p> <p>Category I methods were used by the Selected Area, with the exception of a Category II method for metabolism being used in the Gwydir Selected Area resulting in that data not used being used for the Basin-wide evaluation. There were also suggestions in the interviews that some standard methods were modified by some Selected Areas. We have no information on the process used by the CEWO for approving of use of non-Category I or II methods, or of modifications to these standard methods.</p>
<p>Evaluator 2</p>	<p>Moderately Appropriate</p> <p>Standard methods were fit for purpose. They were developed by an expert team and were also independently reviewed to check if appropriate methods were adopted. However, there are some cases where they were not consistently applied at Selected Areas:</p> <ul style="list-style-type: none"> • Warrego-Darling - fish methods used were not consistent with other SAs. • Vegetation diversity sampling wasn't undertaken in the Lower Murray, but it was in the other 6 SAs • Stream metabolism wasn't sampled in the Gwydir but was in the other 6 SAs. <p>This screenshot is from the Standard methods report (Hale, 2014) which suggests Cat 1 fish monitoring should have been undertaken in all SAs. Also Cat II Veg diversity monitoring should have been undertaken in all SAs.</p>

Table 1: Indicators for each of the Selected Areas

Standard Method	Goulburn	Edward-Wakool	Lower Murray	Lachlan	Murrumbidgee	Gwydir	Warrego/Darling
LTIM Standard Protocol: Ecosystem Type	I	I	I	I	I	I	I
LTIM Standard Protocol: Tree Stand Condition	III	III	III	III	III	III	III
LTIM Standard Protocol: Vegetation Diversity	II	II	II	II	II	II	II
LTIM Standard Protocol: Fish (River)	I	I	I	I	I	I	I
LTIM Standard Protocol: Fish (Wetland)	III	III	III	III	III	III	III
LTIM Standard Protocol: Fish (Larvae)	III	III	III	III	III	III	III
LTIM Standard Protocol: Fish (Movement)	II	II	II	II	II	II	II
LTIM Standard Protocol: Waterbird Breeding	II	II	II	II	II	II	II
LTIM Standard Protocol: Waterbird Diversity	II	II	II	II	II	II	II
LTIM Standard Protocol: Macroinvertebrate Diversity	III	III	III	III	III	III	III
LTIM Standard Protocol: Stream Metabolism	I	I	I	I	I	II	I
LTIM Standard Protocol: Water quality	II	II	II	II	II	II	II
LTIM Standard Protocol: Hydrology (River)	I	I	I	I	I	I	I
LTIM Standard Protocol: Hydrology (Wetland)	II	II	II	II	II	II	II

Standard methods were not consistently applied in the Lower Murray. For example, Vegetation diversity was not measured. Matter transport was included even though there was no standard method in Hale et al. (2014).

The vegetation Basin Matter had problems because of inconsistent application of standard methods. See Capon and Mynott (2018). Although they don't identify any particular SA.

There were problems with data loss for the stream metabolism/water quality standard method. "The use of multiple sites within a Selected Area and multiple data years mean that data losses from a few sites are far less problematic. Extended periods of high water levels for many months is an ongoing challenge as most logger battery systems will run for around 8-10 weeks. Once the battery fails, no further data is recorded, although data already present is not lost." (Grace, 2020).

Perhaps an appropriate standard method would have been able to cope with these difficulties. It also seems there were problems with measuring stream metabolism on the Warrego-Darling. Possibly because water was not flowing or was highly turbid.

Survey (Q24) responses had a large proportion of "Don't know", there was also a marked difference between the responses of the client and service providers. Of the client participants, of these that selected a response other than "Don't know", all choose "A lot" or "A great deal". The service providers were much less positive with some selecting "Not at all" or "A little". There were also differences between the Selected Areas but the numbers are too small to draw conclusions.

The written comments to question 23 and 24 confirm there were issues when applying standard methods to some Selected Areas and Basin Matters. There seems to be concern about fish and also application of the standard methods to unregulated ephemeral streams.

- “The standard method originally proposed for floodplain hydrology was unworkable”
- “...innovation was actively discouraged...lack of responsiveness to real world outcomes...”
- “Some modifications made to suit local conditions and objectives”
- “Fish and metabolism...were very costly and not necessarily fit for purpose for all SAs”
- “...the protocols used [for waterbird diversity and breeding] were more comprehensive than those outlined in the standard methods”
- “The methods were most obviously fit for purpose for the Southern Basin, but not necessarily the best of methods for the northern parts of the basin – particularly stream metabolism, the hydrology methods (which no one used)”
- “Worked well for most indicators, though fish were an overkill and the stream metabolism model did not work out...”
- “Need improvements in flexibility of monitoring in unregulated systems”
- “The standard methods may not apply as well to streams that cease to flow for extended periods, unregulated systems. There may need to be some nuancing for these systems”

The interview responses are generally similar.

- “I know there was a lot of argy bargy and disagreements about those things across the various science provider groups are working on the project at the Selected Area and the Basin-scale. So my understanding is, though, is that after a while, everybody knuckled down and did it.”
- “I think that it gave everyone ulcers. Within the office, within the people managing the contracts and among the scientists, we couldn't get them to agree”
- “The SRA is the perfect contrast to this. A protocol, standard methods”
- “The methods were handed to us. Yes, some of them could have been better. That were probably reasonable at the time. It's useful to have some form of standardization. But its never going to be good fit for purpose everywhere.”
- “I do know that every single Selected Area doing vegetation in their own way was probably not the best way to go. But we had all the best intentions in the world of getting people to do things in one way and then as things went down the track, people went their own way”
- “I think they were pretty good. The standard methods in some cases were probably not as good as they could have been, for different locations. I know certainly the fish methods were an overkill in some in some areas, and it was really arduous for our guys to try and meet those standard methods. But generally, they were fine.”
- “...getting information at the Selected Area scale, meeting those cat 1 methods meant we couldn't do sites we probably would have done otherwise, to get better information at that Selected Area scale”

	<ul style="list-style-type: none"> • “...specifically the metabolism model, ninety five percent of our data never met the requirements to go in that model. So what are we doing it for?” • “...decisions were made about how the data was collected, for example, to align to previous work. And ... that led to divergence in what were originally very standard methods, particularly in vegetation. That ultimately meant...a patchwork of methods across the Selected Areas. And when people tried to retrofit those back together, it was extremely difficult. And I'd argue that the benefits of veering from the original plan, which were sort of talked up at the start clearly probably haven't paid off.” • “...getting standard methods across very diverse types of systems from the Gwydir through the Lower Murray, you know, was challenging.” • “...there certainly was not consistent adherence to methods across Selected Areas, in many aspects. Probably more so for the fish and the metabolism, but certainly for the vegetation data everyone seemed to be collecting things in a different way in their Selected Areas.” • “Why did LTIM come off the rails? - I think it went off the rails because many...the groups that came into LTIM already had established programs where they'd done short term monitoring... so the common excuse given for not adhering to the standard methods was ‘we've been collecting data in these four Billabong's for the last five or six years prior to LTIM starting’” • “[The] standard method for larval fish, we knew, ...there would be significantly under sampling So they weren't “Standard methods” because they had different detection probabilities” • “Overall, I think for the Lower Murray, LTIM worked well, other than some of the Category one designs.” <p>Difficulties with the fish method were highlighted and this was also brought out at the Fish workshop held in 2015 (Fish workshop minutes, 30 Oct 2015). The different approaches required for unregulated and ephemeral systems are also noted as well as the challenges in sampling different sized rivers. Another issue was the lack of time available to get agreement on the standard methods, much shorter than was available to the SRA.</p> <p>There were concerns that efforts to link LTIM monitoring to existing programs, compromised the use of standard methods.</p>
<p>Evaluator 3</p>	<p>Appropriate</p> <p>My evaluation is Fit for purpose and consistently applied.</p> <p>Category 3 methods are fit for purpose by definition. The following evaluation is for category 1 and 2 methods.</p> <p>It is important to note that standard methods are not necessarily good partners for measuring transient items such as biological communities. For example, one would expect many environmental variables (e.g. flow, and habitat) and consequently, say fish or vegetation species/communities, to vary between the Selected Areas, hence the best methods for measuring them may also be expected to be different between the different areas. Consider an extreme example, TLM monitoring for vegetation, The Coorong does not have river red gum communities, all other icon sites do, so the vegetation indicator clearly uses a different method there than elsewhere. In such instances, it is the indicator that is to be compared between the Selected Areas</p>

	<p>that is more important, not the method used to measure it. Thus I treat the question by suggesting standard methods and standard indicators can be interchanged appropriately in some cases.</p> <p>“An important component of the LTIM design and implementation phases will be to employ standard methods for indicator measurement, site selection and data management” – program logic and rationale document. Site selection is not transparent and along with data management is not considered in this response.</p> <p><u>FISH</u>. Fit for purpose. Standard methods recognized limitations from previous studies in the region and supplemented it with methods designed for purpose and using best available practice (using details provided by Stoffels 2106 Basin-scale evaluation fish). Assume the same methods were used through time, but this is not transparent from the available documents.</p> <p><u>HYDROLOGY</u>. Fit for purpose</p> <p><u>STREAM METABOLISM</u>. Appears to be fit for purpose albeit for a notoriously difficult indicator.</p> <p><u>VEGETATION</u>. Fit for purpose. A typical example as described above where the indicator remains the important issue, not the actual method used. Table 2 in Capon and Campbell (2017) demonstrates that the indicator (vegetation diversity) remains standardised, but the sampling design is adjusted according to the Selected Area. This is best practice. Also this one demonstrates that the methods were changed through time to reflective adaptive monitoring as required. Good.</p> <p><u>ECOSYSTEM DIVERSITY</u>. Another good example of the standard method not really applying, rather it is the methodology and indicator used that is considered is fit for purpose.</p>
<p>Revision comments – Evaluator 1</p>	<p>I agree with evaluator 3 logic and maintain my judgement of appropriate.</p>
<p>Revision comments – Evaluator 2</p>	<p>My judgement was because of some comments in the interviews about fish, I think, where they said because you have all these different volumes of flows, you cant just keep sampling in the same way because the fish have got more room to move. But I'm not a fish person. But that was the argument. I don't have domain knowledge in fish, so if the other evaluators have got strong views, I'd be happy to move.</p>
<p>Revision comments – Evaluator 3</p>	<p>I was a little bit flexible and got away from ‘fit for purpose’ into the term of ‘best practice’ because there are a lot of issues and there is no generic method. There is no standard method that you can apply in all the habitats and in every site is different. The methods evolved over the life of the project, so they do the best they can each time, so fit for purpose probably not ideal, but best achievable practice is probably appropriate. I looked at this question by suggesting standard methods and standard indicators can be changed to the appropriate situation as no single method will fit all purposes.</p> <p>Methods evolve considering all the constraints – the larger the spatial scale the harder it is to have standard methods. I judged appropriate based on indicators. Maybe need to say moderately appropriate.</p>

	<p>The use of standard methods is an ideal that is difficult to achieve in dynamic systems and shouldn't even be attempted for some scenarios. That is, where the sampling units (e.g. a stretch of river) have either; a) different characteristics, or; b) different points of relevance in different locations. For example, different flow, channel shape, vegetation types, fish species present and so on. And plainly, the diversity (in characteristics or points of reference) of the sampling units must increase as the spatial extent of the program increases. At the MDB scale, biological type measures are bound to be varied and presumably require different methods on occasions. For example, any method (say nets or electrofishing) for measuring fish species present have a bias of some kind (towards different sized fish or to more or less mobile fish etc.). Thus, given there are different types of fish communities over a large spatial scale like the MDB, then clearly the same sized nets for fish in different parts of the basin will have difference biases. In this example, the way the data are used for reporting may or may not overcome the biases.</p> <p>On the other hand, studies where the sampling unit (e.g. a volume of water) and the point of reference (e.g. EPA guidelines) remains the same should use standard methods. For example, measuring water chemistry will always be looking for the same indicators in a standard volume of water (say ppm), measuring toxicity levels in soils and so on.</p> <p>Using a standard indicator may be more useful than standard method. For example, in the lower reaches it may be salinity that is the major determinant of water quality, in upper reaches it may be dissolved oxygen or temperature. If you go to a range of locations and measure many completely different fish populations, you may be able to use a standard indicator such as body mass index of individual fish as an indicator to moderate sampling bias.</p> <p>Thus, I use the term appropriate when considering the indicator rather than the method. This rationale would allow evaluator 2 to agree on an overall Appropriate rating.</p> <p>Alternatively, if we go with the strict terminology of standard methods, then I agree with evaluator 2 and wish for a moderately appropriate consensus rating</p>
Consensus final rating	Appropriate – caveat that this rating is achieved as it was decided that the indicator/data were appropriate, not necessarily the standard methods

Micro 8.5.3	KEQ How appropriate were the category III methods for addressing CEWOs strategic requirements?
Evaluator 1	<p>Appropriate</p> <p>As noted in KEQ8.5.2, a number of ecological indicators were monitored using Category III methods. These included: included tree stand condition, wetland fish, fish larvae, and macroinvertebrate diversity, and were used largely to answer evaluation questions at the local scale such as 'what was the contribution of CEW to larval fish production?'</p>
Evaluator 2	<p>Inappropriate</p> <p>The Cat III methods mentioned in Hale et al., (2014) are:</p>

	<ul style="list-style-type: none"> • Tree Stand condition • Fish Larvae • Fish Wetland • Macroinvertebrate <p>Tree Stand condition was not considered a priority so was not used in any Selected Area.</p> <p>Macroinvertebrates were monitored in the Gwydir and the Goulburn but not in the other 5 Selected Areas. There is no reporting on macroinvertebrates in the Basin Matters reports or the synthesis reports. That is Cat III macroinvertebrate sampling was not useful for addressing CEWOs strategic requirements.</p> <p>In the final fish report (King et al., 2020) there is a comment: “Additional sampling (Category 2 and 3 sampling) of fish movement and fish occurrence on floodplain habitats also occurred at various Selected Areas. These data are not included in this Basin-scale analysis of fish response to CEW, but can be found within relevant Selected Area reports.”</p> <p>This suggests Cat III fish methods were not useful for the CEWO.</p>
<p>Evaluator 3</p>	<p>Appropriate</p> <p>The category two methods are included in the response for the category 1 methods above.</p> <p>The category 3 methods by definition are not designed for and should not be used for the basin wide reporting. That is, they are locally relevant and should not be used in any modelling process (see response for 8.6.4 below). The scope provided in Gawne et al. 2014d for category 3 is “Optional monitoring with Selected Area specific protocols and mandatory reporting requirements. This includes Selected Area specific monitoring using locally appropriate methods.”</p> <p>I agree that the specific CEWO strategic requirements, mainly relating to basin wide reporting and evaluation in unwatered areas are poorly met by the current methods.</p>
<p>Revision comments – Evaluator 1</p>	<p>Value of category III methods is limited for the CEWO. I question the need for macro invertebrate micro invertebrates, I understand the link to, you know, fish food and all the rest of it. There’s no way any Selected Areas make those linkages clear. They did in the conceptual models, but not in terms of any of the evaluation. Will change rating to inappropriate</p>
<p>Revision comments – Evaluator 2</p>	<p>Category three. I don't think they're appropriate for addressing CEWO strategic requirements. There was category III fish data collected that didn't get included in the Basin-scale analysis so its of no strategic value. Similarly other category III methods were not useful either</p>
<p>Revision comments – Evaluator 3</p>	<p>We make a note to the CEWO that an add-on value from the category 3 indicators (irrespective of methods) is not in terms of strategic requirements, but in terms of local outcomes. That is, through enhanced community engagement and local ownership of the program which leads to better outcomes and participation for category 1 and 2 methods through increased interest.</p>

Consensus final rating	Inappropriate
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Micro 8.5.4	KEQ	How appropriate were the predictive modelling approaches adopted to predict outcomes of environmental watering in areas not monitored for each Basin Matter?
Evaluator 1		<p>Moderately Appropriate</p> <p>Hart and Butcher (2018 in their mid-term review of LTIM expressed concern regarding the capacity of the Basin Matters team to develop, test and implement quantitative models for fish, vegetation and metabolism in time to the project’s completion. Further, they recommended that development of a comprehensive <i>modelling development plan</i> 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). This apparently was not done.</p> <p>However, it appears that in the latter stages of the LTIM project a number of preliminary models have been developed using ecological outcome data from the Selected Areas and that these will have application in predicting outcomes of environmental watering in areas not monitored. Some examples include:</p> <ul style="list-style-type: none"> • Hydrological modelling approaches appropriate for assessing the contributions of CEW (and other environmental water) in both monitored and non-monitored areas • Ecosystem diversity models based on best-available mapping data, included in the most recent ANAE classification (Brooks, 2020) – there are, however, some questions regarding the accuracy of the method used to determine the extent and duration of floodplain inundation • A generalised linear mixed statistical model developed to assess fish responses (abundance, species diversity, recruit abundance, spawning abundance, larval abundance) to flow regimes with and without CEW to provide counterfactual comparisons for inferring effects of CEW on fish populations (King et al., 2020) - these fish models were successful for some species, but limited by a lack of data for other species and in some areas • Vegetation models that related hydrological variables with vegetation species and vegetation communities - these were limited by the lack of ecologically relevant inundation data (Capon and James, 2020, Appendix E) • A robust stream metabolism model developed and used to provide an indication of the likely metabolism in streams in non-monitored areas (Grace et al., 2020) - this metabolism model is only applicable to running waters, and not wetlands or the more lake-like conditions in the Lower Murray Selected Area, and needs considerably more data before it can be properly tested for rivers in northern Basin • A hydrology-hydraulic habitat model was developed for application in the Lower Murray region. <p>Despite the recent progress in the production of statistical models for some ecological indicators, the lack of robust predictive models and their application to non-monitored regions of the Basin is still a major concern.</p>
Evaluator 2		Inappropriate

	<p>Predictive modelling approaches were generally either not done or delivered too late in the project to be useful.</p> <p>Fish: some good work on building spawning prediction models (see the first 2 annual fish Basin Matters reports). Other fish models are discussed in the final fish Basin Matters report (King et al., 2020). But there are also challenges: “It is likely that the limited number of sampling years, the low variation in flow conditions during LTIM project and the range of CEW flow delivery types that occurred during LTIM resulted in the limited evidence of a spawning response to CEW at the Basin-scale. Further sampling years with more varied flow conditions may tighten these relationships.”</p> <p>Fish and Vegetation Basin Matter reports highlight problems with data which hampered modelling (Stoffels et al., 2018; Capon and Mynott, 2018).</p> <p>Survey (Q25) responses indicated many were concerned about appropriateness of predictive modelling approaches. Apart from “Don’t know”, “Not at All” is the response with the greatest frequency for all Basin Matters apart from hydrology.</p>
<p>Evaluator 3</p>	<p>Inappropriate</p> <p>My assessment is inappropriate, but this may be because of the serious lack of transparency around this issue in the documentation provided. In general the analytical/statistical methods used are OK but the sampling design was poor from the start. The synthesis reports generally do not present actual results and methods, but just the synthesis.</p> <p>In the 2020 synthesis report the only modelled outcomes are for lengths and areas watered, there is little attempt to predict outcomes for the Basin Matters.</p> <p>However King et al 2020 do present details of modelled responses for fish. Before such modelling could be performed or interpreted there needs to be clarification around;</p> <ul style="list-style-type: none"> • How the Selected Areas were selected initially. • How they were then validated as representative of the basin, or how results have been calibrated to allow basin wide response predictions. • How the models were validated and updated regularly. That is, which sites in non-Selected Areas were subsequently assessed for model validation, how they were selected and, how the actual versus modelled results were compared? This is somewhat related to the earlier point about the project rationale/outcomes framework focusing on Selected Areas and long-term resilience rather than annual watering events. <p>These issues are eluded to in King et al 2020 “this approach inherently relies on predictions from the modelled data and making them susceptible to model errors, which do not occur if comparisons are made on actual measurements alone”.</p> <p>Further, the King 2020 paper reads to me as if the ‘Basin-scale’ analysis is actually just the combined Selected Area analyses. That is, given the models include random effects for each Selected Area, I doubt that the results were modelled for the entire basin (as suggested in the Stoffels foundation document). The King approach is a more defensible analyses, but of course it does not report at the Basin-scale, because we have no idea how the Selected Areas were chosen and if they represent the basin or not. In essence, it’s ok to use the method as is but call it something other than the Basin-</p>

	<p>scale analysis. It would be sensible to refrain from inferring that the effects of CEWO can be inferred at the Basin-scale using the Selected Areas approach, until model validation can be made. And this is not a simple issue, it may take another 50 years.</p> <p>The vegetation Report (Capon and James 2020) also does not use the pre-program method of prediction. It merely documents the wetland classifications of the CEW and suggests what may have happened there to the vegetation. It includes vague statements like “It can therefore be expected” and “are very likely to”. In other words, there is no attempt to validate the predictions, so the models have negligible value. In the 2020 report there was an attempt to make basin wide predictions based upon the responses in the four Selected Area, however this was unsuccessful because of the lack of data for training the model, let alone the need for calibrating it using additional data from unmonitored sites.</p> <p>I think the reporting for bother fish and veg is transparent, but there should be no attempt to claim that basin wide evaluations are being attempted. They should just stick to reporting the Selected Areas, which they do very well.</p> <p>If the next phase of CEW is serious about reporting unmonitored areas, they should as a starting point, consider how the 2014 to 2019 predictions performed in unmonitored sites, but with data from other programs. Secondly, it is essential in the future to include validation data sets in the modelling program.</p>
Revision comments – Evaluator 1	Predictive models are appropriate if you want to do any inferring – only in the last report was there ‘preliminary’ models. Why inappropriate? Need to have a further conversation on standard methods and Selected Areas being able to produce good information to validate what is happening at the larger scale. After reflection prepared to go with inappropriate
Revision comments – Evaluator 2	Not done or either too late to be useful.
Revision comments – Evaluator 3	No validation and it could have been done (for example using TLM data); also no knowledge of what the relationship of the Selected Areas are to the rest of the basin – i.e. Are they representative? No documentation of bias and no indication if bias changes over time. Not described as ‘sentinel’ sites/areas. No census to establish/justify the Selected Area being sampled. Need a different sampling frame, e.g. some indicators/variables are applicable to whole of basin – but it has not been determined if the current variables are relevant at whole of basin. See the earlier response (KEQ 8.5.1) where a more optimal sampling design for a wider spatial scale was described and the same principle apply here.
Consensus final rating	Inappropriate

Mid KEQ 8.6	To what extent was best available knowledge (including scientific, local and cultural knowledge), evidence and analysis incorporated into monitoring and evaluation findings? For Basin Matters and Selected Areas?
Evaluator 1	Appropriate

	<p>Review of the Selected Area technical annual reports indicates that best available scientific and local knowledge was appropriately used to develop the MEPs, to assess the monitoring results, and to evaluate the findings regarding the contribution of CEW to the ecological outcomes.</p> <p>Similarly, review of the Basin Matters reports indicates that best available scientific and local knowledge was appropriately used to assess the Selected Area monitoring results, and other relevant information, and to synthesise this information to evaluate the contribution of CEW to the ecological outcomes Basin-wide.</p> <p>There was no consideration of cultural knowledge.</p>
<p>Evaluator 2</p>	<p>Appropriate</p> <p>Warrego-Darling: To an appropriate extent. The Warrego-Darling annual reports had inputs from University of New England plus, Eco Logical Australia, 2rog consulting, DPI Fisheries and Department of Planning, Industry and Environment – Water. Not sure about input from MDFRC (KEQ015). The M&E requirements document (Gawne et al., 2013f) had input from a range of experts, as did the M&E Plan (CEWO, 2014). Stakeholder consultation is detailed in the Gawne et al., 2013f).</p> <p>Lachlan: As above. The Lachlan SA seem to have good access to expert knowledge and strong collaboration (see KEQ1212).</p> <p>Lower Murray: The Lower Murray had access to a wide range of expertise from SARDI, Department of Environment, Water and Natural Resources, CSIRO, University of Adelaide, EPA, in Fusion Consulting. CVs are provided in the MEP and most people have extensive expertise. Other Selected Areas also used best available knowledge.</p> <p>The Basin Matter reports and annual synthesis reports all contribute to best available knowledge being incorporated into findings.</p>
<p>Evaluator 3</p>	<p>Selected Areas. My assessment is Appropriate (As there is no reason to think more or less consultation is better or worse for extent of presenting scientific findings).</p> <p>Edwards Wakool (Watts et al 2018b). Refer to local and cultural entities in their acknowledgements. Provide anecdotal quotes such as “providing the first contemporary evidence of localised spawning in this species in the study focal area”, (p.13) which infers use of local knowledge.</p> <p>Goulburn River (Webb et al 2020). No apparent references to cultural influences, but include some references to local interest groups. For example “Conservation of the fish fauna of the Goulburn River has been recognised as a high priority by fisheries management and natural resource management agencies”. P.15.</p> <p>Gwydir River (Southwell et al 2019c) No references to local or cultural entities in the findings.</p> <p>Lachlan (Dyer et al 2019 a). No references to local or cultural entities in the findings.</p> <p>Lower Murray (Ye et al 2020a). No specific references to local or cultural entities in presentation of findings.</p> <p>Murrumbidgee (Wassens et al 2020b) Reference to traditional owners in acknowledgements. Reference to “culturally significant old man weed” p. 15.</p> <p>Warrego Darling (Southwell et al 2019a). References to ‘regional context’ which suggests relevance to local knowledge.</p>

	<p>Basin Matters. My assessment is Appropriate (As there is no reason to think more or less consultation is better or worse for extent of presenting scientific findings). The Basin Matters are reported at the Basin-scale, so realistically, the local and cultural knowledge if it was relevant was already covered in the Selected Areas reports.</p> <p>Biodiversity (Hale et al 2020). *typo on cover page! Shane BOOKS!!!*. There are many non-Selected Areas investigated, and there is clear use of local knowledge in evaluating these (for relevant species/communities – e.g. Table 6). Also many references to listed species in all groups suggests use of locally relevant knowledge in design, but also in evaluation.</p> <p>Ecosystem Diversity (Brooks 2020). This one is a whole of basin assessment so there is no local or cultural entity that is relevant. However, there is references to different wetland types within regions and so this infers local knowledge is used anyway. Maybe by the producers of the wetland classification scheme, not the actual Basin Matters report. Either way it is considered totally appropriate.</p> <p>Fish King et al (2020). Again local and cultural relevance would have been at the Selected Area scale, so not really assessable.</p> <p>I stopped reading them now, because they all suffer the same issue. Local and cultural knowledge does not apply when scaling up from SAs to the basin.</p> <p>To my mind, this KEQ is trivial. The providers are scientists who should be independently evaluating the results and presenting findings relevant to the BP and outcomes framework. The scientific, local and cultural interpretation of those findings should be performed by those relevant groups. None of the 5 high level outcomes mention cultural or local knowledge.</p> <p>My assessment is <i>not assessed</i>.</p>
<p>Consensus final rating</p>	<p>Appropriate</p>

<p>Mid KEQ 8.7 How appropriate was the LTIM Basin-scale Evaluation Plan, was it fit for purpose?</p>	
<p>Evaluator 1</p>	<p>Appropriate</p> <p>The purpose of the LTIM project was to: evaluate the contribution of CEW to the objectives of the Murray-Darling Basin Authority’s Environmental Watering Plan; evaluate the ecological outcomes of CEW at each of the seven Selected Areas; infer ecological outcomes of CEW in areas which are not monitored, including impacts on other ecosystem components; and to support the adaptive management of CEW.</p> <p>The LTIM Basin-scale Evaluation Plan established a robust process by which the Selected Area monitoring data (and other relevant information) could be used (Gawne et al., 2014c.d): first, to evaluate the ecological outcomes of CEW at each of the seven Selected Areas; second, to evaluate the contribution of CEW to the objectives of the EWP (Biodiversity, ecosystem processes, resilience); and third, to determine adaptive management lessons.</p>

	<p>Inference of the ecological outcomes in non-monitored areas which received CEW was poorly defined, and appeared to depend upon the development of predictive models that were either not produced or only preliminary versions were available close to the end of LTIM.</p> <p>The Evaluation Plan was fit for purpose as originally devised, but the application and outputs from parts of this Plan were not as complete as expected, for example, see KEQ8.9.</p>
<p>Evaluator 2</p>	<p>Appropriate</p> <p>The Basin Evaluation Plan is:</p> <p>Gawne B, Roots J, Hale J, Stewardson M (2014) Commonwealth Environmental Water Office Long– Term Intervention Monitoring Project: Basin Evaluation Plan. Report prepared for the Commonwealth Environmental Water Office by the Murray–Darling Freshwater Research Centre, MDFRC Publication 42/2014, December, 55pp</p> <p>This was earlier released as three documents:</p> <ul style="list-style-type: none"> • Parts A Evaluation Framework, • Part B Implementation • Part C Project Management and Governance <p>The Plan is of high quality. It describes how the data collected from monitoring each of the Basin Matters at the Selected Areas will be used to evaluate the outcomes of Commonwealth environmental water at the Basin-scale. Extrapolation to non-monitored areas is addressed. Activities are related to basin plan objectives.</p> <p>Some of the promise of the plan did not end up being delivered but the plan itself is exemplary.</p>
<p>Evaluator 3</p>	<p>Moderately Appropriate</p> <p>Moderately fit for purpose. Because the third of the 5 high level objectives is poorly addressed;</p> <p>“3. infer ecological outcomes of Commonwealth environmental watering in areas of the Murray– Darling Basin (MDB) not monitored”. This is acknowledged in the plan by the words “reporting on outcomes and applying findings, to the extent possible, in areas not monitored”.</p> <p>Keeping my response simple for the sake of brevity, consider the steps listed on page 10, notable step 2;</p> <p>“2. Determine the actual outcome of the watering action, as follows:</p> <p>a. For Selected Areas where the expected outcome is monitored, monitoring data provides information on the condition of the system with the watering action.</p> <p>b. For areas where the expected outcome is not monitored, the actual outcome will need to be inferred using multiple lines of evidence including predictions based on conceptual or quantitative models.”</p>

	<p>Step b could have been validated by incorporating existing programs (e.g. TLM and MDBFS sites) as not monitored but modelled/predicted outcomes sites! That is, every year when predictions of responses to EW are made, include other sites that are monitored by other agencies using the same protocols. The models could be validated and calibrated by comparing predicted to actual responses! The relevance of the Selected Areas models to the rest of the basin could be better understood.</p> <p>The other 4 high level objectives are well addressed.</p> <p>Gawne B, Roots J, Hale J, Stewardson M (2014) Commonwealth Environmental Water Office Long– Term Intervention Monitoring Project: Basin Evaluation Plan. Report prepared for the Commonwealth Environmental Water Office by the Murray–Darling Freshwater Research Centre, MDFRC Publication 42/2014, December, 55pp.</p>
Revision comments – Evaluator 1	
Revision comments – Evaluator 2	
Revision comments – Evaluator 3	Four of the five were quite good – happy to go to Appropriate
Consensus final rating	Appropriate – caveat: the modelling process was not well spelt out in the Evaluation Plan for inferring to non monitored sites. No validation of the modelling, led to problems in the whole project.

Mid KEQ 8.8	How appropriate were data management arrangements in supporting capture and making available data generated by the LTIM project?
Evaluator 1	<p>Inappropriate</p> <p>As noted in KEQ1.7, the LTIM project data management arrangements (largely the MDMS) were minimally effective, and were also minimally appropriate for supporting the systematic capture and making available data generated by the project.</p> <p>Data management requirements, formats and templates were initially designed by Brooks and Wealands (2013). However, rather than the purpose-built system proposed by Brooks and Wealands (2013), the CEWO opted for an off-the-shelf system. It appears the CEWO did not have the required data management skills within house to properly service this system. Towards the end of LTIM the CEWO contracted Dr Shane Brooks to get this system in order, which according to feedback in the interviews he did very well.</p> <p>As have been noted elsewhere in this review, the Selected Area teams used their own data management systems and made little use of MDMS.</p>

<p>Evaluator 2</p>	<p>Moderately Appropriate</p> <p>There were major problems with data management during the program but these were sufficiently resolved by the end to allow systematic capture and facilitate data availability.</p> <p>Cross-reference: KEQ 1.7, 8.9.1, 8.9.2, 13.1, 13.2</p> <p>Surprisingly to me, the survey responses (Q26) are generally positive, which, other than “Don’t know”, largely range from “A moderate amount” to “A great deal”.</p> <p>The written survey responses generally point out initial problems that have improve over time:</p> <ul style="list-style-type: none"> • “There have been improvements over the life of the project but this has been painful at times.” • “MDMS got issues at the start and early stage, but its improving” • The MDMS process was really hard for everyone involved. We are still ironing out issues with LTIM data now. • “Great in theory, implementation was extremely cumbersome (and that was with fantastic assistance – so absolutely no criticism of the people involved)”
<p>Evaluator 3</p>	<p>Moderately Appropriate</p> <p>This is another double-barrelled question unfortunately (capture & access).</p> <p>Evaluation based on comments made in “LTIM_Grp1_interviews.docx” copy downloaded 25/08/20. In other words, it’s not a measured or observed evaluation, just a perceived evaluation</p>
<p>Revision comments – Evaluator 1</p>	<p>I think the whole data management was problematic – happy to change to moderate as it ultimately got better.</p>
<p>Consensus final rating</p>	<p>Moderately Appropriate</p>

<p>Micro 8.8.1</p>	<p>KEQ At the Basin-scale?</p>
<p>Evaluator 1</p>	<p>Moderately Appropriate</p> <p>See above</p>

Evaluator 2	<p>Moderately Appropriate</p> <p>Cross-reference: KEQ 1.7, 8.8.1, 8.8.2, 13.1, 13.2</p> <p>As noted above. There were major problems for the first 4 years of the project that were significantly resolved at the final year.</p>
Evaluator 3	<p>Appropriate.</p> <p>Now, not that it was at the start! There has been improvement through time and the small sample size of interviewees who had an opinion tend to be happy and happier now than at the start. This response is in relation to data capture and data access.</p> <p>There was a clear lack of standardised data storage at the start of the program. For example, even though using standardised methods for fish, in the early years the Selected Area teams used different formats for recording some variables.</p>
Revision comments – Evaluator 3	<p>Moderate on the basis that it has improved.</p>
Consensus final rating	<p>Moderately Appropriate</p>

Micro 8.8.2	KEQ	At the Selected Area scale?
Evaluator 1		<p>Moderately Appropriate</p> <p>See above</p>
Evaluator 2		<p>Moderately Appropriate</p> <p>Major problems for much of the project that were resolved in the end, to a significant extent.</p> <p>There was nothing in the SA reports I looked at that mention data or issues.</p> <ul style="list-style-type: none"> • Warrego-Darling: There is nothing in the annual reports about data management. • Lachlan: Very little mention of this. Nothing on Monitoring Data Management System MDMS or data management in the final summary report. • Lower Murray: No mention of this in the SA reports.

	It is clear that SA teams had difficulty inputting data to the MDMS because the Basin Matter teams had a lot of trouble getting data out of it. However, there was no acknowledgement of this in the SA annual reports. Interview and survey responses confirm issues in the early years of the project.
Evaluator 3	Moderately Appropriate There is a tone of unhappiness at the start with improvements over several iterations. These improvements are definitely at the Basin-scale, and it's difficult to evaluate at the Selected Area scale, nevertheless, it is inferred to have improved if the Basin-scale has improved. This response is only in regards to data access, not to data capture.
Consensus final rating	Moderately Appropriate

IMPACT

- 2 high-level KEQs
- 4 mid-level KEQs
- 2 micro-level KEQs

High KEQ 9	To what extent has the LTIM project had an impact in terms of improving water management practices?
Evaluator 1	<p>Moderate Impact</p> <p>Our assessment is that the LTIM project had a moderate impact in improving water management practices in the MDB and through this to informing and improving Basin Plan implementation.</p> <p>However, well documented information (evidence) for this generally agreed (survey, interviews) finding is not available.</p> <p>The final Selected Area and Basin Matters reports (2018-19) generally provide comments on key findings, and implications (or recommendations) for future environmental water management relevant for either a particular Selected Area or Basin-wide. These are useful contributions to the adaptive management of CEW. However, there are very few comments in these report on exactly how environmental watering management practices have changed as a result of the new knowledge generated. One exception was the Goulburn Selected Area (Webb et al., 2020) where it was noted that <i>'the relationships developed between the monitoring team and local, state and federal water managers ... has allowed improved timely decision-making for individual flow actions to maximise the likely ecological outcomes, and has also improved the planning process for annual watering planning'</i>.</p> <p>Additionally, each of the final Basin Matters reports has provided a cumulative evaluation of the contribution of each indicator to Basin Plan objectives over the 5-years of LTIM. These are mostly quite general and say little about how the measured outcomes related to the expected outcomes after 5-</p>

	<p>years, or indeed whether particular conditions (e.g. the very dry conditions that existed over the period 2014-2019 especially in the northern Basin) would have influenced these expectations.</p> <p>It is known that the very good interactions between Selected Area teams and CEWO Water Delivery teams, and the timely input of new knowledge, did result in changed environmental watering management practices, and thus improved Basin Plan implementation. However, the impact of these ‘science-practice partnerships’ on Basin Plan implementation was only moderate because the outcomes were poorly communicated within the LTIM project team and with key stakeholders.</p> <p>The feedback (survey, interviews) has been generally positive regarding the impact of LTIM on environmental water management. It was noted that perhaps LTIM's primary benefit has been the changes in the way CEWO manages its water across particular assets. It was suggested that in the early days of LTIM, water managers did not interact with scientists or read their reports., but this has now changed and has resulted in improvements in CEWO's capacity to deliver environmental water and achieve better ecological outcomes. However, others have suggested that while this is probably true, it is hard to gauge because the decision-making processes are not transparent, a finding also noted in the mid-term review of LTIM by Hart and Butcher (2018).</p> <p>One end-user commented on the impact of the LTIM project in demonstrating the local benefits of managed environmental water events in the Edward-Wakool system. This region has been particularly contentious regarding environmental flows. It was noted that in-stream vegetation responses have been good, as have water quality benefits for salinity, but not for large-scale hypoxic blackwater mitigation or blue-green algae. Another key finding was that there has been limited outcomes for native fish breeding, probably because of the current limited scale of the environmental water flows allowed in this system.</p>
Evaluator 2	<p>Moderate Impact</p> <p>The evaluation of these KEQs are based survey and interview responses.</p>
Consensus final rating	<p>Moderate Impact</p>

Mid KEQ 9.1	What level of impact has the LTIM project had on the adaptive management of environmental water?
Evaluator 1	<p>Moderate Impact</p> <p>See above</p>
Evaluator 2	<p>Moderate Impact</p> <p>The evaluation of impact is based on survey and interview responses.</p>

	<p>Survey response to question 27; the responses are divided between Basin Matters, Selected Areas and the basin. For the Selected Areas, the responses are reasonably positive, ranging from “Somewhat impactful” to “Extremely impactful”. However, for the Basin Matters, about 20% responded “No impact” or “A little impact”. The impact at the Basin-scale was lower than any of the Selected Areas or the Basin Matters.</p> <p>Survey comments were also mixed but there were positive comments associated with some Selected Areas.</p> <ul style="list-style-type: none"> • “...adaptive management learnings...don’t seem to have really been incorporated into adaptive management of water delivery” • “There is a lot of room for more active input into decision making...” • “There have been substantial changes in the management of water in the Lachlan because of this program...” • “There has been little impact on the delivery due to constraints in volumes and coordination” • “The CEWO’s capacity to deliver outcomes, and improve water use has been greatly improved” • “At the start of LTIM, water managers did not interact with scientists, or read their reports. The opposite is true at the end of LTIM” • “...we are all using this knowledge directly to inform if we need to refine that EWR” <p>The interview comments provide positive statements about adaptive management in particular Selected Areas such as the Lachlan, Goulburn and Gwydir, but also concerns about application in other areas and at the Basin-scale:</p> <ul style="list-style-type: none"> • “The data/analysis was important to test responses and adjust, but the rationale for delivery was often not informed by LTIM but rather from other sources” • “I wouldn't say that there's been great uptake... it's still quite early, I think, for those for the LTIM project to have a really significant impact. • “some of the learning from that led to trying some new water delivery patterns in the Gwydir” • “The trade off, saying our data show that vegetation is in good condition at the end of last year, so let's use the spring fresh on perch spawning this year rather than vegetation. So now I think it's had pretty good impacts [in the Goulburn].” • “I think in the Lachlan it's been very impactful” • “From a lower Murray point of view, as I discussed before, we have got a much better understanding of what we can expect with a certain amount of water [and] the way it's delivered” • “I think we've come out with some strong messages, in the end. But whether they'll actually get translated into changing the way that water is delivered, I'm not sure” <p>The difference in sentiment at the Selected Area and Basin-scales was provided by one respondent. They thought local water managers rely on a few contacts for advice and that LTIM has expanded the range of people they are comfortable consulting with. At the Basin-scale, links to decision makers are less direct with consultation required to pass through layers of the bureaucracy.</p>
<p>Consensus final rating</p>	<p>Moderate Impact</p>

Mid KEQ 9.2	How impactful has knowledge gained through the LTIM project been in informing and improving Basin Plan implementation and/or outcomes?
Evaluator 1	Moderate Impact See above
Evaluator 2	Moderate Impact Survey response to question 28; the responses were reasonably positive with 75% including “Somewhat impactful, very impactful or extremely impactful”. The survey comments are mixed which suggest there were impacts at some areas and scales but not at others: <ul style="list-style-type: none"> • “Only somewhat impactful at the Basin-scale” • “Major adjustments have been made to South Australian requests for environmental flows in light of the results from the monitoring program” • “The capacity for the Commonwealth to defend its use of CEW, and justify CEW, has been important” • “The major findings are only now becoming clear and it will take managers and policy makers time to imbed this knowledge in plans and policies” For the Lachlan, there were changes in monitoring as a result of recommendations of the LTIM project with additional monitoring being undertaken upstream of the Selected Area to assess impacts of CEW on fish (Dyer et al., 2019a). Interview comments provide mixed sentiment: <ul style="list-style-type: none"> • “I think this work is being quite impactful in enabling us to fulfil our role in implementing the Basin Plan.” • “I think, we've made it very clear that you can't achieve all of the objectives of the basin plan while you're only delivering water in channel.” • “I think it's been quite effective at the Selected Area, I'm a bit uncertain about the Basin-scale.” • “In terms of implementation, I think it has been quite influential. I think the jury's out in terms of whether the changes are actually going to succeed.”
Consensus final rating	Moderate Impact

High KEQ 10	How impactful have the LTIM project been in fostering improved collaboration?
<p>Evaluator 1</p>	<p>Moderate Impact</p> <p>Stakeholder feedback (survey, interviews) suggests that the LTIM project has had considerable impact in fostering improved collaboration between CEWO Delivery Team and the associated state environmental water managers, and with Selected Area scientists. It was noted that these improved relationships were primarily associated with Selected Area sites, and CEWO water managers responsible for other areas often are 'out of the loop' in terms of information sharing and collaboration.</p> <p>Also highlighted were the advantage of the consortium approach used to establish the Selected Area teams, with university scientists, water agency scientists and environmental water managers, and consultants all working together.</p> <p>Regarding the LTIM projects impact in raising awareness of the CEWO's aims and approach, stakeholder feedback suggests this has been quite effective within Selected Area teams and associated environmental water managers, but minimal with Basin communities</p>
<p>Evaluator 2</p>	<p>High Impact</p> <p>Cross-references: KEQ 8.4</p> <p>The evaluation is based on survey and interview responses as the available reports do not address impact.</p> <p>Survey question 29 addresses this KEQ. There are a broad spread of responses from "No impact" to "Extremely impactful" suggesting people had different experiences.</p> <p>Most of the survey written comments are positive:</p> <ul style="list-style-type: none"> • "The level of collaboration has progressively built over the five years of the program and is now very impressive. • "LTIM has helped improve collaboration, particularly across research organisations" • "LTIM has really helped in working with other agencies" • "Across the Universities it has been impactful – we now see consortium arrangements ... didn't exist 5 years ago" • "The LTIM processes has probably helped to bring environmental water managers, community engagement specialists and researchers together and improve each other's understanding of their roles and the opportunities that can be produced if they work collaboratively." <p>The following themes emerge from the interview comments:</p> <ul style="list-style-type: none"> • challenges in collaboration between the Basin Matter and Selected Area teams and the need for a stronger bridge between them

	<ul style="list-style-type: none"> • Successful collaboration at the Selected Area scale between NRM organisations, universities, research organisations and government • Scientific collaboration to utilize a range of skills • The need for more collaboration as people are actually monitoring similar systems, e.g. wetlands, in different areas. • Improvements in collaboration with time. Ironically, some of this was because of the problems with the MDMS. Basin Matter teams had to collaborate with Selected Area teams to get the data they needed because it was not available in a data base. <p>There were many comments that collaboration could have been better and should receive an increased focus in future projects.</p>
Revision comments – Evaluator 1	
Revision comments – Evaluator 2	Based on discussion re micro – agree to have this as moderate
Consensus final rating	Moderate impact

Mid KEQ 10.1	What impact has the LTIM project had on partnership mechanisms and initiatives to build stronger coherence and collaboration between participating organisations?
Evaluator 1	<p>Moderate Impact</p> <p>Stakeholder feedback (survey, interviews) suggests that the LTIM project has had considerable impact in fostering improved collaboration between CEWO Delivery Team and their associated state environmental water managers, and with Selected Area scientists. However, the feedback suggests that the project has had low impact on improving the collaboration between environmental water managers (federal and state) and the Basin Matters team.</p>
Evaluator 2	<p>High Impact</p> <p>Survey question 30 addresses this KEQ. There is a broad range of response, more positive at the Selected Area scale rather than the Basin-scale or associated with Basin Matters.</p> <p>There are relatively few survey comments, but they are generally positive.</p> <ul style="list-style-type: none"> • “It’s been a good opportunity to achieve more collaboration between partner organisations” • “There is a lot of collaboration between the CEWO and relevant water management agencies which has come about through the LTIM project”

	<ul style="list-style-type: none"> “...this is improving. If you look at where it started, we have come a long way.” “Has probably helped build relationships in those catchments with an LTIM site. However, those within CEWO who don’t manage an LTIM site are often ‘out of the loop’ in terms of information sharing and collaboration” <p>There are few interview responses but there are indications of collaboration at the Selected Area scale. One interviewee mentions a “Collaboration Forum”, a meeting between Selected Area leads. Another a Collaboration project which where all of the Basin Matters teams were to work together to build predictive models.</p>
Revision comments – Evaluator 1	
Revision comments – Evaluator 2	Based on micro KEQs agree to have this as moderate
Consensus final rating	Moderate Impact

Micro KEQ	At the Basin-scale?
10.1.1	
Evaluator 1	See above
Evaluator 2	<p>High Impact</p> <p>There were a range of mechanisms to promote collaboration amongst the LTIM project team:</p> <ul style="list-style-type: none"> Annual forum Collaborative forum amongst Selected Area leads Fish methods refinement workshop A collaboration project to build predictive models Basin Matter workshops for vegetation, ecosystem diversity, and biodiversity <p>The acknowledgement section in the first Basin Matter report for hydrology includes a long list of people suggesting collaboration at the Basin-scale (Stewardson and Guarino, 2016a).</p>

Revision comments – Evaluator 1	My argument all the way through – is I don't think they did terribly well in collaboration. CRC collaboration was good – meetings were annual and more frequent for different purposes – well funded, and with knowledge brokers – helped enormously – dedicated to improving collaboration. Peter Cullen was very strong on collaboration.
Revision comments – Evaluator 2	What would good collaboration look like? Thinking back to the example of the CRCFE there are some options to encourage collaboration, has as knowledge brokers. Happy to change to moderate.
Consensus final rating	Moderate Impact

Micro 10.1.2	KEQ	At the Selected Area scale?
Evaluator 1		Moderate Impact See above
Evaluator 2		High Impact Interview and survey responses suggested there was successful collaboration at the Selected Area scale. Warrego-Darling: The Acknowledgment sections of the annual reports suggests links between University of New England, consultants (Eco Logical and 2rog), CEWO, DPI fisheries, NSW Office of Water, NPWS staff at Toorale National Park and State Conservation Area. Dr Fiona Dyer from the Lachlan LTIM team. There was also cooperation with Homesteads at Yanda and Akuna. Lachlan: A large number of people are acknowledged in reports and there seem good relationships with other organisations such as DPI Fisheries. Lower Murray: Large team, from a range of organisations have worked together. For the Goulburn there was an annual forum. Similar in other Selected Areas
Revision comments – Evaluator 1		

Revision comments – Evaluator 2	Tentative information initially – happy to down grade after discussions with evaluator.
Consensus final rating	Moderate Impact

Mid KEQ 10.2 To what extent has the LTIM project raised awareness of the CEWO's aims and approach across the communities of the Basin?	
Evaluator 1	Moderate Impact Stakeholder feedback (survey, interviews) suggests that the LTIM project has had a moderate impact in raising awareness of the CEWO's aims and approach with Selected Area teams and other associated environmental water managers, but low impact with Basin communities.
Evaluator 2	Insufficient Evidence There is no information available to evaluate this KEQ
Revision comments – Evaluator 1	I would say agree with evaluator 2 – no evidence at all. If focus at communities at the basin level – there may be five or six key people. Gwydir and Warrego did a better job -
Revision comments – Evaluator 2	It would relate to what the communities thought about the program. Nothing in the interviews really either, This will be insufficient evidence and will be captured by Stage 2.
Consensus final rating	Insufficient Evidence

EFFICIENCY

- 4 high-level KEQs
- 7 mid-level KEQs
- 15 micro-level KEQs

High KEQ 11 How efficiently has the LTIM project achieved its objectives and outcomes?	
Evaluator 1	Moderately Efficient

	<p>The LTIM project has been moderately efficient in achieving its objectives and outcomes.</p> <p>The initial program logic and rationale for LTIM was focused largely on the Basin-wide assessment of the contribution of CEW to Basin Plan ecological outcomes, using information provided by the seven Selected Area monitoring teams.</p> <p>Implementation of the Selected Area monitoring programs appears to have been technically efficient; these programs are complex logistically and require considerable flexibility in responding to environmental watering actions. Further, the preparation of annual Selected Area evaluations reports appears to have been done efficiently, with the separate sections of the Technical Reports prepared by the relevant expert team member.</p> <p>Regarding the Basin Matters annual Synthesis reports, the task of evaluating the contribution of CEW (and other environmental water) on the broad Basin Plan objectives – biodiversity, ecosystem processes, resilience and water quality and salinity - was completely new and had not been done before at this Basin-scale either within Australia or overseas (see KEQ11.2.2). This required the integration of information from the six Basin Matters reports, and additionally, obtaining and integrating additional information from non-monitored area within the Basin that received CEW. These reports also showed evidence of improvements in the evaluation methods over the 5-year period but were not produced on time.</p> <p>Given the fact that this was a new and complex task, the difficulties in obtaining relevant information, and the fact that there were improvements over time in the evaluation process, the Basin-wide is assessed as moderately efficient.</p> <p>This Evaluator had insufficient information on exactly how the allocated funds were spent and was not able to assess the efficiency with which resources and time were allocated to address the LTIM project objectives.</p>
Evaluator 2	<p>Moderately Efficient</p> <p>The LTIM project has been moderately efficient in achieving its aims and outcomes. This evaluation of based on the meso and micro KEQs below along with survey responses. There was a lack of data to evaluate most of these KEQs so this overall evaluation is aggregated from the information that is available.</p> <p>Efficiency was addressed in the survey, question 31. Most responses range from “Somewhat efficiently to Extremely efficiently” with more positive ratings for Selected Areas compared to Basin Matters or the Basin-scale.</p>
Consensus final rating	<p>Moderately Efficient</p>

Mid KEQ 11.1	How efficiently were the funds and time allocated to address the LTIM project objectives?
Evaluator 1	<p>Insufficient Evidence</p> <p>This Evaluator has not rated this KEQ because of insufficient information on how exactly the allocated funds were spent. However, on the face of the information available my assessment is that the Selected Area look to have been well funded, while the Basin Matters team has been underfunded, particularly the preparation of the Synthesis reports.</p>

	<p>As noted above this evaluation has limited information on the allocation of funds to the Selected Areas and the Basin Matters team (Gawne et al. (2014a – Table 1); CEWO (2019 – Tier 3 Project Plan, Version 3.2, page 46). These documents indicate that the budgets for the Selected Areas ranged from around \$2.7-4.4 million over the 5-years and for the Basin Matters team around \$4.0 million. Also, over the 5-years, CEWO allocated an additional ca. \$622,000 for special monitoring of frogs, birds, blackwater and algae.</p> <p>The fact that the Basin Matters team received approximately the same funding as each Selected Area suggests an inequitable distribution of funds, particularly given the initial focus of LTIM was on Basin-scale evaluation. This relatively low funding for the Basin Matters team may also provide the reason for the relatively low impact and effectiveness of the Basin-scale evaluations.</p> <p>Feedback from the interviews suggests that the cost of the fish programs in each Selected Area were very high, being perhaps 40-50% of the total budget. Additional feedback was that Selected Area team members contributed a considerable amount of in-kind time to the project.</p>
<p>Evaluator 2</p>	<p>Moderately Efficient</p> <p>This evaluation is tentative as it is based on little information. For example, there is no information available on internal Selected Area budgets.</p> <p>Summary of the financial information that I have access to is as follows ¹¹.</p> <p>Total project budget \$32.3 million.</p> <p>Monitoring and Data Management System \$1.261 million (3.9% of the total budget)</p> <p>The M&E Advisers had a total contracted amount of about \$6 million (18.6% of the total project budget) which presumably includes the cost of all the Basin Matters teams and support of the MDMS. The Selected Area budgets ranged from \$2.7 million (8.3%) to \$4.4 million (13.6%). The total SA budget is about 80% of the total LTIM budget. The does seem high when the project was focused on outcomes at the Basin-scale.</p> <p>The budgets listed in Gawne et al. (2014) (Basin evaluation Part C) provide some information on time allocated to tasks. These would likely have changed throughout the project but can be compared with the initial LTIM budget of \$23.43 million.</p> <p>This suggests the project management was budgeted at about 3% of the initial total project fee which seems reasonable for a complex project. The relative cost of each of the Basin Matter components, based on time allocations were: Ecosystem diversity 1, Biodiversity 1.5, Fish 2.9, Stream metabolism and water quality 3.0, Vegetation diversity 4.7, Hydrology 12.0. The hydrology budget does not include in-kind contribution from the MDBA which are relied on in the Hydrology foundation report. This makes hydrology seem expensive but it also possibly had a larger scope, providing a report card for most catchments in the basin. However, the initial expectation was that Basin-scale reporting would be provided for all Basin Matters.</p>

¹¹ Financial information taken from Commonwealth Environmental Water Office (not dated) Tier 3 Project Plan Long Term Intervention Monitoring Project. Version 3.2. and Gawne B, Everingham P, Hale J (2014) Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Basin Evaluation Plan – Part B: Implementation. Report prepared for the Commonwealth Environmental Water Office by the Murray–Darling Freshwater Research Centre, MDFRC Proposal 486/2014 revised July 2015, August, 37pp.

In the interviews, there were comments that there was insufficient time budgeted to critical reports such as the Basin Synthesis report – “A handful of days”. This is not consistent with the budget in Gawne et al. (2014) (Basin evaluation Part C) which suggests there were 40 to 50 days per year allocated to this task, which seems reasonable, provided there was sufficient information being fed upward by the Basin Matters reports.

The themes from the interview responses for this KEQ are:

- A concern that too much time was spent on reporting and reviewing reports. The issue related to reviews was the large number of organisations that were provided with opportunities for review.
- Reports could have been better focussed to meet objectives. This also relates to the timing and frequency of reports which could have been better timed to meet the needs of water managers.
- Insufficient time spent on communication and collaboration within and between teams (although some others suggest the annual forum, where this issues was addressed, was an inefficient use of resources).
- Insufficient allocation of resources to modelling. The lack of modelling made it challenging to meet project objectives related to reporting on the influence of CEW at the basin-scale.

Relevant interview comments about efficiency in addressing objectives:

- “There was an awful lot of added value in what has been provided under the LTIM project and a substantial amount of scope creep so the CEWO have received substantially more than paid for.”
- “...the time required, and expected, to provide the information (including reporting) was massively more than was budgeted”.
- “...expensive but inefficient project management and administration”
- “We could have used those resources better. I don't think those once a year, bigger than Ben Hur forums were good value for money.”
- “Like to see less resources going into reporting. I think our reporting requirements...were massive compared to where other resources were. And being involved in that reporting process, it is very labour intensive”
- “...instead of delivering the report, deliver a paper plus a workshop might actually be a more efficient way of both giving value to the researchers, but also helping engage the managers in a conversation about what the data means. ... How effective is writing that report in terms of getting the message across to the managers? I suspect that...not many people read those reports.”
- “And also just the review process as well. ...t's always great to have their input, but I just found sometimes that the different rounds of review for this document that we produce every year, there is a lot of time that goes into that. And you just wonder whether some of those resources can be shifted elsewhere.”
- “The annual reporting might be a little inefficient. Given How few people evidently read those reports.”
- “The thing that was particularly inefficient was trying to extract commonalities across Selected Areas. So every Selected Area produced a report in a different format and a different template. And there wasn't a lot of structured reporting consistently applied across Selected Areas that will enable you to then pull out common outcomes or things like that.”

	<ul style="list-style-type: none"> • “I think there was an awful lot of resources that got swallowed up and vanished and not put towards effective tasks. An awesome amount of Basin-scale budget got sucked up into project administration at the start of the project.” • Comment on the efficiency of Selected Area and Basin Matter teams working together. “So I think having the Selected Area experts working together with the Basin team to kind of work out what the questions are and design the program would be potentially more efficient.” • “But I think the other major gap that this gets in the way of adaptive management is knowledge management. And there is no consistent knowledge management framework for the Basin plan.” • “I think the problem with a lot of science communication is it is delivered when the project’s ready to deliver, which doesn't necessarily coincide, in fact, almost never coincides, with when the client or the end-users are ready to use it.” • “Yes and no. I mean, I overall, I think the quality of the data sets is good. But I think a lot of the reports, I actually don't think are particularly high quality. I think the information content for their length and the amount of effort that had to go into producing them is low.” • “So clearly when the models haven't been developed, that's something that we obviously didn't allow enough resources for.” • “I think modelling was one of the greatest weakness. So in hydrology, we didn't have access to the modelling to run scenarios on the whole, apart from the Murray. And I think that’s probably the next area for the ecological responses ... That needs to be kind of a stronger investment in a model based evaluation rather than just simply a statistical analysis of a factorial experiment.” <p>A standout efficiency issue relates to the Monitoring Data Management System which did not perform as expected until toward the end of the project after additional funds were allocated by CEWO. The cost of the MDMS, at 3.1% of the total project budget, seems reasonable, but performance of the system was clearly below expectations.</p>
<p>Revision comments – Evaluator 1</p>	<p>Big question re funding and should be done more quantitatively. Need to be careful about what could be said here about finding and use of resources.</p>
<p>Revision comments – Evaluator 2</p>	<p>Happy to say insufficient as no internal budget on Selected Areas. There are some interesting outcomes – the Basin Matter funding was about the same as <i>each</i> of the Selected Areas yet the program had a basin focus. Ecosystem diversity delivered a good outcome for little investment.</p>
<p>Consensus final rating</p>	<p>Insufficient Evidence</p>

Micro KEQ At the Basin-scale and by Basin Matter?
11.1.1

<p>Evaluator 1</p>	<p>Insufficient Evidence</p> <p>This Evaluator has not rated this KEQ because of insufficient information on how exactly the allocated funds were spent. However, on the face of the information available my assessment is that the Selected Area look to have been well funded, while the Basin Matters team has been underfunded, particularly the preparation of the Synthesis reports.</p> <p>The fact that the Basin Matters team received approximately the same funding as each Selected Area suggests an inequitable distribution of funds, particularly given the initial focus of LTIM was on Basin-scale evaluation. This relatively low funding for the Basin Matters team may also provide the reason for the relatively low impact and effectiveness of the Basin-scale evaluations.</p> <p>Feedback from the interviews suggests that the cost of the fish programs in each Selected Area were very high, being perhaps 40-50% of the total budget. Additional feedback was that Selected Area team members contributed a considerable amount of in-kind time to the project.</p>
<p>Evaluator 2</p>	<p>Moderately Efficient</p> <p>The Basin Matter teams did produce good work and generally met their objectives, as discussed elsewhere. This section focusses specifically on inefficiencies.</p> <p>Comments from interview and survey related to Basin-scale and Basin Matters:</p> <ul style="list-style-type: none"> • “fish completely over allocated, vegetation under allocated” • How efficient was the data sharing between Selected Areas and the Basin Matter team? “Inefficient, inefficient, very inefficient” • “Well, I think the inefficiency is that the quantity of reporting was too great and disproportionate to the outcomes. ... some of the other Basin Matters, having to produce a lot of work early on when there was incredible amounts of uncertainty - I think that was probably an inefficient process. Those resources could have been better spent improving the modelling or something else.” <p>Early in the project the predictive modelling to be done by Basin Matter teams was a key task in enabling LTIM to meet project objectives. The fact that this was done late, or not at all suggests an inefficiency, as this prevented extrapolation of results to unmonitored areas both within Selected Areas and at the Basin-scale.</p>
<p>Revision comments – Evaluator 1</p>	
<p>Revision comments – Evaluator 2</p>	<p>I agree there was little evidence to evaluate this KEQ.</p>
<p>Consensus final rating</p>	<p>Insufficient Evidence</p>

Micro 11.1.2	KEQ	At the Selected Area scale?
Evaluator 1	Insufficient Evidence	See argument given in KEQ11.1
Evaluator 2	Insufficient Evidence	<p>Unfortunately, no information was available on internal budgets for the Selected Areas.</p> <p>There is a small amount of data that is possibly related to this KEQ as summarised here.</p> <p>Warrego-Darling: Some things were monitored that were not recommended or agreed in earlier planning e.g. Water bird diversity and macroinvertebrates. Funds for this work may have been better directed to other projects.</p> <p>Lachlan: The reports suggest that there was monitoring of areas that were unlikely to respond to CEW and lack of monitoring of areas that were likely to respond. See KEQ 4.1.4.</p> <p>Lower Murray: The impression is that there was insufficient environmental water to achieve ecological outcomes so there was a lot of monitoring with few results. The expected outcomes listed in the MEP include fish responses: increased spawning, increased larval abundance and increased recruitment. These were not detected. There were early indications that a response was unlikely but this issue was not addressed.</p> <p>Murrumbidgee: There are concerns that there was too much focus on wetlands and too little on other responses.</p> <ul style="list-style-type: none"> • “So the Murrumbidgee completely focuses on wetlands. When you're in the office, it was like it's not about wetlands, are we delivering flows for these purposes? But somehow that Selected Area is focused on wetlands.”
Consensus final rating	Insufficient Evidence	

Mid KEQ 11.2	How technically efficiently was the LTIM project implemented - were the optimal methods of producing the outputs adopted?	
Evaluator 1	Moderately Efficient	<p>This KEQ is focused on how technically efficiently the LTIM project was implemented, in particular on the intended quality and quantity of the deliverables, and on whether there were improvements over time.</p> <p>The initial program logic and rationale for LTIM was focused largely on the Basin-wide assessment of the contribution of CEW to Basin Plan ecological outcomes, using information provided by the seven Selected Area monitoring teams. However, this ‘top down’ approach was contested by the Selected</p>

	<p>Areas, such that the current LTIM project is more centred around ecological outcomes at local Selected Areas (Hart and Butcher, 2018). This change caused much disruption to the project and was very inefficient.</p> <p>Implementation of the Selected Area monitoring programs appears to have been technically efficient; these programs are complex logistically and require considerable flexibility in responding to environmental watering actions. Further, the preparation of annual Selected Area evaluations reports appears to have been done efficiently, with the separate sections of the Technical Reports prepared by the relevant expert team member.</p> <p>Regarding the Basin Matters annual Synthesis reports, the task of evaluating the contribution of CEW (and other environmental water) on the broad Basin Plan objectives – biodiversity, ecosystem processes, resilience and water quality and salinity - was completely new and had not been done before at this Basin-scale either within Australia or overseas (see KEQ11.2.2). This required the integration of information from the six Basin Matters reports, and additionally, obtaining and integrating additional information from non-monitored area within the Basin that received CEW. These reports also showed evidence of improvements in the evaluation methods over the 5-year period, but were not produced on time.</p> <p>Given the fact that this was a new and complex task, the difficulties in obtaining relevant information, and the fact that there were improvements over time in the evaluation process, the Basin-wide is assessed as moderately efficient.</p> <p>There is insufficient information to determine the extent to which the intended Basin Matters and Selected Area deliverables were achieved within the resources available to each.</p>
<p>Evaluator 2</p>	<p>Moderately Efficient</p> <p>This evaluation is mainly based on interview responses. The main themes are as follows:</p> <ul style="list-style-type: none"> • Fish methods, and possibly metabolism are costly and could be more efficient. • Some thought the Cat 1 methods were costly, while others were not sure of the contribution of Cat II or Cat III methods. • There was also a pointer to more efficient methods of data collection. <p>Relevant comments from the survey and interviews about methods:</p> <ul style="list-style-type: none"> • “The one thing we could probably more be more efficient in was the immediate capture of data into an electronic format. So using a data entry system as collecting data rather than paper sheets and then going back to the office and transcribing data into a database. Having not done a lot of fieldwork in the last 15 years, I don't really know how feasible that is, but you could save a lot of time on that step.” • “Fish had a huge investment. So in some Selected Areas, they made up more than 40 or 50 percent, some from 60 percent of the budget. And that amount of money was then shifted to, say, a government provider, because only that government provider had the infrastructure. So I'm talking about electrofishing. They all had to subbie out the electrofishing to the NSWs or Victorians. And that was super costly. Did that need to be done, I don't know.” <i>(note I have not been able to verify the actual budget spent on fish monitoring in each Selected Area).</i> • “The Cat 1 methods were not very cost effective and took up a big proportion of Selected Area budgets”

	<ul style="list-style-type: none"> • “I think the challenge around the Cat1 was that they didn't, you know they were designed without a budget.” • “There is always an argument about fish. We allocate an enormous amount of money to fish and whether it's really worth it in the long run... So I guess the fish is one of the areas where, with better linkages between Basin-scale condition assessment and intervention assessment, I reckon you could probably save a bit of money and get a better outcome.” • “I guess, spending so much money on, yes metabolism and fish. They could have been more efficient and we could have worked those a little better, I think.” • “... some of the area focused monitoring [Cat II and III indicators]. ... while it represented value, I'm not sure it contributed as much to telling this story as some of the standard approaches.” • “there were some things that we didn't think about. I'm never quite sure what happened with the Northern basin metabolism stuff. I mean, you know, it doesn't work in a non-flowing system”... they ... put loggers in still water and then found bizarre signals... And then they had one year that they lost them all.”
Consensus final rating	Moderately Efficient

Micro 11.2.1	KEQ	At the Basin-scale and by Basin Matter?
Evaluator 1	Moderately Efficient	<p>The production of the Basin Matters annual reports was quite inefficient given the difficulties experienced in obtaining relevant Selected Area data either from the MDMS data base or from the Selected Area teams.</p> <p>Further, the production of the annual Synthesis reports was also inefficient given the difficulty in obtaining relevant information on areas that receive CEW but were not monitored as part of LTIM (e.g. Macquarie Marshes; Barmah Forest, Hattah Lakes). Hart and Butcher (2018) also noted this issue and recommended that <i>‘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.’</i></p>
Evaluator 2	Inefficient	<p>Major inefficiencies in meeting objectives at the basin sale were the related problems of obtaining good data from the Selected Areas, and building models to provide counter factuals to compare with outcomes of CEW and use predictive models to extrapolate to unmonitored areas.</p> <p>Other issues are noted at KEQ11.2 and KEQ11.1.</p>

Revision comments – Evaluator 1	All they tried to do is to take the Selected Area data – but depends on the selection of sites, so it’s a question of if the Selected Areas were the right mix/structure. Counter factual for hydrology was fine/doable, but for fish it’s a totally different question – much harder and not necessarily even possible.
Revision comments – Evaluator 2	Fundamentally they didn’t get very far with the Basin-scale in the life of the project. The models will drive the
Consensus final rating	Inefficient

Micro 11.2.2	KEQ	At the Selected Area scale?
Evaluator 1	Moderately Efficient	<p>The Basin Matter team were required to provide annual reports containing their evaluation of the contribution of CEW (and other environmental water) on the outcomes of six ecological (and hydrological) indicators Basin-wide. This task was completely new and had not been done before at this scale either within Australia or overseas.</p> <p>This Evaluator has rated the hydrology and ecosystem diversity Basin Matter reports as having been efficiently produced, and notably had develop new and improved methods for processing and presenting the relevant data, and showed continual improvement in the approach developed over the 5-year period. The other Basin Matters reports (vegetation diversity, fish, biodiversity and metabolism and water quality) were moderately efficiently produced given the available resources and the difficulties experienced in obtaining relevant Selected Area data either from the MDMS data base or from the Selected Area teams. These also showed evidence of continual improvement in the evaluation methods over the 5-year period. None of these six annual Basin Matters reports were produced on time.</p> <p>The preparation of the Basin Matters Synthesis reports was particularly challenging. These required the integration of information from the six Basin Matters reports and evaluation of the contribution of CEW to the broad Basin Plan objectives – biodiversity, ecosystem processes, resilience and water quality and salinity. Additionally, this required obtaining and integrating additional information from non-monitored area within the Basin that received CEW. These reports also showed evidence of improvements in the evaluation methods over the 5-year period. Again, none of these annual Synthesis reports was produced on time.</p>
Evaluator 2	Moderately Efficient	Comparing annual reporting with MEPs suggest that most planned deliverables were achieved satisfactorily. The main gap seems to be the extrapolation of data to unmonitored areas both within the Selected Areas and to the basin more broadly
Consensus final rating	Moderately Efficient	

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Micro 11.2.3	KEQ	To what extent were the intended quality and quantity of deliverables, achieved within the available resources for each Basin Matter?
Evaluator 1	Moderately Efficient	<p>The Basin Matter team were required to provide annual reports containing their evaluation of the contribution of CEW (and other environmental water) on the outcomes of six ecological (and hydrological) indicators Basin-wide. This task was completely new and had not been done before at this scale either within Australia or overseas.</p> <p>This Evaluator has rated the hydrology and ecosystem diversity Basin Matters reports as having been efficiently produced, and notably had develop new and improved methods for processing and presenting the relevant data, and showed continual improvement in the approach developed over the 5-year period. The other Basin Matters reports (vegetation diversity, fish, biodiversity and metabolism and water quality) were moderately efficiently produced given the available resources and the difficulties experienced in obtaining relevant Selected Area data either from the MDMS data base or from the Selected Area teams. These also showed evidence of continual improvement in the evaluation methods over the 5-year period. None of these six annual Basin Matters reports were produced on time.</p> <p>The preparation of the Basin Matters Synthesis reports was particularly challenging. These required the integration of information from the six Basin Matters reports and evaluation of the contribution of CEW to the broad Basin Plan objectives – biodiversity, ecosystem processes, resilience and water quality and salinity. Additionally, this required obtaining and integrating additional information from non-monitored area within the Basin that received CEW. These reports also showed evidence of improvements in the evaluation methods over the 5-year period. Again, none of these annual Synthesis reports was produced on time.</p>
Evaluator 2	Moderately Efficient	<p>Monitoring was well done. Modelling was delayed or not done. Adaptive management lessons from some Basin Matter themes were not particularly strong for ecosystem diversity and vegetation.</p>
Consensus final rating	Moderately Efficient	

Micro 11.2.4	KEQ	To what extent is there evidence that the LTIM project has continued/attempted to improve, by finding better or lower cost ways to deliver outcomes?
Evaluator 1	Insufficient Evidence	<p>This Evaluator has no evidence that the LTIM project (presumably mainly CEWO) attempted to find lower cost ways to deliver outcomes.</p>

<p>Evaluator 2</p>	<p>Efficient</p> <p>Relevant interview responses include:</p> <ul style="list-style-type: none"> • “the last couple of years where I've been involved, there has been an evolution of the reports getting a lot better and answering the foundation report questions a lot more clearly” • “when we found efficiencies within our project, I guess we expanded our program.... We went back to CEWO and said we've been able to do things more efficiently in the first year and said, ‘do you mind if we expand our number of sampling sites?’. So, we expanded to fit the budget. • “LTIM did not actively embrace new and emerging technologies (UAVs, eDNA). Methods were locked in which provided standardised approaches but had the effect of discouraging new methods. (Caveat – this did not mean that new technology was not used, but rather that the effort required to obtain approval was high).” • “early feedback on fish was that it was taking people an enormous amount of time ... so we did make some modifications to the fish method to help make that faster. • “The first round of reports...I don't think anyone was particularly happy with what came out. And that started with the area reports and went all the way through. ... so there was definitely a learning curve and a capacity development process...I suspect that there is still room for improvement.” <p>One respondent mentions documenting improvements in methods via emails to CEWO as part of seeking approval for these new methods.</p> <p>There is evidence of continual learning. Vegetation and ecosystem diversity held collaborative workshops to resolve issues at the end of the project. There were serious attempts to address data issues for vegetation and fish. Hydrology attempted to resolve issues around inundation monitoring and came up with a work around when the original plans could not be achieved. Stream metabolism had to overcome data issues in the Warrego-Darling. In the Lachlan, additional monitoring was undertaken upstream of the original Selected Area to assess fish response to environmental flows.</p> <p>There also appears to have been tension between adopting new, potentially more efficient methods, and the need to maintain consistency with earlier data collected by agreed methods</p>
<p>Revision comments – Evaluator 1</p>	<p>I think this micro KEQ should be insufficient evidence.</p>
<p>Revision comments – Evaluator 2</p>	<p>Could only be based on what was said. There is examples of continued learning, but not really good evidence, there is some, but no direct evidence. Agree to insufficient evidence according to rubrics.</p>

Consensus final rating	Insufficient Evidence
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High KEQ 12 How efficient was the collaborative process within the LTIM project?	
Evaluator 1	<p>Moderately Efficient</p> <p>It is clear from the survey and interviews that the initial LTIM project did not place much focus on the need for collaboration between the various teams. And while collaboration across the LTIM project did improve after the first 2-3 years, this lack of collaboration could have been reduced if there had been a consolidated LTIM project collaboration and communications plan from the start. Additionally, and probably related, there is essentially no documentation of the efforts to facilitate collaboration and the outcomes from these efforts.</p>
Evaluator 2	<p>Moderately Efficient</p> <p>The importance of collaboration appears to have been underestimated in the early stages of LTIM. Interview responses suggest collaboration could have been better between the Basin Matters team and the Selected Areas teams. There was also potential to improve collaboration between Selected Areas teams. Generally the annual forums seemed to work well, had good engagement and were thoroughly reported.</p>
Consensus final rating	Moderately Efficient

Mid KEQ 12.1 How efficient was the LTIM project in taking up opportunities for joint activities, pooling of resources and mutual learning with other organisations and networks?	
Evaluator 1	<p>Moderately Efficient</p> <p>It appears from the interviews that there was considerable collaborative activity within the LTIM project, particularly in years 3-5, and with state agency water managers. However, this was not driven by a consolidated LTIM project collaboration and communications plan, and is poorly documented. For this reason, it is difficult to assess the efficiency of the collaboration that occurred.</p> <p>Stakeholder feedback (survey, interviews) suggests that collaboration between Basin Matters team members was moderately efficient, with MDFRC/Centre for Freshwater Ecology (CFE) coordinating the interactions between relevant MDFRC/CFE staff and expert consultants engaged by Centre for Freshwater Ecology. However, as reported in KEQ10, collaboration between the Basin Matters and Selected Area teams was limited and inefficient. This was made clear by Hart and Butcher (2018) in their mid-term review, and as a result we understand that CEWO made an allocation of extra funds in 2017 to assist with improving collaboration. The Basin Matters team did make efforts to collaborate with other agencies and individuals working in non-LTIM areas that received CEW, but we have no evidence of the efficiency of these interactions.</p> <p>Collaboration within Selected Area teams was effective (see KEQ1.6 and KEQ10) and efficient, particularly those between the scientists and environmental water managers. Stakeholder feedback was very positive about the success of these collaborations. Collaboration between the seven Selected Area teams</p>

	did occur though special workshops and other interactions, but it was difficult to assess the efficiency of these collaborations since little has been reported on where they occurred, what was discussed and what were the outputs.
Evaluator 2	Moderately Efficient This varies between Basin Matters teams, with some taking up opportunities, others less so. There was generally good collaboration at many of the Selected Areas.
Consensus final rating	Moderately Efficient

Micro 12.1.1	KEQ	At the Basin-scale and by Basin Matter?
Evaluator 1		Moderately Efficient Stakeholder feedback (survey, interviews) suggests that collaboration between Basin Matters team members was moderately efficient, with MDFRC/Centre for Freshwater Ecology (CFE) coordinating the interactions between relevant MDFRC/CFE staff and expert consultants engaged by Centre for Freshwater Ecology.
Evaluator 2		Moderately Efficient Biodiversity: Collaboration with MDBA for water bird data, GeoScience Australia for inundation data and use of the Wetland Insight Tool data. Work with CSIRO (Heather McGuinness), NSW DPIE (Jennifer Spencer) Ecosystem diversity: Collaboration with Geoscience Australia; held a collaborative workshop. Fish: Collaboration with NSW fishers at some SAs. Workshop in 2015 to resolved issues. Hydrology: Collaborated with CEWO, MDBA, VEWH, Water HSW, GMW, DEW, OEH, Mallee CMA, North Central CMA, Goulburn-Broken CMA, Geoscience Australia. Stream metabolism and water quality: Limited collaboration, no use of water quality data from the gauged network. Vegetation: Held a collaborative workshop in March 2020 which was organised by Fiona Dyer (Lachlan SA lead, and Cherie Campbell).
Consensus final rating		Moderately Efficient

Micro 12.1.2	KEQ	At the Selected Area scale?
Evaluator 1		<p>Moderately Efficient</p> <p>Collaboration within Selected Area teams was effective (see KEQ1.6 and KEQ10) and efficient, particularly those between the scientists and environmental water managers.</p> <p>Stakeholder feedback was very positive about the success of these collaborations. Collaboration between the seven Selected Area teams did occur though special workshops and other interactions, but it was difficult to assess the efficiency of these collaborations since little has been reported on where they occurred, what was discussed and what were the outputs. Have rated collaborations at Selected Area scale as Moderately Efficient – many opportunities were lost.</p>
Evaluator 2		<p>Moderately Efficient</p> <p>All the Selected Areas appear to have had good consultation at the stage of developing the requirements reports at the start of the project.</p> <p>Warrego-Darling: Collaboration with Lachlan LTIM, Collaboration with Toorale NP managers.</p> <p>Lachlan: Used water quality data from partner organisations. Good links to NSW fisheries.</p> <p>Lower Murray: No particular evidence of collaboration in the final SA report. However the Lower-Murray SA team was already large and included SARDI, University of Adelaide and CSIRO. It may have been difficult to find other people, outside this team, to engage with.</p>
Consensus final rating		Moderately Efficient

Mid KEQ 12.2	How efficient was the Annual Forum in improving collaborative processes?	
Evaluator 1		<p>Moderately Efficient</p> <p>There is evidence from both the surveys and interviews that the Annual Forums were a moderately efficient mechanism for improving collaboration.</p> <p>The Basin Matters and Selected Area teams all engage in the Annual Forums. The outcomes of these Annual Forums are well documented in the report produced after each Forum. In KEQ1.2, we assessed that these were effectively organised, convened and reported on, and were also effective in improving collaboration between the Selected Area teams, Basin Matters teams, environmental water managers and other stakeholders. However, it is difficult to assess the efficiency of the Annual Forums in improving collaboration since we have insufficient information on the resources and time they required.</p>

	<p>The stakeholder feedback (interviews) indicates that the Annual Forums became more effective and efficient with time; in the initial years they were focus on resolving issues with monitoring methods, but in later year were more concerned with the highlighting how the interactions between the scientists and environmental water managers were improving the management of environmental water, at least in the seven Selected Areas.</p> <p>Views were expressed in the interviews that the collaborations and learnings that were facilitated by the Annual Forums may have been increased if these Forums had been held twice a year.</p>
Evaluator 2	<p>Efficient</p> <p>The Basin Matters and Selected Area teams were thoroughly engaged in the annual forum process. SA teams attended and presented at the annual forum. Basin Matter teams also attended and presented and were actively involved. The annual forum discussed changes in procedures, use of software, changes in data handling procedures. Action lists were prepared following during the forum with actions assigned to individuals. At the following forum there was a review of actions since the previous forum. There was a clear sense of continuous improvement and processes to facilitate this were taken seriously.</p>
Revision comments – Evaluator 1	I think this is moderate
Revision comments – Evaluator 2	Agree, based on discussion of aggregation of micro KEQs
Consensus final rating	Moderately Efficient

Micro KEQ	To what extent did the Basin Matter and Selected Area teams engage with the process?
12.2.1	
Evaluator 1	See above
Evaluator 2	<p>Efficient</p> <p>The Basin Matters and Selected Area teams were thoroughly engaged in the annual forum process. SA teams attended and presented at the annual forum. Basin Matter teams also attended and presented and were actively involved</p>
Revision comments – Evaluator 1	Moderate is more appropriate based on rubrics

Revision comments – Evaluator 2	Agree: I was reasonably impressed by the Annual Forum reports, and also the follow up in subsequent year was good. Organisation of the Annual forums was fairly good. But agree to say moderate.
Consensus final rating	Moderately Efficient

Micro KEQ 12.2.2	To what extent did the Annual Forum lead to improved efficiency over time (e.g., innovating, learning, adaptive management)?
Evaluator 1	See above
Evaluator 2	Efficient The annual forum discussed changes in procedures, use of software, changes in data handling procedures. Action lists were prepared following during the forum with actions assigned to individuals. At the following forum there was a review of actions since the previous forum. There was a clear sense of continuous improvement and processes to facilitate this were taken seriously
Revision comments – Evaluator 1	Could be convinced to go to efficient – certainly got better, not focused on methods, improved to consider what managers needed. Agree to change
Revision comments – Evaluator 2	
Consensus final rating	Efficient

High KEQ 13	How efficient was the LTIM project in managing and sharing data?
Evaluator 1	Inefficient The LTIM project data management arrangements were inefficient in both systematically capturing data and in sharing this data.
Evaluator 2	Inefficient

	<p>There was a lack of efficiency. There was a large amount of time and money spent resolving issues that could/should have been better addressed early in the project. Data management issues delayed key aspects of the project, particularly model building. This reduced the overall quality and quantity of results.</p> <p>Some of the issues that plagued data management were identified early but were not addressed. For example, alternative common species names, were identified in 2013¹². However, this issue was not resolved until Nov 2018¹³.</p>
Consensus final rating	Inefficient

Mid KEQ 13.1 How efficient have data management arrangements been in capturing data generated by the LTIM project?	
Evaluator 1	<p>Inefficient</p> <p>Management of data generated by Selected Areas to inform Basin-scale evaluation has until the later years of LTIM been inefficient. Selected Area teams generally used their own data management arrangements, being reluctant until the last years of LTIM to use the MDMS data base established by CEWO (see KEQ1.7). This caused problems for the Basin Matters team in undertaking their Basin-scale evaluations and was highly inefficient.</p>
Evaluator 2	<p>Inefficient</p> <p>There were major problems with data management arrangements for much of the project. See details at KEQ 1.7, 8.8.1, 8.8.2, 13.1, 13.2</p>
Consensus final rating	Inefficient

Micro KEQ 13.1.1	How efficiently has Selected Areas data been managed to inform Basin-scale analysis?
Evaluator 1	<p>Inefficient</p> <p>See above</p>

¹² Brooks S. and Wealands S. (2013) Long-term Intervention Monitoring Data Management Strategy. Prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication X/2013, May, Xpp

¹³ LTIM Data Standard_REVISED_October2017 18

Evaluator 2	<p>Inefficient</p> <p>Cross-reference: KEQ 1.7, 8.8.1, 8.8.2, 13.1, 13.2</p> <p>As noted above. There were major projects for the first 4 years of the project. These were significantly resolved at the final year but delayed model building and inference to Basin-scale.</p>
Consensus final rating	Inefficient

Mid KEQ 13.2 How efficient have data management arrangements been?	
Evaluator 1	<p>Inefficient</p> <p>The LTIM data management arrangements were inefficient. There has not been efficient data sharing between Selected Area teams and Basin Matters team, the result of the less than effective MDMS data base, and the general lack of close collaboration between the two sets of teams.</p>
Evaluator 2	<p>Inefficient</p> <p>Cross-reference: KEQ 1.7, 8.8.1, 8.8.2, 13.1, 13.2</p> <p>Data sharing from Selected Areas to the Vegetation and Fish themes were a major problem</p>
Consensus final rating	Inefficient

Micro KEQ 13.2.1 How efficiently has the data sharing between Selected Area and Basin Matter teams been?	
Evaluator 1	<p>Inefficient</p> <p>There has not been efficient data sharing between Selected Area teams and Basin Matters team. This was the result of the less than effective MDMS data base, and the general lack of close collaboration between the two teams.</p>
Evaluator 2	<p>Inefficient</p> <p>Basin Matters reports have lists of data provided by the Selected Areas. This suggests that data must have been supplied, however there were issues with efficiency. There was a significant delay in providing appropriate data, particularly to the fish and vegetation Basin Matters teams.</p>

Consensus final rating	Inefficient

Micro KEQ 13.2.2	How efficiently have end-users been able to access LTIM data?
Evaluator 1	Moderately Efficient There were problems with the end user access to data in the MDMS. These were apparently largely resolved by the end of LTIM
Evaluator 2	Moderately Efficient As discussed in other KEQs, there were many issues with LTIM data. There is discussion in the annual form about data issues and there is a genuine attempt to resolve issues during the life of the project. Thinking of the Fish Basin Matters team as an end user of LTIM data. They were eventually able to get the data they needed to report on and model fish questions however, it took until the final year of the project before data could be accessed satisfactorily. There were also problems with data for the vegetation matter which required assistance from Senior staff to resolve (Nick Bond and Shane Brooks). (See the acknowledgements section of the Capon and Mynott, 2018). Appendix C of Capon and Mynott (2018) provides details of data issues and attempts at resolution. The reason I allocated this as “moderate”, rather than a lower rating, is because it seems issues were largely resolved by the end of the project.
Consensus final rating	Moderately Efficient

High KEQ 14	How efficient was the LTIM project in generating the agreed outputs?
Evaluator 1	Moderately Efficient The LTIM project was moderately efficient in using available resources to achieve results of the greatest possible value to LTIM teams, CEWO and end users. The objectives of LTIM, particularly to provide an evaluation of the contribution of CEW (and other environmental water) to Basin-scale ecological outcomes relevant to the Basin Plan, was always going to be challenging to address. The area of environmental flow management was relatively new, the 5-year timescale for the project was short (compared to the time for ecological restoration), and the conditions over the 5-year period were relatively dry with limited CEW available.

	Our assessment is that the project was moderately efficient in producing useful new understandings at the Selected Area scale, inefficient in using this Selected Area and other knowledge in producing new understandings at the Basin-scale, and moderately efficient in improving the adaptive management of CEW and other environmental water, at least in the seven Selected Areas.
Evaluator 2	Moderately Efficient LTIM was moderately efficient in generating agreed outputs. As noted in KEQ 14.1.1 the promise of predictive modelling to create counter factuals and extrapolate. beyond monitored areas was generally not met or met much later than expected. There were also some issues at the Selected Area scale as noted in KEQ 14.1.2.
Consensus final rating	Moderately Efficient

Mid KEQ 14.1	To what extent did the LTIM project represent the best possible use of available resources to achieve results of the greatest possible value to participants, CEWO and end users?
Evaluator 1	Moderately Efficient The LTIM project was moderately efficient in producing useful new understandings at both the Selected Area and Basin-scale, and at least the Selected Areas used the knowledge generated to improve the adaptive management of CEW at the local-scale. The LTIM project was moderately efficient in producing useful new understandings at the Basin-scale. However, it does not appear that this new Basin-scale knowledge resulted in improved adaptive management. The Basin Matters team did produce predictive models relating e-flows to fish populations, vegetation communities, and stream metabolism, that will contribute to the capacity to infer the ecological outcomes from CEW actions in other non-monitored parts of the Basin. The LTIM project was moderately efficient in producing useful new understandings at the Selected Area scale. This new knowledge was efficiently shared with the CEWO delivery teams resulting in improved adaptive management of CEW at the Selected Area scale. The Selected Area teams did not extend this knowledge to infer the ecological outcomes from CEW actions in other non-monitored parts of their area.
Evaluator 2	Moderately Efficient The rating for the micro KEQs below, for the basin-scale and Selected Area evaluations, are both “moderate”. The interview responses were also considered. An overall rating of moderate was selected. Interview responses: Overall Do you consider the expenditure worthwhile? “ “Oh, yeah, definitely. And I think we've we can demonstrate, both at the Selected Area and at the Basin-scale, we were able to demonstrate these really positive outcomes. And if we hadn't had the LTIM program, we wouldn't have those long term datasets. “

Consensus final rating	Moderately Efficient

Micro 14.1.1	KEQ	At the Basin-scale and by Basin Matter?
Evaluator 1		Moderately Efficient See Above
Evaluator 2		<p>Moderately Efficient</p> <p>This is a large and impressive project but there are areas where things could have been done better. In particular, the promise of predictive modelling to create counter factuials and extrapolate beyond monitored areas was generally not met or met much later than expected.</p> <p>Issues that detract from 'best possible use of available resources'.</p> <ol style="list-style-type: none"> 1. Biodiversity <ul style="list-style-type: none"> • No predictive ability or counter factual 2. Ecosystem diversity <ul style="list-style-type: none"> • Lack of objectives for 1-year and 5-year outcomes • No real assessment of different outcomes with and without CEW 3. Fish <ul style="list-style-type: none"> • Problems with data • Predictive models were only developed in the final year 4. Hydrology <ul style="list-style-type: none"> • Lack of prediction of inundated area. 5. Stream metabolism water quality <ul style="list-style-type: none"> • Lack of attention to water quality. No attempt to make use of the water quality data already collected as part of the stream gauge network

	<p>6. Vegetation</p> <ul style="list-style-type: none"> No predictive ability or counter factual
Consensus final rating	Moderately Efficient

Micro 14.1.2	KEQ	At the Selected Area scale?
Evaluator 1		<p>Moderately Efficient</p> <p>See Above</p>
Evaluator 2		<p>Moderately Efficient</p> <p>While LTIM has had some impressive achievements. There are areas where things could have been done better and these are not just with the benefit of hindsight.</p> <p>1. Lack of Stream metabolism monitoring in the Gwydir</p> <p>It is not clear why Cat 1 stream metabolism indicators were not monitored in the Gwydir. This meant there was one SA where stream metabolism data could not be reported. This meant there was a lack of reliable stream metabolism data for the whole of the northern basin.</p> <p>2. Monitoring in the Warrego-Darling</p> <p>Warrego-Darling: Some things were monitored that were not recommended or agreed in earlier planning e.g. Water Bird diversity and Macroinvertebrates. There were also issues with metabolism monitoring and questions around the suitability of standard methods in a system with little flow.</p> <p>3. Lachlan: The reports suggest that there was monitoring of areas that were unlikely to respond to CEW and lack of monitoring of areas that were likely to respond.</p> <p>Lack of monitoring of the Lachlan between Wyangala dam and Lake Brewster when this was known to be a better reach for fish response and was a target for watering. Lack of monitoring of Great Cumbung Swamp when this was a targeted area for CEW. Veg monitoring concentrated in areas that didn't get water with little monitoring in areas that got a lot of water. See KEQ 0194 and 0414.</p> <p>4. Lower Murray: The impression is that there was insufficient environmental water to achieve ecological outcomes so there was a lot of monitoring with few results. The expected outcomes listed in the MEP include fish responses: increased spawning, increased larval abundance and increased recruitment. This was not detected.</p>

	<p>Some short term watering projects in the Lower Murray, prior to LTIM resulted in low confidence that flow led to increased spawning and recruitment of golden perch. These projects are reviewed in Gawne et al. (2015, LTIM pilot). The recommendation in these studies was the flows greater than 15,000 ML/d were required. At the end of LTIM, the final report for the Lower Murray SA found no response from Golden Perch and recommended flows greater than 20,000 ML/d were required. The impression is that there has been little advance in knowledge. Also see KEQ 0181.</p> <p>In the 2017 annual form report (Gawne et al., 2017), there is recognition that, in the Lower Murray: “Indicators may not be particularly informative at this stage...”. So the issue of potential lack of response was known by at least mid-project. In the interviews “...I would say outcomes have been fairly muted”.</p>
<p>Consensus final rating</p>	<p>Moderately Efficient</p>

APPENDIX B: DOCUMENTS REVIEWED

This bibliography includes all documents that were loaded onto the Master NVivo file for the LTIM Evaluators, as well as additional documents that were uploaded onto the CEWOs SharePoint and shared with the Evaluators.

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APPENDIX C: REPORT CARDS

FOCAL AREA: HOW WELL HAS THE LTIM PROJECT ACHIEVED ITS OBJECTIVES?

Five high-level KEQs¹⁴ underpinned by 29 mid-level and 38 micro-level KEQs were aggregated to provide a *moderately effective* judgement for this focal area. The number of KEQs for this focal area reflected the number and complexity of the objectives in the Head Contract and captured the different spatial scales at which activities took place (i.e., Selected Area, Basin scale and Basin Matter).

Key Evaluation Questions

1: How effective was the LTIM project in planning, reporting and collaborating to support adaptive management?

1.1 How effectively did the LTIM project undertake and report on the Pilot Basin Evaluation in 2014-15 to test the proposed Basin-scale evaluation process and methodology as described in Gawne et al. (2014c, Section5) (from Head contract B2.1 (a))?

1.1.1 To what extent were the objectives of the Pilot Basin Evaluation achieved (from Basin Evaluation Plan Part B, Section 5): to synthesise the outcomes of past Commonwealth environmental watering actions using the Outcomes Framework and, to the extent possible, the Basin Matter evaluation methods?

1.1.2 To what extent were the objectives of the Pilot Basin Evaluation achieved (from Basin Evaluation Plan Part B, Section 5): 2. where possible, to assess the information available in the context of the Basin Matter evaluation methods, which would include testing the likelihood of being able to successfully implement the Basin Evaluation methods as described in this plan?

1.1.3 To what extent were the objectives of the Pilot Basin Evaluation achieved (from Basin Evaluation Plan Part B, Section 5): 3. to test and refine the integrated evaluation approach based on existing data?

1.2 How effectively has the LTIM project Annual Forum been organised, convened and reported on each year of the project as described in Gawne et al. (2014a, Section 6.1) (from Head contract B2.1 (e))?

1.3 How effective was the technical review at the final year of the project, as described in Gawne et al. (2014a, Section 6.2) (from Head contract B2.1 (f))?

1.4 How effective was consultation with monitoring and evaluation providers prior to the finalisation of the Basin Evaluation Plan and Basin Matter Foundation Reports (from Head contract B2.1 (g))?

1.5 How effective was the technical review processes undertaken by the technical advisors (MDFRC/LaTrobe) of the draft Selected Area Evaluation Reports (from Head contract B2.1 (h))?

1.6 How effectively did the LTIM project staff collaborate and/or participate in collaboration with other parties (from Head contract B2.1 (i))?

1.7 How effective were the data management tasks as specified in Gawne et al. (2014d), to support the evaluation and reporting on outcomes as per B.2.1 (from Head contract B2.1 (j))?

1.8 How effective was the LTIM project in supporting the adaptive management of Commonwealth environmental water (objective 4 Gawne et al. 2014)?

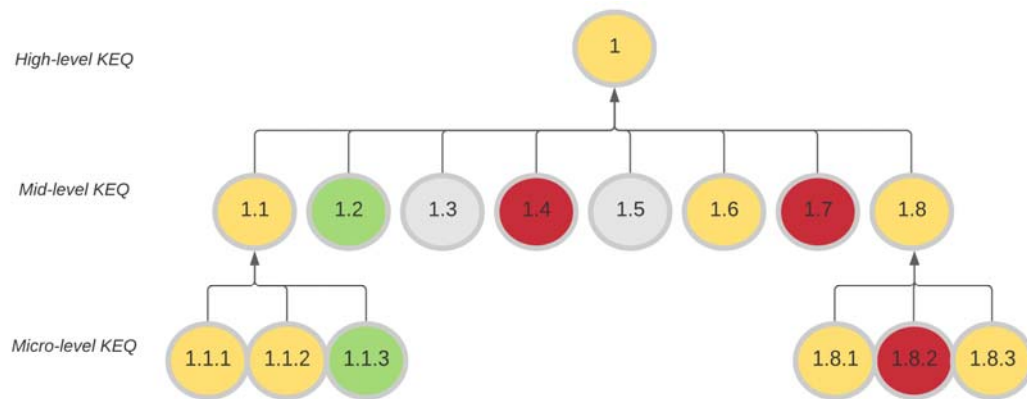
1.8.1 How effectively did the LTIM project support adaptive management of CEW in each Selected Area?

1.8.2 How effectively did the LTIM project support adaptive management of CEW at the Basin-scale?

1.8.3 How effective has the reporting of adaptive management by Selected Areas been (i.e. annual evaluation report and Quarterly reports)?

¹⁴ See Butcher and Schreiber (2020) p 6.

Evaluators' judgement by KEQ



Arrows indicate aggregation of ratings from micro- to mid- to high-level KEQs. Key to shading: red = minimally effective, yellow = moderately effective, green = effective, grey = insufficient evidence to make a judgement.

KEQ 1 addressed several objectives from the Head Contract with the MDFRC/LaTrobe University. It assessed the effectiveness of the Pilot Basin Evaluation (KEQ 1.1), the Annual Forum (KEQ 1.2), consultation with service providers in the early planning phase (KEQ 1.4), collaboration (KEQ 1.6), data management (KEQ 1.7) and adaptive management of CEW at different spatial scales and by Basin Matter (KEQ 1.8). Only the Annual Forum was assessed as 'effective', data management and consultation with service providers in the early planning phase were both rated as 'minimally effective' and the remainder were rated as 'moderately effective'. There was insufficient evidence to rate the remaining two mid-level KEQs: 1.3 which related to an end-of-project technical review which was agreed to be undertaken by CEWO (this project) with funds reallocated to other tasks by LaTrobe, and 1.5 which addressed the effectiveness of the technical review of the Selected Area reports by the Monitoring and Evaluation Advisors.

Cross referencing

Focal area final judgement: Hart et al. (2020) pp. 3-4.

Evaluation rationale for each KEQ: Hart et al. (2020), Appendix A, pp. 22-39.

Key Evaluation Questions

1A: How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at each of the seven Selected Areas (objective 5 Gawne et al. 2014)?

1A.1 How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Warrego Darling Selected Area?

1A.2 How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Gwydir Selected Area?

1A.3 How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Murrumbidgee Selected Area?

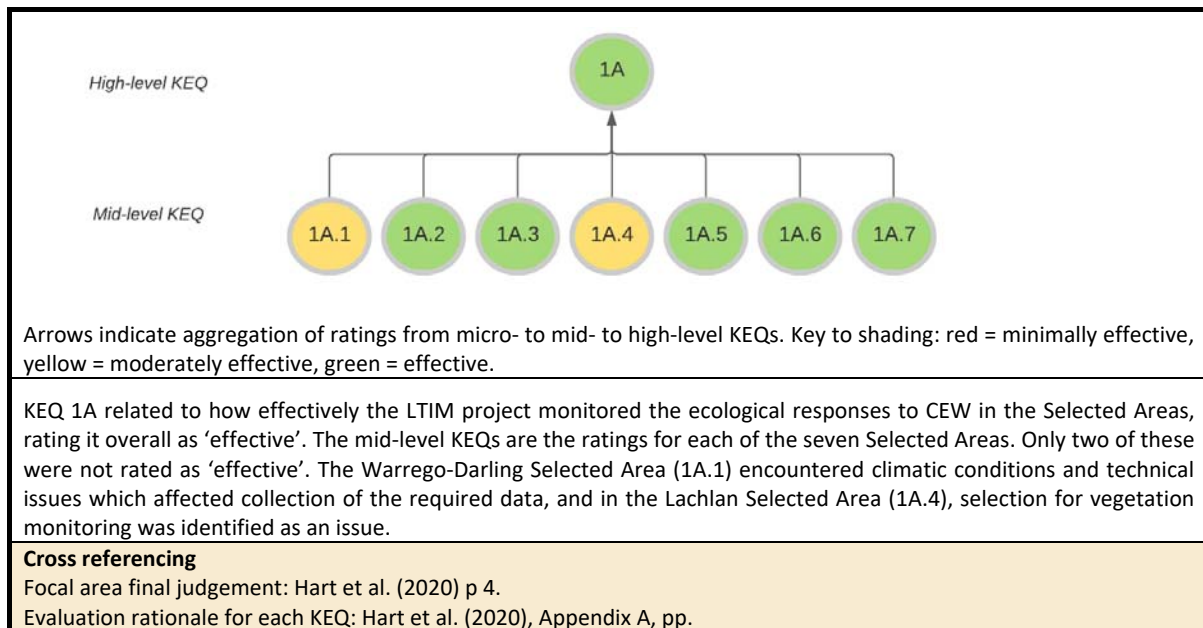
1A.4 How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Lachlan Selected Area?

1A.5 How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Goulburn River Selected Area?

1A.6 How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Edward-Wakool Selected Area?

1A.7 How effective has the LTIM project been in monitoring the ecological response to Commonwealth environmental watering at the Lower Murray Selected Area?

Evaluators' judgement by KEQ



Key Evaluation Questions

2: How effectively did the LTIM project evaluate Basin-scale contribution of CEW to the Basin Plan objectives using the CEWO Outcomes Framework and following the process and methodology outlined in Gawne et al. (2014a, Section 2.4) (from Head contract B2.1 (b)) (objective 1 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)?

2.1 How effectively did the CEWO Outcome Framework align to the Basin Plan Environmental Water Plan (EWP) and Water Quality and Salinity Plan objectives?

2.1.1 How effectively did the LTIM project align to the Basin Plan EWP objectives in S8.05 (labelled 'biodiversity')?

2.1.2 How effectively did the LTIM project align to the Basin Plan EWP objectives in S8.06 (labelled 'ecosystem function')?

2.1.3 How effectively did the LTIM project align to the Basin Plan EWP objectives in S8.07 (labelled 'resilience')?

2.1.4 How effectively did the LTIM project align to the Basin Plan objectives in S9.04 (labelled 'water quality')?

2.2 How effectively did the LTIM project evaluate the contribution of CEW to the Basin Plan objectives (includes Chapter 8 and 9 objectives)?

2.2.1 How effectively did the LTIM project evaluate Basin-scale contribution of CEW to Basin Plan EWP objectives S8.05 - 'biodiversity'?

2.2.2 How effectively did the LTIM project evaluate Basin-scale contribution of CEW to Basin Plan EWP objectives in S8.06 - 'ecosystem function'?

2.2.3 How effectively did the LTIM project evaluate Basin-scale contribution of CEW to Basin Plan EWP objectives in S8.07 - 'resilience'?

2.2.4 How effectively did the LTIM project evaluate Basin-scale contribution of CEW to Basin Plan objectives relating to water quality?

2.3 How effectively did the LTIM project document and report annually on the cumulative evaluation of the contribution of CEW at a Basin-scale as described in Gawne et al. (2014b, Section 6.3)?

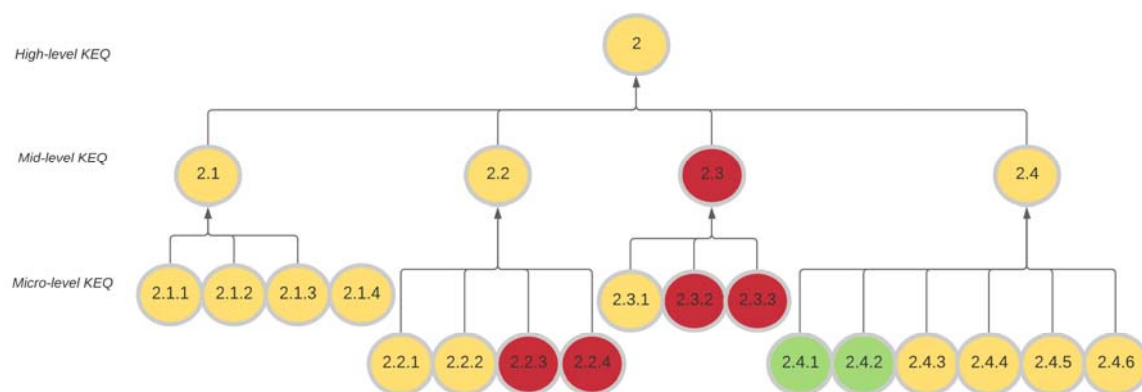
2.3.1 How well did the annual Basin Evaluation Report meet the reporting requirements as specified in Gawne et al. (2014b, Section 6.3)?

2.3.2 How effectively did the LTIM project report on annual evaluation of the contribution of CEW at the Basin-scale?

2.3.3 How effectively did the LTIM project report on the cumulative evaluation of the contribution of CEW at the Basin-scale?

- 2.4 How effectively did the LTIM project undertake annual evaluation of CEW on the six specified Basin Matters as described in Gawne et al. (2014a, Section 3 and 2014b Section 2.2)?
- 2.4.1 How effective was the annual evaluation of hydrology?
- 2.4.2 How effective was the annual evaluation of ecosystem diversity?
- 2.4.3 How effective was the annual evaluation of vegetation?
- 2.4.4 How effective was the annual evaluation of fish?
- 2.4.5 How effective was the annual evaluation of stream metabolism and water quality?
- 2.4.6 How effective was the annual evaluation of generic diversity?

Evaluators' judgement by KEQ



Arrows indicate aggregation of ratings from micro- to mid- to high-level KEQs. Key to shading: red = minimally effective, yellow = moderately effective, green = effective.

For KEQ 2, the evaluators judged the Outcomes Framework (CEWO 2013b) as being 'moderately effectively' aligned with the Basin Plan Environmental Watering Plan (EWP) and Water Quality and Salinity Plan objectives. This rating acknowledges that the Basin-wide Environmental Watering Strategy (BEWS) was developed after the Outcomes Framework and that the Outcomes Framework only addresses a subset of the EWP objectives (e.g. threatened species and obligations under international conventions and treaties are not included). The evaluators recommend that the further work be undertaken to improve alignment to the Basin Plan. This should include updating the Outcomes Framework as per Reporting Matter 10 Implementation of the environmental management framework (see Matter 10(c), Basin Plan Implementation Agreement Task 33.3).

KEQ 2.3 found that the LTIM project was only 'minimally effective' in reporting on the annual and cumulative evaluation of the contribution of CEW at the Basin-scale. Until the latter years of LTIM there was insufficient information from the Selected Areas to enable any cumulative evaluation, and even then, 4-5 years of data is hardly enough given the time for many of the ecological outcomes sought to become apparent. Whilst the annual reports improved over time, the evaluations were still very general in relating the contributions of CEW to each particular Basin Matter. It was only in the final years of the project that statistical models were developed for fish, vegetation and metabolism that provided some predictive capacity regarding outcomes of CEW in non-monitored areas.

At the micro-level, both the Hydrology and Ecosystem diversity matters were judged as 'effectively' evaluating the contribution of CEW to meeting the Basin Plan objectives (KEQs 2.4.1 and 2.4.2 respectively); the rest were rated as 'moderately effective'.

Cross referencing

Focal area final judgement: Hart et al. (2020) p 6.

Evaluation rationale for each KEQ: Hart et al. (2020), Appendix A, pp. 53-85.

Key Evaluation Questions

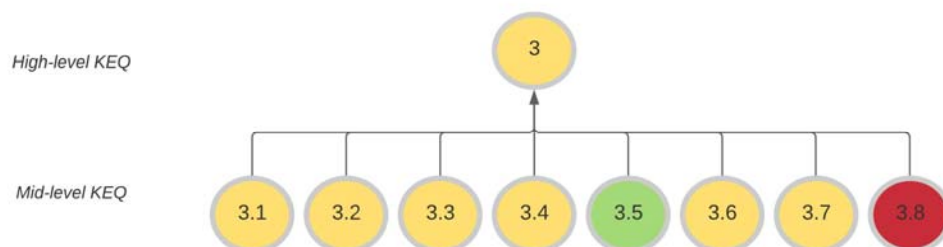
3.1 How effectively did the Warrego Darling Selected Area evaluate the ecological outcomes of CEW?

3.2 How effectively did the Gwydir Selected Area evaluate the ecological outcomes of CEW?

3.3 How effectively did the Murrumbidgee Selected Area evaluate the ecological outcomes of CEW?

- 3.4 How effectively did the Lachlan Selected Area evaluate the ecological outcomes of CEW?
- 3.5 How effectively did the Goulburn River Selected Area evaluate the ecological outcomes of CEW?
- 3.6 How effectively did the Edward-Wakool Selected Area evaluate the ecological outcomes of CEW?
- 3.7 How effectively did the Lower Murray Selected Area evaluate the ecological outcomes of CEW?
- 3.8 How effectively were the Selected Area outcomes incorporated into the Basin-scale synthesis reports?

Evaluators' judgement by KEQ



Arrow indicates aggregation of ratings from the mid-level KEQs to the high-level one. Key to shading: red = minimally effective, yellow = moderately effective, green = effective.

KEQ 3 focused on the key objective of evaluating the ecological outcomes of Commonwealth environmental water (CEW) at the Selected Area scale. Evaluation of the ecological outcomes of CEW at most of the Selected Areas was rated as 'moderately effective' with the standout being the Goulburn River Selected Area (KEQ 3.5). Basin-scale evaluation (KEQ 3.8) was considered 'minimally effective'.

Cross referencing

Focal Area judgement: Hart et al. (2020) pp. 5-6.

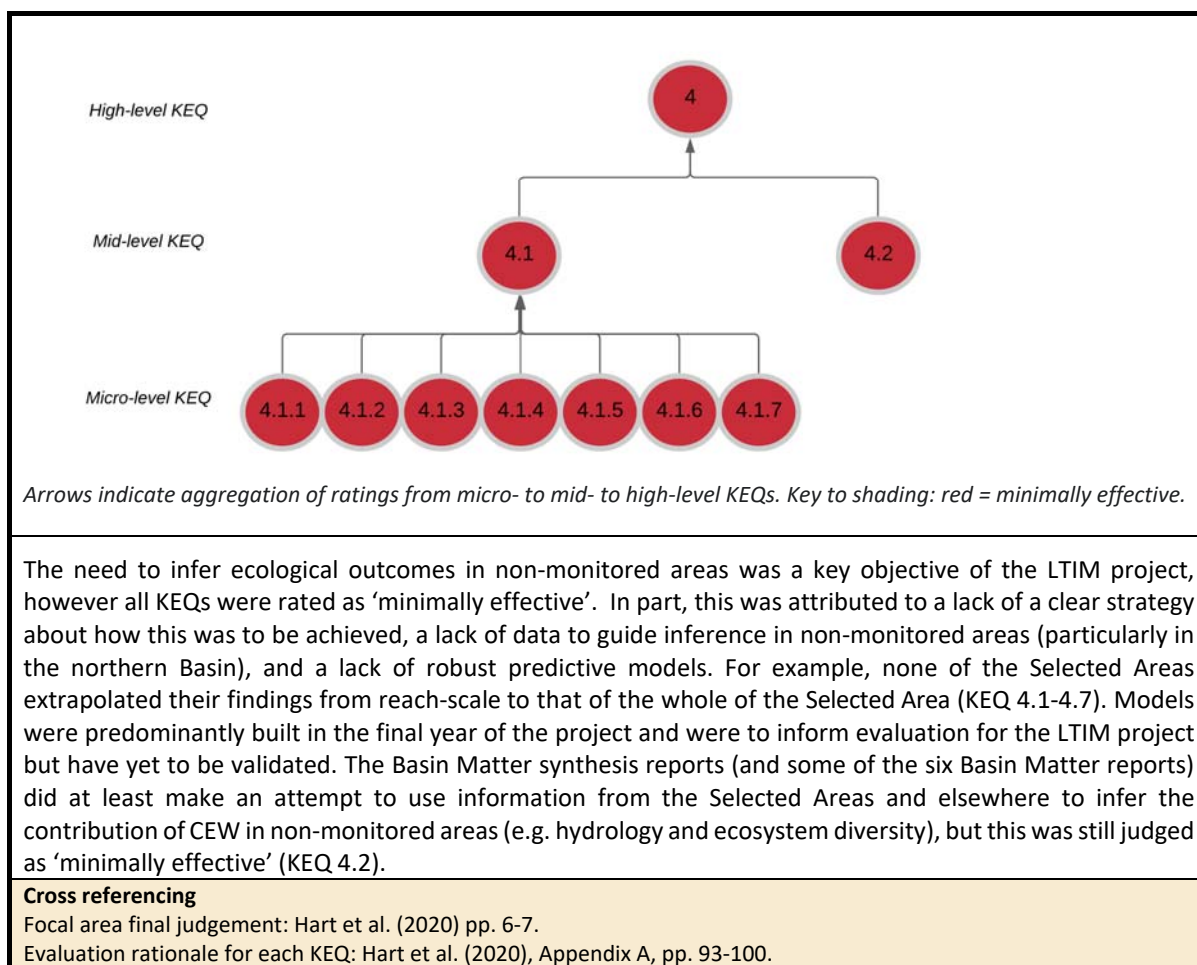
Evaluation rationale for each KEQ: Hart et al. (2020), Appendix B, pp. 85-93.

Key Evaluation Questions

4 To what extent did the LTIM project infer ecological outcomes of Commonwealth environmental water to areas in the Basin not monitored (objective 3 Gawne et al. 2013)?

- 4.1 How effectively did Selected Area services providers extrapolate their findings from reach to whole of Selected Area scale?
 - 4.1.1 How well did the Warrego Darling Selected Area infer ecological outcomes of CEW to areas not monitored?
 - 4.1.2 How well did the Gwydir Selected Area infer ecological outcomes of CEW to areas not monitored?
 - 4.1.3 How well did the Murrumbidgee Selected Area infer ecological outcomes of CEW to areas not monitored?
 - 4.1.4 How well did the Lachlan Selected Area infer ecological outcomes of CEW to areas not monitored?
 - 4.1.5 How well did the Goulburn River Selected Area infer ecological outcomes of CEW to areas not monitored?
 - 4.1.6 How well did the Edward-Wakool Selected Area infer ecological outcomes of CEW to areas not monitored?
 - 4.1.7 How well did the Lower Murray Selected Area infer ecological outcomes of CEW to areas not monitored?
- 4.2 How effectively did the LTIM project infer ecological outcome of CEW from Selected Area to areas in the basin not monitored?

Evaluators' judgement by KEQ



FOCAL AREA: HOW WELL FINDINGS WERE COMMUNICATED TO ALL STAKEHOLDERS?

A single high-level KEQ was used to address this focal area. Two mid-level KEQs and nine micro-level KEQs were nested below this high-level KEQ.

Key Evaluation Questions

5 How effective was the LTIM project at communicating key findings?

5.1 How effectively were the outputs and key findings of the LTIM project communicated to end users such as the MDBA, CEWO water delivery teams, other collaborators in the LTIM project?

5.1.1 To what extent did planned outputs (reports) meet CEWO reporting requirements (see reporting template) and timelines?

5.1.2 To what extent were planned outputs targeted at key audiences (both in terms of providing relevant information and in a format useful to the end-user)?

5.1.3 To what extent did the project identify and make use of existing communication channels and networks used by key stakeholders?

5.1.4 To what extent were end users aware of the key findings from the LTIM project relating to Basin Matters and Selected Areas?

5.1.5 To what extent were the communication and engagement activities captured in a Communications Plan?

5.1.6 How effective were the cause and effect diagrams (CED) in communicating key relationships between environmental watering and ecological outcomes?

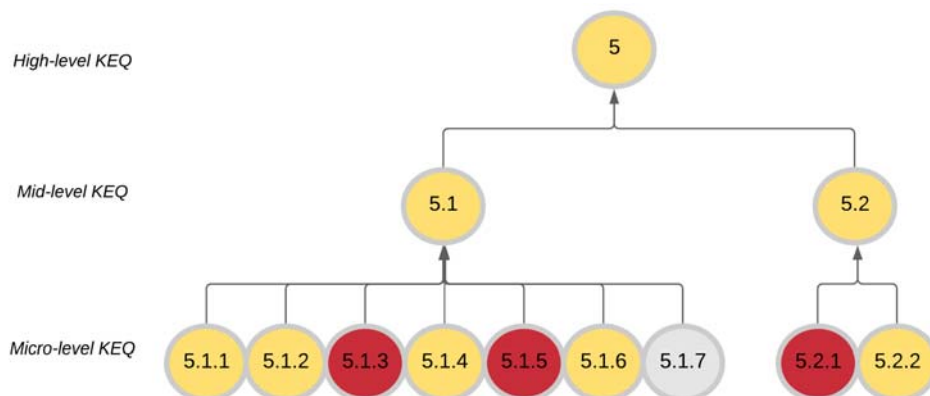
5.1.7 How effective were the Basin Matter synthesis workshops in communicating to key stakeholders (Basin Matter leaders, M&E Provider leaders, M&E Partners and other key individuals) the evaluation approach being undertaken (Gawne et al. 2014b, p 23)?

5.2 How effectively were key findings conveyed to inform adaptive management?

5.2.1 How effectively were key findings conveyed to inform adaptive management at the Basin-scale?

5.2.2 How effectively were key findings conveyed to inform adaptive management at the Selected Area scale?

Evaluators' judgement by KEQ



Arrows indicate aggregation of ratings from micro- to mid- to high-level KEQs. Key to shading: red = minimally effective, yellow = moderately effective, grey = insufficient evidence to make a judgement.

Overall, the LTIM project was assessed as being 'moderately effective' in communicating the findings to all stakeholders. The evaluators identified the lack of a communications strategy from the commencement of the LTIM project as a failing at the whole-of-project level. At the Selected Area scale, local communication plans were established in some cases; however, the effectiveness of these plans varied. In general, there was a lack of reporting on what communication activities were undertaken by Selected Area and Basin Matter teams and other project members. The evaluation failed to find any evidence that the CEWO drew together and documented communication activities that took place within the LTIM project or coordinated overall communication activities. Consistent feedback from the interviews was that neither the Selected Area nor the Basin Matter reports were particularly effective in targeting key stakeholders. In some cases, this meant there was insufficient evidence from which to evaluate one micro-level KEQ (KEQ 5.1.7).

Cross referencing

Focal area final judgement: Hart et al. (2020) p 8.

Evaluation rationale for each KEQ: Hart et al. (2020), Appendix A, pp. 100-118.

FOCAL AREA: HOW WELL WERE THE ENVIRONMENTAL OUTCOMES DEMONSTRATED?

A single high-level KEQ was used to address this focal area. Seven mid-level KEQs and four micro-level KEQs were nested below this high-level KEQ.

Key Evaluation Questions

6 How effectively has the LTIM project demonstrated its outcomes?

6.1 How effectively has the LTIM project demonstrated the contribution of CEW to achieving Basin Plan objectives (note this includes Chapter 8 and 9 objectives)?

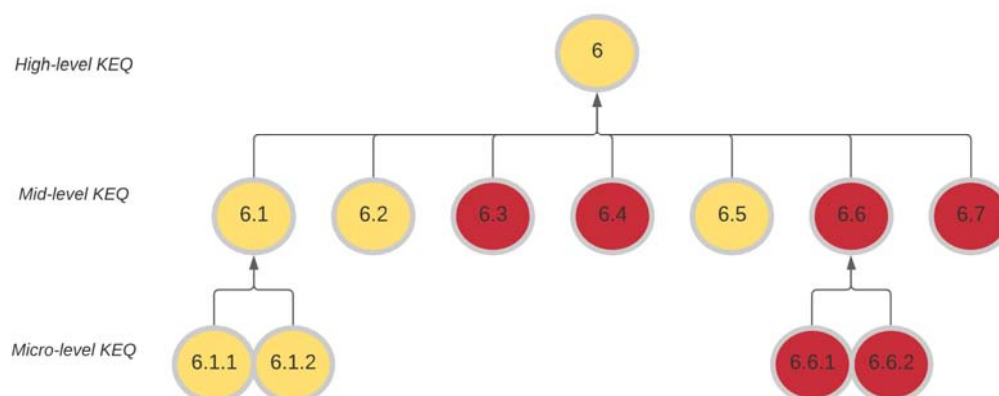
6.1.1 How effectively has the LTIM project demonstrated the contribution of CEW to each of the Basin Matters?

6.1.2 How effectively has the LTIM project demonstrated the contribution of CEW to achieving outcomes in Selected Areas?

6.2 How effectively has the LTIM project demonstrated its outcomes where the expected outcome is monitored and provides information on the condition of the system with the watering action (Evaluation Plan, p7)?

- 6.3 For areas where the expected outcome is not monitored, how effectively have multiple lines of evidence, including predictions based on conceptual or quantitative models, been used to demonstrate potential outcomes (Evaluation Plan, p7)?
- 6.4 How effectively has the LTIM project compared and contrasted the expected, observed and no flow predicted outcomes to inform an evaluation of the overall outcome of the watering action (Evaluation Plan, p7)?
- 6.5 To what extent have critical success factors been identified to improve future management of CEW (Evaluation Plan, p7)?
- 6.6 How effectively the LTIM project improved capacity to predict outcomes of environmental flow allocations and their management over 1–5 years?
- 6.6.1 How effectively were the outcomes related to the six specified matters incorporated into the environmental water adaptive management process (Selected Area, Basin-scale)?
- 6.6.2 How effectively have the predictive tools or processes developed or refined as part of the LTIM project informed environmental watering regimes (Selected Area and Basin- scale)?
- 6.7 How effectively has the LTIM project demonstrated that short term, less than 1-year outcomes, contribute to longer term outcomes?

Evaluators' judgement by KEQ



Arrows indicate aggregation of ratings from micro- to mid-KEQs and to the high-level KEQ. Key to shading: red = minimally effective, yellow = moderately effective.

Overall, the LTIM project was assessed as being ‘moderately effective’ in demonstrating environmental outcomes, including aspects such as the contribution of CEW to Basin Plan objectives and at Selected Areas (e.g. KEQs 6.1, 6.2). The evaluators noted that there was scope to build on the relatively good quantitative assessments at Selected Areas, for example by increasing the use of statistical models to better demonstrate the contribution of CEW and other environmental water sources to ecological outcomes.

Increased use of statistical models could also overcome issues related to the mismatch of the LTIM design being based on Selected Areas yet there being the need to report at the Basin scale. Such a focus on watering outcomes related to vegetation, fish, biodiversity, and stream metabolism and water quality responses has the potential to increase the quantitative rigour of the demonstration of outcomes and strengthen predictive models to provide counterfactuals and infer outcomes to areas not monitored. Although qualitative descriptions of outcomes are provided in the annual synthesis reports, quantitative demonstration of ecological outcomes at the Basin scale was challenged by the lack of a method to infer outcomes to areas not monitored.

Cross referencing

Focal area final judgement: Hart et al. (2020) pp. 7-8.

Evaluation rationale for each KEQ: Hart et al. (2020), Appendix A, pp. 118-139.

FOCAL AREA: TO WHAT EXTENT DID THE LTIM PROJECT SUPPORT THE CEWO'S LEGISLATIVE REPORTING REQUIREMENTS?

A single high-level KEQ was used to address this focal area. Two mid-level KEQs and six micro-level KEQs were nested below this high-level KEQ.

Key Evaluation Questions

7 How well has the LTIM project contributed to the CEWO’s ability to meet their legislative reporting requirements?

7.1 To what extent has the information provided by the LTIM project contributed to the CEWH delivering on its Water Act reporting requirements?

7.1.1 How appropriate was the information provided by the LTIM project in meeting the CEWH annually reporting requirements to the Commonwealth Water Minister, and relevant State Ministers for each of the Basin States (section 114(1)) which includes information on achievements against the objectives of the Basin Plan’s Environmental Watering Plan (section 114(2a))?

7.2 How appropriate was the information provided by the LTIM project for contributing to the CEWH delivering on its Basin Plan reporting requirements?

7.2.1 How appropriate was the LTIM project for supporting the annual reporting requirements to the MDBA on the identification of environmental water and the monitoring of its use (Basin Plan Schedule 12, item 9)?

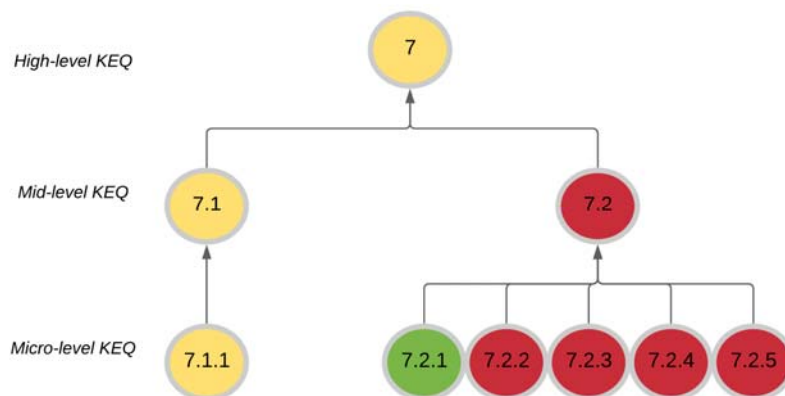
7.2.2 How appropriate was the LTIM project for supporting the annual reporting requirements to the MDBA on the extent to which local knowledge and solutions inform implementation of the Basin Plan (Basin Plan Schedule 12, item 6)?

7.2.3 How appropriate was the LTIM project for supporting the annual reporting requirements to the MDBA in relation to the implementation of the Environmental Management Framework (Basin Plan Schedule 12, item 10)?

7.2.4 How appropriate was the LTIM project for supporting the annual reporting requirements to the MDBA in relation to the implementation of the Water Quality and Salinity Plan (Basin Plan Schedule 12, item 14)?

7.2.5 How appropriate were the LTIM project synthesis reports in meeting the 5 yearly reporting requirements to the MDBA on the achievement of environmental outcomes at a Basin-scale by reference to the targets to measure progress towards the environmental objectives in Schedule 7 (Basin Plan Schedule 12, item 7)?

Evaluators’ judgement by KEQ



Arrows indicate aggregation of ratings from micro- to mid- to high-level KEQs. Key to shading: red = inappropriate, yellow = moderately appropriate, green = appropriate.

Overall, the evaluators found the LTIM project only ‘moderately effective’ for this focal area. The evaluators judged the LTIM project as supporting the CEWO in meeting some, but not all, of its legislative reporting requirements as specified in the Water Act 2007 and the Basin Plan (S12). The required reporting scale is at the Basin scale, and the annual Basin-scale evaluation reports provide information on the contribution of CEW to protection of biodiversity, ecosystem function and resilience of the water-dependent ecosystems of the MDB. Although valuable, for most Basin Matters, these reports are focused on information collected at the Selected Areas. As noted elsewhere, there were challenges in obtaining a Basin-scale synthesis for matters such as vegetation and fish.

The LTIM project is not contributing appropriate information in several areas where the CEWO is required to report. These include the water quality targets (see Basin Plan, Schedule 11), implementation of the water quality and salinity plans, and the extent to which local knowledge and solutions inform implementation of the Basin Plan (KEQ 7.2.2, Schedule 12, item 6). KEQ 7.1 addressed whether the LTIM project supported the CEWO in meeting their reporting requirements under the Water Act. The LTIM project was considered ‘appropriate’ for the identification of environmental

water and the monitoring of its use (Basin Plan Schedule 12, item 9) (KEQ 7.2.1) but 'inappropriate; for Schedule 12, items 6, 10, 14 and 7 (KEQ 7.2.2-7.2.5).

Some stakeholder feedback (survey, interviews) regarding the level of the CEWO's legislative reporting requirements was that this has not turned out to be as onerous as was originally thought when the LTIM project was being designed and that the emphasis of the project had shifted somewhat from Basin scale to more focus on the Selected Areas.

Cross referencing

Focal area final judgement: Hart et al. (2020) p 7.

Evaluation rationale for each KEQ: Hart et al. (2020), Appendix A, pp. 139-146.

FOCAL AREA: TO WHAT EXTENT WAS THE LTIM PROJECT FIT FOR PURPOSE?

A single high-level KEQ was used to address this focal area. Eight mid-level KEQs and nine micro-level KEQs were nested below this high-level KEQ.

Key Evaluation Questions

8 How appropriate was the LTIM project design, in terms of being fit for purpose in meeting the CEWO's strategic requirements?

8.1 How appropriate was a program logic, being fit for purpose and including specifying measurable (SMART) objectives and outcomes, to be adopted by the LTIM project?

8.1.1 At the Basin-scale and for Basin Matters?

8.2 How appropriate was the program logic as specified in the foundation documents, was it fit for purpose?

8.2.1 How appropriate was the program logic in terms of its alignment to the Basin Plan objectives (Chapter 8 and 9, BWS and reporting requirements)?

8.3 To what extent did the project design consider complementary recent, ongoing, or planned projects in the same area during the planning phase?

8.3.1 At the Basin-scale and at the Selected Area scale?

8.4 To what extent did the cause and effect diagrams include best available knowledge (including scientific, local, and cultural knowledge)?

8.5 To what extent were the best practice scientific methods employed in the LTIM project?

8.5.1 For each Basin Matter?

8.5.2 How appropriate were the Standard Methods, were they fit for purpose and consistently applied at the Selected Areas?

8.5.3 How appropriate were the category III methods for addressing CEWOs strategic requirements?

8.5.4 How appropriate were the predictive modelling approaches adopted to predict outcomes of environmental watering in areas not monitored for each Basin Matter?

8.6 To what extent was best available knowledge (including scientific, local and cultural knowledge), evidence and analysis incorporated into monitoring and evaluation findings? For Basin Matters and Selected Areas?

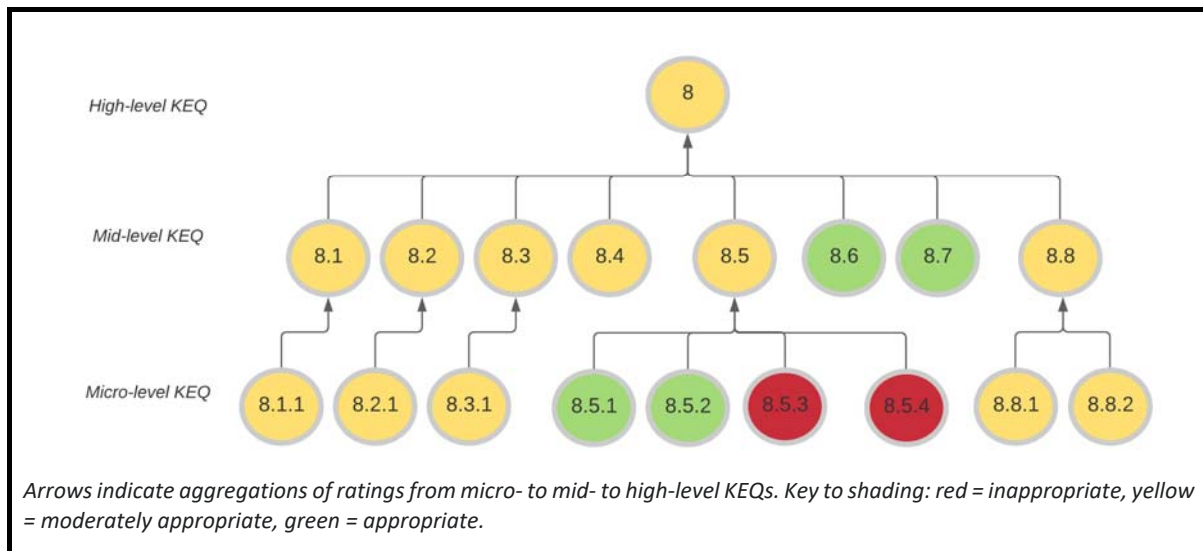
8.7 How appropriate was the LTIM Basin-scale Evaluation Plan, was it fit for purpose?

8.8 How appropriate were data management arrangements in supporting capture and making available data generated by the LTIM project?

8.8.1 At the Basin-scale?

8.8.2 At the Selected Area scale?

Evaluators' judgement by KEQ



The evaluators' assessment was that the LTIM project design was 'moderately appropriate' in terms of being fit for purpose in meeting the CEWO's strategic requirements (KEQ 8). The Basin-scale Evaluation Plan developed for LTIM was considered fit for purpose in most areas (KEQ 8.7). The LTIM project design made appropriate use of existing scientific and complementary knowledge and cause-and-effect diagrams in developing appropriate standard methods. In addition, best available scientific and much local knowledge was appropriately used to develop the Selected Area Monitoring and Evaluation Plans (KEQ 8.6), which were the basis for monitoring and evaluating the contribution of CEW to ecological outcomes at the Selected Areas. There was, however, no consistent consideration of cultural knowledge, a factor that is being addressed as part of the Flow-MER project and beyond.

Opportunities to strengthen future projects included greater attention to the setting of SMART objectives and to predictive modelling and inferring outcomes from environmental watering at sites not monitored (see also Section 3.3). The need for more consistently stating SMART objectives was noted in a previous review of the LTIM project (Hart and Butcher 2018) but does not appear to have been addressed. There is also much scope to bolster predictive modelling as an output from the LTIM project; this was generally either not done as expected or delivered late in the project (KEQ 8.5.4). This highlighted an important gap: the lack of a specified process for inferring environmental watering outcomes in areas that were not monitored. This requires predictive modelling, which in turn depends on considered site selection, measurements of covariates and the development and testing of stochastic relationships. All these factors require considerable attention at the program design stage.

The evaluators noted some stakeholder feedback that questioned the appropriateness of the LTIM program logic, which commenced with the focus on being able to evaluate the Basin-wide contributions of CEW (and other environmental water) based largely on information provided at a Selected-Area local scale. The LTIM project is very focused on evaluation at the seven Selected Areas with a lesser focus on integrating these local-scale findings to the Basin-scale. This increased focus on Selected Area is reflected in CEWO's investment in LTIM, with approximately the same funding for the entire Basin Matters team as for each Selected Area team

LTIM project reporting, survey responses and interviews all pointed to data management issues (KEQ 8.8), particularly in the first four years of the project. Issues included inconsistent QA/QC, unbudgeted time and effort for entering and accessing data, and difficulty sharing data and information in a timely manner. Feedback from stakeholders indicated that the situation clearly improved in the latter stages of the project.

Cross referencing

Focal area final judgement: Hart et al. (2020) pp. 8-9.

Evaluation rationale for each KEQ: Hart et al. (2020), Appendix A, pp. 147-175.

CRITERION: IMPACT

Two high-level KEQs were used to address this criterion. Four mid-level KEQs and two micro-level KEQs were nested below the high-level KEQs.

Key Evaluation Questions

9 To what extent has the LTIM project had an impact in terms of improving water management practices?

9.1 What level of impact has the LTIM project had on the adaptive management of environmental water?

9.2 How impactful has knowledge gained through the LTIM project been in informing and improving Basin Plan implementation and/or outcomes?

10 How impactful have the LTIM project been in fostering improved collaboration?

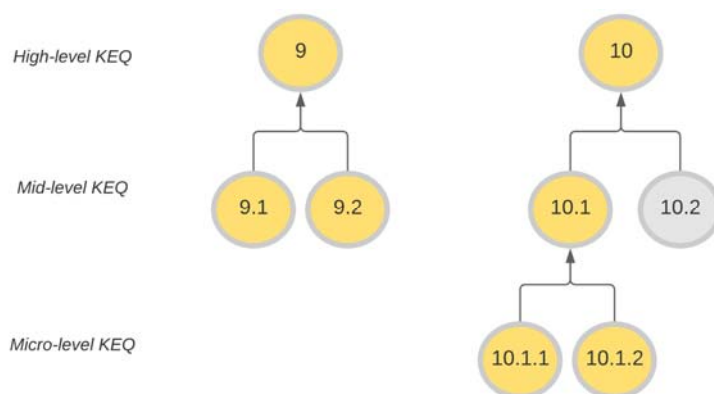
10.1 What impact has the LTIM project had on partnership mechanisms and initiatives to build stronger coherence and collaboration between participating organisations?

10.1.1 At the Basin-scale?

10.1.2 At the Selected Area scale?

10.2 To what extent has the LTIM project raised awareness of the CEWO's aims and approach across the communities of the Basin?

Evaluators' judgement by KEQ



Arrows indicate aggregation of ratings from micro- to mid- to high-level KEQs. Key to shading: yellow = moderate impact, grey = insufficient evidence to make a judgement.

Overall, the evaluators rated the LTIM project as having a 'moderate impact'.

The evaluators considered there was sufficient stakeholder feedback to confirm that the LTIM project has had an impact in improving environmental water management practices (KEQ 9.1), particularly at Selected Areas, despite there being limited documented information (evidence) in support of this generally agreed finding.

The evaluators acknowledged the very good interactions between Selected Area teams and the CEWO water delivery teams, and that knowledge generated by the LTIM project resulted in changed environmental watering management practices, and thus improved Basin Plan implementation. However, the impact of these 'science-practice partnerships' on Basin Plan implementation was only 'moderate' because the outcomes were poorly communicated within the LTIM project team and with key stakeholders.

The impact of the LTIM project on adaptive management of environmental water (KEQ 9.2) was also rated as 'moderate'. This reflected the positive influence that the LTIM project had at Selected Areas, but its limited influence on environmental water management at the Basin scale. The evaluators suggested two reasons for the limited impact of the LTIM project at the Basin scale: the Basin-scale information base regarding the ecological outcomes of CEW was considerably less than that at the Selected Area scale; and the links between the Basin Matter team and the environmental water managers were not strong.

Similarly, there was a 'moderate' impact of the LTIM project on fostering improved collaboration between researchers and environmental water managers (KEQ 10). The consortium approach used to establish the Selected Area teams, with university scientists, water agency scientists, environmental water managers and consultants all working together was advantageous and fostered collaboration at the Selected Areas. There was also a range of information-sharing activities (e.g., Annual Forums, Selected Area leads workshops, workshops to refine fish monitoring methods, Basin Matter workshops). Despite being useful for information-sharing, stakeholder feedback suggested that these activities rarely led to collaboration between Selected Area and Basin Matter participants.

Stakeholder feedback suggested that the LTIM project helped raise awareness of the CEWO's aims and approaches (KEQ 10.1) at Selected Areas, but there was insufficient information available to gauge any change in awareness amongst Basin communities more generally (KEQ 10.2).

Cross referencing

Focal area final judgement: Hart et al. (2020) pp. 9-10.

Evaluation rationale for each KEQ: Hart et al. (2020), Appendix A, pp. 175-183.

CITERION: EFFICIENCY

Four high-level KEQs were used to address this criterion. Seven mid-level KEQs and 15 micro-level KEQs were nested below the high-level KEQs.

Key Evaluation Questions

11 How efficiently has the LTIM project achieved its objectives and outcomes?

11.1 How efficiently were the funds and time allocated to address the LTIM project objectives?

11.1.1 At the Basin-scale and by Basin Matter?

11.1.2 At the Selected Area scale?

11.2 How technically efficiently was the LTIM project implemented - were the optimal methods of producing the outputs adopted?

11.2.1 At the Basin-scale and by Basin Matter?

11.2.2 At the Selected Area scale?

11.2.3 To what extent were the intended quality and quantity of deliverables, achieved within the available resources for each Basin Matter?

11.2.4 To what extent is there evidence that the LTIM project has continued/attempted to improve, by finding better or lower cost ways to deliver outcomes?

12 How efficient was the collaborative process within the LTIM project?

12.1 How efficient was the LTIM project in taking up opportunities for joint activities, pooling of resources and mutual learning with other organisations and networks?

12.1.1 At the Basin-scale and by Basin Matter?

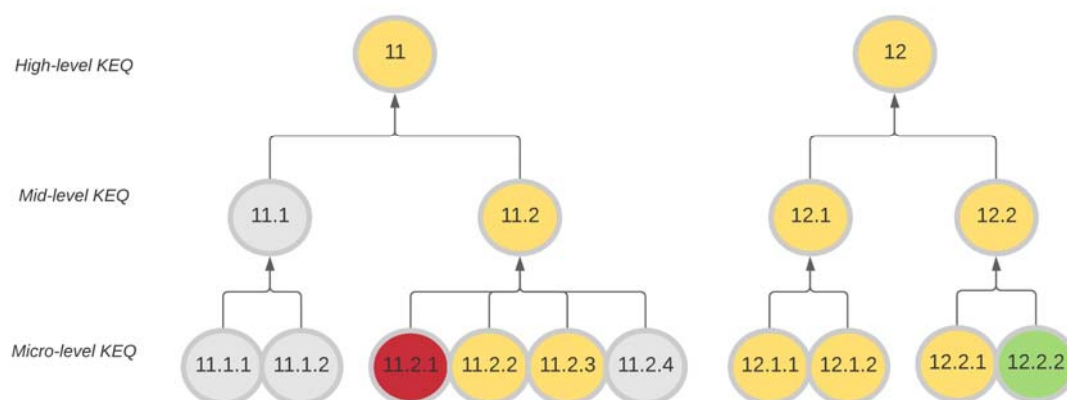
12.1.2 At the Selected Area scale?

12.2 How efficient was the Annual Forum in improving collaborative processes?

12.2.1 To what extent did the Basin Matter and Selected Area teams engage with the process?

12.2.2 To what extent did the Annual Forum lead to improved efficiency over time (e.g., innovating, learning, adaptive management)?

Evaluators' judgement by KEQ



Arrows indicate aggregation of ratings from micro- to mid- to high-level KEQs. Key to shading: red = minimally efficient, yellow = moderately efficient, green = efficient, grey = insufficient evidence to make a judgement.

Overall, the evaluators rated the LTIM project as being 'moderately efficient' for all four KEQs relating to this criterion (see below for KEQ 13 & 14).

The evaluation of KEQ 11 was challenged by a lack of data. For example, the evaluators found there was insufficient evidence from which to consider aspects such as the efficiency of funding allocations and the extent to which the LTIM project became more efficient over time (KEQ 11.1).

Based on those questions that could be addressed, the LTIM project was evaluated as 'moderately efficient' in achieving its objectives and outcomes. Implementation of the Selected Area monitoring programs appears to have been technically efficient, although some interview responses expressed concern about the cost and time allocated to some indicators. The evaluators also noted issues with efficiency of the Basin-scale evaluation (KEQ 11.2.1), which relied on predictive modelling that was either delayed or not carried out. Efficiency was also reduced because of problems with data management.

The evaluators noted that the early stages of LTIM focused predominantly on implementing Selected Area monitoring and evaluation plans (MEPs), with collaboration between Selected Area teams getting little attention. Although collaboration within the LTIM project, rated as 'moderately efficient' (KEQ 12), did improve after the first two to three years, the early lack of collaboration could have been addressed if there had been a consolidated LTIM project collaboration and communications plan from the start. Additionally, and related, there is essentially no documentation of the efforts to facilitate collaboration and the outcomes from these efforts.

One positive feature was the Annual Forums (KEQ 12.2.2) which seemed to work well, had good engagement, and were well reported.

Cross referencing

Focal area final judgement: Hart et al. (2020) pp. 10-11.

Evaluation rationale for each KEQ: Hart et al. (2020), Appendix A, pp. 183-199.

Key Evaluation Questions

13 How efficient was the LTIM project in managing and sharing data?

13.1 How efficient have data management arrangements been in systematically capturing data generated by the LTIM project?

13.1.1 How efficiently has Selected Areas data been managed to inform Basin-scale analysis?

13.2 How efficient have data management arrangements been?

13.2.1 How efficiently has the data sharing between Selected Area and Basin Matter teams been?

13.2.2 How efficiently have end-users been able to access LTIM data?

14 How efficient was the LTIM project in generating the agreed outputs?

14.1 To what extent did the LTIM project represent the best possible use of available resources to achieve results of the greatest possible value to participants, CEWO and end users?

14.1.1 At the Basin-scale and by Basin Matter?

14.1.2 At the Selected Area scale?

Evaluators' judgement by KEQ

