



Foundation Report Update 2020: Stream Metabolism and Water Quality

Commonwealth Environmental Water Office (CEWO):
Monitoring, Evaluation and Research Program



Australian Government

Commonwealth Environmental Water Office



The Flow-MER Program

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

The Flow-MER Program is being undertaken from 2019 to 2022 and is led by CSIRO in partnership with the University of Canberra, and collaborating with Charles Sturt University, Deakin University, University of New England, SARDI, Arthur Rylah Institute, NSW Department of Primary Industry, Australian River Restoration Centre and Brooks Ecology & Technology. The Program delivers to the Commonwealth Environmental Water Office, Department of Agriculture, Water and the Environment.

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Murray River system near Albury, NSW.
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Foundation Report Update 2020

This report was prepared for the Commonwealth Environmental Water Office as part of the Flow-MER Program. It is to be read in conjunction with the published Basin Matter Foundation Reports 2019. The Report Updates outline key changes in the adopted Evaluation approach for the Flow-MER Program. Unless otherwise stated, the Evaluation is conducted as reported in the original Foundation Reports 2019.

Changes in approach have only been adopted where there have been significant advances in methodology and available data, or where unmonitored areas were not previously evaluated. In all other cases, the approach is intended to be consistent with the Evaluation conducted under the Long-Term Intervention Monitoring Project (LTIM).

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Abbreviations and acronyms

Abbreviation/acronym	Definition
CEWO	Commonwealth Environmental Water Office
ER	Ecosystem respiration
Flow-MER	The CEWO Monitoring, Evaluation and Research Program (2019-2022)
GPP	Gross primary production
K _{O2}	Reaeration rate
LTIM	Long-Term Intervention Monitoring Project (2015-2019)
MER	Monitoring, Evaluation and Research Program (2019-2022)

1 Introduction

The Commonwealth Environmental Water Office Monitoring Evaluation and Research Basin-scale Project (Flow-MER) builds on the evaluation process developed for the Long-Term Intervention Monitoring (LTIM) project. Foundation reports were produced under LTIM for six themes: (1) Hydrology; (2) Ecosystem Diversity; (3) Species Diversity; (4) Vegetation; (5) Fish; and (6) Stream Metabolism and Water Quality. The reports provide a summary of why these themes are used to evaluate the effectiveness of Commonwealth Environmental Water; the criteria used for evaluating short and long-term outcomes; the approach adopted in the evaluation; as well as any anticipated risks for the evaluation process.

The Foundation Report Updates 2020 have been produced under Flow-MER to report on any changes to the original Foundation Reports 2019 developed in LTIM. Updates are provided to reflect the focus on including unmonitored areas across the basin-scale evaluation, as well as advances in available methods and data. The Updates provide consistency with the Flow-MER Evaluation and Research Plan.

A summary of updates for Stream Metabolism and Water Quality is provided in Table 1. In addition, amendments have been made to align with Flow-MER as the new project name (LTIM removed), and with Flow-MER timeframes for assessment requiring the removal of reference to 5-year evaluations (replaced with annual and long-term).

Table 1 Summary of updates for the Stream Metabolism and Water Quality Foundation Report Update 2020

Section	Updates
Why	Additional context for water quality and productivity objectives linked to Basin Environmental Water Strategies.
What	Additional text to articulate Commonwealth Environmental Water evaluation questions for water quality with the MER theme broadened to Water Quality, Metabolism and Food webs.
How	Additional context provided for metabolism and water quality, updated BASEv@ fitting routine information, amendment to provide opportunity for Selected Areas to adjust fitting criteria in BASEv2 to evaluate events (e.g., blackwater, algal bloom).
Risks	Amended to include specific reference to: <ul style="list-style-type: none">• Instrument failure and BASEv2 fitting routing rejection rates for modelled data• Selected Area Theme leads as part of consultative group• Amended Standard Methods• Inclusion of reporting metabolism in 'carbon' units

2 Why

Building on the Foundation Report 2019 (Grace, 2018), we provide here additional context for water quality and productivity objectives linked to Basin Environmental Water Strategies.

A key objective of the Basin-wide Environmental Watering Strategy is 'Improved Ecological Process' based on more productive and diverse food webs and ecological communities supported by the increased movement of carbon, nutrients and salt. In turn, achieving these productivity and water quality objectives supports the Basin Plan Objectives of improving the life cycle completion of key plants and animals, and meeting the needs of the whole fish community. Stream metabolism is responsive to flow management and represents a measure of energy production that underpins many ecological processes that form targets of the Environmental Watering Strategy.

Water quality is included as a Basin Matter as it is one of the principal objectives of the Basin Plan, it is known to respond to changes in flow, and it can be a significant influence on the outcome of a watering action for biota (e.g. fish and waterbirds). There are instances where the objective of a watering action is the amelioration of reduced water quality (e.g. dissolved oxygen, salinity) to prevent disturbance to an ecosystem.

3 What

Building on the Foundation Report 2019 (Grace, 2018), we provide here additional text to articulate Commonwealth Environmental Water evaluation questions for water quality with the Flow-MER theme broadened to Water Quality, Metabolism and Food webs:

What did Commonwealth environmental water contribute to Water Quality?

- pH levels?
- Turbidity regimes?
- Temperature regimes?

Data from Selected Areas will be analysed to report on regional impacts and aggregated to estimate the effect of Commonwealth environmental water on water quality, primary productivity and decomposition across the Basin.

For the Flow-MER program we have amended the outputs for the Basin Evaluation to clarify that the long-term evaluation will include all LTIM and Flow-MER data, and providing clarity on the aggregation of data for Basin scale evaluation – in particular for un-monitored sites. The outputs will therefore comprise:

- Summary of key thresholds and desired states for water quality, primary production and decomposition, based on a review of existing information,
- Annual evaluation of watering action outcomes on salinity effects, with a focus on the Lower Murray, drawn from the Lower Murray Selected Area Report,
- Long-term and Basin-wide evaluation of water quality based on aggregation of data across Selected Areas and additional available state- or agency-based information to provide estimates of changes to the frequency or magnitude of adverse water quality events (e.g. hypoxic or algal bloom conditions) or changes to the transport of material (e.g. salt, nutrient cycling) at the Basin scale,
- Annual and longer-term evaluation of reach-scale estimates of Gross Primary Production (GPP) and Ecosystem Respiration (ER), together with predictions of rates in the absence of Commonwealth environmental water, and
- Longer-term evaluation based on aggregation of data from all Selected Areas to provide an estimate of the amount of organic matter produced and recycled in response to Commonwealth environmental water at the Basin scale.

4 How

4.1 Data

Building on the Foundation Report 2019 (Grace, 2018), we provide here: additional context for metabolism and water quality; updated BASEv2 fitting routine information; and amendment to provide opportunity for Selected Areas to adjust fitting criteria in BASEv2 to evaluate events (e.g. blackwater, algal bloom).

The Flow-MER Project Standard Methods for stream metabolism and water quality have been designed to provide data appropriate for the evaluation of outcomes in response to Commonwealth environmental watering at the Selected Area and Basin scale. Data on pH, EC and turbidity may be complemented by water quality monitoring data collected through other relevant programs such as short-term monitoring instigated by CEWO and/or MDBA in response to planned watering actions or a potential water-quality event.

The Selected Areas will provide daily estimates of gross primary production (GPP), ecosystem respiration (ER) and reaeration rate (K_{O_2}) from the diel dissolved oxygen curves for each site. The BASE fitting routine (Grace et al. 2015) is to be used, and is available, along with an extensive user manual available at (<https://github.com/dgiling/BASE#base-v22>). The fitting routine also provides an uncertainty estimate for each parameter that allows Selected Areas to interrogate data inclusion. This program has been updated to BASEv2 which incorporates modifications and improvements as suggested by Song et al. (2016). Extreme events such as algal blooms and hypoxic blackwater events can generate data that fails to meet the uncertainty criteria specified within BASE. These periods are of ecological significance and SA teams can modify the rejection criteria to allow specific investigation of extreme events.

4.2 Developing the evaluation approach

Building on the Foundation Report 2019 (Grace, 2018), we provide here additional context for water quality.

The lack of water quality data arising from LTIM limits the capacity to predict water quality responses to flow, as does the variation in response limit predictive capacity through time and across the Basin. Levels of uncertainty around water quality predictions currently limit their value, and progressing this challenge will form a part of models developed during Flow-MER (2019-22).

Outputs amended to include 'carbon production' as an additional measure of stream metabolism. Using these techniques, we will develop quantitative and qualitative models of stream metabolism that will:

- Estimate the rate of stream metabolism (as carbon production) in the absence of environmental watering at the reach scale for reaches that are monitored,
- Estimate both environmental flow and non-flow rates of stream metabolism (as carbon production) at the reach scale for reaches that are not monitored,

- Support estimation of Basin-scale changes to stream metabolism in response to environmental watering.

5 Risks

5.1 Data

Building on the Foundation Report 2019 (Grace, 2018), we provide here text amended to include specific reference to instrument failure and BASEv2 fitting routing rejection rates for modelled data:

The major risk associated with data collection is that the prescribed protocols for assessing logger performance are not performed or performed inconsistently with regard to the standard method, instrument failures, and rejection of data from the BASE fitting routine. All subsequent estimation of daily rates of primary production and ecosystem respiration is entirely contingent upon the quality of the logger data. With the new generation fluorescence-based probes, instrument drift is a much smaller concern than with the older Clark electrodes, but it still must be considered.

5.2 Site-based modelling

Building on the Foundation Report 2019 (Grace, 2018), we provide here text to reference Selected Area Theme leads as part of consultative group, and reference to amended Standard Methods:

Modelling of the estimated rates of primary production and respiration as a function of discharge – and particularly, watering events will be investigated by each Selected Area in consultation with the Stream Metabolism team from across Selected Areas. Revised Standard Methods to provide flexibility for the collection and analysis of metabolism data will permit Selected Areas to better explore the biophysical and chemical mechanisms regulating changes in dissolved oxygen.

5.3 Basin-scale modelling

Building on the Foundation Report 2019 (Grace, 2018), we provide here text inclusion of reporting metabolism in 'carbon' units, reference to the Standard Methods allowing for inclusion of state- and agency-based metabolic and water quality data (if collected in line with Standard Methods):

Metabolism in a number of units (e.g., oxygen, carbon), the use of data from state- and agency-based broad scale monitoring programs combined with hydrology data (Commonwealth environmental water and counter-factual scenarios), will facilitate the exploration and modelling of water quality and metabolism responses at Selected Area and Basin scale.

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