QUEENSLAND WATER
MODELLING NETWORK

Strategic Review of Models

GREAT BARRIER REEF EWATER SOURCE CASE STUDY

Report prepared by
BMT, The University of Queensland and
The University of Western Australia
For Queensland Water Modelling Network

Queensland Government

The Queensland Water Modelling Network (QWMN) is an initiative of the Queensland Government that aims to improve the state's capacity to model its surface water and groundwater resources and their quality. The QWMN is led by the Department of Environment and Science with key links across industry, research and government.

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Introduction

The QWMN

The Queensland Water Modelling Network (QWMN) was established in 2017 to build the capacity of the water modelling sector, encouraging engagement between modellers, end-users, researchers, among others.

A range of collaborative projects have been initiated to improve the state's capacity to model its surface and ground water resources. The QWMN's 2018-2020 Research, Development and Innovation Strategy noted that investment in water modelling would benefit from an objective, transparent and adaptive process for evaluating water models and identifying key challenges, opportunities and risks for future model development and application.

The Model Assessment Framework

The QWMN commissioned BMT, The University of Queensland and The University of Western Australia to undertake a strategic review of Queensland water models, including the development of a framework for assessment. The Model Assessment Framework was designed as a generic tool to rank the current state of a model (or set of models) in servicing the needs of different applications. It provides a process to identify the strengths and weaknesses of a model, pinpoint gaps in specific areas, prioritise opportunities and risks for model improvement, and provide a context for model adaptability.

Framework in action

The Model Assessment Framework was applied to several case studies to test its applicability and usefulness. This case study focuses on pollutant export modelling for the Great Barrier Reef using eWater SOURCE. Two independent assessors used the framework to analyse the model and sought input via interviews with two end-users. The case study assessment and classification provide point in time analysis and are reflective of the views of the participants. It is presented to illustrate how the framework operates in practice and to build collective understanding of how model assessment can support continuous improvement and guide where future action should be focused.

The QWMN community is encouraged to provide feedback on their observations of the assessment process as well as nominate other models and projects for analysis. It is anticipated that ongoing implementation of the framework will identify further refinements for consideration. Non-QWMN modellers and model owners are also encouraged to use the framework and share the results. QMWN contact information is provided on page 11.

eWater SOURCE

eWater Source is an integrated modelling platform that combines water resources management with water policy and governance capabilities. It is not a single hydrological model and constituent generation model. Rather, it is a range of component models that have been incorporated into an adaptable platform. The eWater SOURCE Catchment model was used for this case study.

Assessment

The following assessment examines eWater SOURCE using the eight components of the framework. More information about the components and ratings can be found in the Strategic Review of Models – Model Assessment Framework report.

Policy drivers

Context

The Great Barrier Reef (GBR) is a unique and iconic ecosystem under threat from anthropogenic activity in its catchments. The Reef 2050 Water Quality Improvement Plan (Reef 2050 WQIP) sets targets for reducing sediment and nutrient pollution loads to ensure aquatic ecosystems are protected from contaminants reaching marine waters.

eWater SOURCE is a component of the Reef 2050 WQIP Modelling Program and has been developed and used to identify the impact of change in land use management on nutrient, sediment and pesticide loads across several GBR catchments. This study case focused specifically on the Burdekin catchment, which is characterised by three main land uses: cane farming, dryland cropping (e.g. cotton) and horticulture (e.g. bananas), and grazing. An important water management asset in the catchment is the Burdekin Falls Dam, which in addition to supplying water, also retains nutrients and sediment as a result of less vigorous water flow within the reservoir. eWater SOURCE is used extensively in conjunction with other paddock scale models to predict end-of-catchment loads. Paddock models are used to examine a range of scenarios exploring changes to land use management practices, environmental conditions, etc. and then cascade them into suitable inputs for the eWater SOURCE catchment model.

Decisions

The WQIP models support decision-making for catchment management investment to identify the most effective load response proportional to capital expenditure and inform broad recommendations for action at the sub-catchment scale. Land use management practices and catchment improvement works targeting herbicides, dissolved nutrients and sediments can be linked to their associated implementation costs. This enables model outputs to be directly correlated with market efficiency (i.e. dollar spent per load reduction). Decisions are based on a combination of a range of modelling tools (including eWater SOURCE models and outputs) and other lines of evidence.

Acceptable uncertainty

A clear definition of acceptable uncertainty was not able to be articulated during the assessment process. This is in part due to the scale of management practices and recognition that their implementation is difficult, if not impossible, to accurately quantify. As a result, the existing modelling uncertainty is considered acceptable, at least at this point in time. There has been significant effort to quantify the uncertainty of loads prediction from eWater SOURCE models and also a drive to understand the impact of additional observation data on changing the overall uncertainty of catchment loads as a function of changing land management practices.

Decision risk

Three major risks were identified.

- The greatest risk from adopting largely inaccurate and/or highly uncertain model results to support decision-making is failing to achieve the 2025 water quality targets. This failure could lead to significant financial and ecological/ environmental cost (i.e. deterioration of the GBR).
- Incorrect representation of land management practices could result in sub-optimal allocation of funding towards management improvements and reduced support for the model and modelling outcomes by stakeholders.
- There is a reputational risk in regard to the credibility of modelling, and science in general, particularly in relation to uncertainty. Given stakeholder interest, modelling and associated uncertainty should be communicated as transparently and as clearly as possible.

Change in drivers

A major driver for the adopted modelling approach is the evolving understanding of the ecological functioning of the GBR in response to climate change and catchment management practices. As a result, management practices in relation to certain elements may receive more focused attention from time to time. For example, modelling approaches were recently adapted in response to interest in dissolved nutrient and herbicide loads. Another important dimension is the sheer scale of the catchment and number of processes. The processes of interest can change between the lower (stream and estuarine transport) and upper catchments (gully erosion, floodplain deposition and sediment trapping, reservoir dynamics, etc.). Often, requirements to model these specific processes lead to a change in model approach.

Scientific understanding

Application of eWater SOURCE for assessments like catchment load prediction usually involves the simulation of different processes for different constituents. These are described below with an individual rating.

- Rainfall runoff – this encompasses prediction of surface runoff from rainfall and other climate drivers. Model validation against specific industry-standard metrics (i.e. Moriasi et al. 2007, 2015) indicates the approaches adopted are sound. This is usually well-understood and there is recognition that loads are well-correlated with rainfall events. However, predictions of baseflow in certain catchments have been identified as a problem. **(Rated: 4)**
- Hill slope erosion – the Revised Universal Soil Loss Equation (RUSLE) is the current approach used to predict sediment loads associated with hill slope erosion. It is recognised that the approach requires validation across different parts of the catchment and may not be entirely appropriate in some conditions. **(Rated: 3)**
- Sediment loads – the existing processes used to represent gully erosion implemented within eWater SOURCE are considered to be overly simplistic. Development of a more complex representation of gully erosion is currently underway to address this deficiency. Developments for better representation of streambank stability and associated sediment loading are also required. **(Rated: 3)**
- Nutrient generation – there are two different approaches currently being used. The first method used to model nutrient run off from cane farms and banana farms uses a very refined load generation model accounting for land management practice and climate. The second uses the Event Mean Concentration/Dry Weather Concentration (EMC/DWC) approach for drylands and pastures. It is considered to be very simplistic and not necessarily fit-for-purpose. **(Rated: 3)**
- Herbicides and other contaminants of importance – point-based models are coupled with eWater SOURCE to predict herbicide loads. Other contaminants like Tebuthiuron, which is used to kill trees in grasslands, are modelled using the overly simplistic EMC/DWC approach. **(Rated: 3)**
- Nutrient transformation – the representation of nutrient transformation within the catchment model is fairly rudimentary. Significant areas of transformation in the catchment can be attributed to processes occurring in Burdekin Falls Dam, along the river systems floodplains, wetlands, and estuaries. Empirical functional relationships are currently employed to model nutrient retention within the Burdekin Falls Dam. An untested in-stream pesticide decay model is also often coupled with eWater SOURCE for improved representation of contaminant fate and transport processes during dry weather conditions. **(Rated: 2)**

Technological readiness

As a software tool, eWater SOURCE meets expectations of the modeller in terms of documentation,validation and support. **(Rated: 5)**. It should be noted that this rating was based on the experience of the case study participants, and other users in different applications might have different ratings.

Data availability

There is a large and diverse amount of observational data used as part of the Burdekin catchment model. Given the diversity of datasets, rankings were individually attributed. The key areas of improvement in data collection and adoption are listed below.

- The hydrology model is limited by lack of rainfall data in the western areas of the catchments. The long-term rainfall runoff model functions satisfactorily in most conditions. However, accuracy in predictions of event-based catchment runoff in these areas hinders model performance.
(Rated: 4)
- Soil mapping is sparse in certain areas, which precludes the appropriate setup of sediment generation models. **(Rated: 3)**
- Farming behaviour and irrigation demand are not well understood. In the Burdekin, irrigation regimes play a major role in defining soil-moisture content and associated runoff generation within the hydrology models. **(Rated: 2)**
- Processes affecting nutrient assimilation in the Burdekin Falls Dam are not well understood, largely due to insufficient monitoring and associated research. A nutrient monitoring program for the reservoir is currently being implemented.
(Rated: 3)

Communication

The bulk of the modelling outputs related to sediment loads is presented through official report cards for the catchment. The communication is fairly well established and aspects like performance are clearly communicated.

It is understood there will be an increased need to quantify and communicate uncertainty to end-users and stakeholders, particularly noting some farmers may be adversely (i.e. financially) affected by policy changes associated with management practices. Gaps in communication about uncertainty have already been identified. Attempts have been made to communicate with interested parties, however it was acknowledged that the treatment and understanding of uncertainty is probably not as robust as it could or should be.

There is also a clear need for the development of an effective approach in facilitating information exchange between modellers and end-users, and in some instances, stakeholders. At present, the onus for effective communication of uncertainty rests solely with the modeller. There are also instances where end-users make ad-hoc requests for modelling outputs that are not necessarily aligned with the model's intended purpose. These requests are often made without consideration of the uncertainty involved in the modelling process. End-users' education is required to improve understanding of modelling complexities and limitations. A mechanism to involve both end-users and modellers in the formulation of acceptable ways to address (or quantify) and communicate uncertainty is recommended. The ultimate aim is for uncertainty appreciation and communication to become a shared responsibility of both modellers and end-users. **(Rated: 3)**

Community of practice

The size of the community of practice for eWater SOURCE in regard to contaminant fate and transport was observed to be very limited. The small size was reflected in the difficulty recruiting a workforce with adequate skills in catchment water quality modelling, particularly for regional areas. It was also noted that a major risk exists with potential staff turnover and succession (i.e. change of job or career, senior staff retirement, etc.) affecting both in-house knowledge and program continuity.

There was also the perception that government is the major user of catchment water quality models and should promote training opportunities in the water quality space, particularly in regional areas. The representation of academics in the community of practice is limited. A link to academia will be key in terms of maintaining availability of a suitably skilled workforce. **(Rated: 3)**

Governance system

Internal and external layers of governance were identified for the Burdekin catchment model. Good governance practices were observed for both internal and external layers. Well-established practices and processes to share model information and results exist. Model results are regularly backed up and systematically catalogued. Internal development of plug-ins and scripts are shared seamlessly through the group and resources like ‘Git’ are regularly used. There is also a good level of satisfaction with support from eWater and the role they play in maintaining model functionality. **(Rated: 4)**

Adaptability

The ability of eWater SOURCE to use plug-ins developed by individual modellers makes its use fairly adaptable. The basic modular architecture was also identified as a significant contributor to model adaptability. It was also observed that finding the right developers for the plug-ins might be a challenge and this might influence the overall model adaptability. **(Rated: 4)**

Assessment findings

The ratings and weightings for each of the assessment categories are presented in the table below.

Several components were given qualitative importance, in order from most to least important as follows:

- communication
- data availability and scientific understanding
- technological readiness
- community of practice, governance system and adaptability.

The eWater SOURCE model adopted for pollutant exports in the Burdekin catchment received an overall score between 3.40 and 3.57. This indicates the model ranks as an established model with significant progress towards a mature model. Refer to the complementary document, 'Strategic Review of Models - Model Assessment Framework' for further information. The overall score outcome was not sensitive to the weightings. This reflects its relatively consistent ratings across the assessment areas. For models that have more discrepant results across different assessment areas, weightings are likely to have larger influence in the overall classification outcome. Identified areas for action are data collection, scientific understanding of relevant processes, community of practice, and communication of uncertainty (i.e. lower ratings).

eWater SOURCE assessment classification

Category	Rating	Equal weighting	Heavily biased weighting	Weakly biased weighting
Scientific understanding	3.00	1.00	3	1.67
Technological readiness	5.00	1.00	2	1.33
Data availability	3.00	1.00	3	1.67
Communication	3.00	1.00	4	2.00
Community of practice	3.00	1.00	1	1.00
Governance system	4.00	1.00	1	1.00
Adaptability	4.00	1.00	1	1.00
Combined score	**N/A**	**3.57**	**3.40**	**3.48**

Future opportunities

Reflections for future assessments

The assessors made the following reflections regarding implementation of the framework for future model assessments.

- Assessments offer an opportunity to highlight successes, establish benchmarks and pinpoint deficiencies. Shared assessments will enable learnings to be used as a starting point for model improvement initiatives.
- Identifying model owners and increasing their engagement with end-users and stakeholders will help refine future model functionality, data transfer and communication.
- Communication is key to sharing knowledge and building capability across the water modelling sector. Ensuring all relevant players are involved in scoping the assessment will enable a more comprehensive and robust review of water models.

Want to know more?

The QWMN encourages engagement and collaboration across the network to help share knowledge and build capacity in the water modelling sector. Feedback and enquiries are welcome via qwmn@des.qld.gov.au

References

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