QUEENSLAND WATER
MODELLING NETWORK

Strategic Review of Models

A SNAPSHOT

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

Surface water and groundwater systems across Queensland are monitored to support natural resource management and water planning (State of Queensland, 2021). Water models are important ‘virtual laboratories’ that help environmental managers understand the impact of their decisions on Queensland’s water assets.

The water modelling community includes a diverse range of groups from water modellers and researchers to land owners and natural resource managers. The Queensland Water Modelling Network (QWMN) was established in 2017 to support best-practice use of water models and coordinate collaborative projects designed to build capability across the sector.

The QWMN’s 2018-2020 Research, Development and Innovation Strategy raised the need to conduct a strategic review of water models to help identify, substantiate and prioritise investment in water modelling over the next five years (2020-2025). The 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 QWMN commissioned BMT, The University of Queensland and The University of Western Australia to undertake a strategic review of Queensland water models including developing an approach to classify models and a framework for assessment. The work was informed by consultation with the water modelling community as well as industry and academic research.

It is envisaged the review’s two reports – Model Classification and the Model Assessment Framework – will be ‘living’ documents that may be updated to reflect learnings from the assessment process or future capability e.g. technology advances. Model owners are encouraged to share their assessments with the QWMN to help build understanding of capability as well as support an open dialogue between modellers and end-users about future modelling requirements.

Methodology

The Strategic Review of Models project sought to develop a method for evaluating water models that addressed the needs of both modellers and end-users. The project involved a number of different activities to collate information, test ideas and receive feedback:

- consultation with the water modelling community (a range of participants from government, academia and industry across multiple sectors)
  - internet survey (60 questions relating to modelling approaches, processes, uses, applications, communication and uncertainty)
  - stakeholder workshop (discussion about survey topics as well as co-design of the framework)
  - practitioner interviews (case study discussion and assessment)
- industry and academic research
- literature review.

Review outcomes

Model Classification

The QWMN Water Model Catalogue collates and provides a concise overview of 18 of the major water models currently used by the Queensland Government.

While the catalogue provides comprehensive information for the specified models, it was not designed to be an exhaustive list, particularly as new models and modelling platforms emerge over time. A broader classification methodology was therefore developed to enable improved understanding and comparison of models. The expanded classification was organised into different themes that helped to guide community engagement activities and informed the development of the Model Assessment Framework.

Major water models in use by the Queensland Government

1. 2CSALT
2. APSIM
3. Aussie GRASS
4. BC2C
5. eWater SOURCE – water quantity
6. eWater SOURCE – water quality
7. GRASP
8. HEC-RAS
9. HowLeaky
10. IQQM
11. MEDLI
12. MIKE
13. MODFLOW
14. Sacramento
15. SIMHYD
16. SoilWater App (SwaApp)
17. TUFLOW
18. WATHNET

Model Assessment Framework

The Model Assessment Framework was developed to help determine the current status of models, identify how they are being applied and help guide future improvements and developments. In its most simple form, it has been designed as a generic tool to rank a model (or set of models) in servicing the needs of different applications.

The framework 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. It specifies eight components that were found to be instrumental in determining whether a model is fit-for-purpose and whether investment in future developments is warranted. These components are: Policy drivers, Scientific understanding, Technological readiness, Data availability, CoP, Governance system, Adaptability and Communication.

Conceptual representation of the Model Assessment Framework illustrating the overarching role of defining the policy drivers in relation to each of the other components.

Policy drivers

Context | Decision(s) | Acceptable uncertainty | Decision risk | Change in drivers

Scientific understanding

- System processes unknown
- Observed process
- Processes able to be described in detail
- Processes able to be explained in broader context of other processes of systems
- Ability to predict how the process of system will operate or adapt under new conditions

Technological readiness

- Basic ideas and structure described
- Basic principles coded and tested
- Software components are functionally integrated
- Prototype established and is in active testing and/or use
- Fully developed, tested and supported software

Data availability

- No data available
- Literature values and/or data from other systems available
- Data from similar systems available
- Data from target system available but is limited
- Verified data at excellent spatial and temporal resolution available for target system

Communication

- Significant challenges to communicate simulation outcomes to decision makers
- Limited ability to communicate key results with little/no information on performance or uncertainty
- Basic ability to communicate outcomes including performance testing and uncertainty
- Well established methods to present outcomes, including performance measures and uncertainty
- Demonstrated capacity to communicate in ways that significantly aid decision making, performance metrics and uncertainty embedded in communication methods

Community of Practice (CoP)

- No CoP established
- Limited and fragmented CoP
- Basic CoP
- Established CoP
- Well-established and connected CoPs

Governance system

- No system
- Limited system in place or newly emerging system
- Functional system in place
- Established system in place with identifiable protocols
- Well-established system with demonstrated record of active governance of model

Adaptability

- No capacity to adapt
- Limited capacity - adaptation possible but not readily achievable in a practical sense
- Basic capacity for adaptation exists subject to technical, cost or time constraints
- Model is able to be adapted given modest resources
- Well-established processes for rapid adaptation of model to suit specific need

Each component outlined above specifies a five-level assessment hierarchy that incorporates an expanded set of assessment scales originally inspired on the NASA Technological Readiness Level (TRL) concepts (see Sauser et al. 2006, Banke 2010, Heder, 2017). It is intended that models are categorised with a numerical value from 1 to 5 for each component and an overall model assessment score calculated as the sum of all the values awarded.

CASE STUDY

Great Barrier Reef and eWater SOURCE

A case study has been developed 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.

This case study assessed pollutant export modelling for the Great Barrier Reef using eWater SOURCE. The model has been adopted as one of the main components of the Reef 2050 Water Quality Improvement Plan (WQIP) Modelling Program. The main objective of this modelling program component is to identify the impact of change in land use management on nutrient, sediment and pesticide loads and their combined effects on the aquatic ecosystems of the Great Barrier Reef. This case study specifically focused on the Burdekin catchment.

The main land uses of the catchment are: 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. e-Water SOURCE is used extensively in conjunction with other paddock scale models to predict end-of-catchment loads reaching the Great Barrier Reef marine areas.

Two independent assessors used the framework to analyse the model and sought input via interviews with two end-users. This application of eWater SOURCE received an overall score of 3.57 (equal weighting for all components) out of five. This score indicates the model ranks as an established model with significant progress towards a mature model. Identified areas for action are data collection, scientific understanding of relevant processes, community of practice, and communication of uncertainty. The case study assessment and classification provide point in time analysis (May 2020) and are reflective of the views of the participants involved.

Detailed information about the assessment can be found in the Strategic Review of Models – Great Barrier Reef eWater SOURCE case study.

Summary of model assessment scores

Scientific understanding	3
Technological readiness	5
Data availability	3
Communication	3
Community of practice	3
Governance system	4
Adaptability	4
Total	**3.57**

Insights

A number of insights were gained during the project that reinforce the importance of the QWMN's work to build capacity and capability across the sector.

Model functionality

- There was a relatively equal balance between proprietary and open source models. However there is a desire for non-sensitive software/data/information for government and non-profit organisations to be made open source or to be available under a free licence arrangement.
- More than half of modelling community members consulted felt that modelling required an advanced level of competence.
- New data sources can experience issues relating to confidence in their quality and there is a need to ensure robust and efficient data processing tools are available for their uptake.
- Reduction in efforts required for model pre-processing, input data quality and control checking, uncertainty handling, and stakeholder communication and knowledge transfer were identified as focal areas for model investment.

Engagement and communication

Increasing engagement between different groups of stakeholders

- An improved understanding of the water modelling pipeline will enable future actions and improvements to be better targeted (modellers understanding how data will be used/end-users better able to articulate capability requirements).
- Clear data parameters are needed to support improved data transfer between different groups and projects.

Stronger communication links across the sector

- There is a need to clarify the benefits and limitations of models, particularly in relation to managing uncertainty.
- A significant amount of the communication of modelling results currently happens through reports, workshops, handover notes and other documents stipulated through license agreements. Future governance arrangements should identify how communication could be improved.

New focus areas

- A number of areas were suggested for further examination:
  - education in new modelling paradigms/approaches
  - improvement of science underpinning solute transport across soils
  - improved emphasis on metropolitan area issues (i.e. Southeast Queensland)
  - greater attention to climate change, greenhouse gas emissions, adaptability and water security.

Community of practice collaboration

- There are risks associated with succession planning, including access to model support, updates and the ability to innovate. Future governance should seek to address these wherever possible.
- There is a need for targeted user groups to share information and upskill, for example climate science modelling data.
- The modelling workforce was felt to be one of the most important aspects of the whole water modelling workflow. A shortage of new talent was identified and better training, motivation and mentorship could help attract well-prepared professionals.

Future opportunities

The QWMN invites all members to engage with Strategic Review of Models reports and provide observations and feedback via qwmn@des.qld.gov.au

Water model owners are encouraged to assess their models by applying the framework and engaging end-users in the evaluation to build a comprehensive picture of what works and where improvements could be made.

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