QUEENSLAND WATER MODELLING NETWORK

2024 Challenge Statements

DES1231898 – 2024 Strategic Priorities for the Queensland Water Modelling Network

January 2024

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, Science and Innovation with key links across industry, research and government.

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Background

Water models help policy makers and resource managers make informed decisions that reflect current understanding of the complicated natural and socio-economic systems driving water quality and availability for communities and the environment.

The Queensland Water Modelling Network (QWMN) is a Queensland Government initiative to improve the state's capacity to model the quantity and quality of its surface water and groundwater resources. It provides the tools, information and collaborative platforms to support best-practice use of water models, and the uptake of their outputs by decision-makers. The QWMN is led by the Department of Environment, Science and Innovation (the Department) with key links across industry, research and government.

QWMN goals

- Build a state-wide network with national influence to deliver transformative change
- Foster integrated and scalable modelling to address water risks and opportunities
- Champion a community of practice to leverage expertise
- Encourage strategic co-investment and co-production in water modelling research, development and innovation
- Increase application of water modelling to inform decision-making

The *QWMN Research, Development and Innovation (RDI) Strategy 2021-2024* (RDI Strategy) aims to grow the knowledge and capability of Queensland's water modelling community by identifying four (4) priority research areas for concentrating effort and future investment.

These priority topics are:

- **climate change and variability** – water modelling plays a vital role in informing Queensland's response to future climate change and existing climate variability
- **landscape restoration and redesign** – water modelling can improve the design, evaluation and effectiveness of investment in landscape rehabilitation and restoration efforts
- **building trust and confidence** – water models are often seen as complex and opaque, resulting in misconceptions and a lack of confidence in their outputs and end uses
- **model improvement and integration** – water models need to be fit-for-purpose, integrated, robust and adaptable to ongoing advances in knowledge and technology.

The Department, on behalf of the QWMN, is looking to support research, development and innovation projects that address one or more of the 2024 challenge statements. Supported projects will:

- focus on real-world impact, end-user uptake and connection beyond technical models to broader frameworks and knowledge systems (e.g. cultural, environmental, economic, social).
- include an explicit and resourced communication and engagement element that will build a greater awareness of project outcomes, increase understanding and trust in models and better engage end users.

If the project engages with First Nations peoples it must consider the principles of shared agency and mutual benefits from engaging First Nations peoples, consistent with the department's *Gurra Gurra Framework 2020–2026* (the framework). To be consistent with the framework and its intent, proposed projects will consider and, where possible, include:

- Working in partnership from the earliest stages of a project
- Working together to define outcomes and benefits

- Empowering First Nations leadership
- Structurally enabling co-governance and co-stewardship
- Respecting community-led decision-making processes and timeframes
- Exploring new ways of working through co-design and co-delivery

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The Queensland Water Modelling Network is looking to support a number of collaborative projects through this open procurement process. This process may support one (1) project that can be completed within two years (i.e., by 30 June 2026) in addition to several single year projects. Funding levels are capped at $55,000/year (including GST) for pilot/proof of concept activities and $110,000/year (including GST) for fully fledged projects. Proposal outlines are sought to address one (1) or more aspects of the 2024 challenge statements.

1. First Nations engagement

1.1. Context

Aboriginal and Torres Strait Islander people have lived on the Australian continent for more than 60,000 years. During that time, a great diversity of Aboriginal and Torres Strait Islander nations formed with complex societies and cultures centred on a deep and enduring connection to place ('Country').

The management of Country is underpinned by their complex value systems and many First Nations people recognise that the land, water, natural resources and people are a single, connected system that must be managed holistically.

Water is the link that flows across and connects humans to the natural environment and is vital for many aspects of First Nations peoples' lives with a range of cultural, spiritual, social, environmental and economic values associated with both ground and surface water sources.

First Nations peoples have lived by and looked after waterways for thousands of generations. The Queensland Government recognises that the indispensable knowledge and perspectives of First Nations people are needed to achieve sustainable and socially equitable water management and build community resilience to climate change, floods and other extreme events.

The Queensland Government is committed to working with Aboriginal and Torres Strait Islander Queenslanders to achieve a reframed relationship and acknowledge our shared history.

Path to Treaty is central to this commitment and is a critical step in setting the foundation for a new and just relationship—one that acknowledges the injustices experienced by Aboriginal and Torres Strait Islander people, and provides a platform for truth-telling, equality and opportunity.

The Department of Environment, Science and Innovation recognises, respects and values First Nations peoples and cultures. We recognise that First Nations people have rights and interests in the country on which we work. We are committed to walk the Path to Treaty to reframe our relationships with First Nations peoples and incorporate their priorities and perspectives in our decision-making and operations.

The *Gurra Gurra Framework 2020-2026* (the Gurra Gurra Framework) is supporting DESI to prioritise and accelerate this commitment.

1.2. Challenge

The QWMN welcomes project proposals that will strengthen and reframe relationships with First Nations peoples and establish genuine and permanent partnerships, which would bring significant cultural and scientific benefits for the QWMN and its end users and impactful outcomes for Country and people.

Of particular interest are projects that will work towards:

- Identifying and recognising relevant cultural values and First Nation's aspirations
- Incorporating traditional knowledge and cultural values into the water modelling pipeline
- Building trust, confidence and engagement of First Nations peoples in water models
- Developing Indigenous Research Methodologies for water modelling and management
- Connecting First Nations and other knowledge systems for mutual benefit
- Fostering water science capability in First Nations communities
- Developing case studies for First Nations engagement on water modelling at a local scale
- Aligning water modelling outcomes with the needs and aspirations of First Nations peoples

- ► Improving understanding of cultural flows and use of water models in cultural flow allocations.

1.3. Minimum requirements

The proposal needs to demonstrate that the project will:

- follow the recommended principles of engagement of the QWMN Review of Protocols for Engagement with First Nations Peoples (p12). Any engagement processes as part of the proposal need to be based on the principles of Free, Prior and Informed Consent (FPIC).
- be co-designed and co-delivered and/or led by First Nations People or an Indigenous business (a business at least fifty per cent owned by Aboriginal peoples and Torres Strait Islander peoples).
- If a proposal is not led by a First Nations People or Indigenous business, an endorsement by the First Nations People or Indigenous business consortium member(s) that the project has been co-designed with and the elements meet the criteria will be required. A similar endorsement will be required at the end of the project to agree it fulfilled the requirements

Proposals are also strongly encouraged to consider the Indigenous Cultural and Intellectual Property rights of any First Nations people engaged and reflect this in all documentation governing project delivery (e.g. contracts). This will be a contract departure for proposals shortlisted for the Proof of Concept Phase.

2. Climate Change and shallow groundwater aquifers

2.1. Context

Groundwater is a critical water resource for a substantial percentage of the Queensland population, in particular, remote and regional communities who may use groundwater as their stable supply supplemented by surface water when available. Proposals under this challenge statement will focus on the shallow aquifers along the coastal fringe where there is likely to be greater short-term measurable/discernible impact than in the deeper aquifers like the Great Artesian Basin.

Climate change and climate variability pose significant threats to the water security of these communities through the direct effect on surface water flows linked to changes in rainfall and evaporation but also the indirect impact on underground water quality and quantity. Improved understanding of how these complex systems interact would help policy makers develop appropriate responses that consider the full suite of end users and their short-term and long-term needs and aspirations.

Many Australian rural townships and First Nation communities depend on shallow groundwater (GW) aquifers for their town water supply (TWS). These GW aquifers depend on recharge from rainfall, which will be affected by climate change. Therefore, there is a need to develop a methodology to assess the vulnerability of these aquifers and the TWS to the impact of climate change. Some of these communities supplement their TWS with surface water when it is available and use the GW aquifer as a back-up supply when the surface water supply fails. The potential impact of climate change on these TWS has not yet been extensively modelled.

2.2. The Challenge

Climate Change modelling of Surface Water Systems

The Department of Environment, Science and Innovation (DESI) has a methodology for assessing the impact of climate change on surface water systems. This consists of modifying historical rainfall and evaporation sequences used in the surface water model using monthly factors derived from General Circulation Models (GCMs) that simulate the effect of climate change on rainfall and evaporations as well as temperature. A description of the methodology can be found in DES (2022).

Rainfall and evaporation sequences produced by this methodology would be suitable for use in GW models. Because some communities of interest have both surface water and GW sources of supply, it would be crucial that the surface water models and GW models use the same rainfall and evaporation sequences in their simulations. Therefore the DESI methodology would be used to derive the climate change rainfall and evaporation sequences used in the GW models.

There are many GCMs, however, the current state of the art of climate change modelling is such that there is no one model that is appropriate for simulating the impact of climate change in Queensland. The current methodology is to run multiple simulations using the results of 11 GCMs that give the best simulation of Queensland climate.

As there is also uncertainty about the efforts to address climate change, there are 3 possible emission scenarios. Therefore, current practice in climate change modelling of Queensland surface water systems is to run 33 scenarios. This can only be done for a limited number of surface water model scenarios on the High-Performance Computer (HPC).

Groundwater Modelling

There is more uncertainty in groundwater modelling then in surface water modelling. While both suffer from insufficient data, with surface water modelling, one can see the flow of water. With groundwater modelling, there is very little information on what is happening below the surface. So, it is important that this uncertainty be reflected in the GW model results.

It is becoming standard practice in GW modelling to deal with this uncertainty by running many realizations of the model to show the uncertainty in the results. A discussion of the methodology can be found in Doherty and Moore (2021).

A study describing an attempt to determine the impact of climate change on a GW system can be found in Gallagher and Doherty (2020). In this study, a GW model was used to assess climate change impact on the Biggenden TWS. 250 realizations of calibration-constrained, hydrogeologically realistic parameter fields were generated. 100 different stochastic realizations of future weather comprising daily time series of precipitation and potential evaporation were used. From this example, it can be seen that applying the many climate change scenarios to a GW model with hundreds of realizations can lead to a very large computational effort.

Therefore, the challenge is to develop a methodology for reducing the computational burden of applying climate change to GW model without too great a sacrifice in accuracy. There are two options:

- reducing the number of GW replicates
- reducing the number of climate change scenarios.

Before developing a methodology to reduce the computational load, it will be necessary to develop a standard for assessing the methodology. This can be achieved by running a simple GW model of a shallow GW aquifer with a TWS demand for the normal number of realizations and climate change scenarios. This will be the benchmark for comparison of the various methodologies for reducing the computational workload.

The GW model used in this study should be able to do the following:

1. Allow the restriction rule to be applied to the TWS, where the demand can be reduced when the level at the monitoring bored drop below specified levels.
2. Similar rules can be applied to the other demand bores in the GW system to simulate an announced allocation rule. This will allow the assessment of ways to reduce the impact of climate change on TWS bores.
3. Identify the realizations and the recharge and crop demand sequences that produce the median and percentile values of the TWS demand.

Software will have to be developed to transform the climate change rainfall, evaporation and streamflow sequences produced by DESI in a format that can be easily used by the GW model.

Software will also have to be developed to present the results of the climate change modelling in a form that can be easily comprehended by potential end users. It may be useful to produce the information in a format that is similar to the one developed by DESI for presenting the results of the surface water climate change results.

The following options have been identified as possible approaches:

Option 1

The first option to be considered is to reduce the number of realizations in the standard GW model by selecting representative GW model realizations. A first approximation would be to use the realizations that produce the median and percentile values of the TWS demand. The results of running these realizations could be compared with the climate change results from the standard model.

Further work with more realizations may be needed to improve the agreement between the results of using a limited number of realizations and the standard model.

Option 2

The second option would be to reduce the number of climate change scenarios.

Climate change affects the rainfall and potential evaporation sequences. The change to these parameters mainly affects the recharge sequences used by the GW model and the crop demand sequences. An analysis could be undertaken of the recharge sequences and crop

demand sequences produced by the climate change sequences to see if the number of sequences can be reduced.

The results of using the selected sequences could be assessed against the results of the standard model.

Option 3

Option 3 may be a combination of these two options to improve GW model predictions.

Option 4

Option 4 may be an alternative method. Attention is drawn to the work of Emeritus Professor George Kuczera of the University of Newcastle who has developed a methodology for thinning replicates in the program WATHNET, which does stochastic modelling of surface water systems. There may be an opportunity to use this method to 'thin' GW realizations.

Once developed, the methodology should then be tested against the standard model and should be applied to some other shallow GW aquifer systems. Possible candidates include the Biggenden aquifer, the Atherton TWS aquifer, and the Biloela aquifer. Another possible candidate could be the Minjerribah (North Stradbroke Island) system.

It should be noted that the study should be for shallow GW aquifers and not deep aquifers such as the Great Artesian Basin.

Another consideration should be that outputs from the climate change GW models will be used in the assessment of economic, environmental, social, and cultural impacts of climate change. This should be considered when developing the software for the presentation of the model results.

This work would be a particular interest to the Urban Water Security Planning group in the Department of Regional Development, Manufacturing and Water. They are willing to be involved in the study to provide guidance as to the requirements of users of the GW model results. This group recognises the needs of communities that are dependent on shallow GW aquifers for their TWS. The Urban Water Security Planning Group were particularly interested in improving the GW model output so that it is more easily understood by potential users.

2.3. Minimum requirements

- DESI methodology to be used to derive the climate change rainfall and evaporation sequences used in the groundwater models
- Proposal should focus on shallow aquifers
- Output from the climate change GW models will be used in assessing economic, environmental, social, and cultural impacts of climate change. This should be considered in developing the software.

2.4. References

- DES (2022) Incorporation of climate change in water resource modelling for Queensland's water plans. Prepared by Queensland Hydrology, Department of Environment and Science.
- Doherty, J. and Moore C., (2021). Decision Support Modelling Viewed through the Lens of Model Complexity. A GMDSI Monograph. National Centre for Groundwater Research and Training, Flinders University, South Australia.
- Gallagher, M. and Doherty J. (2020). Water supply security for the township of Biggenden: A GMDSI worked example report. National Centre for Groundwater Research and Training, Flinders University, South Australia.

3. Modelling the impact of aquaculture on water quality

3.1. Context

Marine prawn and fish aquaculture is expanding in Queensland with the potential to become a large industry. Many of these aquaculture operations are located on estuaries, with intakes from and releases to the local waters. Licensing the quantity and quality of these releases, such that environmental impacts are minimised, requires a tool that can predict the impacts of a range of different release scenarios – in other words a model.

Such a model needs to include a hydrodynamic component linked to a biochemical process model. Such models have been around for many years but are complex to set up and run and are normally only amenable for use by experienced modellers. As a result, significant costs are involved.

Under EIS processes, development proponents may commission such a model and present the results to the regulator, but the department then has the problem of assessing the validity of the results of a complex model, not a trivial task. As the aquaculture industries expand, there is a growing need for robust, fit for purpose models that ensure future developments balance economic benefits with environmental sustainability.

3.2. Challenge

Aquaculture development applications are required to provide modelling that demonstrates the predicted impact of the development on water quality. While the principles and drivers underlying the models are similar (production inputs è releases è nutrients è dissolved oxygen), the individual models are highly specific to the location and proposed development, requiring tailored assessments that are time intensive and which do not foster community trust in the modelling process and its outcomes. If there were a set of principles and parameters that were broadly accepted by key stakeholders and these were used to assess if individual models were fit for purpose, this would help streamline the consistent assessment of aquaculture development applications, contribute to their social licence to operate, increase confidence in the protection of Queensland's Environmental Values and foster community confidence in development decisions taken. This would align with development of the Queensland Aquaculture Roadmap, helping to make the application (by industry) and the evaluation (by DESI) more robust, consistent and efficient.

A successful proposal would include a critical analysis and evaluation of models relevant to aquaculture with particular focus on the expected releases of nutrient/phytoplankton (concentrations/quantities) and the dissolved oxygen regime and their impacts on environmental values through the range of conditions reasonably expected to be experienced by the facility in operation. Similar to the QWMN Wetlands Hydrology Model review this would outline the strengths and weaknesses of existing models applied to aquaculture as they pertain to scale, process, landscape form, cost, availability, etc. and identify any significant/critical gaps. Once applied, this would help identify which models are fit for purpose for different scales (spatial, temporal), and locations. The analysis may help focus future effort and resources to address key gaps and strengthen the aquaculture sector.

The evaluation would build on the QWMN model classification framework that includes:

- Model type
- Model licensing
- Process understanding and expertise required for effective model use
- Type of interface
- Set-up and post processing effort
- Calibration requirements
- Level of support
- Stakeholder communication and knowledge transfer
- Quality control of modelling process
- Model usage context
- Uncertainty handling

It is expected that project would not be limited to desktop studies and literature reviews only but would actively engage with key stakeholders (e.g. industry, government, research, First Nations, community, etc.) to 'reality check' the work and foster shared ownership of the final outputs.

The successful proposal would also include one or more conceptual models to illustrate and quantify aspects of the nutrient processes and modelling of aquaculture releases. This would include a conceptual model that includes information on nutrient, outputs, processes, effects, and management. Based on a literature review, this would provide quantitative information on nutrient flows and impacts on flora and fauna, and provide a reference for stakeholders using or assessing models to predict aquaculture nutrient processes and impacts. (See example: https://wetlandinfo.des.qld.gov.au/wetlands/ecology/processes-systems/nitrogen-concept-model/palustrine/), and also shows the factors influencing inputs to a hydrologic model, the hydrological, hydrodynamic, and nutrient processes within the wetland, the wetland components that influence water flows and processes, and the outputs from an aquaculture wetland model. This will assist in understanding of the modelling process. See examples: https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/modelling/wetlands-modelling/

Conceptual frameworks and associated parameter ranges would be hosted on Wetland Info.

3.3. List of relevant documents

1) Wetlandinfo https://wetlandinfo.des.qld.gov.au/wetlands/ (this would host some of the final project outputs)
2) QWMN Wetlands Hydrology Review - https://science.des.qld.gov.au/__data/assets/pdf_file/0031/249907/qwmn-wetland-hydrology-model-review-sept-2021.pdf
3) QWMN Model Classification Framework - https://science.des.qld.gov.au/__data/assets/pdf_file/0021/247116/QWMN-Strategic-Review-of-Models_Model-classification.pdf

4. Consolidation and extension

4.1. Context

The QWMN was launched in 2017 with an initial tranche of funding of four years to address issues around strategic capacity and capability associated with water modelling in Queensland. The success of the initial pilot phase led to a further four years funding up to 2024.

Annual independent monitoring and evaluation (M&E) assessments have confirmed that the network is meeting a clear need, is run effectively and delivering value for practitioners in the water sector. However, the mid-term M&E assessment in 2022 identified several opportunities to improve program delivery and impact, including the recommendation to take steps to move from an individual project approach to a programmatic approach with a more explicit focus on achieving medium- to long-term outcomes.

This can be achieved in part by building on past QWMN RDI investments, including:

- Consolidation of outputs across projects to build a connected package (or program) of work with common objectives
- Extension of outputs from past projects (e.g. technical reports/reviews, models, decision-support tools) to respond to any recommendations, knowledge gaps, issues and opportunities.

4.2. Challenge

The QWMN welcomes project proposals that will consolidate and/or extend from past QWMN investments to support the network in transitioning to a more programmatic design focussed on delivering real-world outcomes.

In line with recommendations from the mid-term M&E assessment, projects should explicitly link to one or more of the following QWMN medium-term outcomes set out in Appendix A:

- Improved water planning, decision-making and ongoing research in Queensland
- Improved fit-for-purpose integration of Queensland hydrology, groundwater and water quality models
- Models inform and address water risks and opportunities
- End users have the advice available to make informed water risk management decisions
- Knowledge generated is shared across the broader Queensland water modelling community
- Improved integration of traditional knowledge and cultural values in water planning and management.

It is expected that proposals addressing this challenge statement will strengthen the ability of the QWMN to achieve its vision of a state-wide network with national influence that delivers transformative change in the water modelling sector.

4.3. Minimum requirements

The proposal needs to specifically identify past QWMN investments that will be consolidated or extended, with a clear rationale for how this additional investment will assist the network in building a program of connected projects and/or shifting in focus from outputs/activities to medium-term outcomes.

Proposals may only include past QWMN investments where project outputs (e.g. technical reports/reviews, models, decision-support tools, project summaries, visual media) or other publications that are published and publicly available on the QWMN DESI or 3CP websites. For proposals that wish to build on past QWMN investments with unpublished outputs, exceptions may be considered if

at least one member of the original project consortium are included in the proposal as delivery partners.

In recognition of the need to build collaboration and foster innovation in the water modelling sector, proposals are strongly encouraged to incorporate at least one project partner that has either

- not previously been involved in the original project(s) proposed to be consolidated/extended **or**
- not previously worked with one or more of the other delivery partners.

Proposals that replicate past consortia working on the same project will not be considered.