QUEENSLAND WATER MODELLING NETWORK

Research, Development and Innovation Strategy
2018–2020

Queensland Government

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1. Introduction

Water modelling helps us better understand our environment and plan for the future. Queensland has significant strengths in research, development and use of water models to inform how we manage landscapes and catchments, as well as design and manage water for our cities.

However, there are opportunities to improve practices and translate our expertise to achieve better outcomes for our communities and environment. Research, development and innovation are valuable tools to grow our knowledge, solve challenges and capture value from our ideas.

The Queensland Water Modelling Network (QWMN) Research, Development and Innovation (RDI) Strategy (the strategy) identifies where the QWMN will focus future efforts to improve and integrate water modelling activity in Queensland.

The strategy will inform how we better integrate datasets, models and the outputs of different models operating at diverse scales. It will foster collaboration and integration across models, research, practitioners, sectors and levels of government.

The QWMN's goals will guide RDI activities, and its guiding principles will inform future projects and actions. The strategy supports delivery of *Our Future State: Advancing Queensland Priorities* as well as Queensland's Science and Research Priorities.

The priorities in this strategy will be reviewed annually to ensure the QWMN can respond to emerging issues whilst planning for the short, medium and long-term. Improving Queensland's water modelling capabilities will enable us to continue providing the best scientific data to policy makers and natural resource managers.

2. About the QWMN

The QWMN is a Queensland Government-led initiative to improve the state's capacity and capability to model the quantity and quality of its surface water and groundwater resources.

The QWMN provides tools, information and collaborative platforms to support best-practice use of water models and the uptake of their results.

Queensland Water Modelling Network research projects are framed by five areas of focus: model integration; model improvement; model management; building capacity and model uptake; and communications and engagement. The projects address priority modelling needs identified through consultation with modelling groups within government, external partners and consultants.

This strategy recognises arrangements and activities already in place by the QWMN and programs supporting water modelling in Queensland. Initiatives such as the QWMN Modelling Fellowship (Griffith University) and QWMN Innovation Associates Program (an industrial PhD initiative through the International WaterCentre led university consortium) support enhanced model outcomes as well as investing in improving the capability of water modelling sectors.

Future QWMN projects will reflect and complement these initiatives to increase their impact, and align with the QWMN Goals and Principles outlined in this strategy.

The Department of Environment and Science is responsible for the coordination of the QWMN in a partnership with the Department of Natural Resources, Mines and Energy, Queensland Reconstruction Authority and other organisations.

QWMN Goals

1. **Build a state-wide network with national influence to deliver transformative change**
   - ► build a legacy of transformation through a priority model or suite of models
   - ► engage across sectors with a stake in water modelling to inform investment decision-making, planning, research and teaching
   - ► contribute to the state and national agenda through key initiatives and collaboration
   - ► address critical strategic gaps and weaknesses in water models at all scales.

2. **Foster integrated and scalable modelling to address water risks and opportunities**
   - ► improve integration of all Queensland hydrology, groundwater and water quality models, including Great Barrier Reef models
   - ► integrate environmental monitoring activities with water modelling, particularly in priority catchments and basins
   - ► support development and implementation of finer-scale assessment and modelling frameworks to better prioritise and evaluate works.

3. **Champion a community of practice to leverage expertise**
   - ► improve the efficiency, application and use of models by practitioners providing advice to end-users
   - ► engage with Queensland's broader modelling community seeking to partner with the academic, private, public research and government sectors
   - ► support the development of standards or requirements that improve water models over time.

4. **Encourage strategic co-investment and co-production in water modelling RDI**
   - ► identify priority RDI opportunities to improve the efficiency and effectiveness of water modelling in Queensland
   - ► facilitate targeted co-production and co-investment with leading collaborative partners to advance shared goals.

5. **Increase application of water modelling to inform decision-making**
   - ► enhance ability of models to support assessment and consideration of water-related cumulative impacts or responses to scenarios
   - ► seek opportunities to harvest multiple data sources to improve model performance and applicability.

Principles

These goals are supported by principles to inform the QWMN's activities and projects:

Outcome focussed
- ► relate to priority issues and regions
- ► complement past or current activities
- ► respond to Queensland's emerging priorities.

Capacity building
- ► contribute to improved water modelling in Queensland
- ► be informed by and contribute to the best available science and expert knowledge.

Connection and integration
- ► build skills, knowledge and networks
- ► foster collaboration across groups and sectors.

Best practice
- ► increase connectivity and integration of water models and practices
- ► lead step-change improvements in the efficiency, use and application of water models.

The QWMN will focus effort on the following priorities during 2018–2020:

Priority models

HOWLEAKY

eWater Source

medli

MODFLOW

music

Priority regions

Northern Australia

Great Barrier Reef catchments

Northern Murray Darling Basin

South East Queensland and Moreton Bay
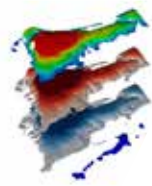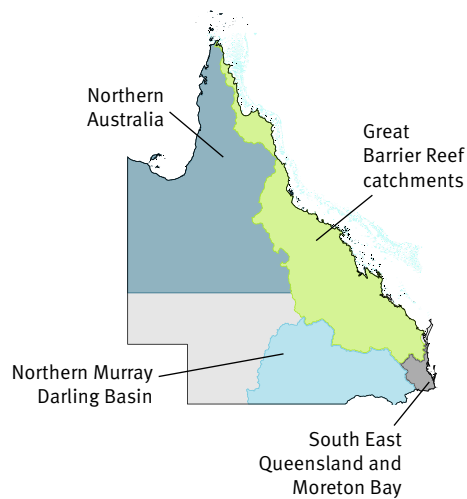
RDI priorities 2018–2020

Climate change and variability

Landscape restoration and redesign

Water planning, integration and management

Model management

Priority models

In 2017, QWMN undertook a review of the key surface and groundwater models used by the Queensland Government. The QWMN Model Catalogue, available online, captures most major models used within Queensland Government. However it is recognised that there are additional models critical to other organisations, and an updated QWMN catalogue is being considered as an action under the Model Management priority.

The QWMN has identified a series of water quality and quantity models as priorities for 2018–2020. The priority models (in bold below) have been selected based on their role in enabling outcomes for the 2018–2020 priorities as well as displaying high RDI potential in Queensland.

Model use	Model name
Farmer decision support	SoilWaterApp
Agricultural systems assessments	**HowLeaky,** APSIM, GRASP – AussieGRASS
Planning support	**MEDLI,** 2CSalt, **MUSIC**
Catchment policy	Sacramento, SIMHYD, IQQM, eWater Source – Quantity, **eWater Source – Quality,** MIKE 11, HEC-RAS, WATHNET
Groundwater policy	**MODFLOW,** BC2C
Receiving water and coastal water quality reporting	eReefs, TUFLOW

The QWMN will consider other models where it can be demonstrated they would help address a significant gap or weakness in the existing suite of models or support better integration of water models in state planning and management (e.g. for flooding, resource planning etc.).

Strategic model review

A strategic review of the state's water models to underpin a roadmap for action is also under discussion. Model managers will be asked to develop a roadmap for model improvement over the next 5–10 years that will help guide the future use, enhancements and capability linked to the role they play in supporting the delivery of State business.

Priority regions

The QWMN supports water modelling activity both state-wide and in specific regions.

Priority regions for 2018–2020 are:

- ► Northern Australia
- ► Great Barrier Reef catchments (Cape York, Wet Tropics, Burdekin, Fitzroy Basin, Mackay Whitsundays, Wide Bay-Burnett) and aligning with activities being undertaken in the marine environment
- ► South East Queensland and Moreton Bay
- ► Northern Murray Darling Basin (linked to South Western Queensland, Darling Downs).
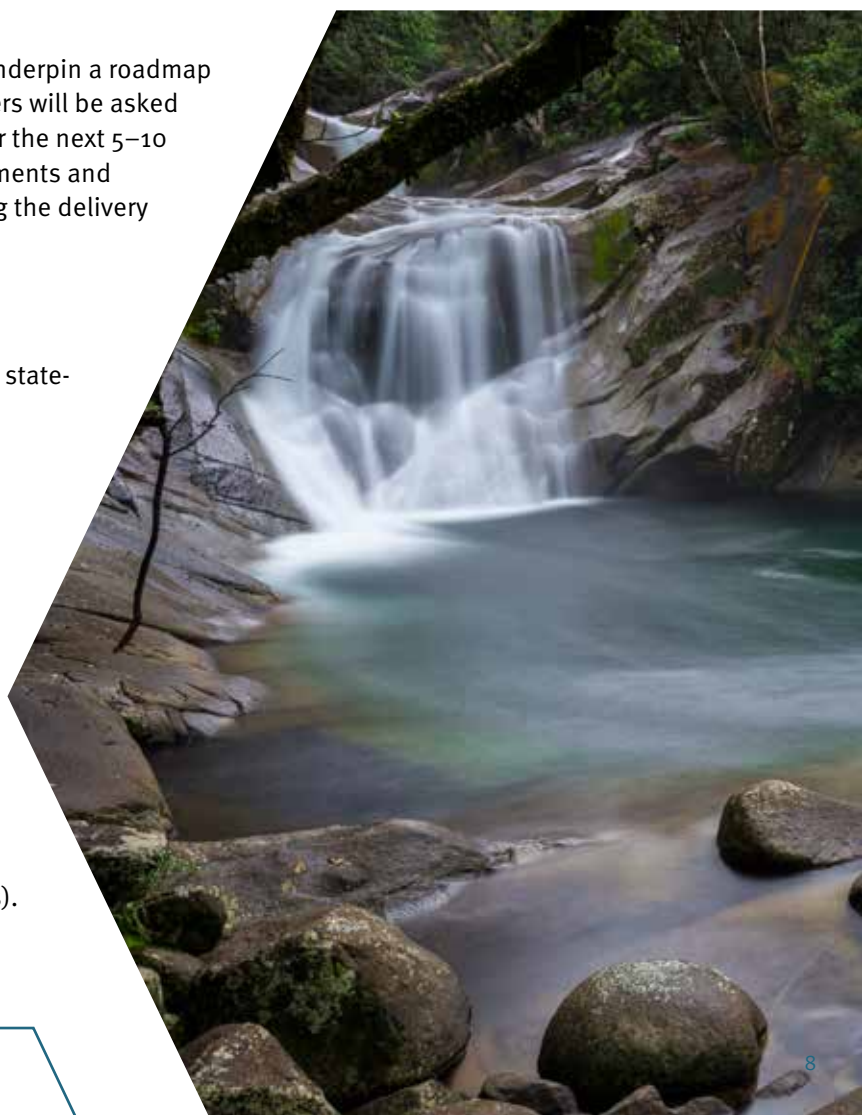
The table below considers interactions between three of the RDI priorities and the priority regions. Model management is not considered as its activities are either model specific or take a statewide approach (e.g. data standards audit).

Model evolution to date

Minimal	(grey)
Being initiated	(light blue)
Work underway	(medium blue)
Well established	(green)

Figure 2. QWMN models mapped according to QWMN RDI priorities and priority regions.

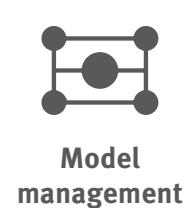| Priority region	RDI priorities		
	Climate change and variability	Landscape restoration and redesign	Water planning, integration and management
Northern Australia	APSIM AussieGRASS GRASP HowLeaky Receiving Water & Coastal Models Sacramento eWater Source	AussieGRASS GRASP HowLeaky MEDLI MODFLOW MUSIC Receiving Water & Coastal Models eWater Source	HEC-RAS MEDLI MUSIC TUFLOW eWater Source WATHNET
Great Barrier Reef catchments	APSIM AussieGRASS GRASP HowLeaky Receiving Water & Coastal Models Sacramento eWater Source	APSIM AussieGRASS BC2C GRASP HowLeaky MEDLI MODFLOW MUSIC Receiving Water & Coastal Models eWater Source	HEC-RAS MEDLI MIKE MODFLOW MUSIC TUFLOW eWater Source WATHNET
South East Queensland and Moreton Bay	APSIM AussieGRASS GRASP HowLeaky Receiving Water & Coastal Models Sacramento eWater Source	APSIM AussieGRASS BC2C GRASP HowLeaky MEDLI MODFLOW MUSIC Receiving Water & Coastal Models eWater Source	HEC-RAS MEDLI MIKE MUSIC TUFLOW eWater Source WATHNET
Northern Murray Darling Basin (South Western Queensland and Darling Downs)	APSIM AussieGRASS GRASP HowLeaky MODFLOW Sacramento eWater Source	APSIM AussieGRASS BC2C GRASP HowLeaky MEDLI MODFLOW MUSIC eWater Source	HEC-RAS MEDLI MIKE MUSIC TUFLOW eWater Source WATHNET

The 2015 Greenfield review's analysis of regional priorities was used as a basis in developing the above table.

Research, Development and Innovation Priorities 2018–2020

The 2018–2020 RDI priorities have been informed by the 2018 QWMN mid-term review, the 2017 and 2018 QWMN Forums and the outcomes of the QWMN research projects.

The focus of the priorities is to address government research, development and innovation challenges in four key fields:

Climate change and variability

Landscape restoration and redesign

Water planning, integration and management

Model management

Significant investments to date have included improved modelling of Great Barrier Reef and South East Queensland catchments, as well as enhanced understanding of Queensland water models, their application for policy-makers and environmental managers, and development of best practice modelling principles.

Climate change and variability

Water modelling plays a vital role in supporting Queensland's response to the challenges and opportunities associated with a changing climate. There are opportunities to enhance water modelling capabilities to capture the latest science and provide advice on the implications of climate change scenarios.

What challenge is the QWMN working to address?

There is a need to establish a consistent approach to climate change modelling in Queensland's water models. Undertaking a strategic assessment of the current gaps in water models' recognition and treatment of climate change and climate variability will help build consistency.

The majority of current water models are designed to handle simulation periods from approximately 1890 to the current date. Increasing the length of simulation enables researchers to better assess the frequency of rare and/or extreme events while simulation into the future enables assessment of the potential effects of climate change.

Opportunities

There are growing demands for increased understanding of how multiple sectors interact in response to climate change and variability. There are opportunities to consider the impact of likely climate change scenarios on Queensland's water quality to inform future policy, planning and management of our assets and environment.

Activity

The outputs of QWMN models support the following state and regional programs linked to climate change:

- ▶ Queensland Climate Transition Strategy
- ▶ Queensland Climate Adaptation Strategy
- ▶ Drought and Climate Adaptation Program
- ▶ Queensland Water Planning Program (Water Plans and Management Protocols in Queensland regions)
- ▶ The Reef 2050 Long-Term Sustainability Plan.

Priorities for 2018–2020

Timeline	Actions
Short-term	▶ Prepare a strategic review paper, identifying gaps and weaknesses in existing water models' coverage of climate change and its impacts with case studies on the Great Barrier Reef, Murray-Darling Basin and South East Queensland.
	▶ Following development of a strategic review paper, consult with the QWMN Community of Practice to test the paper's findings and identify how they would apply in Queensland.
Medium-term	▶ Prepare a conceptual design for inclusion of climate scenarios in major models used for water resource planning and water quality.
	▶ Model the impact of likely climate change scenarios on water quality and quantity.
Long-term	▶ Embed climate science scenarios in water models used in Queensland.
	▶ Improve water modelling capability to handle longer simulation periods.

Landscape restoration and redesign

Landscape rehabilitation and restoration in Queensland is an important field that could benefit from more direct links with water modelling to help guide the design of targeted interventions and how their impact is monitored.

A focus in 2018–2020 is on addressing gully and streambank repair and restoration. Increased integration and information sharing could improve the design and prioritisation of projects as well as reporting on investments.

What challenge is the QWMN working to address?

It is essential for landscapes to be able to maintain their structure and functions to support biodiversity and deliver economic and social benefits provided by land practices in the face of ongoing stressors and disturbances. An increasing challenge for Queensland is to enhance resilience of its landscapes and inform integrated responses to:

- ► flood risk management
- ► pollutant load reduction (sediment, pesticides, nutrients)
- ► carbon sequestration
- ► water security
- ► ecological system needs.

A key focus of the strategy will be to implement recommendations from the 2018 report by Dr Ian Prosser on gully erosion and river sediment transport processes. The report recommended improvements to research, data collection and conceptual design to make them more relevant to the needs of land management agencies and communities.

Broadly, the recommendations included:

- ► Enhancing uncertainty analysis and addressing information gaps in gully mapping and assessment of management effectiveness.
- ► Modelling current rates of gully erosion and improved modelling of streambank erosion.
- ► Improving understanding and application of erosion processes (e.g. in-stream deposition and re-entrainment, daily scaling of model processes) and management responses (e.g. restoration response curves).

The recommendations were largely focused on improving the modelling parameters with respect to sediment in landscape restoration in the Reef modelling and reporting context, but would have broader relevance to the way landscape restoration is approached in other Queensland regions.

Opportunities

There is a growing conceptual understanding of the potential role, fate and transport processes of bioavailable nutrients within catchments. There are research opportunities to improve our knowledge, particularly in regard to calculating the benefits of approaches to reducing bioavailable nutrient delivery to Moreton Bay and the Great Barrier Reef lagoon. It could ultimately inform implementation approaches such as prioritisation of pollutant load reduction programs, water quality offsets and reef credits for nutrients, sediment, carbon and other pollutant outcomes.

A variety of programs are underway to measure and evaluate cost-effectiveness of restoration measures, improve descriptions of streambank and gully attributes and typologies, and confirm and standardise conceptual models. It will be important to align this work with other projects to help clarify agreed standards regarding data collection and model validation.

A further opportunity could explore how wetlands can be appropriately included in the broader modelling framework, through a 'systems approach'. This is particularly the case for landscape redesign using created or enhanced wetlands to remove pollutants (nutrients, sediments, pesticides, carbon) from the system.

Activity

The outputs of QWMN models support the following state and regional programs linked to landscape restoration and redesign:

▶ Queensland Reef Water Quality Program 2018–2022

▶ Reef 2050 Long-Term Sustainability Plan

▶ Reef 2050 Water Quality Improvement Plan

▶ Paddock to Reef Integrated Monitoring, Modelling and Reporting Program

▶ Queensland Natural Resource Investment Program 2018–2020

▶ Queensland Wetland Program

▶ SEQ Resilient Catchment initiatives and other landscape restoration responses

▶ Griffith University Potter Foundation Building Catchment Resilience Project

▶ Catchment Resilience Program.

Priorities for 2018–2020

Timeline	Actions
Short-term	▶ Improve application of paddock-scale erosion processes and management interventions to the catchment scale to underpin better modelling of landscape system responses e.g. altered grazing regimes, enhanced wetlands, erosion control measures. ▶ Develop robust, transparent and repeatable methods for assessing uncertainty in gully and stream process models. ▶ Enhance aspects of gully and streambank restoration modelling, implementing the recommendations of the Prosser review, extending the recent development of the gully classification methods and other modelling activities across government and external agencies.
Medium-term	▶ Develop standard approaches and tools to model key processes and outcomes (gullies, bio-available nutrients, etc.). ▶ Identify the impact and importance of 'coarse sediment' (implications for infrastructure, water supply, etc.).
Long-term	▶ Develop nutrient offset assessment methodology and tools. ▶ Develop a sediment quality model - modelling sources and transport of clay minerals responsible for marine pollution.

Water planning, integration and management

Water models are critical tools in guiding how we plan and manage not only water quality and quantity but also our natural and urban environments. As interest grows in the broader application of water planning and management data, there is increased need to ensure models are contemporary and fit for purpose. There are opportunities to improve integration across model suites, domains and scale to improve system knowledge and design of management interventions.

What challenge is the QWMN working to address?

Several key water models were developed many years ago and there is a need to incorporate new science and knowledge to keep them current. For example, MEDLI, the Model for Effluent Disposal Using Land Irrigation, a Windows® program for designing effluent re-use schemes, was first developed in 1996. The most recent version was released in 2015 to enable it to be run on modern computer operating systems. It is timely to review the science behind MEDLI to complement the improved operating framework, as well as identify any broader applications.

In some communities, urban infill is emerging as an issue which needs to be appropriately managed and can be supported by targeted modelling. The dimensions of floods, including the impact of riverine vegetation across the catchment, are also priorities for communities across Queensland.

Opportunities

There is a strong interest in the broader application of water planning and management data to urban and regional growth and development. There are opportunities to develop and share standard approaches and models that can be applied across rural and urban centres and water sources.

Increased connectivity and integration will help support the ongoing prosperity of regional centres, within the context of the catchment. It will allow impacts beyond the immediate environment to be considered, from the impact of urban water borne pollutants on reef health to the interaction between ground and surface water in designing and delivering water security for remote communities.

Activity

The outputs of QWMN models support the following state and regional programs linked to water planning, integration and management:

- ► Queensland Natural Resources Investment Program 2018–2020
- ► Office of Groundwater Impact Assessment - cumulative management areas
- ► Queensland Water Planning Program (Water Plans and Management Protocols in Queensland regions).

Priorities for 2018–2020

Timeline	Actions
Short-term	► Review the science behind MEDLI and compare with APSIM and HowLeaky in terms of deep drainage and nitrate leaching.
	► Model the impact of urban infill.
	► Improve understanding of implications of uncertainty in environment for water resources policy and management (conduct pilot in the Great Barrier Reef).
	► Improve integration between surface-water models and the MODFLOW groundwater tool to allow surface-water groundwater interactions, including the effects of groundwater extractions, to be simulated.
Medium-term	► Collaborate with the QWMN Community of Practice and the CRC for Water Sensitive Cities on an urban water research project.
	► Review riverine vegetation impacts on flooding outcomes and restoration response within models.
Long-term	► Develop robust approaches for the integration of urban water models/modelled outputs with other models (e.g. eReefs, climate, groundwater, etc.) to support decision making.
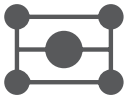
Model management

Water modelling expertise in Queensland does not lie within any single organisation. It is found in a number of government agencies, universities and the private sector, all with different specialities and interests. It is increasingly recognised that modelling is becoming more complex with multiple objectives often directing its delivery. It is important for water models to provide quality data and for decision-makers to understand the scope and limitations of datasets and models. There are opportunities to enhance model management to support increased awareness and better use, validation and access to water models in Queensland.

What challenge is the QWMN working to address?

There is a need to develop a clear plan for model improvement over the longer term. This would include establishing and documenting standards for key datasets for use across government to facilitate data sharing and collaborations. It would also work to increase confidence in models through improved management and better communication of uncertainty, meta-data and model provenance.

Opportunities

There is growing need for water modelling data to support community and resource planning – establishing a shared set of data standards and curation would allow different datasets to be integrated and a more holistic interpretation provided. There are opportunities to increase wider awareness of and access to water models and supporting datasets for policy makers and general users such as students and farmers.

Given ongoing model complexity and variables, there is further opportunity to improve the treatment and communication of model uncertainty. This would support better understanding and the appropriate use of models and their outputs in decision making and resource management.

Activity

The QWMN has supported a number of projects relating to model management including:

- ▶ QWMN Good Modelling Practice Principles
- ▶ QWMN Model Parallelisation Project.

Priorities for 2018–2020

Timeline	Actions
Short-term	▶ Revise and expand the QWMN Model Catalogue to include major models external to government. ▶ Develop an agreed set of data standards and curation for use across government (and beyond).
Medium-term	▶ Improve access to models for policy makers and general users. ▶ Improve treatment and communication of model uncertainty through the development and sharing of case studies (e.g. Reef Reporting, DCAP, etc.).
Long-term	▶ Facilitate improved and open access to models and supporting data.
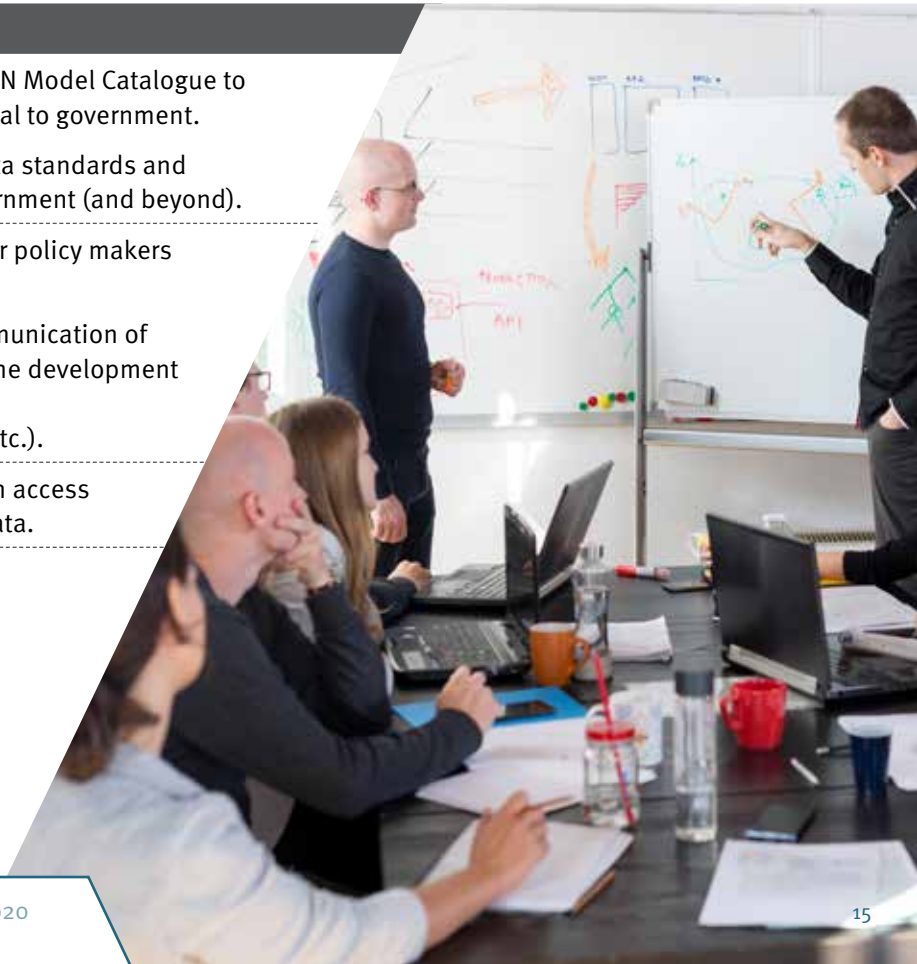
4. QWMN Investment Program 2018–2020

Investment approach

QWMN's investment approach is based on collaboration and co-investment to ensure all available expertise and resources are leveraged.

QWMN members undertake their own modelling investments to address operational enhancements. The QWMN funds RDI projects and activities that contribute to delivering the 2018-2020 priorities using the decision rules outlined below. It is anticipated that the QWMN will lead some projects, while others may be delivered in partnership, including with external groups. For network-led projects, the QWMN will seek to create strategic collaborations to enhance co-investment and co-production opportunities.

Decision rules for investment

REDS

The Queensland Government's science and research investment decision rules were developed to ensure Queensland's research and development investments are targeted and impactful. They were developed after extensive consultation with the research and university sectors, government and industry.

The rules guide evaluation, prioritisation and decision-making around future investment and will inform the QWMN project selection process. They include:

► **Real future impact**: what will be the tangible benefit for Queensland, and how long will it take to happen?

► **External commitment**: what is the involvement of, and commitment from, external collaborative partners and end-users?

► **Distinctive angle**: what is in it for Queensland, and why is Queensland the place to conduct the research?

► **Scaling towards critical mass**: how, and with whom, will collaboration support research, locally (i.e. state-wide) as well as nationally or internationally, to achieve quality and significant capability in Queensland?

QWMN decision criteria

The QWMN uses the following criteria to inform the selection and funding of water modelling projects:

► Queensland-based project team/team members and/or research region

► More than one partner or collaborator

► Co-investment (cash and/or in-kind)

► Innovative process or approach

► Best-practice science

► Knowledge sharing

► Building capability and attracting talent

► Significant end-user engagement.

Funding process overview

The QWMN will fund a range of projects in 2018–2020 that address the priorities, regions and models outlined in this strategy.

Supported proposals will meet the investment decision criteria and respond to the need for:

- ► A whole-of-government/cross departmental or cross-sector approach.
- ► Enhanced application and integration across multiple levels of government, research organisations, utilities, private sector and not for profit organisations.

The type of work that may be supported includes:

- ► Testing and reviewing proof of concepts underpinning a water model/s and potential gaps in application (e.g. testing the models' ability to respond to/reflect climate change).
- ► Collating the science to build consensus regarding best practice and knowledge to enhance conceptual frameworks for the models, their applications and outputs (e.g. to facilitate understanding of gully processes).
- ► Enabling enhanced model impact through strategic and step-change improvements in water models and their outputs (e.g. water security modelling for groundwater dependent communities, improving the efficiency of running model scenarios, integration across model scales and domains).
- ► Developing specifications and/or supporting standards that facilitate better model management, use, validation and access.

Ongoing evaluation

An annual review of priorities coupled with the QWMN evaluation plan will inform how the priorities identified here are rolled out and adopted over time.

5. Further Information

QWMN projects

Information relating to QWMN projects is available via the website.

QWMN contacts

The QWMN can be contacted via email:
QWMN@des.qld.gov.au.

QWMN external engagement

The QWMN has commissioned a consortium of universities led by the International WaterCentre to deliver the QWMN External Engagement Program (EEP). The EEP is working to build capacity in water modelling, facilitate engagement across Queensland's water modelling ecosystem and stimulate innovation. A summary of EEP activities is provided below. The EEP can be contacted via email: QWMN@watercentre.org.

Component	Summary/Activities
Hub	Monitoring and evaluation design
	Strategic plan
	Implementation plan
	Sector priorities report
Community of Practice	Calendar of events
	Community of Practice Events – Brisbane and regional
Education, Research and Training	QWMN Forum
	Mentoring program
	Innovation Associates
	QWMN Hack
	QWMN EEP website
	Skills and knowledge audit