Strategic Water Information and Monitoring Plan, Queensland

Appendices

Prepared by the Department of Environment and Resource Management

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Appendix 1 - Queensland drivers for collecting water information

Section A of the main report discusses the drivers for water monitoring and water data collection in Queensland. The main report outlines the fundamental drivers and organisational drivers in detail. It only briefly mentions the key legislation and strategies in place that affect water monitoring and water data collection.

This appendix provides a more comprehensive list of the legislative drivers and briefly describes the relevance of each driver to water monitoring.

Commonwealth legislation

Water Act 2007

This Act establishes the Murray-Darling Basin Authority (MDBA) to manage water resources in the Murray-Darling Basin. The MDBA has a range of functions including measuring, monitoring and recording the quality and quantity of the Murray-Darling Basin water resources.

The *Water Act 2007* details mandatory monitoring requirements for the Murray-Darling Basin in order to evaluate the effectiveness of the Murray-Darling Basin Plan. This will involve five-yearly environmental monitoring programs. The Act also empowers the Bureau to collect a range of water information parameters from relevant persons and to use this information to develop a range of products, including water resource assessments and a National Water Account (NWA).

Among other obligations under this Act, the Director of Meteorology is required to publish the NWA annually in a form readily accessible by the public. The Act does not specify the purpose, content and structure of the NWA, although s.121 does state that the NWA is to include such matters (if any) as are specified in the regulations.

Water Regulations 2008

The *Water Regulations 2008* require those persons named in the Regulations (named persons) to provide a range of water information to the Bureau, if available.

Whilst this legislation does not currently require named persons to commence any new monitoring or measurement activities, it can have a range of impacts, including for example, the addition of another layer of water data reporting and the necessity to deliver data at a frequency that may differ from other reporting arrangements.

Census and Statistics Act 1905

The *Census and Statistics Act 1905* provides the Australian Statistician with the authority to conduct statistical collections, including the Census of Population and Housing, and, when necessary, to direct a person to provide statistical information. The Act requires the Australian Bureau of Statistics (ABS) to publish and disseminate compilations and analyses of statistical information and to maintain the confidentiality of information collected under the Act. Under

this legislation named persons may be required to supply ABS with water monitoring and water use data.

Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* protects the environment, particularly protected matters of National Environmental Significance, such as Ramsar-listed wetlands. The Act streamlines national environmental assessment and approvals process, protects Australian biodiversity and integrates management of important natural and cultural places.

The Convention on Wetlands of International Importance (the Ramsar Convention) was signed by 18 nations including Australia in 1971. The convention aims to stop wetlands being lost across the world and to conserve and manage remaining wetlands. The convention also lists wetlands considered international treasures; Australia has five wetlands listed by Ramsar.

State legislation

Water Act 2000

Section 35 of the *Water Act 2000* requires the Chief Executive to provide information for planning by: regularly measuring and keeping publicly available records of the volume and quality of water in Queensland; collecting information on the water requirements of, and impacts of water management on natural ecosystems; and collecting information about future water requirements. This Act requires the development of WRPs that list the water and natural ecosystem monitoring requirements for each WRP area. Plans must include: the types of water use subject to the plan; standards for water use practices; stated objectives for water use efficiency, water reuse and water quality; and provision of water for environmental purposes. They must also state the monitoring requirements and responsibilities for each plan area (see section 39 of the *Water Act 2000*). The Act requires water service providers to undertake water monitoring and reporting activities.

Environmental Protection Act 1994 and Environmental Protection (Water) Policy 2009

The purpose of the Act is to protect Queensland's environment while allowing for development that is ecologically sustainable. Monitoring is required to establish the state of the environment, determine environmental objectives and to measure the impact of the release of contaminants. The *Environmental Protection (Water) Policy 2009* sets the framework to achieve environmental values for Queensland waters, in addition to determining water quality guidelines and water quality objectives.

Water Supply (Safety and Reliability) Act 2008

The aim of this Act is to strengthen the safety and reliability of Queensland's water supplies and to protect health by:

- establishing new regulatory provisions for recycled water and drinking water

- incorporating, largely without change, Chapter 3 ‘Infrastructure and Service’ of the Water Act 2000

DERM will ensure that service providers meet the new regulatory provisions, and will continue to manage dam safety, water supply assets, and water and sewerage service providers. This Act compels water service providers to undertake significant monitoring and reporting relating to the management of water supplies.

More information is available from the DERM website

Sustainable Planning Act 2009

From December 2009 the former *Integrated Planning Act 1997* was replaced by the *Sustainable Planning Act 2009.* This new legislation reflects a stronger focus on achieving ecological sustainability. Development approvals are sometimes required prior to constructing works to take or interfere with water. Applications for development approvals are made under this Act. More information is available from the DERM website

Right to Information Act 2009

Right to Information is the Queensland Government's approach to giving the community greater access to information. The Queensland Government has made a commitment to provide access to information held by the Government, unless on balance it is contrary to the public interest to provide that information. The *Right to Information Act 2009* and the *Information Privacy Act 2009* have replaced the *Freedom of Information Act 1992*. The Right to Information reforms are the result of an independent and comprehensive review of Queensland’s freedom of information legislation – known as the Solomon Report.

It is the Queensland Government’s intent that government agencies release information administratively and proactively wherever possible. Access to information under the RTI Act is intended to be the last resort. More information is available online.

Commonwealth and inter-state strategies, programs, plans

National Water Initiative

The intergovernmental agreement on a national water initiative was signed at the 25 June 2004 Council of Australian Governments (COAG) meeting. The National Water Initiative (NWI) represents a shared commitment by governments to increase the efficiency of Australia's water use, leading to greater certainty for investment and productivity, for rural and urban communities, and for the environment. Under the NWI, governments have made commitments to:

- prepare water plans with provision for the environment
- deal with over-allocated or stressed water systems
- introduce registers of water rights and standards for water accounting
- expand the trade in water
- improve pricing for water storage and delivery

- meet and manage urban water demands

More information is available from the National Water Commission website

Murray-Darling Basin Plan

The Murray-Darling Basin Plan will be a strategic plan for the integrated and sustainable management of water resources in the Murray-Darling Basin. The first plan is expected to commence in 2011.

Impacts of this plan on water monitoring include:

- increased monitoring of the use of water resources
- monitoring to identify risks to Basin water resources, such as climate change
- monitoring to assess the success of water quality and salinity management plans

More information is available from the MDBA website

Sustainable Yields projects

The National Water Commission (NWC) commissioned the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to undertake various projects to provide a comprehensive scientific assessment of water yield in all major water systems in Australia. DERM has provided formal input to the projects undertaken to date.

In 2007 and 2008, the Murray-Darling Sustainable Yields Project was undertaken. In March 2008, COAG expanded the program to provide a comprehensive scientific assessment of water yield in all major systems in Australia. In 2009 a sustainable yields project was completed for northern Australia. Future project areas include south-west Western Australia and Tasmania. More information is available online.

Lake Eyre Basin Intergovernmental Agreement

This Agreement, signed in October 2000, is a joint undertaking of the Australian, Queensland, South Australian and Northern Territory governments. The purpose of the Agreement is to ensure the sustainability of the Lake Eyre Basin river systems, in particular, to avoid or eliminate cross-border impacts.

Key objectives of the Agreement include:

- defining a process for raising and addressing water and natural resource management issues in the Agreement Area that have cross-border implications
- to encourage and support relevant water resource management practices
- to encourage and promote research and monitoring to improve understanding and support informed decision making in the Agreement Area
- to raise public awareness of the special biodiversity and heritage values in the Agreement Area.

The Agreement currently applies to the Cooper Creek system, the Georgina and Diamantina river systems, and the Northern Territory portion of the Basin.

The Lake Eyre Basin Five-Year Action Plan 2009-2014 was endorsed in 2009. The Action Plan lists a number of key policies and strategies, including:

- the need to align inter-jurisdictional policy and planning on river flows
- coordination of water quality monitoring and data management frameworks across jurisdictions
- promotion of the integration of assessment outcomes into jurisdictional decision-making
- scoping of the need for consistent and complimentary data management frameworks across jurisdictions to enable data collection and analysis at regional, catchment and whole-of-basin scales
- improved access by the community and stakeholders to data, including the development of internet based systems

More information is available online.

Northern Australia Sustainable Yields

The Northern Australia Sustainable Yields (NASY) project has provided science to underpin the sustainable planning and management of the region's water resources. From Broome in Western Australia to Cairns in Queensland, the NASY project has provided critical information on current and likely future water availability in Northern Australia, which is renowned for its high rainfall, pristine tropical environments and relatively low development.

The NASY project investigated water resources on a catchment-by-catchment basis using four different climate and development scenarios. This information is assisting governments, industry and communities to consider the environmental, social and economic aspects of the sustainable use and management of water resources of northern Australia.

Northern Australia Water Futures Assessment

The Northern Australia Water Futures Assessment is a multidisciplinary program being delivered jointly by the Department of the Environment, Water, Heritage and the Arts and the NWC. This assessment will provide an enduring knowledge base to inform decisions about the development of northern Australia's water resources, such that any development proceeds in an ecologically, culturally and economically sustainable manner. More information is available from their website.

National Water Initiative water accounting requirements

The NWI Intergovernmental Agreement seeks to regularise the practice of water accounting and impart some rigour, such that ‘accounts’ across different water ‘systems’ may be reconciled and disclosed, and a national picture able to be produced, so that consistent and comparable data is available to decision-makers at:

- national level for policy development
- state level for water resource planning and monitoring

- water organisation levels (i.e. water suppliers and users) for water resource management
- farm level for on-farm water management
- stakeholder level for investment decisions

The NWI establishes a commitment on all jurisdictional parties to the development and implementation of water accounting system standards, standardised reporting formats, and water accounts that can be reconciled and aggregated to produce a national water balance.

Specifically, Clause 82 of the NWI states that the parties agree to develop and implement:

- accounting system standards, particularly where jurisdictions share the resources of river systems and where water markets are operating
- standardised reporting formats to enable ready comparison of water use
- compliance against entitlements and trading information
- water resource accounts that can be reconciled annually and aggregated to produce a national water balance

The Natural Resource Management Ministerial Council directed that the National Water Accounting Development Project (NWADP) be undertaken in order to ultimately achieve an operating National Water Accounting Model. To accomplish this objective, the Water Accounting Development Committee (WADC) was formed. The WADC focused on developing water accounting standards and procedures to underpin the suggested National Water Accounting Model. It also focused on preparing recommendations on suitable reporting obligations and assurance arrangements to underpin the integrity of the water accounting standards. Building the extra water accounting capacity that will be needed to support the implementation of the standards is also a priority.

The federal *Water Act 2007* provides the Bureau with the powers to develop water standards and produce the NWA. The WADC has been revised to be the Water Accounting Standards Board (WASB), focused on the development of standards, and the Bureau will undertake the implementation of water accounting.

More information is available from the WASB website

NWI national performance reporting

Queensland has agreed to report independently, publicly and on an annual basis on the benchmarking of pricing and service quality for metropolitan, non-metropolitan and rural water service providers (paragraph 75 NWI Intergovernmental Agreement). Participation in the national performance reports, however, currently operates on a voluntary basis and the reports are also focused on the larger water service providers. This means there is a large section of Queensland's water service providers who do not supply performance report data on a regular basis.

A sub-set of the performance indicators have a similar definition to category 7 data required to be submitted to the Bureau. The Bureau data, however, is collected at more frequent intervals.

The National Performance Report (NPR) data is also able to provide more detailed information on data presented in a water account and would provide valuable disclosure information to a water account.

The Queensland Water Directorate (*qldwater*) Statewide Water Information Management (SWIM) project is developing a compatible level of water reporting to the national performance database for the urban water service providers on a voluntary basis.

More information is available from the National Water Commission website

State

Water resource plans, water resource assessments and resource operations plans

Monitoring requirements are to be achieved by monitoring programs undertaken by holders of Resource Operations Licences (ROL), holders of water entitlements that specify particular monitoring requirements or community groups in coordination with relevant state agencies. These programs must include the monitoring of water quantity and water quality parameters.

The monitoring requirements of ROL and interim ROL holders under WRPs may include:

1. Water monitoring, for:
    - stream flows
    - taking of water
    - releases from storages
    - water storages including inflow, storage volume or water level and outflow
    - groundwater levels
    - water quality
    - water requirements for future consumption
    - efficiency of water use
2. Natural ecosystems monitoring, for:
    - volume, frequency, duration and season of stream flows
    - health and distribution of animal, plant and micro-organism species and communities
    - condition of riverine and estuarine habitats
    - river forming flows
    - groundwater dependent ecosystems
    - operational
    - flood warnings

State Coastal Management Plan

The State Coastal Management Plan describes how the coastal zone and its resources are to be managed. The coastal zone refers to coastal waters and all areas to the landward side of coastal waters in which there are physical features, ecological or natural processes, or human activities that affect, or potentially affect, the coast or coastal resources. More information is available from the DERM website

State of the Environment Queensland

State of the Environment (SoE) reporting is a statutory requirement. DERM is the lead agency required to prepare a report on the state of the environment and the coastal zone at least every four years. A primary component of SoE reporting is the assessment of surface water and groundwater quality and quantity across Queensland. The DERM state-wide ambient water quality monitoring program is associated with data collection for reporting in the SoE. A variety of indicators are used to characterise environmental conditions and pressures associated with inland waters. These indicators relate to:

- water quantity - storage (surface and groundwater), annual runoff
- water quality - physical, chemical and biological

More information is available from the DERM website.

Fitzroy River Water Quality

Major flooding in January/February 2008 affected much of the Bowen Basin area of central Queensland, with significant major flooding occurring in the Nogoa, Mackenzie and Fitzroy systems. In response to social and environmental issues associated with the flood, the government commissioned an independent research project on the status of the water quality of the Fitzroy River. This study currently monitors a range of water quality parameters.

More information is available from the Fitzroy River website.

National Water Quality Management Strategy

Since inception through COAG in 1992, the National Water Quality Management Strategy (NWQMS) - a key reference for nationally endorsed policies, processes and guideline documents relating to water quality management - has been implemented by the Australian Government under the NWI, in cooperation with state and territory governments.

The primary objective of the NWQMS is to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development. The strategy is delivered through local development and implementation of water quality management based on high-status national guidelines.

Through the NWQMS, the community and government assist in the development and implementation of a management plan for each catchment, aquifer, estuary, coastal water or other water body. At present, a total of 21 NWQMS guidelines for managing key elements of the water cycle are available.

More information is available online.

DERM Strategic Plan 2009-13

This plan identifies the primary objectives and strategies of the lead water management agency in the state (DERM). The key water objectives of this plan include:

- protecting and managing the state's water resources
- ensuring natural waters and dependent ecosystems are healthy
- enabling the delivery of safe and reliable water supplies

Many of these strategies will assist the accomplishment of the government's 2020 targets under Toward Q2: Tomorrow's Queensland. The key challenges the state faces in achieving these objectives include:

- growing population and rising standard of living
- dependence on sustainable economic activity
- preparing for the impacts of climate change
- diversity and vulnerability of Queensland's natural environment
- finding a balance between environmental, social and economic values

More information is available from the DERM website.

Regional Water Supply Strategies

Regional water supply strategies are the Queensland Government's approach to ensuring short and long-term water supply security on a regional basis. These strategies have been developed in partnership with local governments, water service providers, industry and community groups, to balance water demand and supply requirements and provide regional water supply solutions.

The aim of these strategies is to:

- assess future needs for a safe and reliable supply of water
- assess the processes and mechanisms required to meet those needs
- obtain agreement for an implementation framework for the strategy that achieves optimum social, environmental and economic terms

More information is available from the DERM website.

Metering Water Extractions Policy

Under the Queensland Government's Metering Water Extractions Policy, DERM will install approximately 16,000 meters as part of a state-wide metering project. The metering of all works that take unsupplemented water for commercial purposes will enable the Queensland Government to greatly enhance its ability to achieve the objectives and outcomes of the national water reform agenda and the NWI.

Metering the water extracted from watercourses, lakes and aquifers provides the Queensland Government with the information needed to implement effective water resource management strategies. Equally importantly, meters also provide entitlement holders with greater security that their entitlement will not be eroded, as well as providing them with up-to-date water use information.

Water users can use this information to modify water use practices to save water and production costs.

Improving Queensland's water resource accounting, monitoring and reporting systems through metering will ensure water resource planning, allocation and management activities are more effective in securing sustainable water allocations and environmental flows. The state-wide metering system is a fundamental mechanism for facilitating the operation of water markets and water trading schemes. Secure water entitlements (along with prices that better reflect the value of water as a tradable commodity) will increase the confidence of investors in the water industry.

Reef Water Quality Protection Plan

The Reef Water Quality Protection Plan (RWQPP) was launched in 2003 as a joint initiative of the Australian and Queensland Governments. As a World Heritage Area, the Governments of Australia have a direct responsibility to ensure the protection and sustainable management of the Great Barrier Reef. The goal of the Reef Plan is to halt and reverse the decline in water quality entering the Reef within ten years.

There are two objectives to achieve this goal:

- reduce the load of pollutants from diffuse sources in the water entering the Reef
- rehabilitate and conserve areas of the Reef catchment that have a role in removing water-borne pollutants

The RWQPP identifies actions, mechanisms and partnerships to build on existing government policies and industry and community initiatives. Monitoring and evaluation is a key strategy associated with achieving the goal of the RWQPP. A report on the condition of the Reef is produced annually.

More information is available online.

Strategy for the Conservation and Management of Queensland's Wetlands

This strategy sets out: the Queensland Government's intent for conservation and management of wetlands, implementation methods, a definition of wetlands, a statement on the values and functions of wetlands, the Queensland Government's objectives for wetlands, and initiatives to achieve these objectives.

Queensland Wetlands Program

Established in 2003 as a joint initiative of the Australian and Queensland Governments, the Queensland Wetlands Program aims to deliver projects that will result in long-term benefits to the sustainable use, management, conservation and protection of Queensland wetlands. The Queensland Wetlands Program continues to deliver on key policy objectives and outcomes of the Queensland Government, to support the *Reef Water Quality Protection Plan*, the *National Water Initiative*, the *Ramsar Convention*, the *Strategy for the Conservation and Management of Queensland's Wetlands*, Statutory Regional Planning, Wild Rivers Legislation and the *Temporary State Planning Policy 1/10: Protecting Wetlands of High Ecological Significance (HES) in Great Barrier Reef (GBR) Catchments*. It had developed tools to address all aspects

of wetlands management from policy and planning, mapping and classification through on-ground works to monitoring and reporting for all parts of the state. There are over 78 projects completed or underway through the Program and it is recognised as one of the most effective and efficient wetlands programs in Australia and continues to deliver quality outcomes, which are available to all Queenslanders through the DERM website Wetland*Info*.

More information is available online.

South East Queensland Healthy Waterways Strategy

The SEQ Healthy Waterways Strategy is a collaboration of government, industry, researchers and the community. The strategy is an integrated set of twelve Action Plans which the partners to the strategy have committed to undertake between 2007 and 2012. Over 500 committed actions to maintain and improve the health of the waterways of SEQ are contained in the strategy. The strategy was developed through extensive consultation to align with the plans of the partners and other relevant bodies. Monitoring and evaluation of progress will be coordinated by the SEQ Healthy Waterways Partnership Office.

More information is available from the Healthy Waterways website.

Creative Commons

The Queensland Government Information Licensing Framework (GILF) was established in 2006 by the Queensland Spatial Information Council to review international trends in transactions with public sector information. GILF has recommended that government agencies move towards a Creative Commons (CC) licensing framework for information that carries no privacy, confidentiality, or other legal or policy constraints.

The Water Division of the Bureau has endorsed the CC Attribution Australia Licence. Each named person must advise the Bureau whether they wish to deliver their data under this CC licence which would ensure that users of the data must attribute them as the copyright holder of the data.

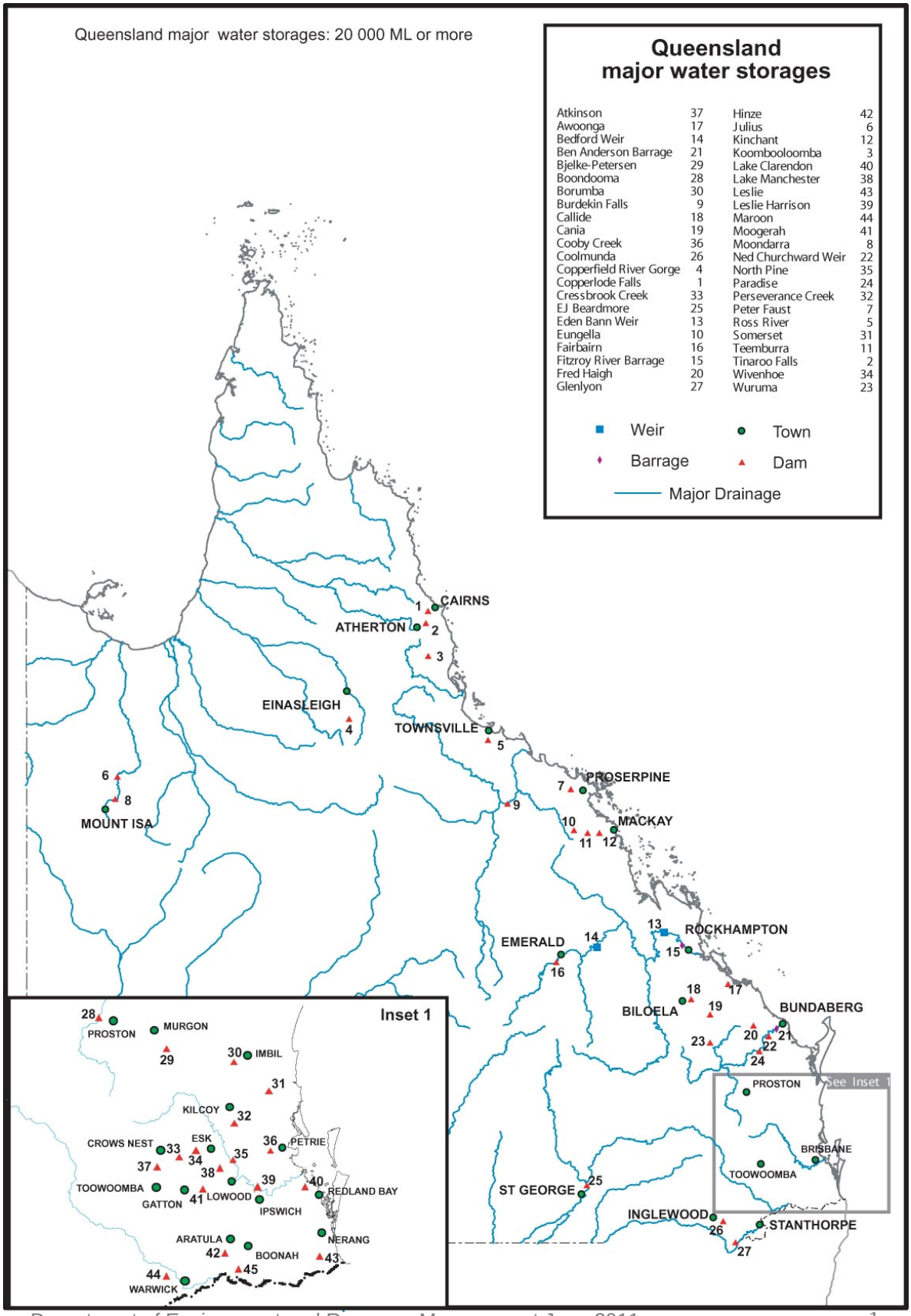
In March 2010 the Queensland Government Chief Information Officer released the GILF Government Enterprise Architecture policy. Queensland government agencies must follow the Government Enterprise Architecture GILF policy, position and guidelines when licensing information products. Approval must be sought with the Chief Information Officer for exemptions or extensions on implementation.

DERM and most other named persons in Queensland have committed to delivering water data to the Bureau under the CC Attribution Licence.

More information is available online.

Appendix 2

Appendix 2.1: Queensland major water storages



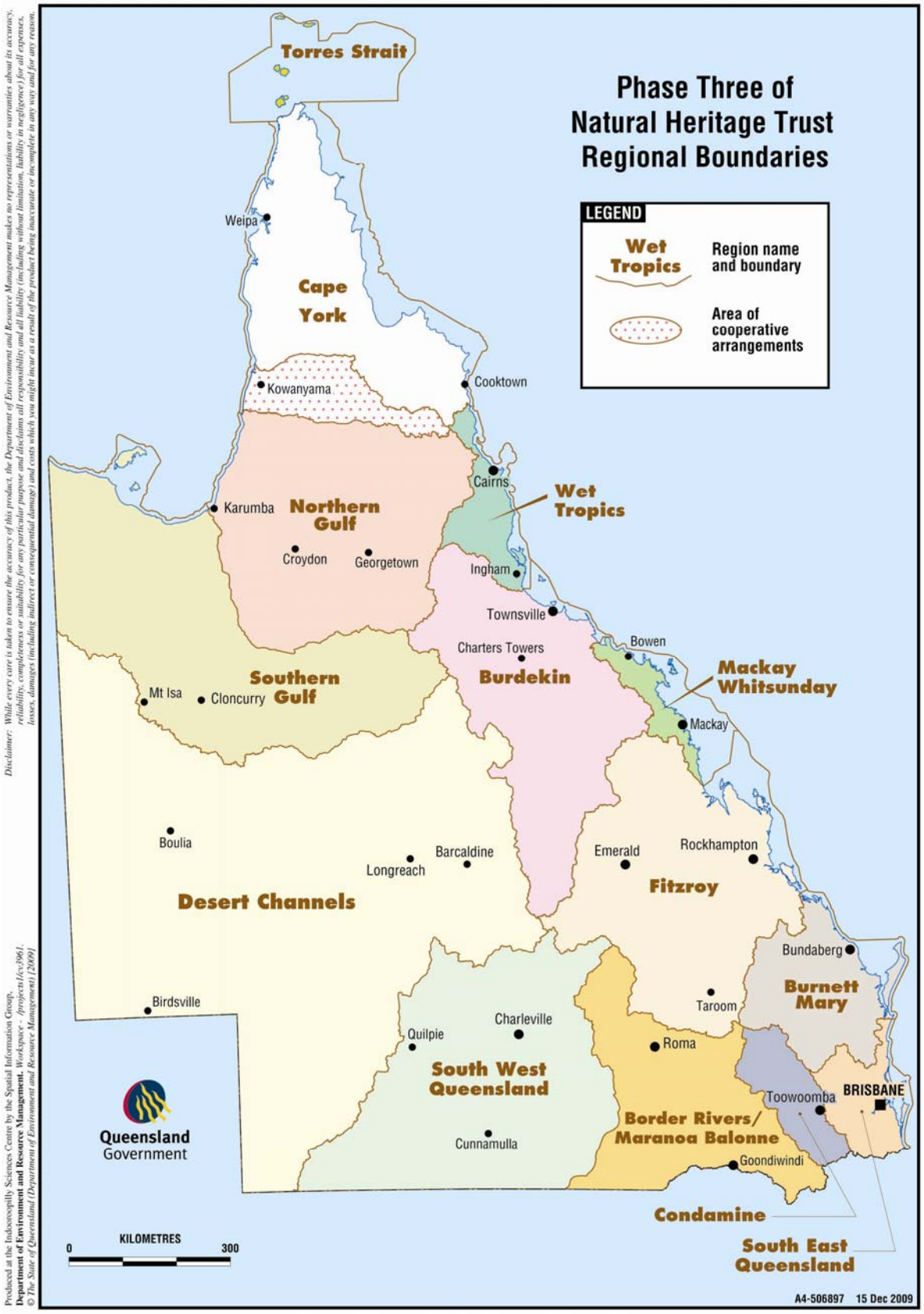
Appendix 2.2: The location of the Great Artesian Basin

Appendix 2.3: The location of the Great Barrier Reef

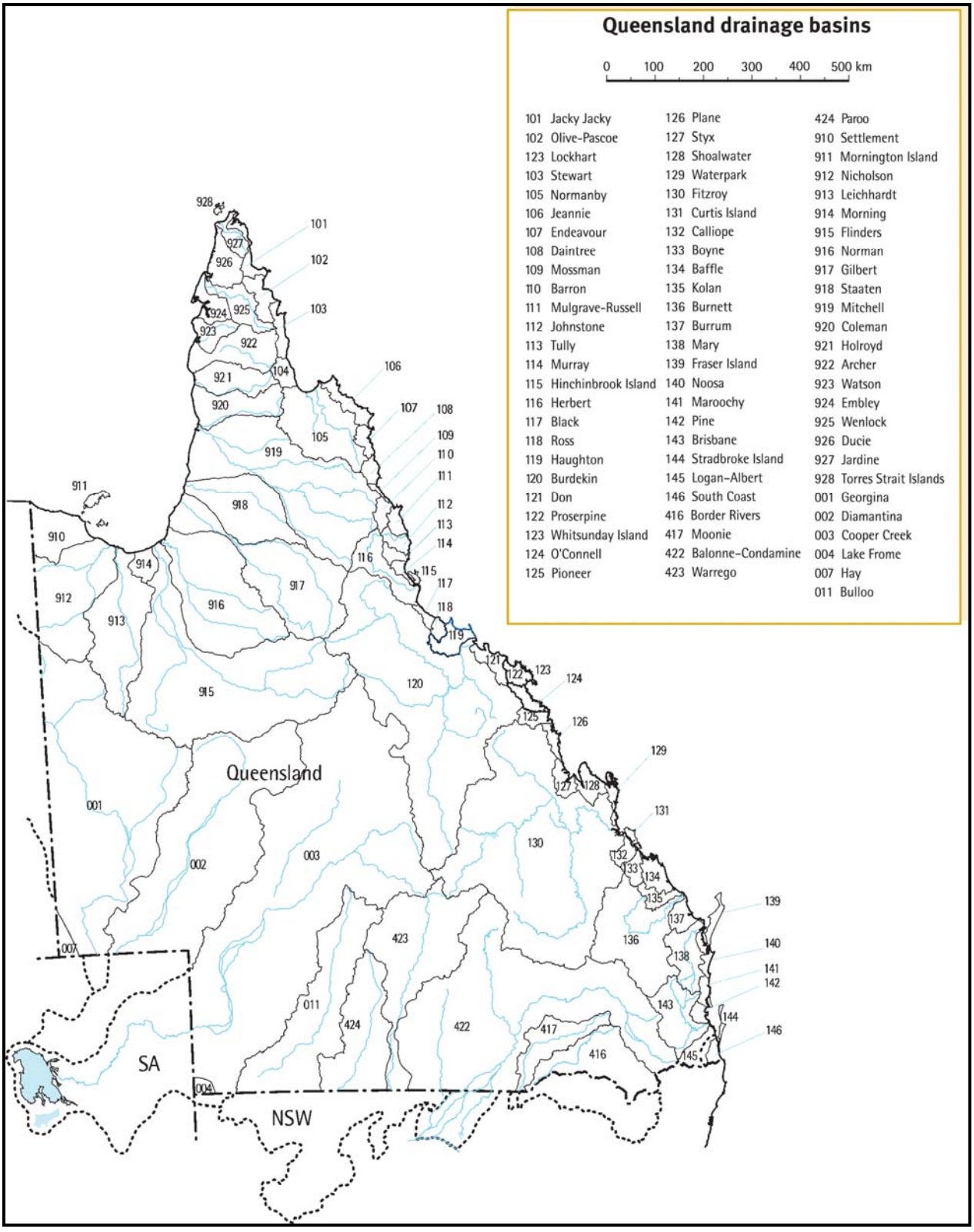
Appendix 2.4: The location of water resource plan regions in relation to drainage basins

Appendix 2.5: Local government areas within Queensland

Appendix 2.6: The location of regional natural resource management bodies across Queensland



Appendix 2.7: The location of Queensland drainage basins



Appendix 3 – State and federal government programs

Queensland Integrated Waterway Monitoring Framework

The Queensland Government has identified a need to improve the coordination and comprehensiveness of waterways monitoring programs and improve how data is shared and used to improve water quality and ecosystem health. The comprehensive Queensland Integrated Waterways Monitoring Framework has been developed and is being implemented to ensure that all programs are integrated and the data can be used for multiple applications.

The Queensland Integrated Waterways Monitoring Framework creates an 'umbrella' for monitoring activities. Waterway monitoring programs will continue to retain their separate identity and focus. They will have complementary methods and reporting, guided by the Framework.

The Framework facilitates a more collaborative approach to waterway monitoring and reporting across the state, giving a more complete picture on the health of Queensland's waterways. Through the implementation of various sub projects the Framework addresses key monitoring aspects including the following:

- developing and collating a common suite of conceptual models for designing monitoring programs and selecting waterway indicators
- promoting common monitoring and sampling techniques through a comprehensive sampling manual
- increasing data and information accessibility through the development of a Queensland Waterway Monitoring Portal
- designing a set of principles to guide integrated reporting and interpretation of waterway information

The implementation phase includes numerous projects designed to advance integration of government monitoring activities in priority regions, as well as address state-wide issues such as information management and reporting.

Surface Water Ambient Network

The Surface Water Ambient Network (SWAN) has been in operation since 1990. The information generated by SWAN is of significant value at a variety of scales and is used to fulfil obligations such as regular reporting on condition and trend and in various state-wide investigations into broad scale water quality and risks to aquatic health, for example Queensland State of the Environment reporting. It also supports unforseen needs for information, such as, DERM's contribution of continuous EC data to the review of the Fitzroy water quality issues.

Water quality monitoring occurs as a subset of the surface water monitoring network, with point water samples taken at specific sites. Currently SWAN network monitoring occurs at around 44 percent of the surface water monitoring network. Spatial distribution of gauging stations has been traditionally focused on areas of water resource development and therefore the current water quality monitoring network is not representative of catchments, bio-provinces or the state.

An ideal spatial network design would allow the integration of site information at a hierarchy of scales. The role of providing such integrated assessments of aquatic ecosystem health at a bio-province scale is currently achieved through the Stream and Estuary Assessment Program (SEAP).

Stream and Estuary Assessment Program

SEAP is the Queensland government state-wide aquatic ecosystem condition and trend monitoring program, designed to:

- report on the overall condition of the state's aquatic ecosystems
- report on conditions and trends in the state's aquatic ecosystems
- integrate monitoring and assessment activities in freshwater and estuarine aquatic ecosystems
- assess water quality condition using Queensland Water Quality Guidelines methodology (assessment includes salinity (EC), nutrients (total nitrogen and total phosphorus) and turbidity)
- improve current understanding of processes and components of the aquatic ecosystem that relate to condition

SEAP uses an ecological risk assessment to prioritise a comprehensive list of threats to aquatic ecosystems. A conceptual causal chain based on three major components: human pressures; physical, chemical and biological stressors; and ecological responses, is developed for each of these priority threats and is used to guide selection of indicators for condition assessment and to identify gaps in current understanding. Condition assessment is then based on a multiple lines of evidence approach using indicators from each component for each threat.

Paddock to Reef Program: integrated monitoring, modelling and reporting for the *Reef Water Quality Protection Plan*

As part of the Reef Water Quality Protection Plan, the Queensland Government (DERM) leads the Reef Plan Event Monitoring Program, monitoring nutrient and sediment loads at approximately 35 sites across the Great Barrier Reef catchments. Intensive monitoring conducted through the program is used to assist the development and calibration of robust catchment models.

A revised monitoring and evaluation strategy was completed in 2009 for the Reef Water Quality Protection Plan and will be implemented by June 2010. This program will enable the evaluation of the efficiency and effectiveness of the Reef Plan implementation, facilitate reporting on progress towards its goals and objectives, and in the long term inform adaptation and improvement. It will achieve this by:

- developing and implementing a Reef Plan monitoring and evaluation strategy to measure the efficiency and effectiveness of the plan
- developing and implementing an integrated and coordinated Paddock to Reef Monitoring, Modelling and Reporting Program as part of the Reef Plan Monitoring and Evaluation Strategy
- improving data and information management to support data sharing assessment and reporting

Assessment for prioritising an integrated waterway monitoring program in Queensland

Led by DERM, and in partnership with DEEDI, the project team are in consultation with the Great Barrier Reef Marine Park Authority and other key stakeholders, such as regional NRM bodies. The main activities of the project, which commenced in December 2008, are:

- to collate information on policy and land drivers for improved waterways quality monitoring
- to develop a methodology for prioritising geographic areas based on environmental risk
- to analyse data to identify priority geographic areas
- to deliver a report on priority geographic areas for integrated waterways monitoring, and the policy and land use drivers within each

DERM water assessment program

DERM operates a number of gauging stations across Queensland, information from which is used to assess and manage the state's available water resources, as well as support a range of other state and water quality monitoring programs. Continuous telemetry stream flow data is available on the DERM website.

DERM wetlands assessment program

DERM also monitors wetlands. In Queensland the term wetland applies to six ecological systems, which are lacustrine (lakes), palustrine (swamps, bogs and fens), and estuarine, riverine, marine and underground wetlands. Long periods of drought in recent years have significantly impacted the extent and quality of some wetland habitats. It is too early to determine the impact of recent flooding on freshwater wetlands.

Wetlands are monitored for a range of parameters, such as to determine whether wetland extent is increasing or decreasing or to identify changes in risk to wetland or the condition of wetlands. In recent years Queensland has developed tools to monitor changes in the extent of wetlands by using state-wide mapping datasets and the results are reported in the Queensland SoE report. Wetlands mapping has been developed and is available for pre-European, 2001 and 2005 extents and the 2009 extent should be released by 2011.

Tools to assess the risk to and condition of freshwater wetlands (lacustrine and palustrine) have been developed as part of the Queensland Wetlands Program (QWP). Pressure and condition indicators are included through a stressor based framework that allows pressures to be directly linked to condition to better enable the development of management actions.

There is no current broad-based risk or condition monitoring program for lacustrine and palustrine wetlands but the QWP tools have been applied for some wetlands in the MDB, Wide Bay and Fitzroy catchments. A project to assess the risk to lacustine and palustrine wetland in the Great Barrier Reef catchment is presently underway. More information on the stressor models and the stressor framework can be found on the DERM website Wetland*Info*.

A list of the other major current monitoring programs in Queensland wetlands is also available from the DERM website

DERM water quality monitoring programs

DERM conducts a variety of ambient and event monitoring programs throughout Queensland, often forming partnerships with local government, catchment groups and other relevant agencies. Water quality is typically assessed by either intermittent point water quality samples and handheld field readings or continuous time series

measurement of parameters such as EC, temperature and turbidity. More information can be found on the DERM website.

Ecosystem Health Monitoring Program

The freshwater component of the Ecosystem Health Monitoring Program (EHMP) uses rigorous science to provide a detailed regional overview of the ecosystem health of the non-tidal reaches of rivers and streams throughout SEQ. The program measures waterway health using a broad range of biological, physical and chemical indicators of ecosystem health. These indicators were chosen because they provide essential information about the condition of SEQ's waterways. The regional scale approach and ecosystem-based objectives ensure that effective management and investment of implementation strategies and activities are in place throughout SEQ.

The event monitoring program is a specific task under the EHMP that supports both freshwater and estuarine/marine components and provides important data for the calibration of estuarine and catchment models. While the EHMP in general is an ambient monitoring program assessing water quality during base flow conditions, the event-based program provides information on the potential pollutant loads and impacts associated with sediment and nutrients sourced from non-urban catchment areas during "wet" periods (i.e. during/following significant rainfall events). Data from this program is used to provide information on catchment land use change and performance benchmarks for the assessment of catchment remediation measures, such as riparian rehabilitation works.

The program's objectives are to:

- better characterise the quantity and quality of different diffuse sourced pollutant concentrations during runoff (storm) events
- adjust and validate the event mean pollutant concentration values used in catchment models and provide locally-specific data for parameters of concern that have not been quantified as yet
- provide performance benchmarks against which the effectiveness of planned catchment remediation measures can (eventually) be assessed

Sustainable Rivers Audit

The Sustainable Rivers Audit is an initiative of the former Murray-Darling Basin Commission and is designed to measure the health of the rivers at Basin scale. The Audit uses scientific indicators of health to determine the current status of the Basin's rivers and any potential trends. Hydrology is one of the indicators used.

The audit aims to:

- determine the ecological condition and health of river valleys in the MDB
- improve knowledge of river health indicators
- help detect trends in river health over time
- trigger changes to natural resource management through improved knowledge

For more information visit the MDBA website.

Lake Eyre Basin Rivers Assessment

This monitoring program is designed to assess the condition of watercourses and catchments within the Lake Eyre Basin Agreement Area. Whilst assessments of the Basin will be undertaken at 10 yearly intervals, monitoring information will be collected routinely to gather the data required. It is noted that both high and low flows in the Basin have important ecological functions, and that overall flow patterns, rather than just individual floods, are important to maintain the ecology of the Basin.

Appendix 4 – Impact of Modernisation and Extension of Hydrological Monitoring Systems Program funding

The Australian Government's five year $80 million funding program for Modernisation and Extension of Hydrologic Monitoring Systems (M&E Program) has been administered by the Bureau of Meteorology (the Bureau). This program works with state and territory agencies, water service providers, NRM bodies and other water information managers to build nationally consistent reporting and access to information about Australia's water resources. It has also given an opportunity to upgrade ageing water monitoring equipment.

Each financial year, the Project Evaluation Committee (PEC) appointed by the Bureau assesses project applications and subsequently recommends potential projects to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities. Funded projects have delivered a range of outcomes by addressing identified gaps and issues in jurisdictional strategic water information and monitoring plans (SWIMP).

During the first four years of the M&E Program, 15 of the 25 Queensland named persons who applied for funding were successful; receiving over $14 million worth of funding. The fifth and final funding round was launched on 22 February 2011 with applications due by 29 April 2011.

M&E Program funding round	Number of Queensland projects	Total funding received in Queensland ($)
Round 1 – 2007-08	6	1,148,300
Round 2 – 2008-09	20	2,277,228
Round 3 – 2009-10	20	3,765,524
Round 4 – 2010-11	14	6,996,786
Total Rounds 1-4	**60**	**14,187,838**

M&E Program is focussed on the delivery of water data for water resource assessment and water accounting purposes. This program is only open to those organisations named in the federal *Water Regulations 2008* to deliver certain water data to the Bureau.

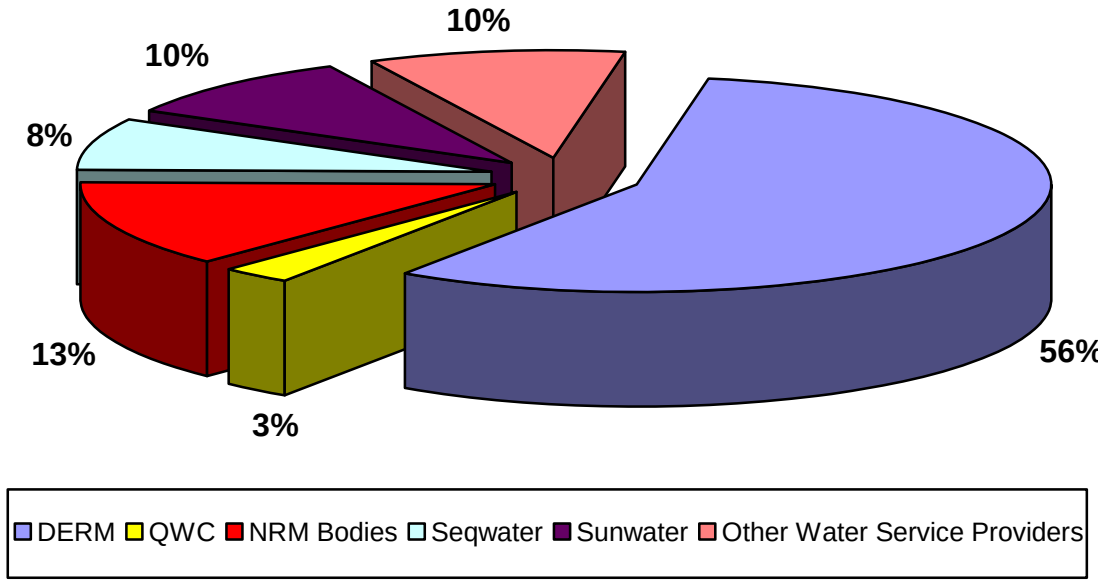
This Appendix summarises the key funded activities, presents different analysis of the impact of M&E Program funding and summarises the benefits from the funding. Each jurisdictional SWIMP in 2011 includes the outcomes of a review of the impact of M&E

Program funding on the closure of key water monitoring and information gaps in the jurisdiction. Section C details funded activities to close gaps and summarised the key findings of this review.

The sixty projects that were successful in receiving funding under rounds 1-4 represent half of the applications submitted by Queensland named persons; 25 of which were allocated to DERM.

Graph 1 below presents the percentage of the total funding received by each of the larger data providers and collectively by NRM bodies and water service providers (including councils and water boards).

Graph 1 Percentage of funding allocated to Queensland named persons, rounds 1-4

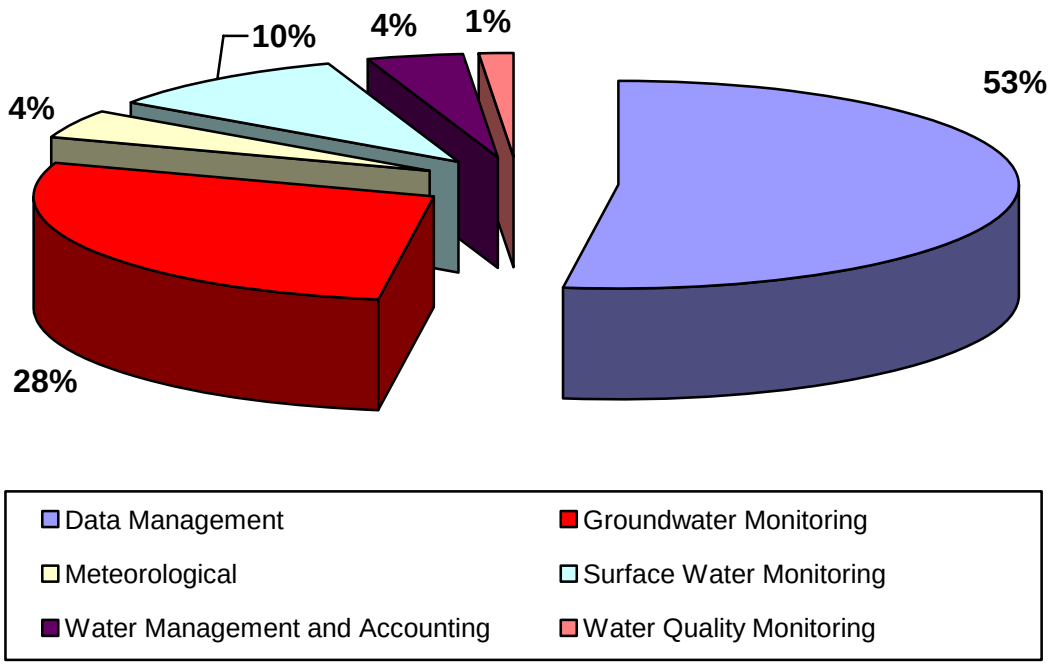


There were 56 gaps identified in the SWIMP 2010, presented under six different water activities grouped according to the issues they were addressing. For example, the need for more bores is presented under the activity “Groundwater monitoring” and the need for more gauging stations is presented under the activity “Surface water monitoring” but for the purpose of prioritising gaps they are grouped together under the gap category heading “Spatial and temporal gaps”.

The majority of the funding received was acquired to close data management system gaps (37 percent), purchase monitoring equipment (21 percent) and to address spatial gaps in monitoring networks (18 percent).

Graph 2 presents the percentage of the total funding received that was expended on each water activity.

Graph 2 Percentage of total funding in Queensland, by water activity



The following analysis refers to gaps by their number only. These gaps are numbered as they appeared in the Queensland SWIMP 2010; however in order to cater for funded projects that were not aligned to gaps in the 2010 SWIMP gaps 54-56 were created. A table of all these gaps is presented on pages 11-16 of this appendix.

Groundwater monitoring

There are eight gaps identified in the Queensland SWIMP 2010 relating to groundwater monitoring activities. The successful projects addressed gaps 1, 2 and 4 with an estimated 75 percent closure of gaps 2 and 4 for each organisation and an estimated 50 percent closure of gap 1 for each organisation.

During rounds 2 and 3 of the M&E Program DERM improved bore site location records by remeasuring them to one datum. This provides valuable elevation data and contributes to the Bureau's geo-fabric project in the Murray-Darling Basin (MDB) and in south west Queensland. 5% percent of DERM monitoring bores are now aligned to one datum; there remains therefore a significant number of bores that need alignment.

Eighty continuous telemetry systems will be installed across the groundwater monitoring network with Round 4 M&E Program funding. Data from these loggers will be made available to the public through the web in real time, enabling water users to monitor groundwater levels and improve decision making in relation to sustainable water use strategies. (This project had a secondary objective to install ten gauging stations and purchase some surface water monitoring equipment)

Another DERM project provides an additional 228 monitoring bores within ten water resources plan areas across Queensland, increasing the state's capacity to assess,

manage and account for the groundwater resources and to better understand surface-groundwater interactions.

It is worth noting that while this project helps to close Gap 1, it simultaneously increases Gap 2 as some of the new bores will require continuous telemetry.

Overall, 28 percent of the funding granted to Queensland named persons helped to address groundwater gaps.

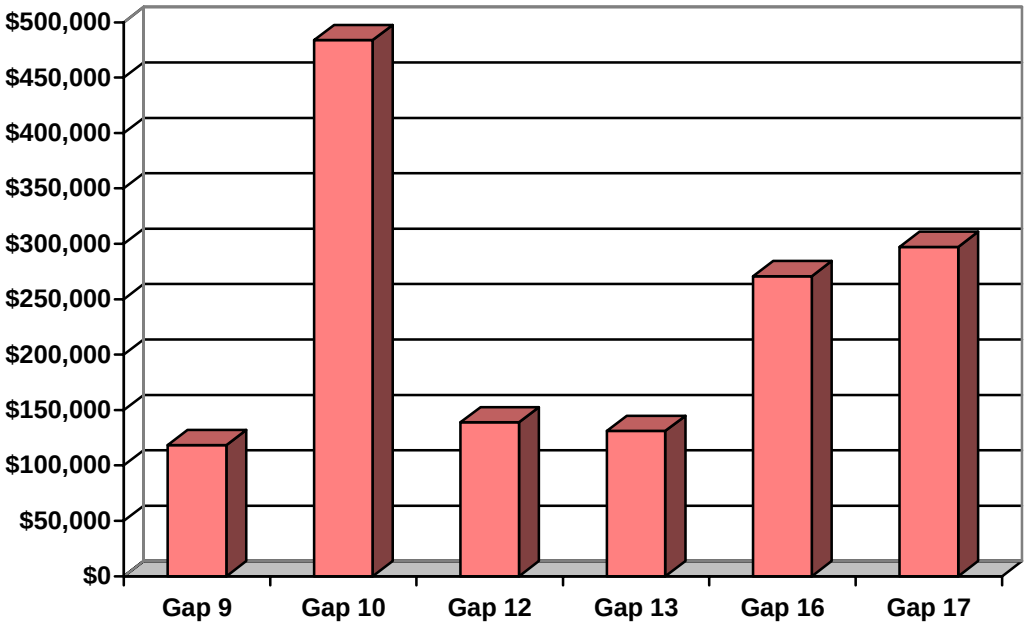
Table 1 Summary of funding allocated to Queensland named persons to address groundwater monitoring gaps

Type of activity	Number of projects	Total funding
Groundwater monitoring	4	$3,981,911

Surface water monitoring

The M&E Program (rounds 1-4) has helped to address 6 out of 9 surface water monitoring gaps, as presented in Graph 3. There were 31 applications submitted from Queensland named persons to address surface water monitoring gaps with 19 of them granted funding. The vast majority of projects were for the enhancement or installation of monitoring equipment. These projects received almost $900,000 in funding, or about 32 percent of the funding granted to Queensland named persons. (A further $745,000 was given to a DERM groundwater monitoring project, as noted above, for the installation of ten gauging stations and the purchase of some surface water monitoring equipment).

Graph 3 Funding expended to address surface water monitoring gaps in Queensland



SunWater and Seqwater were the major recipients of funding for surface water monitoring activities. SunWater received funding to upgrade all existing data loggers to a new technology, to purchase modern flow measurement equipment, to install new sensors, transducers and a number of continuous water level monitoring stations. SunWater fully resolved gap 10 for their organisation and about 75 percent of gap 9.

Seqwater obtained M&E Program funding to upgrade its entire monitoring network with new data loggers or sensors and to undertake bathymetric surveys at four storages. The funding program has assisted Seqwater to close gaps 9 and 17 and to address most of gap 10 for this organisation.

The upgrade of telephone telemetry to ALERT system allowed also Rockhampton Regional Council for improved coverage and currency of the data used for flood warning as well as standardisation and upgrade to a new technology of instruments.

Table 2 Summary of funding allocated to Queensland named persons to address surface water monitoring gaps

Type of activity	Number of projects	Total funding
Surface water monitoring	19	$1,440,365

Meteorological monitoring

There were eight meteorological monitoring gaps identified in the Queensland SWIMP 2010, all of which relate to flood warning activities. The Natural Disaster Resilience Program (NDRP) is the primary source of funding for flood warning installations, therefore only 6 of the 29 proposals (20 percent) were granted funding under the M&E Program. Approved projects received over $630,000 addressing gaps 18 and 19 from the Queensland SWIMP 2010, representing about 4 percent of the total funding received by Queensland named persons.

The acquired funding allowed several councils to install additional automatic rainfall stations, upgrade existing stations, remotely monitor water levels, increase coverage of rainfall data or to improve the availability of data for flood warning purposes.

Table 3 Summary of funding allocated to Queensland named persons to address meteorological monitoring gaps

Type of activity	Number of projects	Total funding
Meteorological monitoring	6	$632,952

Water quality monitoring

The Queensland SWIMP 2010 identified seven water quality monitoring gaps. Although there has been very significant investment by the Bureau in the data management system adopted by NRM bodies (see Data Management) there were a small number of water quality monitoring projects that did not receive funding. These projects aimed to address spatial gaps in NRM body monitoring networks as well as the need to improve the capacity of organisations to monitor for sediments and stream pollutant loads. These unfunded projects represent gaps that are still outstanding.

Funding was received by South West NRM under rounds one and two of the M&E Program to purchase and install on-site infrastructures for two mobile water-sampling units and to provide training to field staff. South West NRM had previously identified a lack of baseline data and the need to expand water quantity and quality monitoring within the region. Western Queensland catchments make up 52 percent of Queensland's portion of the Murray-Darling River system; these rivers include the Warrego, Paroo, Bulloo, Nebine and Mungallala rivers. This funding has enabled them to increase the amount of baseline data collected in these river catchments.

Table 4 Summary of funding allocated to Queensland named persons to address water quality monitoring gaps

Type of activity	Number of projects	Total funding
Water quality monitoring	2	$179,250

Water management and accounting

The Queensland SWIMP 2010 identified five gaps relating to water management and accounting however the only named person to propose projects to address these gaps was DERM. Three DERM projects to support water accounting objectives, addressing gaps 36 and 37, received overall funding of around $550,000.

With this funding DERM was able to achieve the following:

- Contribution to the development and implementation of a national database for Urban National Performance Reporting. The database has allowed for a single point of truth for urban water service provider data storage and management. Data is able to be validated and verified by both lead state water agencies and the NWC within the database.
- Analysis of DERM's current data management systems and the data needs of water accounting. It was found that the majority of data needed for water accounting was manually obtained (e.g. from water supply scheme operator annual reports or websites) and not stored in DERM systems.
- Contribution to the development of the National Water Account.
- Development of a systems analysis report, business case and specifications for WARS
- Provision of three WRP area water accounts to the Bureau

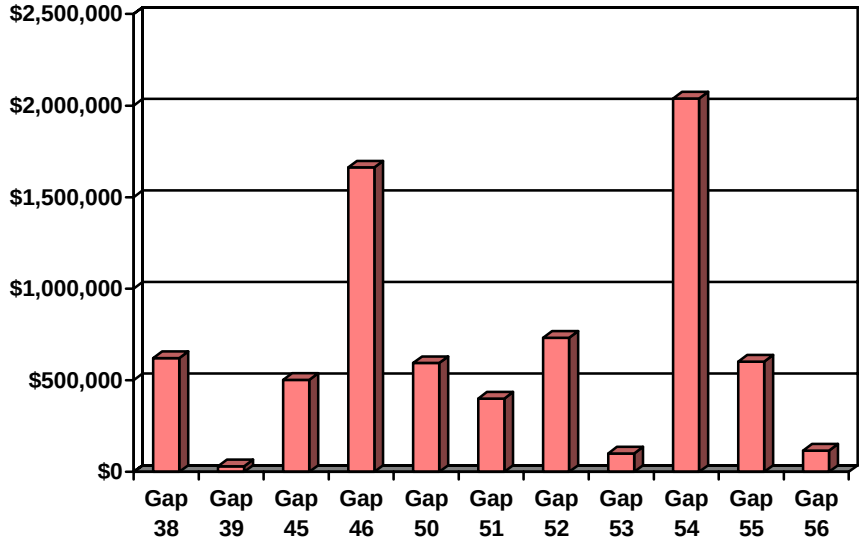
Table 5 Summary of funding allocated to Queensland named persons to address water management and accounting gaps

Type of activity	Number of projects	Total funding
Water management and accounting	3	$555,170

Data management

Under rounds 1-4 of the M&E Program seven Queensland named persons have received a total funding of over $7.3 million for 26 projects to address data management gaps. These projects include thirteen investing in data management systems, six to improve data reporting and analysis and five projects to support the development of standards.

Graph 4 Funding expended to address data management gaps in Queensland.



Data management systems

Of the thirteen projects funded to invest in new or to upgrade existing water data management systems two key systems received funding over consecutive rounds – SWIM and WaterQ.

The Bureau has funded enhancements to the SWIM data management system over three rounds of funding. Urban water service providers use the SWIM system managed by *qldwater* to reformat and deliver data to a number of state and federal reporting agencies including the Bureau. The SWIM system has been enhanced to deliver data in WDTF, to cater for parameters not previously managed by the SWIM system and to improve the process of delivering data from water service provider systems to SWIM, such as automating data checking arrangements. This investment has improved the accuracy, breadth and currency of data being provided to the Bureau by almost one quarter of the named persons in the state; with the added benefit of delivering this data in WDTF format.

The uniDap WaterQ data management system has been adopted by the majority of Queensland NRM bodies to manage their water quality data and make data available to their communities over the internet. The Bureau has invested over $1.5 million dollars in this system to enable it to manage the parameters required under the Water Regulations and to deliver the data to the Bureau in WDTF. Several catchment management authorities around Australia are also adopting this system to deliver their data to the Bureau.

There are nine named persons in Queensland only delivering rainfall data to the Bureau as per previous arrangements. There are around 12 with no current data to report. Of the remaining persons delivering new data to the Bureau under the Water Regulations around 70 percent will be delivering through either the SWIM system or WaterQ. Therefore this investment in these two systems has been a strategically sound

investment from the Bureau's point of view. The advantages to the state include the increased comparability of data and the potential for increased adoption of standard methods for coding data and metadata.

Other data management systems that received funding from the Bureau include the water management systems of DERM, SunWater, Seqwater and GAWB, as detailed in Section C of the Queensland SWIMP 2011.

Data reporting and Analysis

The key projects funded to improve data reporting and analysis were the Strategic Water Information Coordination (SWIC) projects and others to improve the reporting of spatial data to the Bureau.

DERM received over $600,000 funding from rounds 1-4 of the M&E Program for the SWIC project which included other coordination activities such as promotion of the benefits of CC licensing. This investment has had a number of benefits for the Bureau including more efficient communication with named persons in the state and improved understanding of the complexities concerning the collection of data from Queensland water monitoring organisations.

In order to support the Bureau's development of a National Geofabric Information System (NGIS) funding of around $140,000 was allocated to DERM to trial the ARC-Hydro data model, a geo database design for representing groundwater datasets within ArcGIS, as the Bureau wish to use this system to receive and manage groundwater data for the NGIS. Further funding of almost $600,000 was received to provide data and trial a delivery process for sending relevant DERM groundwater data to the NGIS model.

Funding of $400,000 was also received by DERM to improve the surface water spatial dataset for SEQ in order to support the Bureau's National Geofabric project.

Standards

DERM has received funding of $650,000 in total for a range of projects to support the development of standards. A key project was funded to develop a set of guidelines to encourage improved consistency across different organisations contributing water quality data including information about collection, analysis and storage. The second stage of funding was to collect feedback from other jurisdictions to develop this framework up to one that could be adopted at a national level.

Another key project is developing a set of national standards for the use of Acoustic Doppler Current Profilers (ADCP). In recent years ADCPs have become a fundamental piece of instrumentation for hydrologists. The standards are being developed in collaboration with relevant agencies in all jurisdictions and will cover the three major areas of ADCP application: open channel measurements, in-situ applications, velocity indexing and point velocity meters.

Another project is developing a 'best practice' monitoring framework for the collection of water quality data in SEQ for adoption by the key monitoring stakeholders in this region.

Standards related projects have received five percent of the total funding received by Queensland named persons; all standards related applications proposed by state organisations were funded to some level.

Modelling

Several projects funded for purposes identified elsewhere, such as the installation of new monitoring sites, will provide data to support modelling and, therefore, will help address modelling gaps. In particular the DERM project to align gauging stations and bores in south west Queensland and in the QMDB to a known datum will improve the accuracy of data for modelling purposes.

Training and resources

Many of the M&E Program funding recipients included training components in the scope of their projects however, round 2 DERM project "08-09 Qld 1.6 Engagement of Australian co-ordinator for technical innovation, education and monitoring procedures standardisation" aimed to assist with the future proofing and development of water monitoring skills at a national level. The objectives of this project included establishing best practice procedures and work practices relating to the introduction of new technologies into the water monitoring discipline. The position engaged all state agencies to ensure consensus in any procedural development and to guarantee that any new equipment will be used in a standardised way by the respective water monitoring bodies to provide quality data information to the Bureau.

Both the SWIM and uniDap WaterQ projects requested funding for some level of training, however this component was not always funded.

Four other projects addressed training and resources needs. Approximately $300,000 was spent on the purchase of hydrographic equipment and improving field staff skills. During round one of the funding program DERM conducted a series of workshops addressing the use of the Hydstra software – aimed at new users through to advanced level users. With Round 2 M&E Program funding DERM developed a training package focused on rating modules which was delivered to staff in seven regional offices.

Table 6 Summary of Funding granted for data management

Type of activity	Number of projects	Total funding
Data management	26	$7,398,190

1.1.1 Conclusion

Investment by the Bureau through the $80 million five year M&E Program has been of significant value to both the Bureau and the jurisdictional organisations named in the Water Regulations.

Key benefits from this investment for Queensland organisations include, but are not limited to:

- New or enhanced data management systems for DERM, SunWater, Seqwater, almost all other named water service providers (SWIM) and all the named NRM bodies (WaterQ) and others – for a total investment of over $4.8MIL (34 percent of all funding received in Queensland).
- Installation of new monitoring sites and the upgrading of monitoring technology for DERM, SunWater, Seqwater, water service providers and NRM bodies – for a total investment of over $1.04MIL (7 percent of all funding received in Queensland).
- Full or partial closure of gaps for many organisations.
- Improved communication between key water data providers, including working together on the development of standard approaches to data reporting, metadata and the use of certain monitoring equipment.

Key benefits from this investment for the Bureau include, but are not limited to:

- Improved understanding of the roles, responsibilities and data collections of Queensland water data providers
- Improved communication with state organisations – including improved recognition from them of Bureau objectives and products; along with appreciation for the investment to assist them with their data reporting.
- Data from water service providers representing about 40 percent of those named persons in the state currently delivering data to the Bureau is now coming through the SWIM system. This data is more current and accurate and is delivered in WDTF.
- Data from all NRM bodies coming through the WaterQ system in WDTF.
- Data coming from a number of key organisations is now more current, accurate and better managed and much of it is delivered in the Bureau's preferred WDTF format.

Table 7 Gaps identified in the Queensland SWIMP 2010, by type of activity

Type of Activity	Gap Id	Description of the gap	Gap Category	Priority	Ranking
Groundwater Monitoring	Gap 1	Spatial and temporal gaps exist in all bore networks, but particularly in the north, south east and south west regions.	Spatial and temporal gaps	2	H+
	Gap 2	The installation of data loggers on bores would result in data better able to characterise recharge events and water level depletion.	Monitoring equipment	2	H+
	Gap 3	A number of existing data loggers attached to bores require upgrading to improve data currency and to minimise data loss.	Monitoring equipment	2	H+
	Gap 4	Bore locations should be aligned to a known datum to improve the quality of data collected and to support development of a national geofabric dataset.	Modelling gaps	2	H+
	Gap 5	There is a lack of measured data relating to connected groundwater systems and base flows (surface water-groundwater connectivity).	Modelling gaps	2	H
	Gap 6	The analysis, evaluation and reporting of bore monitoring data is inconsistent.	Data Reporting and Analysis	1	H+
	Gap 7	A lack of sufficient bore monitoring data, particularly in high risk areas, impacts on the development of accurate models.	Modelling gaps	2	H+
	Gap 8	Resourcing for monitoring operations and for training to increase monitoring staff skill levels are emerging issues across all groundwater networks.	Training and Resources	3	H+
Surface Water Monitoring	Gap 9	Spatial and temporal gaps exist in state surface water monitoring networks.	Spatial and temporal gaps	2	H+
	Gap 10	A number of existing gauging station data loggers require upgrading to improve data currency and to minimise data loss.	Monitoring equipment	2	H+
	Gap 11	Gauging stations and storage gauges should be aligned to a known datum to improve the quality of data collected and	Modelling gaps	2	H+

		to support development of a national geofabric dataset.			
	Gap 12	Enhanced ratings of gauging stations and storages are required to improve the accuracy of data collected.	Modelling gaps	2	H
	Gap 13	Bathymetric surveys of storages are required to confirm storage capacities.	Metadata	1	M
	Gap 14	There is a recognised need to standardise analysis techniques used for surface water monitoring.	Data Reporting and Analysis	1	H
	Gap 15	Additional data collection is required to reduce uncertainty in river modelling – issues particularly noted in the QMDB and the northern North-East Coast catchments.	Modelling gaps	2	H+
	Gap 16	A lack of appropriately trained staff and adequate operational resources are emerging issues across agencies.	Training and Resources	3	H
	Gap 17	There is a need to upgrade to automatic systems and install telemetry for instantaneous recording of storage levels.	Monitoring equipment	2	H
Meteorological	Gap 18	Gaps exist in spatial and temporal monitoring in flood warning networks, including in the high resolution ALERT-type networks and for inland towns and regions, particularly in south west Queensland and in the catchments of major storages.	Spatial and temporal gaps	2	H
	Gap 19	Upgrades to gauging equipment are required for some organisations managing flood warning systems.	Monitoring equipment	2	H
	Gap 20	Flood warning networks for inland towns and regions and in south west Queensland need to be further developed.	Spatial and temporal gaps	2	M
	Gap 21	There is a specific need for improved rain and water level monitoring in catchments above large storages.	Spatial and temporal gaps	2	M
	Gap 22	Stage-discharge ratings relationships for new and existing gauging and flood warning stations are required to provide data to assist predictions of critical flood	Modelling gaps	2	H+

		heights at key towns and rural areas, and to assist water resource objectives.			
	Gap 23	A major review is required for all gauging and ratings in the QMDB rivers and in other rivers where this would assist the collection of data for both flood warning and water resource assessment purposes.	Modelling gaps	2	H+
	Gap 24	Technical and institutional support is required for local governments and regional bodies operating monitoring networks, especially rainfall and river height monitoring for the purposes of flood warning.	Training and Resources	3	M
	Gap 25	A lack of skilled operators is a critical issue in obtaining enhanced ratings at flood warning sites.	Training and Resources	3	H
Water Quality Monitoring	Gap 26	Spatial and temporal gaps exist in the water quality monitoring networks of the lead water agency, NRM bodies and local governments.	Spatial and temporal gaps	2	H
	Gap 27	More data loggers and probes are required to obtain real-time water quality datasets.	Monitoring equipment	2	H
	Gap 28	Frequency of sampling for some parameters, such as sediments and nutrients needs to be increased.	Spatial and temporal gaps	2	M
	Gap 29	Further monitoring of salinity, nutrients and pollutant loads is required, especially in the QMDB and SEQ.	Spatial and temporal gaps	2	H
	Gap 30	Inconsistent methodology for determining sediment, nutrient and pollutant loads from event monitoring impacts on data quality.	Standards	1	M
	Gap 31	Better analytical methods of historical and real-time water quality data are required, especially for data poor areas.	Data Reporting and Analysis	1	H
	Gap 32	There is a need for enhanced modelling capacity, particularly in the south east and south west regions.	Modelling gaps	2	H

Water Management and Accounting	Gap 33	Multiple reporting requirements of federal agencies for water trading information are an issue for state organisations.	Data Reporting and Analysis	1	M
	Gap 34	Aggregating state water trading information up to a national level is complex and requires significant collaboration between state and federal agencies.	Data Reporting and Analysis	1	H
	Gap 35	Enhancements to DERM and SunWater data management systems may be required once specifications for water allocation and trading data are available.	Data Reporting and Analysis	1	H
	Gap 36	There is a wide range of data that is currently unavailable for inclusion in the National Water Account due to inadequacies in data collection processes and systems, incomplete data measurement and recording, or is currently not required to be measured or recorded but is required for the first NWA and for implementation of the AWAS across Queensland.	Spatial and temporal gaps	2	H
	Gap 37	Enhanced information systems to better collect, manage, and deliver NWA and AWAS compliant data and information are required.	Data Management Systems	1	
Data Management	Gap 38	Standardised approaches to data processing, management and quality coding are required across all monitoring organisations.	Standards	1	
	Gap 39	Standards for the use of Doppler technology and for the development of ratings curves are high priorities for the larger monitoring organisations.	Standards	1	
	Gap 40	Further review work and inter-jurisdictional collaboration is required on a range of field and operational work practices with a view to creating Australian standards.	Standards	1	
	Gap 41	Defined quality coding and metadata and appropriate enhancements to data management systems are required to ensure integration of data is possible.	Metadata	1	

	Gap 42	Alignment of data reporting standards and formats between state and federal agencies such as the Bureau is required.	Data Reporting and Analysis	1	H
	Gap 43	Development of a national framework for water quality metadata is required.	Standards	1	H
	Gap 44	SunWater requires upgrading of its TimeStudio system to the new WISKI system to ensure reliable storage and reporting of SunWater time-series data. A tool to convert data in WISKI into WDTF for delivery to the Bureau is required.	Data Management Systems	1	H+
	Gap 45	Seqwater requires a new centralised data management system that will better manage the data from their extensive water monitoring networks. Upgrading to WISKI would also make their data compatible with SunWater and DERM systems. A tool to convert data in WISKI into WDTF for delivery to the Bureau is required.	Data Management Systems	1	H+
	Gap 46	The uniDap WaterQ system needs further enhancement to incorporate standardised metadata coding, as being developed in Queensland and New South Wales.	Data Management Systems	1	H+
	Gap 47	There is a need for a method to easily integrate data from different SCADA systems.	Data Management Systems	1	H
	Gap 48	Data validation is required for data in DERM's surface and groundwater databases.	Metadata	1	H
	Gap 49	Many organisations have valuable data that should be digitised to expand datasets and assist with trend analysis and to better understand the quality of data.	Modelling gaps	2	H+
	Gap 50	Further enhancements to the SWIM data management system are required to ensure sustainable reporting of urban water data to the Bureau in WDTF – including enhancement of the QA/QC module, capture and translation of historical data and metadata into WDTF and upgrades of the SWIM WDTF coding to comply with the latest version of	Data Management Systems	1	H+

		WDTF.			
	Gap 51	The surface hydrology spatial dataset requires cleaning, segmenting, networking, direction, edge matching, editing and attribution to improve the quality of data and maximise benefits for water managers and data users.	Modelling gaps	2	H+
	Gap 52	Mechanisms need to be developed to transfer data into the National Groundwater Information Service data model being developed by the Bureau.	Data Reporting and Analysis	1	M
	Gap 53	A coordinated training and accreditation framework would assist in enhancing standardisation in monitoring techniques and processes for quality coding and metadata capture.	Training and Resources	3	H
	Gap 54	Data management systems of many monitoring organisations require enhancement.	Data Management Systems	1	H+
	Gap 55	Strategic coordination is required to assist named persons with their data reporting to BOM.	Data Reporting and Analysis	1	H
	Gap 56	The data sharing capacity of water data collectors should be improved to allow wider access to relevant water data.	Data Management Systems	1	H

A Methodology for Reviewing Groundwater Monitoring Networks

Version 1.6
May 2009

Queensland Government
Department of Environment and Resource Management

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1.5	03/09	Ross Carruthers	Final draft for peer review
1.6	05/09	Ross Carruthers	Final report - comments from Sanjeev Pandey incorporated

Contents

Executive Summary

A well designed monitoring network is essential for any management program aimed at the protection and sustainable use of groundwater. The Department of Environment and Resource Management (the department) is responsible for the management of Queensland's groundwater resources and undertakes a range of groundwater monitoring activities throughout the state.

The purpose of this report is to outline a methodology for reviewing groundwater monitoring activities undertaken by the department. While the outlined methodology was developed for networks within the Burnett and Mary Basins, it may be applied to other areas. Application of the methodology should ensure that the department's groundwater monitoring bores and the networks they constitute are:

- managed in a way that ensures appropriate collection of data
- managed in a cost effective manner
- adequately covering all aquifers of concern
- meets the need of water planning
- capable of filling current knowledge gaps and
- updated on an ongoing basis to account for new, replacement and abandoned bores.

The methodology involves a combination of tools including Multi-Criteria Analysis (MCA), GIS based systems and expert knowledge. The steps required to undertake the review process are:

1. define the existing network
2. rank the existing network
3. design network and monitoring schedule to meet monitoring requirements
4. refine network to align monitoring requirements and resource availability
5. identify bores requiring replacement
6. identify proposed new monitoring bores and
7. identify bores for equipping with continuous monitoring technologies.

It is recommended that the methodologies described be applied to all groundwater monitoring networks with the exception of the Ambient Groundwater Quality Network. It is recommended that any robust review of this network be undertaken by Natural Resource Science Centre (NRSC) taking into consideration the original methodology used in its establishment.

1. INTRODUCTION

1.1. Background

A well designed monitoring network is essential for any management program aimed at the protection and sustainable use of groundwater. The Department of Environment and Resource Management (the department) is responsible for the management of Queensland's groundwater resources and undertakes a range of groundwater monitoring activities throughout the state. Current monitoring includes measurement of water levels, water quality and salinity resulting from either seawater intrusion or dryland processes.

It is important that monitoring be conducted at appropriate frequencies and locations to detect changes in resource condition. Data must be well distributed, meet groundwater assessment requirements, relate directly to key management issues and address knowledge gaps.

Monitoring is primarily focused on water resource planning and management to underpin sustainable use of the resource.

Some of the key objectives include:

- Determination of condition and trend
- System conceptualisation and resource assessment
- Construction and calibration of groundwater models to assess system performance
- On going assessment of performance of water resource plans
- Compliance actions

EHA (2007) defined a number of key principles that should be considered when determining groundwater monitoring requirements including:

- determination of aquifer systems most at risk of adverse groundwater impacts
- consideration of magnitude and value of aquifer systems
- monitoring system design that accounts for aquifer geometry, recharge / discharge areas, proximity to saline influences and GDEs

- monitoring requirements that underpin departmental water resource planning and management initiatives
- construction, calibration and verification of groundwater models
- use of continuous monitoring technologies to optimise data return for effort
- monitoring needs for groundwater assessment and management and
- monitoring of groundwater quality and quantity.

Groundwater monitoring provides a point of truth that directly links management decisions with resource responses. Because groundwater resource conditions and departmental management approaches change over time, it is critical that monitoring networks be reviewed on a regular basis.

There is also a need for documentation of concise methodologies and documentation relating to state controlled groundwater monitoring networks in order to fulfil new Commonwealth legislative obligations. The Bureau of Meteorology is now responsible for analysing, managing and reporting all of Australia's water resources information. Under these regulations, the department is required to provide the Bureau of Meteorology with detailed water information on request. The Bureau of Meteorology's new water information functions are described in the Commonwealth *Water Act 2007* under Part 7 - Water Information. These new functions are supported by the Water Regulations 2008.

This report outlines a methodology for reviewing the department's groundwater monitoring activities.

2. METHODOLOGY

A key driver for this review is the need to establish a methodology that could be applied to future reviews. It is intended that this methodology be used when undertaking future reviews so that a degree of consistency can be maintained throughout the department.

For the purpose of this review process, the groundwater monitoring network has been separated into separate component networks with each component network based on the purpose for which the monitoring is undertake. This enables monitoring activities associated with specific purposes to be analysed comparing like against like. For the network review conducted for the Burnett and Mary Basins, the following component networks were reviewed: -

- Groundwater level monitoring network
- Seawater intrusion monitoring network
- Ambient groundwater quality network

The steps required to undertake the review are:

1. define the existing network
2. rank the existing network
3. design network and monitoring schedule to meet monitoring requirements
4. refine network to align monitoring requirements and resource availability
5. identify bores requiring replacement
6. identify proposed new monitoring bores and
7. identify bores for equipping with continuous monitoring technologies.

2.1 Define the Existing Network

The first step in reviewing the monitoring network is to establish the total network available. The department's groundwater monitoring network was last reviewed in 2004. As a result of this review the report '2004 Sub-Artesian Bore Monitoring Network Index' was produced. The report documented the number, location and monitoring frequency of all bores selected for the networks.

It should be recognised that this index does not include all bores available for monitoring. Some bores were excluded from the index based on the criteria under which the 2004 review was undertaken. In many areas, groundwater management approaches have since changed and bores which were excluded may now be an important part of the monitoring network. Consequently, in considering the total number of bores available for assessment through the network review it is necessary to consider:

- bores recorded in the "2004 Sub-Artesian Bore Monitoring Network Index"
- bores excluded from "2004 Sub-Artesian Bore Monitoring Network Index" but are in good condition and in priority areas
- monitoring bores that were recorded in the index but have since been abandoned and
- monitoring bores that have been drilled since 2004 (including those drilled through the National Action Plan for Salinity and Water Quality program and the Mulgildie Great Artesian Basin drilling program).

Once the total available network has been determined, the individual monitoring bores are mapped to:

- determine which aquifer units are being monitored
- show how individual monitoring bores align with the various aquifer units and
- show the distribution of the various types of monitoring being undertaken (eg. water level, seawater intrusion, water quality).

This enables the monitoring network to be divided into discrete subsets comprised of individual aquifers and monitoring types, ensuring all components of the monitoring networks are assessed.

2.2 Rank the Existing Network

An essential aspect of any review process is the analysis of the relative importance of each component of the system being reviewed. Multi-Criteria Analysis (MCA) is a generic term to describe a decision making tool that analyses multidimensional issues. The principal function of MCA is to combine data from several criteria to form a single index of evaluation. MCA enables standardised scores to be assigned to a criterion that relates to one aspect of an issue. For example, the amount of seawater entering the aquifer at a monitoring bore can be rated by the levels of conductivity recorded, with higher conductivity levels being given a higher score than lower levels. This allocation of a score independent of the type of criteria being assessed, allows different data types such as conductivity and condition of the monitoring bore, to be considered in one analysis.

MCA also provides the option to weight a particular criterion to achieve a higher standardised score. Once all criteria have been assigned a score, this data can be entered into a matrix and exported into MCA software such as Facilitator. This data may then be used to assign both a score and an overall ranking, allowing the decision maker to readily assess its overall importance.

While the MCA process has been used in decision making processes since the 1960s, the development of MCA based software such as Facilitator enables large datasets to be easily handled and updated as conditions change. This results in a methodology that can:

- clearly show how decisions are made, allowing for easy justification of assessment
- prioritise monitoring networks
- be used as a tool for consultation with key stakeholders including scientists, community and government agencies
- be used as a web based communication tool for sharing information and receiving input from other departmental staff and
- be easily and accurately replicated.

A key strength of the MCA in reviewing monitoring networks is flexibility. Due to changes in stressors acting on groundwater systems (eg: the volume of extraction and

fluctuating climatic conditions), areas that require more comprehensive monitoring may change over time. As aquifer conditions change it is possible to change the scores given to each criterion and rerun the analyses to determine if the importance of individual bores in the network has changed. Once the initial analysis has been undertaken and all bores have been ranked against each criterion, any changes need only be applied to those individual bore criteria. This enables future reviews of the network to be undertaken easily with minimum resources.

The MCA process should only be used as one available tool when ranking monitoring bores in order of importance. It is essential that other key sources of expert knowledge and information are used to assist in the ranking process. This might include input from a range of stakeholders including:

- hydrogeologists when considering groundwater assessment needs
- Natural Resource Science Centre (NRSC) staff when ranking bores installed to monitor dryland or irrigation salinity
- groundwater modellers if looking at bores within a modelled area
- water planning officers when considering specific monitoring requirements for Water Resource Plans and Resource Operations Plans
- groundwater managers when considering requirements for implementing management strategies such as announced allocations or restrictions and
- local monitoring staff to provide input on issues such as monitoring requirements for groundwater dependent ecosystems, town water supplies and knowledge of bore condition and access.

Application of both the MCA process and expert knowledge results in a more robust process with greater endorsement and ownership by those key stakeholders who have contributed.

The resultant rankings can be used as a tool to assess future changes to the monitoring network should available resources increase or decrease, priorities change, or more systems require increased management. The ranking process provides a means for deciding how the available resources can be distributed to create the most efficient monitoring network.

2.2.1 Ranking the Groundwater Level Network

For the network review conducted for the Burnett and Mary Basins, ranking of the groundwater level monitoring network was based on the criteria below. Each criterion is assigned a score for each bore. These scores are processed and collated using the Facilitator MCA software, then fine-tuned using expert knowledge prior to assigning an overall score for each bore. The overall scores are then use to assign a rank for each bore.

Key Indicator Bores

This criterion relates to the frequency that data from this bore has historically been used as input to groundwater management decisions such as Announced Allocations and management of the saltwater front and preparation of groundwater level contour maps, and/or if it is a nodal bore for a groundwater model.

It is recognised that there are a number of methodologies available to 'optimise' a groundwater monitoring network for the purpose of on-going groundwater model construction and calibration. Some of these even utilise existing models. Therefore, it is envisaged that application of such methods, wherever applicable and feasible, will assist in identifying and prioritising indicator bores as a separate exercise.

Recorded Water Level Fluctuation

This criterion relates to the recorded groundwater level fluctuations that have historically occurred at each monitoring bore. The use of this criterion will reduce the importance of bores where groundwater levels are fairly stable, while increasing the importance of those bores where the groundwater levels fluctuate strongly in response to climatic influences. These fluctuations are expressed as a percentage deviation from the historical average water level.

Groundwater Management Area

This criterion ranks monitoring bores as to whether they are in a currently managed area such as a Water Resource Plan (WRP), Resource Operations Plan (ROP) or Wild Rivers managed area. Areas that have a high likelihood of requiring future management as identified through a separate risk assessment process are also scored.

Multipurpose versus Single Use Bore

This criterion ranks monitoring bores according to the number of different data types collected at each bore. A higher ranking will be assigned to those bores that are used for a number of data collection types. For example a bore that contains a data logger and is also used to measure water levels and salinity profiles will rate higher than one that is only used for water level measurement.

Influence on Bore by External Factors

This criterion ensures that bores that are influenced by factors such as tidal influence or nearby irrigation pumps etc., will rank lower than those that are not.

Distance to Nearest Groundwater Level Monitoring Bore

This criterion identifies groundwater level monitoring bores that are isolated and therefore representative of a greater area rank higher than those that may occur in a cluster and therefore potentially overlap each others data. As bore lines are used to determine aquifer characteristics along a transect, there is the potential for this to give a low score for bores that are isolated in the overall monitoring network but that are close to others on the same bore line. Therefore bores in the one transect are to be treated as a single bore for the purpose of this criteria.

Monitoring Bore Data Representative of Aquifer

This criterion ensures that data collected from monitoring bores is indicative of the conditions of the majority of the aquifer. For instance a bore located in a perched aquifer

may be hydrologically disconnected from the main aquifer, and therefore it will not give readings that are representative of the majority of the groundwater resource for that area.

Bore Condition/Access
This criterion identifies bores that are in poor condition or are difficult to access.

The complete methodology for ranking including full description of criteria and associated scoring used in the Burnett and Mary Basins review is discussed in Appendix 1. It is recognised that these criteria may be unsuitable for application in other areas of the state. It is recommended that the criteria be tested for applicability prior to implementation and changes made to suit local requirements or conditions as necessary.

2.2.2 Ranking the Seawater Intrusion Network

As for the water level network, the MCA process and expert knowledge is used to rank all of the bores in the seawater intrusion network. For the network review conducted for the Burnett and Mary Basins the following criteria were used. The complete methodology is outlined in Appendix 1. It is again recommended that the criteria be tested for applicability prior to implementation in other regions.

Key Indicator Bores
This criterion relates to the frequency that data from this bore has historically been used in regards to providing data for seawater intrusion management decisions such as Announced Allocations, mapping the saltwater front, providing data for council in relation to town water supply bores, and/or if it is a nodal bore.

Recorded Conductivity Fluctuation
This criterion relates to the recorded conductivity fluctuations and hence influence of seawater intrusion on groundwater resources that has historically occurred at each monitoring bore. The use of this criterion will reduce the importance of bores where the seawater intrusion may have stabilised while increasing the importance of those bores where the seawater/groundwater interface is still in a state of flux. These fluctuations are expressed as a percentage deviation from the historical average conductivity values.

Proximity to Seawater Wedge
This criterion ranks monitoring bores based on their distance to the saltwater wedge. It is assumed that seawater intrusion monitoring bores that are further from the saltwater wedge will have a lower priority than those monitoring bores that are closer.

Distance to Nearest Conductivity Monitoring Bore
This criterion simply ensures that seawater intrusion monitoring bores that are isolated and therefore representative of a greater area rank higher than those that may occur in a cluster and therefore overlap potentially each others data.

2.2.3 Ranking the Groundwater Quality Network

The Ambient Groundwater Quality Monitoring Network was designed using a methodology developed by water chemistry specialists within the Natural Resource Science Centre (NRSC). The groundwater quality network within the Burnett and Mary catchments is relatively small and includes only 46 bores spread across 6 discrete aquifer units. An attempt was made to rank the monitoring bores using the following criteria:

- Original AMBIENT Water Quality Bore
- Influence on Bore by External Factors
- Change in Extraction Rate of Area
- Surrounding Land Use
- Distance to Nearest AMBIENT Water Quality Bore and
- Monitoring Bore Data Representative of Aquifer.

However, an initial assessment of results indicated that this was not an appropriate methodology.

It is recommended that any robust review of this network be undertaken by NRSC taking into consideration the original methodology used in the establishment of the network. The review should also consider outcomes from the departmental aquifer risk assessment in determining whether the extent of the current network adequately represents high value aquifer systems across Queensland.

To identify the current network, a schedule of bores currently monitored for water quality under the Ambient Groundwater Quality Monitoring Network should be developed. This is necessary as bores documented as being part of the existing network may have been decommissioned and replaced.

2.3 Design Network and Monitoring Schedule to Meet Monitoring Requirements

Once the ranking is established for each discrete aquifer unit, the ranking order can be used in the design of a network and monitoring schedule to meet monitoring requirements.

The EHA report 'Review of the Sub-artesian Bore Monitoring Network' (2007) identified a number of key principles to guide the department's monitoring efforts. These principles can be used in conjunction with outcomes from the MCA ranking of the existing network and expert knowledge to determine the most suitable network for your area. At this stage in developing your monitoring network you should only consider existing monitoring bores. There will be an opportunity to identify any proposed new monitoring bores later in the process.

In relation to the monitoring schedule, many bores across Queensland are currently monitored on a quarterly basis to determine groundwater level trends. In areas where water levels are relatively stable (eg. Central Condamine or GAB intake Beds) or where monitoring is aimed at assessing long term trends (eg. dry land salinity monitoring bores), quarterly readings provide sufficient data for most assessment and management tasks. However, many aquifer units react to recharge events much more quickly than a three month lag and the quarterly frequency does not properly characterize the aquifer response. Where possible, monitoring should be carried out more frequently in these areas to accurately capture groundwater level peaks and depletions.

Another factor to be considered in determining the monitoring schedule is the risk of adverse groundwater impact that may be associated with the aquifer unit. Where aquifer units are at low risk and monitoring is aimed at establishing background data only, then monitoring more frequently than quarterly is difficult to justify. However, where aquifers are higher risk and are likely to be managed or modelled into the future, a more concentrated monitoring schedule (eg. continuous, monthly or bi-monthly) should be considered.

A departmental aquifer risk assessment process is currently being undertaken for a number of major aquifers across the state. The outcomes of this risk assessment may be used to compare levels of risk by aquifer unit. Where a risk assessment hasn't been undertaken for a particular aquifer unit, the departmental risk assessment framework provides a detailed methodology for assessment of risk.

The MCA ranking process can also be used to determine the relative importance of each aquifer. This is done by averaging the individual ranking scores for all monitoring bores within each aquifer unit to produce an aquifer system ranking. The aquifer system rankings for all aquifer units in the region can then be compared as an indicator of relative importance. The results of this analysis should always be used in combination with expert advice.

Once the most suitable network and monitoring schedule has been designed, the list of monitoring bores including registered number, aquifer system, bore location and monitoring schedule should be compiled, included in the final report and clearly labelled. For example the groundwater level network list should be labelled as the 2009 Groundwater Level Monitoring Network.

2.4 Refine Network to Align Monitoring Requirements and Resource Availability

To this point the methodology for network review has involved:

- determining the existing network
- ranking all monitoring points in the existing network and
- establishing a suitable network and monitoring schedule.

The next step is to refine the network, where necessary, to align monitoring requirements and resource limitations. These resource limitations may include people resources, financial resources or other resources such as vehicles or equipment. There is a range of strategies than can be used to match monitoring requirements to resources, including:

- sourcing additional monitoring resources
- reducing the monitoring frequency and
- reducing the number of bores being monitored.

Individual bore rankings and aquifer system rankings can be used to assist in this process. However it is essential that all key stakeholders be consulted prior to considering any reductions in the monitoring network. As previously discussed, key stakeholders may include hydrogeologists, NRSC scientists, groundwater planners, managers, modellers and local monitoring staff.

Any amendments (eg. changes to bores monitored or monitoring schedule) made to the designed network should be clearly identified using additional columns in the network list..

It is intended that the network lists be upgraded and amended as adjustments are made to the network. These adjustments might occur as a result of bores being constructed, decommissioned or replaced or as a result of changes in resourcing levels or changes in the management priorities of individual aquifer units.

2.5 Identify Bores Requiring Replacement

Despite ongoing maintenance, any groundwater monitoring network that has been established for more than forty years will contain bores that require replacement. The most common bores that require replacement include:

- bores located within private property and constantly being damaged by farm equipment;
- bores with screens that have collapsed and that are subject to sand or gravel intrusion;
- bores that appear to be intersecting more than one aquifer;
- bores impacted by nearby production bores; and
- shallow bores becoming permanently dry due to water level decline.

Bores requiring replacement should be documented in a replacement bore schedule in priority order using the MCA ranking to determine priority. Any available funding for replacement bores can then be distributed equitably according to priority of bores being replaced.

2.6 Identify Proposed New Monitoring Bores

The EHA report 'Review of the Sub-artesian Bore Monitoring Network' (2007) identified a number of key principles to guide the department's monitoring efforts. To identify sites for proposed new monitoring bores, a gap analysis based on the principles outlined in Section 1.1 of this report should be undertaken to identify deficiencies in the existing network.

As part of the gap analysis the results of departmental aquifer risk assessment processes should be used to identify high value 'at risk' aquifers that may require future management intervention.

The following expert advice should also be sought to further refine the gap analysis:

- Groundwater modellers – to identify future monitoring requirements for existing and proposed groundwater models
- Water planners – to provide advice on monitoring requirements for Water Resource Plans and Resource Operations Plans
- Groundwater hydrogeologists – to identify monitoring needs for groundwater assessment purposes
- Water managers – to identify monitoring needs for groundwater management purposes and

- Monitoring staff – to provide logistical advice in relation to monitoring runs and access conditions.

A GIS-driven mapping approach using departmental spatial information systems, groundwater, water entitlement and other relevant databases can then be used to determine proposed bore sites, taking into account:

- the extent of the current groundwater monitoring network
- a range of aquifer characteristics including geometry, recharge zones, discharge zones, aquifer and adjacent system water quality
- areas of high levels of extractions
- Groundwater Dependent Ecosystems
- suitable road reserves and other locations for bore sites and
- information gained through research and through expert advice.

A proposed monitoring bore schedule in priority order can then be developed. This will enable the installation of proposed monitoring bores as funds become available.

2.7 Identify Bores for Equipping with Continuous Monitoring Technologies

One of the most significant recent developments in practical groundwater science has been the development of reliable, low-cost data loggers capable of monitoring groundwater level, temperature and salinity. As identified by EHA (2007) the collection of continuous groundwater data assists in the characterization of recharge events and water level depletion. To help offset establishment costs the frequency of visits to continuously-logged bores could be reduced to 6 months. This is particularly valid in highly managed areas where bores are now read monthly, especially if these bores are equipped with telemetry for remote downloads. This will also enable real-time groundwater data to be available to the community via the internet, promoting a more educated resource user and making groundwater management decisions more transparent and understandable.

A number of monitoring bores across the state are currently equipped with continuous monitoring technologies. The MCA rankings and expert knowledge can be used to assess whether continuous monitoring should be retained at these sites using the installed continuous monitoring technologies or whether changes to bore sites or continuous monitoring technologies are required. A schedule of these bores should be produced including proposed amendments to current arrangements.

There may be additional bores where equipping with continuous monitoring technologies is essential to meet assessment and management requirements into the future. A schedule of these bores should be developed using the MCA rankings and expert knowledge to prioritise these bores for installation with continuous monitoring technologies as funds become available.

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EHA 2007 Review of the Sub-Artesian Groundwater Monitoring Network- Final Report, Report to Queensland Department of Natural Resources and Mines, Report Number GW-06-10-REP-001.

Appendix 1 – Multi Criteria Analysis

Method

Multi-Criteria Analysis (MCA) for Review of the Groundwater Monitoring Networks (Groundwater Level Network & Seawater Intrusion Network)

Computer file:	**Multi-Criteria Analysis (MCA) for revising Groundwater Monitoring Networks.doc**
Version Number:	**1.5**
Date Adopted:	**12/5/09**
Prepared By:	
Work Unit:	**Water Services**
Reviewed by:	
Work Unit:	
Review Date:	
Authorised By:	
Work Unit:	Queensland Government Natural Resources and Water

Amendment History

Version	Date	Reviewed by	Amendment Comments
1.0	17/11/2007	Shane Moloney	Document created.
1.1	24/12/2007	Ross Carruthers Ashley Bleakley	Comments provided.
1.2	17/01/2008	Shane Moloney	Comments incorporated
1.3	11/02/2008	Ross Carruthers Graeme long Gavin Eddie	Comments provided
1.4	11/02/2008	Shane Moloney	Comments incorporated
1.5	3/03/2009	Graeme Long	Groundwater Level & Seawater Intrusion combined to create one document.

1 Purpose and scope

This document is designed to provide a justifiable and consistent approach for the Revision of groundwater monitoring networks. The aim is to create a qualitative/semi quantitative method that can be easily and accurately replicated by any user at any time.

This method describes a process to use in the identification and prioritisation of the Groundwater Level Monitoring Network and the Seawater Intrusion Monitoring Network using Multi-Criteria Analysis software, a qualitative/semi-quantitative decision based support tool, in the identification and prioritisation of the individual monitoring bores that comprise the Groundwater Monitoring Network.

Concept: To create a qualitative/semi quantitative method that can be easily and accurately replicated.

Applications of the MCA:

- Prioritisation of monitoring bores for revision of the network.
- Clearly show how decisions are made, allowing for easy justification of assessments made regarding revision of the groundwater monitoring networks.
- Tool for consultation with key stakeholders including scientists, community and government agencies.
- Web based tool for sharing information and receiving input from other NRW staff.

Quality Assurance

This MCA is a qualitative /semi quantitative method where potential for considerable subjectivity may arise whilst scoring alternatives against criteria. This can be minimised by the following:

- Ensuring that criteria are clearly defined.
- Record justification for scores in the comments section of the database whilst scoring.
- Ensure appropriately trained staff undertake the assessment
- Verify scores with experts and community representatives.

2 Equipment

Software:

- MapInfo/ArcView – Geographic Information System (GIS) software package.
  - Ask your GIS information Officer to install this program on your computer. Also check licence availability for your area.
- Facilitator – A Multi Objective Decision Support System Software which uses decision rules, a hierarchical system for ranking criteria, score functions and linear programming to identify preferred management options consistent with the ranking of criteria.

  - You can find a working version here: http://sourceforge.net
  - In order to operate Facilitator a Java Runtime Environment is required.
  - Java Runtime Enviroment (JRE) is available here: http://java.sun.com/javase/downloads
  - Facilitator 'User Guide' is available on the same site.
  - Facilitator 'Quick Start" guide.(See Appendix A)
  - System requirements: Windows 2000 or better

3 Method

Development of MCA Criteria

The MCA criteria described in this report have been developed by the groundwater staff in Bundaberg office for the process of reviewing the monitoring networks within the Burnett, Mary and Baffle catchments. It is recognised that these criteria and / or the scoring processes associated with each criterion may be unsuitable for application in other areas of the state. It is recommended that the criteria and / or associated scoring processes be tested for applicability prior to implementation and that changes are made to suit local requirements or conditions as necessary.

Filters prior to MCA:

GIS data may be used to determine coverage of monitoring bores in relation to areas with different management priorities. For example the first step in determining the adequacy of the current monitoring network may be to map current monitoring bores and compare these locations with groundwater management areas of current and/or future management concern.

4 Groundwater Level Monitoring Network

Criteria used in MCA for prioritising Groundwater Level Monitoring Network:
Prioritisation of Groundwater Level Monitoring Network in Water Resource Plan areas will be based on the following criteria:

- Key Indicator Bores
- Recorded Water Level Fluctuation
- Groundwater Management Area
- Multipurpose versus Single Use Bore
- Influence on Bore by External Factors
- Distance to Nearest Groundwater Level Monitoring Bore
- Monitoring Bore Data Representative of Aquifer
- Bore Condition/Access

Key Indicator Bores:

This criterion relates to the frequency that data from this bore has historically been used as input to groundwater management decisions such as Announced Allocations and management of the saltwater front and preparation of groundwater level contour maps, and/or if it is a nodal bore for a groundwater model.

It is recognised that there are a number of methodologies available to 'optimise' a groundwater monitoring network for the purpose of on going groundwater model construction and calibration. Some of these even utilise existing models. Therefore, it is envisaged that application of such methods, wherever applicable and feasible, will assist in identifying and prioritising indicator bores as a separate exercise.

1. **Primary Indicator Bore:** this is a critical bore for a groundwater model calibration, determination of water sharing (announced allocation) or monitoring of specific requirement under the ROP. Data from this monitoring bore is typically used for greater than 75% of the time to provide for groundwater management decisions. Includes bores that are used to frequently supply data to clients such as councils.

2. **Secondary Indicator Bore:** data from this monitoring bore has been used less than 75% of the time to provide data for groundwater management decisions in areas that have a high priority for future management.

3. **Unlikely Use as Indicator Bore:** there is limited records of data from this monitoring bore being used for groundwater management decisions.

There is a low likelihood of this bore being in an area that will require future groundwater management.

Recorded Water level Fluctuations

This criterion relates to the recorded groundwater level fluctuations that have historically occurred at each monitoring bore. The use of this criterion will reduce the importance of bores where groundwater levels are fairly stable, while increasing the importance of those bores where the groundwater levels fluctuate strongly in response to climatic influences. These fluctuations are expressed as a percentage deviation from the historical average water level.

1. **Large Fluctuations:** Fluctuations of 20% or higher have been recorded.
2. **Moderate Fluctuations:** Fluctuations of 10-20% have been recorded.
3. **Small Fluctuations:** Fluctuations of 0-10% have been recorded.
4. **No Fluctuations Measured**

Groundwater Management Area

This criterion ranks monitoring bores as to whether they are in a currently managed area such as a WRP, ROP or Wild Rivers managed area. Areas that have a high likelihood of requiring future management as identified through a separate risk assessment process are also scored.

1. **Bore in Managed Area:** bore located in a WRP or ROP area or area protected by specific legislation such as the Wild Rivers Act.
2. **Bore in High Risk Area:** bore located in an area that has been identified as having a high likelihood of requiring future management. The risk input comes from a separate process and is primarily based on a combination of environmental and socio-economic factors.
3. **Bore in Medium/Low Risk Area:** bore located in an area that has been identified as having a medium/low likelihood of requiring future management.
4. **Bore in unmanaged Area:** bore located in an area that is not currently managed and has not been identified as requiring future management.

Multipurpose versus Single Use Bore

This criterion ranks monitoring bores according to the number of different data types collected at each bore. A higher ranking will be assigned to those bores that are used for a number of data collection types. For example a bore that contains a data logger and is also used to measure water levels and salinity profiles will rate higher than one that is only used for water level measurement.

1. **Bore is highly utilised:** bore is used to collect three or more data types.

2. **Bore is moderately utilised:** bore is used to collect two data types

3. **Bore is lowly utilised:** bore is used to collect a single type of data.

Influence on Bore by External Factors

This criterion ensures that bores that are influenced by factors such as tidal influence or nearby irrigation pumps etc., will rank lower than those that are not.

1. **Bore Free of Influence:** data collected from the bore is not influenced by external influences.

2. **Bore Influenced:** data collected from this bore may be corrupted by pumping influences etc.

Distance to Nearest Groundwater Level Monitoring Bore/Transect.

This criterion identifies groundwater level monitoring bores that are isolated and therefore representative of a greater area rank higher than those that may occur in a cluster and therefore potentially overlap each others data. As bore lines are used to determine aquifer characteristics along a transect, there is the potential for this to give a low score for bores that are isolated in the overall monitoring network but that are close to others on the same bore line. Therefore bores in the one transect are to be treated as a single bore for the purpose of this criteria.

1. **Bore Highly Isolated:** bore greater than 10 km from nearest groundwater level monitoring bore.
2. **Bore Moderately Isolated:** bore 5km - 10km from nearest groundwater level monitoring bore.
3. **Bore Slightly Isolated** bore 1km - 5km from nearest groundwater level monitoring bore.
4. **Bore Within Cluster:** bore 0km - 1km from nearest groundwater level monitoring bore.

Monitoring Bore Data Representative of Aquifer

This criterion ensures that data collected from monitoring bores is indicative of the conditions of the majority of the aquifer. For instance a bore located in a perched aquifer may be hydrologically disconnected from the main aquifer, and therefore it will not give readings that are representative of the majority of the groundwater resource for that area.

1. **Bore Data Representative of Aquifer:** available historical data collected from this bore (water level, water quality ect.) shows similar results &/or trends to data from other bores in an aquifer.

2. **Bore Data not Representative of Aquifer:** available historical data collected from this bore (water level, water quality ect.) does not show similar results &/or trends to data from other bores in an aquifer.

Bore Condition

This criterion identifies bores that are in poor condition or are difficult to access.

1. **Bore in good condition/Access :** bore is well maintained

2. **Bore poor condition/Access:** bore is in need of substantial maintenance.

5 Seawater Intrusion Monitoring Network

Criteria used in MCA for prioritising Seawater Intrusion Monitoring Network:
Prioritisation of Seawater Intrusion Monitoring Network will be based on the following criteria:

- Key Indicator Bores
- Recorded Conductivity Fluctuation
- Proximity to Saltwater Wedge
- Distance to Nearest Conductivity Monitoring Bore

Key Indicator Bores:

This criterion relates to the frequency that data from this bore has historically been used in regards to providing data for seawater intrusion management decisions such as Announced Allocations, mapping the saltwater front, providing data for council in relation to town water supply bores, and/or if it is a nodal bore.

1. **Primary Indicator Bore:** this is a nodal bore for a groundwater model, or data from this monitoring bore has been used greater than 75% of the time to provide data for seawater intrusion management decisions. Includes bores that are used to frequently supply data to clients such as councils.

2. **Secondary Indicator Bore:** data from this monitoring bore has been used less than 75% of the time to provide data for seawater intrusion management decisions.Data from this bore is used infrequently to develop saltwater intrusion maps.Bore used as back up for Primary Indicator Bores.

3. **Rarely used:** there is limited records of data from this monitoring bore being used for seawater intrusion management decisions.

Recorded Conductivity Fluctuation

This criterion relates to the recorded conductivity fluctuations and hence influence of seawater intrusion on groundwater resources that has historically occurred at each monitoring bore. The use of this criterion will reduce the importance of bores where the seawater intrusion may have stabilised while increasing the importance of those bores where the seawater/groundwater interface is still in a state of flux. These fluctuations are expressed as a percentage deviation from the historical average conductivity values.

1. **Large Fluctuations over an Extended Period and Up Until the Present:** Fluctuations of at least 20% have been measured over at least a 10 year period and are still occurring within the last 5 years.

2. **Small Fluctuations over an Extended Period and Up Until the Present:** Fluctuations up to 20% have been measured over at least a 10 year period and are still occurring within the last 5 years.

3. **Large Fluctuations but Infrequent/Historical:** Fluctuations at least 20% have been measured historically but not within the last 5 years.

4. **Small Fluctuations but Infrequent/Historical:** Fluctuations up to 20% have been measured historically but not within the last 5 years.

5. **No Fluctuations of Conductivity Measured**

Proximity to Saltwater Wedge

This criterion ranks monitoring bores based on their distance to the saltwater wedge. It is assumed that seawater intrusion monitoring bores that are further from the saltwater wedge will have a lower priority than those monitoring bores that are closer.

1. **Bore located 0km -1km either side of mapped 2005 saltwater intrusion line.**
2. **Bore located 1km -2km either side of mapped 2005 saltwater intrusion line.**
3. **Bore located 2km -4km either side of mapped 2005 saltwater intrusion line.**
4. **Bore located 4km -5km either side of mapped 2005 saltwater intrusion line.**
5. **Bore located greater than 5km either side of mapped 2005 saltwater intrusion line.**

Distance to Nearest Conductivity Bore

This criterion simply ensures that seawater intrusion monitoring bores that are isolated and therefore representative of a greater area rank higher than those that may occur in a cluster and therefore overlap potentially each others data.

1. **Bore located 5km - 10km from nearest saltwater intrusion monitoring bore.**
2. **Bore located 1km - 5km from nearest saltwater intrusion monitoring bore.**
3. **Bore located 0km - 1km from nearest saltwater intrusion monitoring bore.**

Appendix A Facilitator 'Quick Start' Guide

Using Facilitator

Facilitator sets out information in a matrix with alternatives on the X-axis and criteria on the Y-axis. For the purpose of this method, the alternatives are the bores and the criteria, are those explained above.

Once all bores have been scored against criteria and associated information recorded in an Access database, the alternatives, criteria and scores are copied to a blank spreadsheet and saved as a .csv (comma separated) file. It can be useful to run a search in excel for blank cells as these will cause facilitator to hang on import.

Importing data

Start facilitator:
→*File – New*
→ *File – Matrix – Import*. Select to import both alternatives and criteria in *comma separated(CSV)* format.

If the file is importing correctly the mouse icon will flicker whilst the computer is processing the information. If after a few seconds the mouse icon is not flickering, facilitator has hung and will need to be shut down using the program task manager (ctrl, alt, delete). If this occurs go back and open up the .csv file in excel and check that no blank cells or extra rows have been inserted whilst converting to .csv format. Parentheses and other punctuation marks can also prevent facilitator from importing (the easiest way to check this is to use the find replace function).**The first cell in the first row should be blank.** The first row contains the criteria headings. Depending on the number of criteria and alternatives facilitator can take 2-3 minutes to import the .csv file

Criteria definition

Once the matrix has been imported by facilitator, the criteria need to be defined. In the pull down menu:
→ *Window – Base criteria*.

Double click on the first criteria in the 'List of Base Criteria' and select the '*Properties*' tab. Define the score range for that criteria and select how you want the scores normalised (i.e. '*More is worst linear*' will interpret 1 as higher than 8 and that the relationship between scores is linear). Repeat this for each criterion.

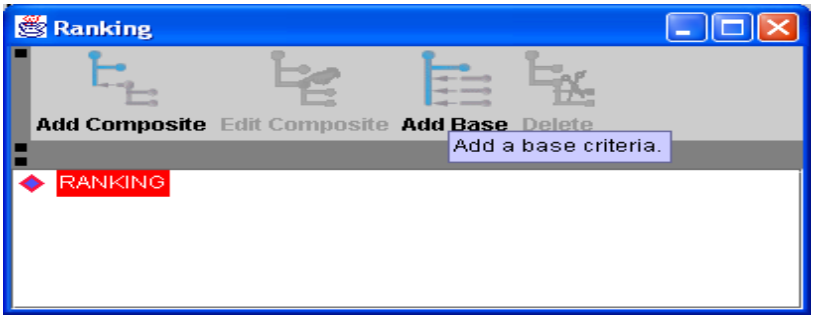
> NOTE:
>
> ❖ If the scores and relationships are **not defined** for all criteria the analysis **will not work**.

Set the run cycle

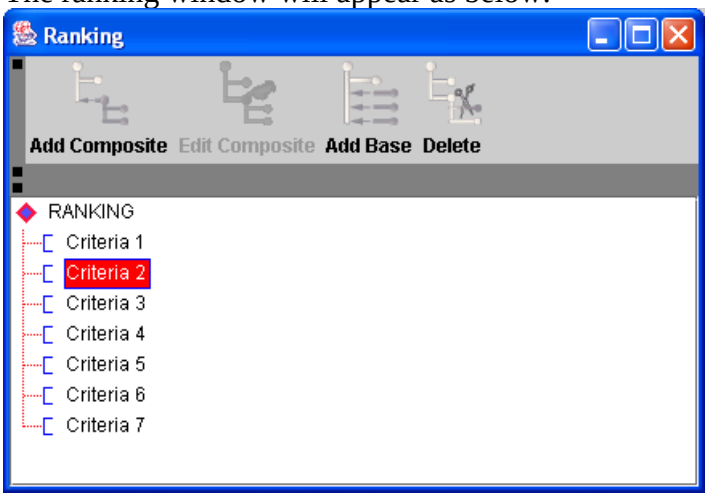
→ *Run – Set cycle*. There will be a brief pause and nothing else apparent (this is normal).

Choose rankings

Criteria should be ranked equally by opening the ranking selection window:
→ *Window – Ranking*. The ranking selection window will appear as shown below.



→ *Add Base – Add a base criteria*. Select all the criteria and click OK.
The ranking window will appear as below.



→ *Double click the second criteria*. This will join the first two criteria, ranking them equally (indicated by the blue lines).

→ Continue this process until all criteria have been 'joined' and hence equal.

NOTE:
- Every-time a criteria or score is changed you will need to set a new cycle and re-enter ranking.
  (this is a shortcoming of the program).

Run analysis

→ *Run – Run analysis*.
This will run the current cycle

Once an analysis has be run the results table will open in a new window. The analysis only takes a few seconds. If it takes longer make sure all criteria have been defined (score ranges and relationships), set a new cycle and re-rank criteria, make sure that none of the cells in the matrix are selected as this will also prevent an analysis from being run. Run analysis. In the results window you can switch between ranked and polar view. By clicking on individual criteria in the ranking window on the left hand side of the screen you can view results for single criteria.

Limitations to Use

As Facilitator is still a beta (test) version of the software there are a number of limitations within the software. The software still has a number of quirks such as the need to set a new cycle every time changes are made to the matrix, this also resets any previous rankings and so they will need to be re-entered. Changing scores assigned within the matrix is also difficult as the cell needs to be selected, the value within the cell highlighted and then the new value added. If only the cell is selected and the new value entered it will be added as a decimal value after the original value. These limitations may be rectified in future versions of facilitator.

Entering data directly into Facilitator is quite cumbersome, there is no ability to cut and paste information, no "fill" facility such as that found in "Excel". Criteria and Alternatives must be set up individually and cannot be written directly into cells as in "Excel". The best way around this is to create a matrix in MS Access and export it as a comma delimited (.csv) file that can then be imported into facilitator. Further details for criteria, such as the score graph and criteria limits will then need to be added individually.

This is still a qualitative/semi-quantitative approach to prioritising bores, and there is some potential for subjectivity within this approach. The Quality Assurance section of this methods document outlines steps that may be taken to reduce this subjectivity. This method however is no more subjective than other methods that are available for monitoring prioritisation, and will become more rigorous as information is collected

during its implementation. This method is also able to be used as a check for other methods and therefore allows for a better assessment of both.

References

Greiner R, Herr A, Brodie J, Haynes D. 2005 A multi criteria approach to Great Barrier Reef catchment (Queensland, Australia) diffuse source pollution problem Marine pollution Bulletin 51 (2005) 128-137

Hajkowicz SA, Collins K. 2007. A Review of Multiple Criteria Analysis for Water Resource Planning and Management. Water Resources Management 21(9):1553-1566.

Heilman, P, Davis, G, Lawrence, P, Hatfield, JL & Huddleston, J (2000) 'The facilitator - an open source effort to support multiobjective decision making', Rizzoli, AE & Jakeman, A J (eds.), Integrated assessment and decision support, proceedings of the first biennial meeting of the International Environmental Modelling and Software Society, Volume 3, iEMSs, 2002. Available online: http://www.iemss.org/iemss2002/proceedings/pdf/volume%20tre/325_heilman.pdf

Appendix 5.2 Groundwater network review gaps

Appendix 5.2.1 Groundwater network review – North region gaps

Aquifer	**Number of Bores required**	**Priority** (Essential; Highly Desirable; or Desirable)	**Comments** (supporting requirement for additional monitoring).
Thortonia Limestone	2	Essential	• New declared area with Gulf WRP monitoring requirements (Nicholson) and no current monitoring • Part of Nicholson Wild Rivers area • Potential GW/SW interaction • Suited to logger/telemetry due to isolation • Social and cultural value, high level of public interest in potential effect of existing mining operations • Require water level trend information
	20	Highly Desirable	
McBride Plateau	2	Essential – Gulf WRP area	• New declared area with Gulf WRP monitoring requirements (Einasleigh) and no current monitoring • Potential GW/SW interaction – major spring flows to rivers on both sides of drainage divide • Suited to logger/telemetry due to isolation • May be subject to future water exploration by QG • Endemic invertebrates known to occur in spring systems • Require water level trend information
	2	Essential – Burdekin WRP area	
	20	Highly Desirable	
Chillagoe Formation	2	Essential	• New declared area with Mitchell WRP monitoring requirements (Chillagoe) and no current monitoring • Locations difficult as karst system • Best locations may be close to protected area (i.e. Cave systems.)

	10	Highly Desirable	• Potential GW/SW interaction • May be able to utilise data collected by Red Dome/Mungana mines • More development expected in area, QG water exploration to west of formation • Require water level trend information
Atherton Basalts (Atherton Area B)	10	Essential	• Data useful for water trading decisions and modelling • Potential GW/SW interaction • Very little known about boundary conditions, sub-catchment divides, spring hydrology, etc. • Require water level trend information • Protected wetland systems with high environmental /economic /social value present in area
	20	Highly Desirable	
Mulgrave River Alluvium	3	Essential	• High risk areas for Salt Water Intrusion, Trinity Inlet (1998 report) • Potential future management • Potential impact of TWS • 3 recommended in DRAFT EHA report • Alternative to 17 private bores nominated for monitoring in draft EHA report • Potential GW/SW interaction data required • Near where Behena Ck. crosses alluvium or closest gauging station • Potential high use with Town Water Supply proposal • Protected wetland systems with high environmental /economic /social value present in area
	25	Desirable	
Cairns Northern Beaches – Various	6	Highly Desirable	• No current monitoring in northern and southern portions • Limited coverage in delta area

costal aquifer units	20	Desirable	• Potential GW/SW interaction • Recharge mechanisms poorly understood and alteration due to development • Protected wetland systems with high environmental /economic /social value present in area
Atherton Basalts – Johnstone Basin	3	Highly Desirable	• Limited bore coverage in upper Johnstone catchment • High usage in unregulated area • 3 private bores recommended for monitoring in DRAFT EHA report • Status may change as will be exploratory drilling in fractured rock by QG over next 12-18 months – may leave obs. Bores for Dept. • Potential GW/SW interaction • Proposed Water Resource Plan area
	20	Desirable	
Johnstone River Alluvium	3	Essential	• One bore to be installed as part of NWC project – essential • 3 new bores recommended in DRAFT EHA report • High usage in unregulated area • Requires future management (WRP) • Potential GW/SW interaction • Potential saltwater intrusion in areas • Boundary and recharge mechanisms not well understood • Protected wetland systems with high environmental /economic /social value present in area
	40	Desirable	
Tully/Murray Alluvium	6	Essential	• Proposed Water Resource Plan • Potential GW/SW interaction • 6 sites recommended in DRAFT EHA report • Current unregulated, existing usage may be significant in some areas • Protected wetland systems with high environmental /economic /social value present in area
	25	Desirable	
Herbert River Alluvium	10	Essential	• 10 new bores recommended in DRAFT EHA report • Potentially high yielding aquifer and expected future development • Potential GW/SW interaction

	40	Highly Desirable	• Areas of potential and known salt water intrusion, particularly in area of town water supply bores • Boundary and recharge mechanisms not well understood
Fractured Rock – Upper Herbert Basin	2	Essential	• Status may change due to exploratory drilling in fractured rock by QG over next 12-18 months – may leave obs. Bores for Dept. Use as such status may change • Potential GW/SW interaction
Atherton Basalts – Upper Herbert Basin	2	Essential	• Will be exploratory drilling in fractured rock by QG over next 12-18 months – may leave obs. Bores for Dept. Use as such status may change • Potential GW/SW interaction
	3	Desirable	
McLean Basalts – Lakeland Downs	2	Essential	• 1 bore recommended by 2006 report • No background water level data • Increased demand of limited resource • Currently considered fully allocated (2006 report) • Potential GW/SW interaction
	6	Highly Desirable	
Haughton/Baratta Alluvium	4	Desirable	• West of alluvium (Dingo Park) • Very little known about boundary conditions • Growing concern over rising salinity • Protected wetland systems with high environmental /economic /social value present in area
Burdekin River Alluvium	4	Desirable	• Base of Stokes Ranges where alluvial boundary conditions unknown • Growing concern over rising salinity (Leichhardt)

Appendix 5.2.2 Groundwater network review – Central West gaps

Aquifer	Number of Bores	Priority	Comments
Pioneer Valley Alluvium	5	Essential	**Pioneer Valley ROP Monitoring** • These bores critical in determining movement of seawater intrusion on Mackay Regional Council water supply bores • Highly stressed groundwater resource. • Under moratorium. • Under announced entitlement. • Modelling purposes.
Pioneer Valley Alluvium	20	Essential	**Pioneer Valley ROP Monitoring** • Sea Water intrusion monitoring • SW/GW interaction monitoring • Under announced entitlement. • Highly stressed groundwater resource. • Under moratorium. • Modelling purposes.
Pioneer Valley Alluvium	3	Essential	**Pioneer Valley ROP Monitoring** • Groundwater Dependant Ecosystem monitoring • Highly developed. • Highly stressed groundwater resource.
Pioneer Valley Alluvium	2	Highly Desirable	**Pioneer Valley ROP Monitoring** • Groundwater Dependant Ecosystem monitoring • Highly developed. • Highly stressed groundwater resource.
Andromache River Alluvium	5	Essential	**Whitsunday ROP Monitoring** • Very limited existing monitoring bores and GW data for aquifer. • SW/GW interaction monitoring • Under moratorium.

O'Connell River Alluvium	5	Essential	**Whitsunday ROP Monitoring** • Very limited existing monitoring bores and GW data for aquifer. • SW/GW interaction monitoring • Under moratorium.

Appendix 5.2.3 Groundwater network review – South East gaps

Aquifer	Lat	Long	Comments
Baffle Ck	-24.28111	151.50388	Look at SW/GW interaction as suggested by TAP
Cooloola Coast	-25.9	153.06	Interaction between SW and GW in Patterned fens wetland
Agnes Waters coastal dunes	-24.22016252	151.9149825	Shallow watertable required for GDE study
Agnes Waters coastal dunes	-24.20795469	151.8959554	Shallow watertable required for GDE study
Woodgate Dune Sands	-25.09285689	152.52438591	Adj. 13710059. Shallow watertable required for GDE study
Woodgate Dune Sands	-24.94800560	152.47713382	Adj. 13700045. Shallow watertable required for GDE study
Central Burnett R. alluvium	-25.468881	151.171805	• High current resource access for irrigation. • Surface water-groundwater interaction occurs • Surface water management area under Burnett ROP • High potential for future development of the resource
Central Burnett R. alluvium	-25.587176	151.192138	
Central Burnett R. alluvium	-25.586244	151.19972	
Central Burnett R. alluvium	-25.629282	151.218701	
Central Burnett R. alluvium	-25.635427	151.215139	
Wide Bay Creek alluvium	-26.010226	152.453116	• High current resource access for irrigation & town water supply • High potential for future development of the resource • Surface water-groundwater interaction occurs • Proposal to manage surface water under the Mary Basin ROP • No existing monitoring bores
Wide Bay Creek alluvium	-26.016103	152.450772	
Wide Bay Creek alluvium	-26.062281	152.305172	
Wide Bay Creek alluvium	-26.06806	152.303331	
Wide Bay Creek alluvium	-26.067222	152.217939	
Wide Bay Creek alluvium	-26.071565	152.221627	
Wide Bay Creek alluvium	-26.115418	152.181076	
Wide Bay Creek alluvium	-26.115837	152.193209	
Wide Bay Creek alluvium	-26.169899	152.176406	
Wide Bay Creek alluvium	-26.165417	152.182805	
Barker Creek alluvium	-26.46959533	152.0570953	• High current resource access for irrigation
Barker Creek alluvium	-26.5716622	151.9873522	
Barker Creek alluvium	-26.70969508	151.8575062	

Barker Creek alluvium	-26.72952918	151.8295105	• High potential for future development of the resource • Surface water-groundwater interaction occurs • Kunioon Coal mine
Coalstoun Lake Basalts	-25.605648	151.916344	• High level of community concern • High likelihood that irrigation is impacting Ban Ban Springs • Moderate current resource access for irrigation • No existing monitoring bores
Coalstoun Lake Basalts	-25.623106	151.88947	
Coalstoun Lake Basalts	-25.653849	151.888561	
Coalstoun Lake Basalts	-25.676732	151.886284	
Coalstoun Lake Basalts	-25.681667	151.859819	
Coalstoun Lake Basalts	-25.672224	151.824928	
Coalstoun Lake Basalts	-25.672085	151.800919	
Coalstoun Lake Basalts	-25.683214	151.79684	
Coalstoun Lake Basalts	-25.685571	151.820937	
Coalstoun Lake Basalts	-25.707617	151.850679	
Coalstoun Lake Basalts	-25.745533	151.863576	
Boonara Ck alluvium	-25.88153691	151.8319846	• High current resource access for irrigation • Moderate potential for future development of the resource • Surface water-groundwater interaction occurs
Boonara Ck alluvium	-25.92899396	151.8816045	
Boonara Ck alluvium	-25.93271963	151.8768587	
Nangur Creek alluvium	-26.12168818	152.0655172	
Nangur Creek alluvium	-26.12210536	152.0684371	
Stuart River alluvium	-26.54730559	151.8039811	• Moderate current resource access for irrigation • Surface water-groundwater interaction occurs • Surface water management area under Burnett ROP • High potential for future development of the resource
Stuart River alluvium	-26.58235338	151.7922279	
Stuart River alluvium	-26.60985793	151.7814158	
Stuart River alluvium	-26.64863017	151.7492311	
Stuart River alluvium	-26.69424129	151.6970456	
Stuart River alluvium	-26.72179598	151.664649	
Upper Mary River alluvium	-26.44358	152.747234	• Moderate current resource access
Upper Mary River alluvium	-26.445201	152.755395	

Upper Mary River alluvium	-26.590341	152.73303	• Surface water-groundwater interaction occurs • High potential for future development of the resource
Upper Mary River alluvium	-26.5900	152.72800	

Aquifer	Number of Bores	Priority	Comments
Moreton Island	6	Essential	• Moreton Island is the largest groundwater resource in SEQ which has no useful groundwater monitoring network • Recommendation to NRW in EHA 2005 report
	6	Highly Desirable	
North Stradbroke Island	6	Essential	• Logan WRP amendment monitoring • No groundwater monitoring in southern end of island • SW/GW interaction monitoring for Groundwater Dependent Ecosystems monitoring
South Stradbroke Island	3	Highly Desirable	• Logan WRP amendment monitoring • Shallow watertable • Saltwater intrusion • Required for future Groundwater Dependent Ecosystems monitoring
Bribie Island	5	Highly Desirable	• Future WRP • High current resource access for TWS. • Surface water-groundwater interaction occurs • No water management area at all • High potential for future development of the resource
Logan & Albert Rivers' Alluvium	12	Essential	• Unmanaged – High Risk • High current resource access for irrigation • High potential for future development of the resource • Surface water-groundwater interaction occurs • No proposal to manage groundwater under the Logan Basin ROP

	12	Highly Desirable	• Widely spaced existing monitoring bores
Gatton Esk Road Implementation Area – Helidon sandstone	6	Essential	**GAB WRP Monitoring** • Required to assist in determining sustainable gw yield on which to base volumetric limits. • 160 licences issued and still no monitoring bores
Clarence Moreton Management area outside Gatton Esk Road Implementation Area– Helidon sandstone – Postmans Ridge	1	Essential	**GAB WRP Monitoring** • This bore is critical in determining effects of Toowoomba Regional Council take from Helidon sandstone on water levels in that aquifer in western Lockyer valley. • Used to determine volumetric limits for licences when issued in this area.
Clarence Moreton Management area outside Gatton Esk Road Implementation Area– Helidon sandstone – Murphy's creek	1	Highly desirable	**GAB WRP Monitoring** • Will be used in determining affects of Toowoomba Regional Council take from Helidon sandstone on water levels in that aquifer in western Lockyer valley. • Used to determine volumetric limits for licences when issued in this area.
Clarence Moreton Management area outside Gatton Esk Road Implementation Area– Helidon sandstone – Withcott and Mulgowie	2	Desirable	**GAB WRP Monitoring** • Used to determine volumetric limits for licences when issued in this area and observe water level trends.

Upper Lockyer Valley Alluvium	10	Essential	**Moreton WRP Monitoring** • Highly stressed groundwater area • Licensing process about to begin in an area which has only recently become a groundwater management area. • Significant surface water-groundwater interaction occurs in upstream areas. • Holes in upstream areas of network need to be filled for modelling work to follow.
Upper Lockyer Valley Alluvium	12	Highly Desirable	**Moreton WRP Monitoring** • Highly stressed groundwater area • Licensing process about to begin in an area which has only recently become a groundwater management area. • Holes in upstream areas of network need to be filled for modelling work to follow.
Warrill Creek Alluvium	21	Essential	**Moreton WRP Monitoring** • Highly stressed aquifer • Significant surface water groundwater interaction affecting performance of surface water scheme. • Licensing process is scheduled to occur in an area which has only recently become a groundwater management area. • Very limited existing network, potential benefited groundwater area issues
Warrill Creek Alluvium	14	Highly Desirable	**Moreton WRP Monitoring** • Highly stressed aquifer • Significant surface water groundwater interaction affecting performance of surface water scheme. • Licensing process is scheduled to occur in an area which has only recently become a groundwater management area. • Very limited existing network, potential benefited groundwater area issues

Upper Brisbane River Alluvium - Harlin	1	Highly Desirable	**Moreton WRP – Monitoring** • Part of a groundwater buffer zone upstream of Wivenhoe Dam. • Moratorium in place and groundwater resource not considered at risk • Concern is potential effect of increased groundwater use on surface water in Brisbane River. • No monitoring bores in place in upstream areas to guide further policy development.
Main Range Volcanics (Hampton and Blackbutt)	2	Desirable	**Unmanaged Area – Low Risk** • Increasing groundwater use in area with no monitoring bores in place
Esk Formation (Toogoolawah)	1	Desirable	**Unmanaged Area – Low Risk** Increasing groundwater use in area with no monitoring bores in place
Emu Creek Alluvium	1	Desirable	**Unmanaged Area – Low Risk** • Increasing groundwater use in area with no monitoring bores in place • This area drains into the Upper Brisbane and potentially a groundwater buffer zone may be enforced in this area in future amendments to the Moreton WRP.

Appendix 5.2.4: Groundwater network review – South West gaps

Aquifer	Number of Bores	Priority	Comments
Central Condamine Alluvium	14	Essential	**WRP/ROP Monitoring** • SW/GW interaction monitoring • Highly developed. • Highly stressed groundwater resource. • Under moratorium. • Under announced entitlement. • Modelling purposes.
Upper Condamine River Alluvium	6	Essential	**Unmanaged – High Risk** • SW/GW interaction monitoring • Highly developed. • Highly stressed groundwater resource • Under moratorium. • Currently under S25 pumping limitations. • Highly developed.
Oakey Creek Alluvium	4	Essential	**Managed Area – High Risk** • SW/GW interaction monitoring • Highly developed. • Highly stressed groundwater resource. • Under announced entitlement. • Under moratorium.
Upper Hodgson Creek Basalts	4	Essential	**Managed Area – High Risk** • Highly developed. • Currently under S25 pumping limitations. • Highly stressed groundwater resource. • Under moratorium.

Toowoomba North Basalts	16	Essential	**Unmanaged – High Risk** • Highly developed. • Few existing monitoring bores over system. tapping whole sequence of basalt formation. • Currently under S25 pumping limitations. • Highly stressed groundwater resource • Under moratorium.
Toowoomba South Basalts	40	Essential	**Unmanaged – High Risk** • Highly developed. • Whole valley catchments with no monitoring bores. • Currently under S25 pumping limitations. • Highly stressed groundwater resource. • Under moratorium.
Nobby Basalts Restricted Area	3	Essential	**Unmanaged – High Risk** • Highly developed. • High level of community concern • Few existing monitoring bores. • Currently under S25 pumping limitations • Highly stressed groundwater resource. • Under moratorium.
Warwick Basalts	15	Essential	**Unmanaged – High Risk** • Highly developed. • Few monitoring bores in range section. • Surface water-groundwater interaction occurs • Currently under S25 pumping limitations. • Under moratorium. • Highly stressed groundwater resource

Emu & Farm Creek Alluvium	3	Desirable	**Unmanaged – Medium Risk** • Moderately developed. • Surface water-groundwater interaction occurs • Currently under S25 pumping limitations • Highly stressed groundwater resource. • Under moratorium.
Freestone Creek Alluvium	3	Desirable	**Unmanaged – Medium Risk** • Moderately developed. • Surface water-groundwater interaction occurs • Currently under S25 pumping limitations • Highly stressed groundwater resource. • Under moratorium.
Glengallan Creek Alluvium	3	Essential	**Unmanaged – High Risk** • Highly developed. • Surface water-groundwater interaction occurs • Currently under S25 pumping limitations • Highly stressed groundwater resource. • Under moratorium.
Dalrymple Creek Alluvium	3	Essential	**Unmanaged – High Risk** • Highly developed. • Surface water-groundwater interaction occurs • Currently under S25 pumping limitations • Highly stressed groundwater resource. • Under moratorium.
Kings Creek alluvium	3	Desirable	**Unmanaged – Medium Risk** • Moderately developed • Surface water-groundwater interaction occurs • Currently under S25 pumping limitations • Highly stressed groundwater resource. • Under moratorium.

Moola/North Myall Creek Alluvium	3	Essential	**Unmanaged – High Risk** • Highly developed. • Surface water-groundwater interaction occurs • Currently under S25 pumping limitations prohibiting pumping. • Groundwater critical. • Under moratorium.
Myall Creek Alluvium	4	Desirable	**Unmanaged – Medium Risk** • Highly developed. • Currently under S25 pumping limitations prohibiting pumping. • Groundwater critical. • Under moratorium.
Eastern Downs Walloon Coal Measures	10	Essential	**WRP/ROP Monitoring.-.High risk** • Highly Developed. • Potential impact associated with large scale extraction of water for mining coal methane gas. • Most used of all GAB sediments stock/domestic purposes. • Lack of monitoring bores in strategic locations. • Highly stressed groundwater resource
Eastern Downs Marburg Sandstone	7	Essential	**WRP/ROP Monitoring – High Risk** • Highly developed. • Very few monitoring bores tap whole sequence of this formation.
Eastern Downs Walloon Coal Measures	10	Essential	**WRP/ROP Monitoring.-.High risk** • Large scale extraction of water for mining coal methane gas. • Most used of all GAB sediments stock/domestic purposes. • Lack of monitoring bores in strategic locations. • Highly stressed groundwater resource
Eastern Downs Helidon Sandstone	5	Essential	**WRP/ROP Monitoring – Medium Risk** • No monitoring bores in this formation. • High areas of use, emergency Toowoomba town water supply and wide scale mining.
Macintyre River Alluvium	5	Desirablel	**Unmanaged Area – Medium Risk** • Moderately developed.

Macintyre Brook Alluvium	5	Desirable	**Unmanaged Area – Medium Risk** • Moderately developed.
Dumaresq River Alluvium	4	Desirable	**Unmanaged Area – Medium Risk** • Moderately developed.
Border River Alluvium	7	Essential	**Unmanaged – High Risk** • Highly developed. • Needs more in strategically placed sites.
Texas Beds	10	Desirable	**Unmanaged – Low Risk** • Low development.
Stanthorpe Granites	5	Desirable	**Unmanaged – Low Risk** • Low development.
Balonne/Maranoa River alluvium	7	Essential	**Unmanaged – High Risk** • Highly developed. • Needs more monitoring bore tapping high and intermediate aquifers.
Upper Maranoa River Alluvium	4	Desirable	**Unmanaged – Low Risk** • Low development.
Warrego River Alluvium	5	Desirable	**Unmanaged – Low Risk** • Low development.

Appendix 5.3 Groundwater network reviews – data loggers required

This table presents the location and number of data loggers required to enhance the DERM groundwater water level network.

Office	Aquifer	Number of loggers	Priority	Type of logger	Comments
BBG	Coastal Burnett Groundwater Management Area	24	Essential	long term	Representative Bore – Burnett ROP Management Zones
BBG	Mulgildie GAB	3	Essential	long term	GAB WRP/ROP Implementation
BBG	Mulgildie GAB	2	Highly Desirable	long term	GAB WRP/ROP Implementation
BNE	Moreton Island	1	Essential		Zero monitoring at present
BNE	North Stradbroke Island	3	Essential		Add to existing network, GW modelling
BNE	South Stradbroke Island	1	Highly Desirable		Zero monitoring at present
BNE	Bribie Island	2	Essential		Add to existing network, GW modelling
BNE	Logan & Albert Rivers' Alluvium	2	Highly Desirable		Add to existing network, GW modelling
TBA	Central Condamine Alluvium	20	Essential	long term	Representative Bore – Central Condamine proposed WRP/ROP Management Zones
TBA	Eastern Downs Walloon Coal Measures	5	Essential	long term	GAB WRP/ROP Implementation
TBA	Eastern Downs Marburg Sandstone	5	Essential	long term	GAB WRP/ROP Implementation
TBA	Eastern Downs Helidon Sandstone	2	Essential	long term	GAB WRP/ROP Implementation
TBA	Oakey Creek Alluvium	6	Essential	long term	Representative Bore – Includes OCGMA
TBA	Toowoomba North Basalts	10	Essential	long term	Representative Bore – Unmanaged

Office	Aquifer	Number of loggers	Priority	Type of logger	Comments
					area
TBA	Toowoomba South Basalts	24	Essential	long term	Representative Bore – Includes UHCGMA (4)
TBA	Warwick Basalts	8	Essential	long term	Representative Bore – Unmanaged area
TBA	Emu / Farm Creeks Alluvium	2	Desirable	long term	Representative Bore – Unmanaged area
TBA	Glengallan Creek Alluvium	3	Essential	long term	Representative Bore – Unmanaged area
TBA	Dalrymple Creek Alluvium	3	Essential	long term	Representative Bore – Unmanaged area
TBA	Kings Creek alluvium	3	Desirable	long term	Representative Bore – Unmanaged area
TBA	Moola / North Myall Creeks Alluvium	3	Essential	long term	Representative Bore – Unmanaged area
TBA	Myall Creek Alluvium	2	Desirable	long term	Representative Bore – Unmanaged area
TBA	Border Rivers Alluvium	18	Essential	long term	Representative Bore – Includes BRGMA
TBA	Balonne River Alluvium	10	Essential	long term	Representative Bore – Unmanaged area
TBA	Upper Maranoa River Alluvium	2	Desirable	long term	Representative Bore – Unmanaged area
MKY	Pioneer Valley Groundwater Management Area	11	Essential		Representative Bore – Pioneer Valley ROP Management Zones
MKY	Proserpine River Alluvium	2	Essential		Whitsunday WRP/ROP Implementation
MKY	O'Connell River Alluvium	1	Essential		Whitsunday WRP/ROP Implementation

Office	Aquifer	Number of loggers	Priority	Type of logger	Comments
MKY	Andromache River Alluvium	1	Essential		Whitsunday WRP/ROP Implementation
MKY	Koumala Carmila Beds	1	Desirable		Representative Bore – Unmanaged area
MBA	Whyanbeel Creek Alluvium	1	Desirable		• Recommendations in Leach report • Require information on water level trends
MBA	Mossman River Alluvium	4	Essential		• Recommendations in DRAFT EHA report • Recommendations in Leach report • Require information on water level trends
MBA	Coastal sediments – Mossman Basin	1	Essential		• Recommendations in DRAFT EHA report • Require information on water level trends
MBA	Cairns Northern Beaches	1	Essential		• Recommendations in Draft EHA report • Require information on water level trends
MBA	Mulgrave River Alluvium	4	Essential		• Recommendations in DRAFT EHA report • Recommendations in Lait report • Recommendations in Leach report • Require

Office	Aquifer	Number of loggers	Priority	Type of logger	Comments
					information on water level trends
MBA	Johnstone River Alluvium	4	Essential		• Recommendations in DRAFT EHA report • Require information on water level trends
MBA	Atherton Basalt – Johnstone Basin	4	Essential		• Recommendations in DRAFT EHA report • Require information on water level trends
MBA	Herbert River Alluvium	8	Essential		• Recommendations in Draft EHA report • Require information on water level trends • One in upper Herbert alluvium
MBA	Atherton Basalt – Herbert Basin	3	Essential		• Recommendations in Draft EHA report • Require information on water level trends
MBA	Atherton Basalts – Atherton Area B	2	Essential		• Require information on water level trends • Proposed trading areas may have water sharing rules

Office	Aquifer	Number of loggers	Priority	Type of logger	Comments
MBA	Tully River Alluvium	1	Essential		• Recommendations in Draft EHA report • Require information on water level trends
MBA	Murray River Alluvium	5	Essential		• Recommendations in Draft EHA report • Require information on water level trends
MBA	Thortonia Limestone	2	Essential		• Remote and access difficult • Require information on water level trends
MBA	Chillagoe	2	Essential		• Require information on water level trends
MBA	McBride Basalt	2	Essential		• Remote and access difficult • Require information on water level trends
MBA	McLean Basalt	1	Desirable		• Remote location • Require information on water level trends

Assessment Network Determination

Part 1 – Determine Site Density Requirements

Involve Principal Hydrographer from each region in this process.

1. Select Drainage Basin for analysis

2. Place a site at the end of all basins and **named** sub-basins.

3. Include a suitable site on any tributary (or tributary of a tributary) where the catchment area exceeds 10% of the total basin (or named sub basin) or is greater than 2,000km2.

4. If an area of significantly higher rainfall is identified (ie mean rainfall is 25% above the mean 50 isohyet) and the area represents more than 10% of the basin or sub-basin then include a site(s) (two if the area is not concentrated) to reflect the different catchment conditions.

5. If a major basin is made up of multiple smaller streams, the method will be: If any one stream contains >25% of the basin it should have a site. For the remaining area of the basin a site should be added for each 'aggregated' area that exceeds 25% of the total catchment/basin. Ie A site will be placed on a small stream that would be representative of the aggregated 25%.

6. If the process identifies the need for 3 sites and the flow data at any of these locations can be derived by either subtraction or addition, then only two sites are required.

7. At the conclusion of each basin appraisal the process should be reviewed in conjunction with the AWRC recommendations (Appendix1) that state the required minimum number of gauging stations based on catchment area (e.g. In the arid zone, flat, include a site at the end of all tributaries to the Basin or sub-Basin which exceeds 7000 km^2 up to 20000 km^2.

Inflow and outflow of all major storages?

Part 2 – Site Prioritisation

The assessment needs may be met in a number of ways, for example:

- A departmental gauging station designed to the highest standard
- A gauging station owned by another authority
- Other methods of flow estimation such as rainfall – runoff modelling.

The accuracy and importance of information from the sites identified in Part 1 will vary. In locations of low water demand and competition, we would generally accept a higher level of uncertainty than in those locations where demand and competition for water is high.
Align with other catchment risk prioritisation; e.g. thru EFAP

- Need to account for trends in water use – *align with WRP approach*
- Risk assessment 'tool' of SKM
- *Usgs uses >25% surface water diversions;*

Part 3 – Sites required to meet other information needs

Involve regional staff, define, management, water harvesting, flood warning requirements etc.

Appendix 1

Catchment areas based on AWRC recommendations[1]

Zone	Gauge Density (km2/Gauge)	
	Mountains & Ranges	Flat Terrain
Mediterranean Zone (Winter rain)	300-1,000	1,000-2,500
Temperate Zone (Uniform rain)	300-1,000	1,000-2,500
Tropical Zone (Summer Rain)	300-1,000	1,000-2,500
Transitional Zone	600-2,000	2,000-5,000
Arid Zone	3,000-7,000	7,000-20,000

Reference: AWRC, 1982. Surface water information network design. Report of the Working Group of the Surface Water Committee, Australian Water Resources Council, Canberra.

Note: the lower figure represents the minimum, the upper the mean.

Appendix 2

Supporting information required

- Catchment map with all major tributaries and their catchment areas
- Map of the basin divided into climatic zones
- 50 year isohyets for the catchment

[1] The zones and catchment areas may need refinement

Appendix 5.5 Surface water network review - gaps

Potential	Location	Sub-basin	Map Name	Longitude	Latitude
P0011001	Eyre Ck	0011 - Eyre	Eyre	138.89300000000	-25.98800000000
P0011002	Mulligan R	0011 - Eyre	Eyre	138.63000000000	-24.89500000000
P0011003	Hamilton R	0011 - Eyre	Eyre	140.05000000000	-23.29500000000
P0011004	Eyre Ck	0011 - Eyre	Eyre	139.52900000000	-24.79500000000
P0011005	Bulloo R			142.96030000000	-28.52790000000
P0011006	Bulloo R			144.60200000000	-25.91100000000
P0012001	Pituri Ck	0012 - Georgina	Georgina	138.73072807500	-22.83745096830
P0012002	Georgina R	0012 - Georgina	Georgina	138.27235845700	-21.58032899680
P0012003	Georgina R	0012 - Georgina	Georgina	138.10300000000	-19.91200000000
P0012004	Buckley R	0012 - Georgina	Georgina	138.17000000000	-20.33900000000
P0021001	Farrars Ck	0021 - Diamantina	Diamantina	141.08743154700	-25.39886372180
P0021002	Spring Ck	0021 - Diamantina	Diamantina	140.78409313100	-24.34392053130
P0021003	Mayne R	0021 - Diamantina	Diamantina	141.57196356600	-23.63365580500
P0021004	Diamantina R	0021 - Diamantina	Diamantina	142.34300000000	-22.52600000000
P0031001	Wilson R	0031 - Cooper	Cooper	142.59222200000	-27.82083330000
P0031003	Kyabra Ck	0031 - Cooper	Cooper	142.95400000000	-25.64100000000
P0031004	Cooper Ck	0031 - Cooper	Cooper	141.74200000000	-26.20800000000
P0031005	Thomson R	0031 - Cooper	Cooper	142.74700000000	-25.39400000000
P0031006	Barcoo R	0031 - Cooper	Cooper	142.79300000000	-25.44700000000
P0032001	Aramac Ck	0032 - Thomson	Barcoo	144.58400000000	-22.96900000000
P0033001	Barcoo R	0033 - Barcoo	Barcoo	144.75943067100	-24.07300000000
P1010001	Harmer Ck	1010 - Jacky Jacky	Jacky	142.85500000000	-11.98200000000
P1020001	Olive R	1020 - Olive	Olive	142.97119853300	-12.21115882640
P1021001	Hann Ck	1021 - Pascoe	Olive	143.07230173600	-12.56059768510
P1030001	Lockhart R	1030 - Lockhart	Olive	143.39344584900	-13.01412738540
P1030002	Nesbit R	1030 - Lockhart	Olive	143.50708066800	-13.53435465290
P1050001	Morehead R	1050 - Hann	Normanby	143.79600000000	-14.94900000000
P1051001	Laura R	1051 - Normanby	Normanby	144.44900000000	-15.26500000000
P1100001	Clohesy R	1100 - Barron	Daintree	145.55000000000	-16.88200000000
P1100002	Petersen Ck	1100 - Barron		145.57861000000	-17.16331200000
P1120001	North Beatrice R	1120 - North Johnstone	Herbert	145.67600000000	-17.56800000000
P1120002	Johnstone R	1120 - Upper Johnstone		145.58640000000	-17.35500000000
P1120003	Johnstone R	1120 - Upper Johnstone		145.64250000000	-17.36330000000
P1120004	Stewart Ck	1120 - Lower Johnstone		145.97749280000	-17.64123990000
P1120005	Rankine Ck	1120 - Lower Johnstone		145.86304920000	-17.54068530000
P1120006	Liverpool Ck	1120 - Lower Johnstone		145.00943750000	-17.72985060000
P1130001	Davidson Ck	1130 - Tully	Herbert	145.79027520000	-17.95901770000
P1130002	Jarra Ck	1130 - Tully	Herbert	145.86388500000	-17.92818410000
P1140001	Meunga Ck	1140 - Murray	Herbert	145.95027510000	-18.23457100000
P1150001	Herbert R	1150 - Herbert		145.25300000000	-17.72470000000
P1181001	Ross R	1181 - Ross	Upper Burdekin	146.78772684500	-19.30034861860
P1201001	Fletcher Ck	1201 - Upper Burdekin	Upper Burdekin	145.97700000000	-19.83200000000
P1201002	Burdekin R	1201 - Upper Burdekin	Upper Burdekin	144.97333333000	-18.87888889000
P1201003	Burdekin R	1201 - Upper Burdekin	Upper Burdekin	146.85666600000	-20.28964000000

Potential	Location	Sub-basin	Map_Name	Longitiude	Latitude
P1202001	Rosella Ck	1202 - Bowen	Lower Burdekin	147.82400000000	-20.78500000000
P1202002	Broken R	1202 - Bowen	Lower Burdekin	148.13695710300	-20.83283908510
P1203001	Belyando R	1203 - Suttor	Suttor	146.84400000000	-23.07300000000
P1203002	Campaspe R	1203 - Suttor	Suttor	146.36148244800	-20.90135085500
P1220001	Lethebrook	1220 -Proserpine		148.52472220000	-20.41333300000
P1270001	Tooloomba Ck	1270 - Styx	Styx	149.65200000000	-22.62300000000
P1304001	Rolf Ck	1304 - Isaac	Styx	149.17900000000	-22.71400000000
P1304002	Harrybrandt	1304 - Isaac	Styx	148.77900000000	-22.00600000000
P1304003	Isaac R	1304 - Isaac	Styx	148.69671360900	-22.42073425450
P1304004	Murray Ck	1304 - Isaac/Connors	Styx	149.19278300000	-21.85166600000
P1280001	Herbert Ck	1280 - Shoalwater	Styx	150.12012872900	-22.75425745840
P1300001	Alligator Ck	1300 - Fitzroy	Fitzroy	150.39610000000	-22.94391900000
P1300002	Marlborough Ck	1300 - Fitzroy	Fitzroy	149.86883279500	-22.96553538200
P1301001	Springton Ck	1301 - Mackenzie	Fitzroy	149.49200000000	-23.48800000000
P1301002	Roper Ck	1301 - Mackenzie	Fitzroy	148.87845609600	-23.03913365990
P1302001	Vandyke Ck	1302 - Nogoa	Nogoa	147.81200000000	-24.17400000000
P1302002	Claude R	1302 - Nogoa	Nogoa	147.26400000000	-24.41200000000
P1303001	Eurombah Ck	1303 - Dawson	Dawson	149.47400000000	-25.90600000000
P1303002	Hutton Ck	1303 - Dawson	Dawson	149.00786654600	-25.70403883920
P1305001	Planet Ck	1305 - Comet	Nogoa	148.70189616400	-24.38003461190
P1305002	Panorama Ck	1305 - Comet	Nogoa	148.54200000000	-24.55000000000
P1305003	Meteor Ck	1305 - Comet	Nogoa	148.49200000000	-24.41800000000
P1320001	Caliope R	1320 - Calliope	Fitzroy	150.82722122000	-24.07194378000
P1340001	Baffle Ck	1340 - Baffle	Burnett	151.63105090000	-24.36862595070
P1340002	Euleilah Ck	1340 - Baffle	Burnett	151.83400000000	-24.42100000000
P1363001	Auburn R	1363 - Boyne & Auburn	Burnett	150.58234286100	-25.72622857400
P1390001	Bogimibah Ck	1390 - Fraser Island	Mary	153.05765136300	-25.30292762640
P1390002	Eli Ck	1390 - Fraser Island	Mary	153.21200000000	-25.28400000000
P1400001	Kin Kin Ck	1400 - Noosa	Mary	152.94700000000	-26.24800000000
P1400002	Big Tuan Ck	1400 - Noosa	Mary	152.81500000000	-25.68800000000
P1431001	Western Ck	1431 - Bremer	Bremer	152.57353444100	-27.65265178270
P1451001	Albert R	1451 - Albert	Albert	153.17500000000	-27.83200000000
P4162001	Commoron Ck	4162 - MacIntyre-Weir	MacIntyre/Weir	150.18000000000	-28.37300000000
P4162002	Weir R	4162 - MacIntyre-Weir	MacIntyre/Weir	150.65100000000	-27.72600000000
P4162003	Yarrill Ck	4162 - MacIntyre-Weir	MacIntyre/Weir	150.16018083800	-28.30599948920
P4162004	Weir R	4162 - MacIntyre-Weir		150.04470000000	-28.40950000000
P4162005	Weir R	4162 - MacIntyre-Weir		149.26700000000	-28.68600000000
P4162006	Weir R	4162 - MacIntyre-Weir		150.11210000000	28.24600000000
P4162007	Weir R	4162 - MacIntyre-Weir		149.87350000000	-28.40010000000
P4162008	Weir R	4162 - MacIntyre-Weir		149.67650000000	-28.38190000000
P4162052	Yambacully			150.18300000000	28.43300000000
P4162053	Brigalow Ck	Gore Hwy?		150.295	28.466
P4164002	Dumaresq R	4164 - MacIntyre Brook	MacIntyre Brook	151.27408734400	-28.41135365340
P4164001	Canning Ck	4164 - MacIntyre Brook	Maranoa	151.14273648900	-28.36041722750
P4222001	Cogoon R	4222 - Balonne	Maranoa	148.61583300000	-27.10888800000
P4222002	Wallumbilla Ck	4222 - Balonne		149.22430000000	26.92080000000
P4222003	Mungallala Ck	4222 - Balonne		147.33490000000	28.00370000000
P4222004	Culgoa R	4222 - Balonne		148.00030000000	-28.61100000000
P4223001	Wilke Ck	4223 - Condamine	Condamine	151.00700000000	-27.13650314170
P4223002	Undulla Ck	4223 - Condamine	Condamine	149.83867423200	-27.16559546080
P4223003	Oakey Ck	4223 - Condamine		151.57350000000	-27.39480000000
P4223004	Cooraanga Ck	4223 - Condamine		150.92060000000	-26.92840000000
P4223005	Condamine R	4223 - Condamine		151.20320000000	-27.63950000000

Potential	Location	Sub-basin	Map_Name	Longitiude	Latitude
P4223006	Condamine R	4223 - Condamine		151.36280000000	-27.80860000000
P4223007	Condamine R	4223 - Condamine		151.24610000000	-27.44010000000
P4223008	Condamine R	4223 - Condamine		151.04670000000	-27.05760000000
P4223009	Condamine R	4223 - Condamine		149.56330000000	-27.05650000000
P4223010	Grasstree Ck	4223 - Condamine		151.35510000000	-27.82640000000
P4223011	Hogson Ck	4223 - Condamine		151.86260000000	-27.70480000000
P4223012	Jimbour Ck	4223 - Condamine		151.08600000000	-27.05080000000
P4223013	Wambo Ck	4223 - Condamine		150.48750000000	-26.86330000000
P4223014	Charley's Ck	4223 - Condamine		150.72270000000	-26.67440000000
P4223015	Glengallan Ck	4223 - Condamine		152.02120000000	-28.10430000000
P4223016	Myall Ck	4223 - Condamine		151.26520000000	-27.18570000000
P4223017	Rosenthall Ck	4223 - Condamine		152.02790000000	-28.23950000000
P4224001	Merivale R	4224 - Maranoa	Maranoa	147.95698000000	-25.79882000000
P4232001	Nive R	4232 - Warrego	South West	146.42700000000	-25.83800000000
P4232002	Langlo R	4232 - Warrego	South West	145.66888800000	-26.12777770000
P4232003	Angellala Ck	4232 - Warrego	South West	146.32100000000	-26.68200000000
P4232004	Warrego R	4232 - Warrego	South West	146.23810000000	-26.40060000000
P4232005	Warrego R	4232 - Warrego		146.08410000000	-26.70750000000
P4242001	Paroo R	4242 - Paroo	Paroo	145.30000000000	-26.66800000000
P4242002	Beechal Ck	4242 - Paroo	South West	145.21700000000	-27.47200000000
P4242003	Yowah Ck	4242 - Paroo	Paroo	144.86280000000	-28.13510000000
P9102001	Lagoon Ck	9102 - Lagoon	Settlement	138.22761424700	-17.35438279570
P9104001	Pandanus Ck	9104 - Cliffdale	Settlement	138.48000000000	-17.49500000000
P9121001	Nicholson R	9121 - Nicholson	Settlement	139.28166003200	-17.89257752780
P9121002	Nicholson R	9121 - Nicholson	Settlement	138.26606920700	-17.88368493310
P9121003	Lawn Hill Ck	9121 - Nicholson	Settlement	138.57092000000	-18.59297000000
P9121004	O'Shannassy R	9121 - Nicholson	Settlement	138.75569526300	-19.11121715170
P9121005	Seymour R	9121 - Nicholson	Settlement	138.76300000000	-19.08000000000
P9130001	Fiery Ck	9130 - Leichhardt	Leichhardt	139.72400000000	-18.50000000000
P9130002	Alexandra R	9130 - Leichhardt	Leichhardt	140.23100247600	-18.48857309860
P9150001	Flinders R	9150 - Flinders	Flinders	144.05418588100	-20.77278659260
P9150002	Stalwell Ck	9150 - Flinders	Flinders	142.91528499200	-20.57971115650
P9150003	Hamilton Ck	9150 - Flinders	Flinders	142.42400000000	-20.97800000000
P9150004	Alick Ck	9150 - Flinders	Flinders	142.17604438300	-20.64400000000
P9151001	Saxby R	9151 - Saxby	Flinders	141.51700000000	-19.85300000000
P9152001	Dugald R	9152 - Cloncurry	Flinders	140.82100000000	-19.54900000000
P9152002	Gilliat R	9152 - Cloncurry	Flinders	141.39500000000	-20.59600000000
P9152003	Julia Ck	9152 - Cloncurry	Flinders	141.32000000000	-20.10000000000
P9160001	Norman R	9160 - Norman	Norman	141.40300000000	-18.84600000000
P9160002	Swan Ck	9160 - Norman	Norman	141.25000000000	-17.72200000000
P9160003	Jumblehole Ck	9160 - Norman	Norman	141.28200000000	-18.29700000000
P9160004	Mundjuro Ck	9160 - Norman	Norman	141.21700000000	-18.94500000000
P9160005	Clara R	9160 - Norman	Norman	141.39900000000	-18.51100000000
P9170001	Venture Ck	9170 - Gilbert	Gilbert	142.72700000000	-18.11100000000
P9180001	Red R	9180 - Staaten	Staaten	142.84400000000	-17.14200000000
P9180002	Rainbow Ck	9180 - Staaten	Staaten	142.72057642200	-16.54515357230
P9180003	Little Wyaaba Ck	9180 - Staaten	Staaten	142.05161898700	-16.76911723480
P9180004	Cockburn Ck	9180 - Staaten	Staaten	141.94600000000	-16.68300000000
P9180005	Vanrook Ck	9180 - Staaten	Staaten	142.66900000000	-17.60400000000
P9190001	Tata R	9190 - Mitchell	Mitchell - Walsh	144.59747592900	-17.47355277090
P9190002	Lynd R	9190 - Mitchell	Mitchell - Walsh	143.82050000000	-17.43514000000
P9190003	Tata R	9190 - Mitchell	Mitchell - Walsh	143.85068448700	-17.32366178510
P9191001	Crosbie Ck	9191 - Alice	Mitchell-Alice	142.81300000000	-15.33600000000

Potential	Location	Sub-basin	Map_Name	Longitiude	Latitude
P9191002	Eight Mile Ck	9191 - Alice	Mitchell-Alice	142.82500000000	-15.44700000000
P9191003	Alice R	9191 - Alice	Mitchell-Alice	142.90100000000	-15.69600000000
P9191004	Maddigans Ck	9191 - Alice	Mitchell-Alice	142.91800000000	-15.81100000000
P9191005	Alice R	9191 - Alice	Mitchell-Alice	141.98727483700	-15.35892670940
P9192001	King R	9192 - Palmer	Mitchell - Walsh	143.49200000000	-15.86200000000
P9192002	Sandy Ck	9192 - Palmer	Mitchell - Walsh	144.20700000000	-16.05000000000
P9193001	Elizabeth Ck	9193 - Walsh	Mitchell - Walsh	144.10583000000	-16.65972000000
P9200001	Coleman R	9200 - Coleman	Stewart	142.60300000000	-14.85100000000
P9200002	Lukin R	9200 - Coleman	Stewart	143.09100000000	-14.61500000000
P9200003	King R	9200 - Coleman	Stewart	143.11700000000	-14.83800000000
P9200004	Coleman R	9200 - Coleman	Stewart	143.35100000000	-14.88900000000
P9210001	Holroyd R	9210 - Holroyd	Stewart	142.18886000000	-14.47986000000
P9210002	Holroyd R	9210 - Holroyd	Stewart	142.85000000000	-14.32500000000
P9211001	Kendall R	9211 - Kendall	Stewart	141.98400000000	-14.19200000000
P9211002	Sinclair Ck	9211 - Kendall	Stewart	141.97344331600	-14.08570414640
P9220001	Archer R	9220 - Archer	Stewart	142.16371534800	-13.54828928060
P9220002	Geikie R	9220 - Archer	Stewart	143.00774352600	-13.43921983460
P9221001	Coen R	9221 - Coen	Stewart	142.32398202200	-13.49033753080
P9230001	Merkunga Ck	9230 - Watson	Olive	141.98400000000	-13.20800000000
P9230002	Tompaten Ck	9230 - Watson	Olive	141.77500000000	-13.44900000000
P9240001	Spring Ck	9240 - Embly	Olive	142.09300000000	-12.72600000000
P9241001	Mission R	9241 - Mission	Olive	142.24817000000	-12.60908000000
P9250001	Wenlock R	9250 - Wenlock	Olive	142.30469000000	-12.40903000000
P9250002	Wenlock R	9250 - Wenlock	Olive	142.94208000000	-13.09656000000
P9260001	Ducie R	9260 - Ducie	Jacky	142.37544000000	-12.12706000000
P9262001	McDonnell Ck	9262 - McDonald	Jacky	142.24315656400	-11.71401834220
P9270001	Elliot Ck	9270 - Jardine	Jacky	142.42909126400	-11.18540156270
P9270002	Jardine R	9270 - Jardine	Jacky	142.57041611800	-11.27390752930
P9270003	Mchenry R	9270 - Jardine	Jacky	142.56400000000	-11.31400000000