Drinking Water Quality Management Plan

Lakes Wivenhoe and Somerset, Mid-Brisbane River and Catchments

April 2010

seqwater
WATER FOR LIFE

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Executive Summary

Obligations and Objectives

The *Wivenhoe Drinking Water Quality Management Plan* (WDWQMP) provides a framework to sustainably manage the water quality of Lakes Wivenhoe and Somerset, Mid-Brisbane River and catchments (the Wivenhoe system). Seqwater has an obligation to manage water quality under the Queensland *Water Supply (Safety and Reliability) Act 2008*. All bulk water supply and treatment services have been amalgamated under Seqwater as part of the recent institutional reforms for water supply infrastructure and management in South East Queensland (SEQ).

The plan is based on the priorities of the *Australian Drinking Water Guidelines 2004* (ADWG, 2004) including the risk-based *Framework for the Management of Drinking Water Quality* and associated guidelines. The WDWQMP emphasises Seqwater's corporate commitment to water quality and sustainability. It outlines the regulatory and formal requirements, and management plans and procedures that are required for managing the water quality of the Wivenhoe system. All supporting documentation is provided on the CD-ROM that accompanies this document.

The objectives of the WDWQMP are to:

1. Provide raw water to water treatment plants (WTPs) that supports delivery of ADWG (2004) standards or better;
2. Meet local Environmental Values and Water Quality Objectives;
3. Identify and manage risks to water quality in the catchments and storage including implementing effective preventive measures;
4. Implement effective monitoring programs, and operational and emergency response procedures;
5. Improve understanding (through research and development) and management of the relationships between catchment sustainability, water quality and public health;
6. Develop partnerships with key stakeholders and community representatives in the delivery of the WDWQMP;
7. Engage Seqwater employees including commitment, training and building awareness;
8. Contribute to safe recreational opportunities for SEQ communities;
9. Develop effective communication, documentation and reporting mechanisms; and
10. Remain abreast of relevant national and international trends in public health and water management policies, and be actively involved in their development.

To ensure continual improvement and compliance with the *Water Supply (Safety and Reliability) Reliability Act 2008*, a program for improvement including actions, accountabilities and dates for completion (or review) is provided in the *WDWQMP Improvement Plan* (Appendix H). The WDWQMP and improvement plan will be reviewed annually and resubmitted to the Office of the Water Supply Regulator at that time.

Key WDWQMP programs

→ Seqwater corporate strategies state the goals and priorities for water quality management, and set the framework for stakeholder engagement. **Seqwater's Stakeholder Support Initiative** seeks to:

- Understand the needs of our regulators.
- Work with our partner Water Grid entities and agencies.
- Clarify our customer and partner expectations.
- Establish appropriate financial and governance systems.

→ **Environmental Values and Water Quality Objectives (WQOs)** are being developed for Queensland waterways pursuant to the provisions of the *Environmental Protection (Water) Policy 1997*. Hence, Seqwater is currently reviewing its HACCP-based water quality monitoring program and aligning it with draft Water Quality Objectives (WQOs), as derived from the Environmental Values for Drinking Water Supply and Aquatic Ecosystem protection. Water quality reporting includes fortnightly reporting for review at the monthly Managers Meeting as well as six monthly and annual trending.

- The WDWQMP includes a series of recent **risk assessments** for the Wivenhoe system and options for managing those risks. There is a high risk of adverse impacts to water quality, particularly in the Upper Brisbane Catchment. Management options will be based on outputs from the new monitoring program as well as those from research and development.
- A **Report Card for Seqwater Catchments and Storages** has been developed to encourage stakeholder engagement and facilitate internal management needs; e.g. prioritisation of resources for catchment management.
- The Western Corridor Recycled Water Project (WCRWP) includes release of **purified recycled water** (PRW) into Lake Wivenhoe. The project has the capacity to supply up to 232 megalitres (ML) of PRW, however return volumes into the lake are likely to be ~40–100 ML/day in the first 12 months or more of operation. The Queensland Government's policy decision is that commissioning of PRW returns into Lake Wivenhoe will commence when the total volume of Lakes Wivenhoe, Somerset and Samsonvale fall below 40%, subject to regulatory approval. PRW returns will be a significant change to the sources of inflow to Lake Wivenhoe; a primary concern is elevated nutrient levels, which may cause changes to the ecological characteristics of the lake. Other potential contaminants include organochlorine compounds, industrial chemicals, pesticides, herbicides, PAHs, metals, pharmaceuticals, hormones, and selected bacteria and viruses. However, these may also be derived from existing inflow sources, and management will be set within the context of managing all sources of inflow and their interrelated impacts.
- **Preventive measures** use a **multiple barriers approach** to prevent contaminants entering the potable water supply. These include planning controls and catchment management plans through to dam offtake management and control of flow releases. Seqwater proactively reviews operational monitoring data to ensure the preventive measures are performing.
- When operational monitoring reveals an exceedance of a water quality trigger value, then various procedures enable **rapid reporting** to and **communication with customers and stakeholders**.
- **Research and development** provides new knowledge, innovative technologies and cost effective approaches to managing water quality in the lakes and surrounding catchments. A Research Plan provides direction for research in four main areas: Water Quality (Human Health), Sustainable Ecosystems, Business Efficiencies and Opportunities, and Synthesis and Knowledge Transfer.
- Management of the Wivenhoe system and operation of Wivenhoe Dam are given the upmost priority within Seqwater, and all **employees are appropriately trained** to fulfil their duties. **Operational controls** include a *Recreation Management Framework*, Emergency Action Plans and various Dam Operations and Maintenance Manuals and Procedures.

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1. Introduction

1.1 Purpose

The purpose of the *Wivenhoe Drinking Water Quality Management Plan* (WDWQMP) is to provide a framework to sustainably manage the water quality of Lakes Wivenhoe and Somerset, Mid-Brisbane River and catchments (hereafter referred to as the Wivenhoe system). The Wivenhoe system is a major source of raw water supply for South East Queensland (SEQ).

The WDWQMP has been prepared by the Queensland Bulk Water Supply Authority (QBWSA) (trading as Seqwater), drinking water service provider **SP507**. The development of this plan is an iterative process and it will be revised, as required, over time.

The management framework for the WDWQMP is shown in Figure 1; the plan is structured according to the elements of this framework and associated management plans, procedures and other supporting documents are provided on the CD-ROM that accompanies this document (see Appendix C: List of Supporting Documents).

The water quality outcomes in Figure 1 reflect Seqwater's corporate commitment to water quality management, as described in Section 2. They recognise that catchments in SEQ are vital regional resources, and that catchment sustainability is crucial for the storage and supply of water that meets the quality requirements of customers and other stakeholders.

The plan is based on the formal requirements promulgated by Queensland Government and Australian Government agencies, and it fulfils Seqwater's obligation to manage water quality under the Queensland *Water Supply (Safety and Reliability) Act 2008* (LEG-00074) (see Section 3.1).

There are a range of management plans in place that relate to land use, source protection, and other activities that affect the water quality of the Wivenhoe system. The WDWQMP also incorporates routine monitoring programs, operational controls and Emergency Action Plans for responding to hazardous water quality events. The plan recognises the importance of research and development for management of the catchments and the Wivenhoe/Somerset storage. Mechanisms must be in place to ensure effective stakeholder engagement (e.g. communication plans and reporting systems), and employees must be appropriately trained and aware of the requirements of the plan. A drinking water quality management framework also requires effective documentation and reporting, review, and a system for continual improvement.

The challenge is to coordinate these activities to allow an integrated approach to managing the water quality of the Wivenhoe system. This is achieved by applying Total Management Planning (TMP) (see *Total Management Planning Guidelines 2001*; LEG-00107), and using the *National Water Quality Management Strategy* (NWQMS) (LEG-00082) as the overarching framework for managing raw water quality (see Section 3.2).

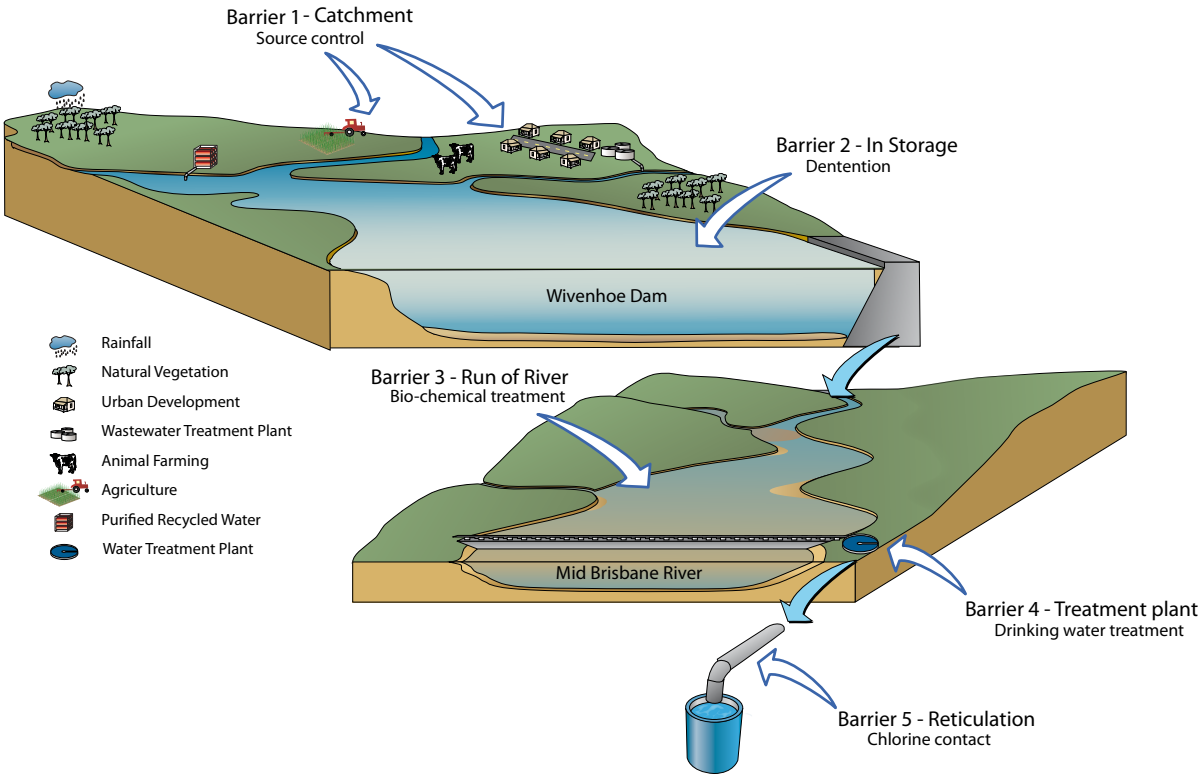
Seqwater's TMP approach is demonstrated by its corporate Integrated Management System (IMS) (see *Integrated Management System-Corporate Manual*; MAN-00005). As part of this process, Seqwater coordinates its risk management activities based on the priorities of the *Australian Drinking Water Guidelines 2004* (LEG-00004) (ADWG, 2004) including the twelve elements of the risk-based *Framework for the Management of Drinking Water Quality* and associated guidelines; e.g. water recycling guidelines (see Section 3.2).

The objectives of the WDWQMP are to:

1. Provide raw water to water treatment plants (WTPs) that supports delivery of ADWG (2004) standards or better (Section 3.2);
2. Meet local Environmental Values (EVs) and Water Quality Objectives (WQOs) (Section 3.4);
3. Identify and manage risks to water quality in the catchments and storage, and implement effective preventive measures (see Sections 5 and 6);
4. Implement effective monitoring programs and operational and emergency response procedures (see Sections 7 and 13);
5. Improve understanding (through research and development) and management of the relationships between catchment sustainability, water quality and public health (see Section 12);
6. Develop partnerships with key stakeholders and community representatives in the delivery of the WDWQMP (see Sections 3.6, 11 and 12.3);

Figure 1 Management framework for the *Wivenhoe Drinking Water Quality Management Plan.*

Figure 2 Multiple barriers for the Wivenhoe system. Barrier 1: all inflow streams and catchment lands. Barrier 2: waters within the impounded lake upstream of the Wivenhoe Dam. Barrier 3: the operations of the dam, and waters released downstream of the dam.



7. Engage Seqwater employees including commitment, training and building awareness (see Section 10);
8. Contribute to safe recreational opportunities for SEQ communities (see Section 11);
9. Develop effective communication, documentation and reporting mechanisms (see Section 13); and
10. Remain abreast of relevant national and international trends in public health and water management policies, and be actively involved in their development.

The WDWQMP is the first in a series of Drinking Water Management Plans (DWQMPs) for Seqwater's catchments and water storages. A table detailing the elements of the ADWG (2004) framework and where these are met throughout the WDWQMP (or *WDWQMP Improvement Plan*; Appendix H), and the key supporting documents are provided on the CD-ROM (see WDWQMP and ADWG Nov 09.xls).

A DWQMP has also been prepared for all of Seqwater's water treatment services (see *Draft WTP Drinking Water Quality Management Plan*; PLN-00004).

1.2 Multiple Barriers

Application of the ADWG (2004) framework requires a multiple barriers approach to water quality management; i.e. catchments, storages and dams, water treatment and disinfection. The Wivenhoe system includes all inflow streams and catchment lands, waters within the impounded lake upstream of the Wivenhoe Dam, the operations of the dam, and waters released downstream of the dam (i.e. barriers 1–3, Figure 2). Management of water quality in the Wivenhoe system must consider a complex relationship of inflows, an understanding of the catchment and its relationship to the treatment train, and the complexities of protecting environmental values

in an 'open' system[1]. Water quality management should, wherever possible, address prevention at the source rather than relying on downstream control (ADWG, 2004). Therefore, catchment management and supply impoundment (storage) are critical in terms of risk mitigation.

Figure 3 illustrates the key processes within the WDWQMP for responding to short and long term risks to drinking water quality, as well as for achieving an overall reduction in risk by applying the multiple barriers approach to management of the Wivenhoe system. The details of these processes are described in the subsequent sections of this plan.

1.3 Institutional Reforms for Water Supply in South East Queensland

The Queensland Government has initiated institutional reforms for water supply infrastructure and management in SEQ. The details of all institutional arrangements and infrastructure have not been finalised; however, the Queensland Water Commission (QWC) is a key agency in the delivery of the reform policies. The QWC's website (www.qwc.qld.gov.au; LEG-00087) has information on the institutional reforms. A simple starting point is *Fact Sheet 2: Urban Water Supply Arrangements in SEQ: An Overview*. This document provides an overview of the QWC's final report to the Queensland Government: *Urban Water Supply Arrangements in South East Queensland (SEQ)–May 2007* (LEG-00095). Further information is also available in the *South East Queensland Water Strategy 2009* (LEG-00094).

Water service providers across the region have been amalgamated in order to rationalise and provide a consistent approach to the provision of water supply services. On 1 July 2008, the *South East Queensland Water (Restructuring) Act 2007* (LEG-00103) established various new water entities, which participate in the SEQ Water Market. Four Queensland Government-owned statutory authorities were established as well as a number of distribution and retail businesses.

The SEQ Water Grid Manager (WGM) (see www.seqwgm.qld.gov.au; LEG-00099, and *SEQ Water Grid Manager–Corporate Profile*; LEG-00098) overseas operation of Grid functions, and the flow of water around the Grid. The WGM purchases bulk water and transport services, and sells water to retail businesses. The WGM specifies how services are to be delivered, and coordinates the major SEQ water supply sources including the following:

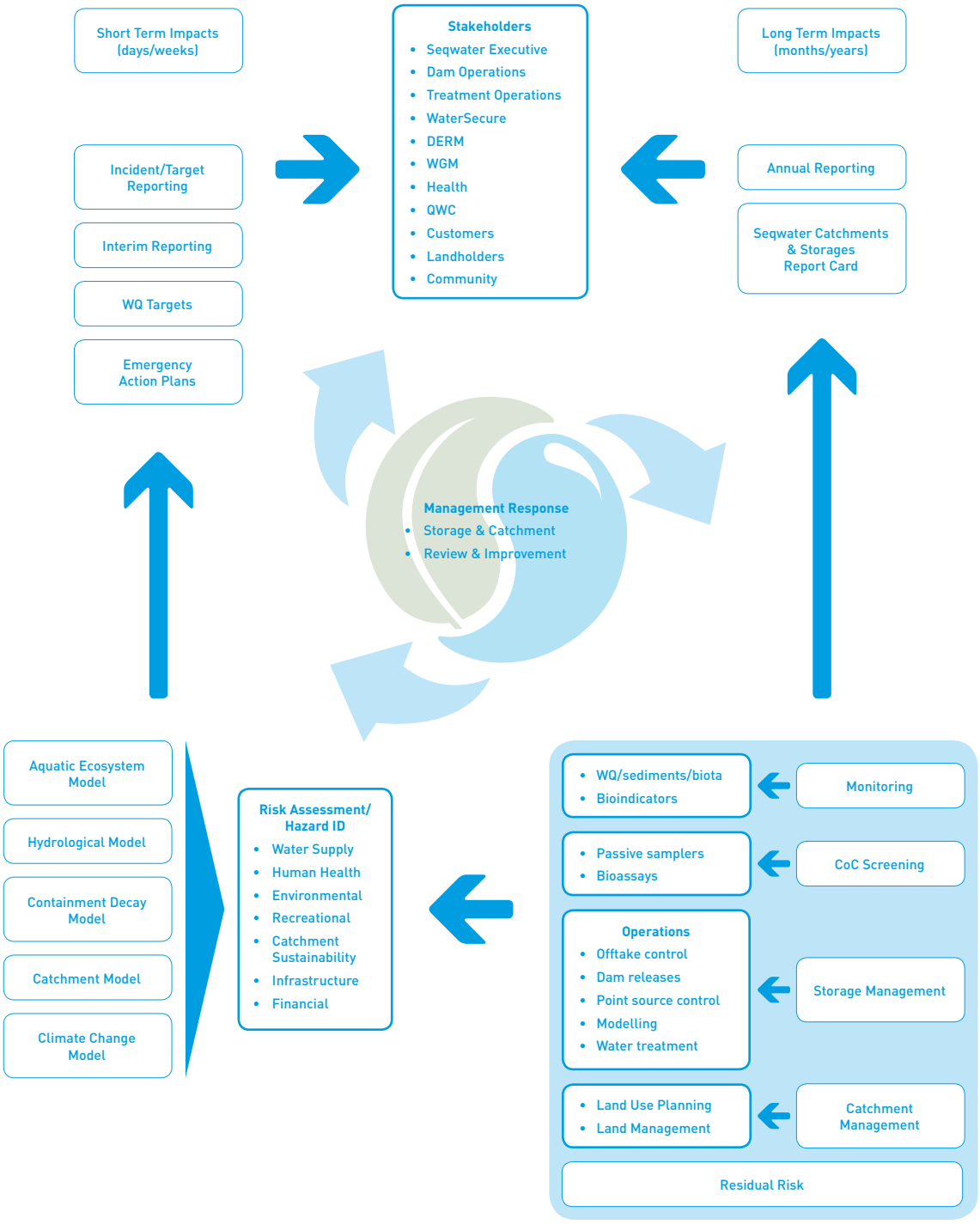
- The Wivenhoe system;
- North Pine Dam and northern pipeline;
- Hinze Dam;
- The future Wyaralong Dam;
- The Western Corridor Recycled Water Project (WCRWP) Scheme; and
- The Gold Coast Desalination Plant at Tugun on the Gold Coast.

All bulk water supply and treatment services have been amalgamated under Seqwater. In the context of the WDWQMP, Seqwater provides water collection and storage services. Under the new institutional arrangements, Lakes Wivenhoe, Somerset and Manchester, and all associated buffer (riparian) lands and some catchment land will be maintained as Seqwater assets.

Manufactured water services including the WCRWP Scheme and the Gold Coast Desalination Plant are operated by the Queensland Manufactured Water Authority (WaterSecure), and the Queensland Bulk Water Transport Authority (LinkWater) manages all bulk water transfer systems. Local government-owned businesses deliver water to customers and collect, transport and treat sewage. Three water retailers operating throughout SEQ have also been identified.

[1] In this instance, 'open' refers to the difference between the lakes and catchments in the Wivenhoe system, and the other elements of the treatment train that are 'closed' systems, typically with controlled engineered points of inflow and release. Physically enclosed systems are not subject to direct environmental impacts and other uses (such as recreational users and surrounding landholders).

Figure 3 Key processes within the *Wivenhoe Drinking Water Quality Management Plan* for responding to risks to drinking water quality. The shaded area represents risk reduction from applying the multiple barriers approach to management of the Wivenhoe system.



The Water Grid is managed through *The Market Rules–SEQ Water Market* (LEG-00076). The *Market Rules* is a regulatory tool designed to regulate aspects of the SEQ Water Market as they apply to the Grid entities (see Section 3). The *SEQ Water Grid–Water Quality Management Plan* (REF-00011) facilitates the mitigation of water quality risks at the Grid level and should be referred to for information on the overall management of the regional water supply system.

1.3.1 Council Amalgamations

On 15 March 2008, local governments in Queensland were subject to amalgamations and boundary alterations. Lake Wivenhoe and its physical catchment (excluding the area upstream from the dam wall at Lake Somerset) were previously included within five local government areas: Esk, Kilcoy, Crows Nest, Rosalie and Nanango Shires. With the addition of the Somerset and Mid-Brisbane catchments, the other relevant areas are Caboolture, Caloundra, Gatton, Laidley, Ipswich and Brisbane. The local government changes resulted in the Lake Wivenhoe, Lake Somerset and Mid-Brisbane catchments being included within the following councils:

- → Somerset Regional Council;
- → Moreton Bay Regional Council;
- → Toowoomba Regional Council (TRC);
- → South Burnett Regional Council;
- → Ipswich City Council;
- → Lockyer Valley Regional Council; and
- → Brisbane City Council.

1.3.2 Water Supply Infrastructure and Planning

Important change is underway as a result of the institutional reforms, including the building of major new water assets by the Queensland Government. These assets, which form part of the Water Grid, include new dams, extra groundwater sources, the WCRWP Scheme and the Gold Coast Desalination Plant.

Regional inter-connector pipelines are being built to allow water from new and existing sources to be moved around the Grid. By connecting the region's major water sources, WTPs and bulk water transport networks, the Water Grid will enable coordination of delivery of urban and industrial water supplies across the SEQ region.

The SEQ urban water supply comes from a variety of sources, but in the main it is derived from the storages of Lakes Wivenhoe and Somerset, Lake Samsonvale (North Pine Dam), Lake Kurwongbah, Lake Baroon (Baroon Pocket Dam), Lake Advancetown (Hinze Dam), Leslie Harrison Dam (Tingalpa Reservoir) and the Stradbroke Island aquifers. Water for irrigation is also supplied from some of these storages and from other regional storages, river systems and groundwater sources.

Total urban and industrial water consumption in SEQ is estimated at 460,000 ML/year and domestic consumption accounts for about two-thirds of this. Rural water use amounts to 150,000 ML/year while another 40,000 ML/year is consumed by power stations. Approximately one-tenth of the total use is unaccounted for; this is attributed mostly to water losses during distribution and unmetered use. The storages listed above deliver a combined annual total of about 500,000 ML and the Wivenhoe system provides over 60% of this (see *Drought Water Quality Risk Assessment (2008)*; RSK-00015).

Within the context of an overall management plan for the Western Corridor, the Lake Wivenhoe scheme provider plan will link to the scheme provider plans for the Bundamba AWTP and the Mount Crosby, Esk and Lowood WTPs. These are the elements of the water treatment train before and after Lake Wivenhoe. Furthermore, links will eventually be required with regional water management plans (e.g. DWQMPs, System Operating Plans and Regional Planning Schemes) and with national management priorities under the National Water Initiative, the *Australian Guidelines for Water Recycling 2008* (LEG-00091), the ADWG (2004) and the National Greenhouse Gas Abatement Scheme (when developed).

These initiatives will have differing priorities; however, they are expected to be consistent in achieving an overall vision that secures water supply to SEQ. They must maintain environmental support systems for water supply and for mitigating risks to human health. Consequently, it is expected that the WDWQMP will be reviewed each year.

A range of additional water infrastructure projects are being considered. The QWC has released the *South East Queensland Water Strategy 2009* (LEG-00094) for consultation and comment. The strategy identifies a range of key infrastructure requirements and the timing for their implementation. Measures identified under the strategy include the development of aquifer sources, regional pipelines, dam upgrades, and further desalination and recycling projects. The strategy also identifies operational objectives and requirements, including water delivery targets and system reliability needs.

The key project affecting the Wivenhoe system is the WCRWP. A key outcome of this project is the release of purified recycled water (PRW) into Lake Wivenhoe, as announced by the Queensland Government in early 2007[2].

The project has the capacity to supply up to 232 megalitres (ML) of PRW a day via 200 kilometres of pipelines. The first of three stages was delivered on 27 August 2007. PRW is now being piped to the Swanbank power station via a 7.3 kilometre, 800 millimetre diameter pipeline that links with the Bundamba AWTP. The second stage was completed in October 2008. It will increase the capacity of the treatment plant to a total of 66 ML per day, and has a connection to Tarong power station (via Lake Wivenhoe). This pipeline links directly to Tarong via the Wivenhoe pipeline, but has no contact with the Wivenhoe system. The final stage was completed at the end of 2008. It connects the Luggage Point and Gibson Island upgraded AWTPs to Bundamba, increasing the capacity of the system to 232 ML per day[3].

The Queensland Government's policy decision is that commissioning of PRW returns into Lake Wivenhoe will commence when the total volume of Lakes Wivenhoe, Somerset and Samsonvale fall below 40%, subject to regulatory approval. Management of PRW and risks from PRW returns are discussed in Sections 4.1.4 and 5.2.1, respectively.

1.4 Organisational Responsibilities

As a result of the institutional reforms, Seqwater's scope of operations was extended to include raw water storage, which is the subject of this plan, and raw water treatment. Previously, water storage and treatment were operated by separate organisations. The main remaining external customers of raw water from the Wivenhoe system are Tarong Energy, TRC[4], as well as a number of irrigators. Details of contact with customers and agreed outcomes are documented in the *Draft HACCP Customer Liaison Register* (HACCP General Folder). To inform the use of this register, Seqwater's organisational structure (to Level 3 Managers), including employees who are responsible for implementation of the WDWQMP, is provided in the Seqwater Organisational Structure Folder. The chart is reviewed and updated on a regular basis. Stakeholder responsibilities for the WDWQMP are identified in the *Draft Land and Water Quality Stakeholder Register* (REG-00003) (see Section 3.6).

[2] Announced through the media by the then Premier Peter Beattie.

[3] Reference from Queensland Water Commission Fact Sheet 10 SEQ Water Supply Projects (03 September 2007).

[4] The 38km Toowoomba Pipeline from Lake Wivenhoe to Cressbrook Dam, with an initial capacity to deliver water at a rate of 14,200 ML per year, was commissioned in January 2010; the intake is near the water tower at Esk.

2. Commitment to Water Quality Management

2.1 Corporate Strategy

The *Corporate Strategic Plan (2009-10 to 2013-14)* (PLN-00019) and *Draft Land and Water Quality Strategy* (POL-00024) are Seqwater's overarching strategies for the WDWQMP. Both of these strategies support the ADWG (2004) framework. The strategic plan has the following vision:

"Water for life – vibrant, sustainable and optimistic urban and rural communities and businesses"

The strategic plan recognises that catchments are vital regional resources. It defines catchments as the combined natural and built infrastructure needed to source, store and supply water to meet the quality and reliability needs of Seqwater customers. The goals of the strategic plan are outlined below:

Goal 1: Water supply security

Description: *In partnership with other grid entities, Seqwater will provide urban consumers with reliable water of a quality that meets or exceeds the ADWG (2004) as required by regulation, contract and best practice. Seqwater provides efficient support and water services to rural consumers to help support sustainable practices, viable enterprises and vibrant rural communities.*

Outcome: *Regulators, communities and business have confidence and trust in the safety, security and reliability of their water supply.*

Goal 1: Catchment sustainability

Description: *In order to ensure the current and future viability of the primary drinking water sources of South East Queensland, Seqwater will effectively research and manage the water catchments to maximise water quality while creating maximum value, including:*

- *Flood mitigation*
- *Rural productivity*
- *Places of recreation*
- *Biodiversity*
- *Green energy*
- *Amenity for the people of Queensland.*

Outcome: *Communities in our region gain the maximum value from their catchments*

Furthermore, Seqwater's *Sustainability Charter* (POL-00028) recognises that catchment quality, community confidence and economic health are essential to Seqwater's business performance.

The *Draft Land and Water Quality Strategy* (POL-00024) provides for stakeholder needs and aims to ensure that the Strategic Objectives for water quality management are maintained (see Table 1). The aims of the strategy, as they apply to the Wivenhoe system, are as follows:

- Use values, objectives and targets are agreed for the water quality of the storage and delivery channels;
- Future investment in water quality management uses evaluations of natural and built infrastructure options, to ensure cost-effectiveness for regional stakeholders;
- Catchment land uses are managed by Seqwater and others to ensure long term compatibility with storage and delivery channel water quality objectives and use requirements;
- The quality of runoff entering the storage and delivery channels is of a standard that at least achieves, and preferably exceeds, the objectives required for water quality; and
- Water quality in the storages and delivery channels achieves the objectives required to protect the uses (values) defined by customers and stakeholders.

Table 1 Land and Water Quality Strategy: 2009-10 Strategic Objectives.

Service Unit	Strategic Objective
Risk Management / Hazard Identification	→ Develop DWQMP framework for Seqwater's catchments and storages → Develop and implement program for managing point source risks (see Research Solutions) → Develop partnerships to support risk management of point source discharges
Monitoring and Reporting	→ Maintain data collection and quality systems → Manage systems reporting and incident reporting → Develop and implement the new *Catchment Water Quality Monitoring Program*
Policy and Planning	→ Develop appropriate water quality policies → Define natural asset benefits to water quality → Develop an economic model to support natural asset maintenance → Implement the *Land and Water Quality Strategy* in line with the *Corporate Strategic Plan* → Develop and implement planning guidelines for water supply catchments → Review high risk developments within water supply catchments → Participate in regional land use planning forums
Catchment Management	→ Finalise the *Draft Water Source Protection Plan* → Implement and monitor Action Plans for Wivenhoe (see *Draft Action Plan for the Water Source Protection Plan*; PLN-00057), Somerset and Mid-Brisbane catchments: → Collaborative catchment management campaign → Enhanced management of storages, offtakes and catchment areas → Threat and emergency response → Polluting activities → Planning and development assessment (see Policy and Planning Service Unit)
Research Solutions	→ Establish research partnerships → Develop and implement research programs in Water Quality (Human Health), Sustainable Ecosystems, Business Efficiencies and Opportunities, and Synthesis and Knowledge Transfer (see Section 12) → Design of the new *Catchment Water Quality Monitoring Program* • Program design: data requirements, database, collection and quality systems • Develop revised *Catchment Water Quality Monitoring Program* system performance indicators • Identify and implement emerging technologies

In addition, the *Draft Water Source Protection Plan (2008)* (PLN-00018) aims to ensure that the core business outcomes associated with the continuity of suitable water supply are achieved. Central to this plan, is the further development and implementation of sustainable land management practices, including land leased for long term grazing. Land management outcomes have been developed that recognise the value of the land and its relationship with the Wivenhoe/ Somerset storage. These land management outcomes focus on protection of the following core values:

- Water quality;
- Sustainable land;
- Biodiversity;
- Landscape (recreation access); and
- Cultural and historic assets.

2.2 Drinking Water Quality Policy

A drinking water quality policy is essential for definition of the levels of service to be provided by a drinking water supply provider and is an integral component of the requirements of the ADWG (2004). Seqwater's *Water Quality Policy* (POL-00012) has been endorsed by the Seqwater Executive as an overarching commitment to water quality. The policy emphasises stakeholder partnerships and embraces the risk-based ADWG (2004) framework and management objectives that will help to achieve an effective multiple barrier system.

Seqwater staff are informed of the *Water Quality Policy* at Business Review Management meetings and as part of the HACCP induction process (see *Water Quality and HACCP Staff Induction*; TRA-00009). The policy is available to all employees on the *Q-Pulse Database* (see *Users Guide to Q-Pulse*; PRO-00031), and will also be available on Seqwater's new intranet (by 2011) (see *WDWQMP Improvement Plan*; Appendix H).

3. Regulatory and Formal Requirements

3.1 Legislative and policy framework

The *Water Supply (Safety and Reliability) Act 2008* (QLD) (LEG-00074) and regulatory guidelines that are being developed under the Act (e.g. *Draft Water Quality and Reporting Guidelines for a Drinking Water Service*; LEG-00141), place specific obligations on drinking water service providers (as defined in the Act) throughout SEQ. These include a requirement to develop DWQMPs for storages and WTPs. The DWQMPs are to be approved by the Office of the Water Supply Regulator (OWSR) within the Queensland Department of Environment and Resource Management (DERM, formerly the Department of Natural Resources and Water). The plans must be structured, as directed by this Office, to meet the requirements of the ADWG (2004) and other standards as defined by the Department of Health through the *Public Health Act 2005* (QLD) (LEG-00075) and *Public Health Regulation 2005* (QLD) (LEG-00068) (specifically Section 18AD(d)).

Management of raw water quality is also obliged under the following Queensland Government and Australian Government legislative requirements:

- *Water Act 2000* (QLD) (LEG-00025), and QWC (Rules Administrator for *The Market Rules–SEQ Water Market*; LEG-00076) obligations, and DERM policies and guidelines;
- *Environmental Protection Act 1994* (QLD) (LEG-00001) and *Environmental Protection (Water) Policy 1997* (QLD) (LEG-00024);
- *Environment Protection and Biodiversity Conservation Act 1999* (Australian Government) (LEG-00119) (EPBC Act) ;and
- *Sustainable Planning Act (2009)* (LEG-00127) and *Sustainable Planning Regulation (2009)* (QLD) (LEG-00155).

The *Market Rules* is a regulatory framework for governing the operational and commercial requirements for entry and participation in the SEQ Water Market. The *Market Rules* operate within the hierarchy of the following statutory instruments:

- Interim Resource Operations Licences;
- Regional Water Security Program;
- System Operating Plan;
- the *Market Rules* including any Water Grid Instructions issued pursuant to the *Market Rules*;
- Water Grid Contract Documents; and
- Operating Protocols made under the *Market Rules* including any Operating Instructions issued pursuant to the *Market Rules*.

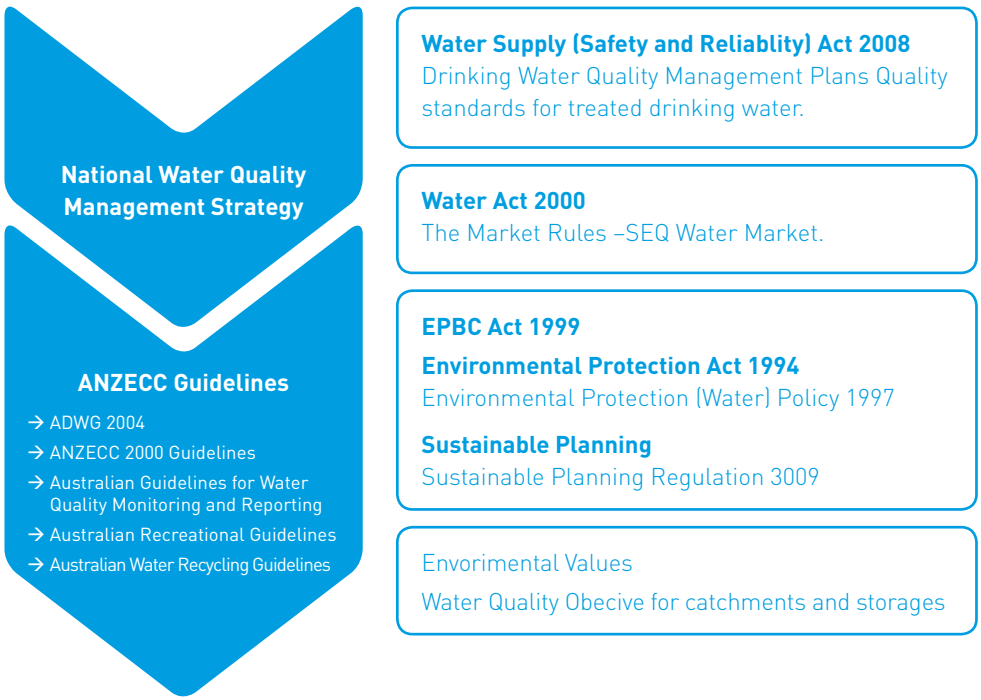
Seqwater is required to agree on Operating Protocols with each other Grid Participant with which its operations interact, and review the Operating Protocols as prescribed by the *Market Rules*. Seqwater must ensure compliance with the Grid Instructions (as issued by the WGM), Operating Instructions (e.g. as issued by other Grid Participants) and Grid Service Provider Performance Standards. Seqwater must also supply water that meets the water quality requirements set out in the WDWQMP, and to issue Operating Instructions (e.g. to other Grid Participants) as prescribed by the *Market Rules* (see Section 13 for information on reporting requirements).

In addition to the regulatory requirements described above, there is a series of other requirements that the WDWQMP addresses as part of the policy framework:

- *National Water Quality Management Strategy* (NWQMS) (LEG-00082), and related and subordinate guidelines, including:
- ANZECC Guidelines;
    - ADWG (2004) (LEG-00004);
    - *Australian and New Zealand Environment and Conservation Council Guidelines for Marine and Fresh Water Quality 2000* (ANZECC 2000 Guidelines) (LEG-00090);
    - *Australian Guidelines for Water Quality Monitoring and Reporting 2000* (LEG-00104);
    - National *Guidelines for Managing Risks in Recreational Water 2008* (LEG-00089);
    - *Australian Guidelines for Water Recycling 2008* (LEG-00091);

3. Regulatory and Formal Requirements (continued)

Figure 4 Key legislative and other formal requirements used to ensure compliance, address the relevant standards for raw water quality and encourage actions for catchment protection.



- → *Queensland Water Quality Guidelines 2006* (QWQG, 2006) (LEG-00085);
- → Draft and Scheduled Environmental Values and Water Quality Objectives;
- → *Queensland Water Recycling Strategy 2001* (LEG-00093); and
- → *Queensland Water Recycling Guidelines 2005* (QWRG, 2005) (LEG-00092).

Interrelationships among the key legislative and other formal requirements are shown in Figure 4. These mechanisms enable Seqwater to not only ensure compliance and address the relevant standards for raw water quality, but are also used to encourage actions for catchment protection by councils and other stakeholders (see Section 6.2.3).

All of Seqwater's operational procedures for water quality management are prepared in accordance with the regulatory and other formal requirements, and compliance is audited as part of the internal audit program (see Section 14). To ensure compliance, Seqwater has developed a detailed *Compliance Obligations Register* (REG-00181). The register has been prepared in accordance with Seqwater's *Integrated Management System-Operational Manual* (MAN-00004). The register is available to all employees on the *Q-Pulse Database* (*Users Guide to Q-Pulse*; PRO-00031) and will also be available on Seqwater's new intranet (by 2011).

3.2 National Water Quality Management Strategy

The NWQMS provides a framework for managing the water quality of aquatic ecosystems to achieve a desired set of EVs; i.e. human uses and selected attributes. It is the primary mechanism for managing Seqwater's water quality operations, and for developing and implementing improvements. The framework integrates the various water quality management guidelines for the EVs that have been identified for the system. The following EVs and their associated guidelines are applicable to the Wivenhoe system:

- Drinking Water Supply EV (ADWG, 2004);
- Aquatic Ecosystem EV and various agricultural and industrial use EVs (ANZECC 2000 Guidelines, and the *Australian Guidelines for Water Quality Monitoring and Reporting 2000*, LEG-00104); and
- Recreational EVs, which include both primary and secondary contact recreation (*Guidelines for Managing Risks in Recreational Water 2008*; LEG-00089).

The following sub-sections summarise the relevant ANZECC 2000 Guidelines under the NWQMS framework, and outline Seqwater's approach to implementing them.

3.2.1 Australian Drinking Water Guidelines

The majority of Queensland's drinking water supplies are provided by local governments, and are managed in accordance with the principles and recommendations of the ADWG (2004). The guidelines provide the water supply industry, regulators and the community with guidance on what constitutes good quality water. As part of the guidelines, the risk-based *Framework for the Management of Drinking Water Quality* for supply management ensures the safety of drinking water at the point of use. The framework comprises twelve elements that are considered good practice for management of drinking water supplies. It is a quality management system that has been specifically designed for the water industry, incorporating a preventive risk management approach from the catchment to the consumer; i.e. catchment to tap.

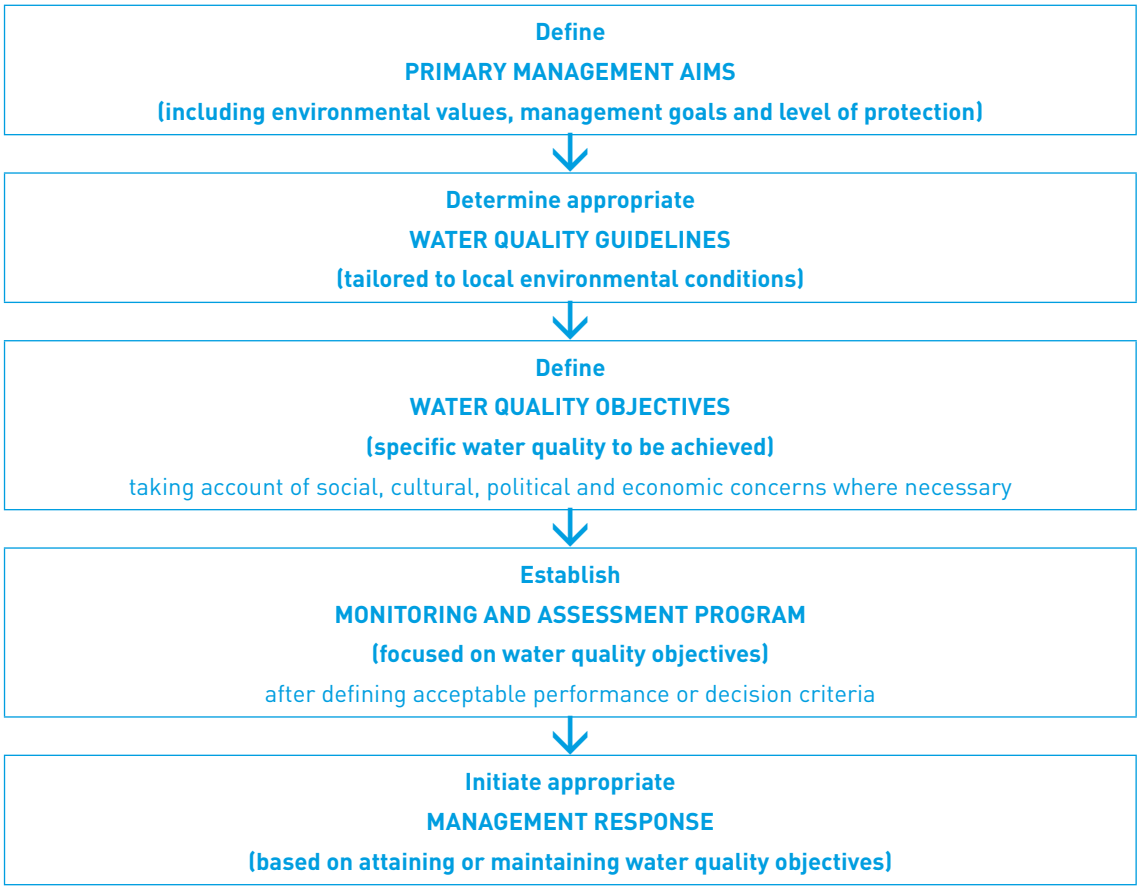
The ADWG (2004) are the authoritative Australian reference for use within Australia's administrative and legislative framework to ensure the accountability of drinking water suppliers (as managers), and that of state and territory health authorities (as auditors of the safety of water supplies). The guidelines are not, as yet, mandatory, legally enforceable standards. The guiding principles of the ADWG (2004) are as follows:

- *The greatest risk to consumers of drinking water is pathogenic microorganisms. Protection of water sources and treatment are of paramount importance and must never be compromised.*
- *The drinking water system must have, and continuously maintain, robust multiple barriers appropriate to the level of potential contamination facing the raw water supply.*
- *Any sudden or extreme change in water quality, flow or environmental conditions (e.g. extreme rainfall or flooding) should arouse suspicion that drinking water might become contaminated.*
- *System operators must be able to respond quickly and effectively to adverse monitoring signals.*
- *System operators must maintain a personal sense of responsibility and dedication to providing consumers with safe water, and should never ignore a customer complaint about water quality.*
- *Ensuring drinking water safety and quality requires the application of a considered risk management approach.*

In terms of treated water supplied from WTPs that are operated by Seqwater, there are two different types of guideline values:

- A **health-related guideline value**, which is the concentration or measure of a water quality characteristic that on the basis of present knowledge does not result in any significant risk to the health of the consumer over a lifetime of consumption.

Figure 5 ANZECC 2000 Guidelines framework for managing raw water quality. Seqwater is implementing this framework to initiate improvements to raw water quality at the catchment scale.



→ An **aesthetic guideline value**, which is the concentration or measure of a water quality characteristic associated with the acceptability of water to the consumer; e.g. appearance, taste and odour.

Although the guidelines are not intended to be applied as standards, some jurisdictions may choose to regulate the guidelines through legislation or operating licences. Application of the ADWG (2004) risk-based framework will vary depending on the arrangements for water supply within each jurisdiction. For example, in some states water supply is managed by one agency, whereas in others it is managed locally by numerous water suppliers. This is likely to affect the manner in and degree to which the framework is implemented. However, all water suppliers and relevant state government agencies are encouraged to use the framework as a model for best practice.

The OWSR has confirmed that all DWQMPs will be regulated against the requirements of the ADWG (2004); the plans must demonstrate achievement of the twelve elements of the ADWG (2004) framework. Where those elements are not demonstrated, the regulator requires that progress on and timing for completion of those elements is identified as part of an improvement plan.

3.2.2 ANZECC 2000 Guidelines

The values in the ADWG (2004) generally relate to product (treated) water quality; hence, their application to defining objectives for storages and delivery channels (raw water quality) requires careful consideration. The ANZECC 2000 Guidelines provide a framework for managing raw water quality (Figure 5). Seqwater is implementing this framework to initiate improvements to raw water quality at the catchment scale.

3.2.3 Australian Guidelines for Water Quality Monitoring and Reporting

The *Australian Guidelines for Water Quality Monitoring and Reporting 2000* (LEG-00104) are used as the basis for designing the new *Catchment Water Quality Monitoring Program*. These guidelines meet the operational monitoring requirements of the ADWG (2004), as well as those of the EVs and WQOs.

3.2.4 National Recreational Guidelines

Water quality risks to recreational use on Lake Wivenhoe will be managed through the national *Guidelines for Managing Risks in Recreational Water 2008* (LEG-00089). Lake Wivenhoe has a history of recreational use that is comprised of a range of primary and secondary contact activities including swimming, fishing, sailing, electric powerboats, canoeing and camping. There are a number of public and leased recreational sites surrounding the lake including Captain Logan Camp, Cormorant Cove, Somerset Park and Billies Bay. In non-drought years, visits to these sites exceed 30,000 people annually, with this number expected to grow as the population of SEQ continues to increase.

To support the requirements of the national *Guidelines for Managing Risks in Recreational Water 2008* (LEG-00089), Seqwater has developed the *Recreation Management Framework* (PLN-00113) (and supporting documents; Community Involvement Folder) for its public recreational areas.

3.2.5 Australian Guidelines for Water Recycling

The Australian Government is implementing a range of measures to secure our future water. This includes water recycling for a range of uses. Hence, to supplement the ADWG (2004), the *Australian Guidelines for Water Recycling 2008* (LEG-00091) (AGWR, 2008) are supported through the *Water Supply (Safety and Reliability) Act 2007* (LEG-00074) and the *Public Health Regulation 2005* (LEG-00068). The need for such a supplement is driven through the growing significance and potential for recycled water returns to drinking water supply sources throughout Australia, as well as the role of recycled water management in the overall management of the water cycle.

Management of Lake Wivenhoe is in transition between the AGWR (2008) and ADWG (2004). PRW returned to the lake will be managed through the AGWR (2008); however, because Lake Wivenhoe is the source of water released to the Mount Crosby, Lowood and Esk WTPs, management of the lake also falls within the framework of the ADWG (2004). To overcome this area of crossover between the AGWR (2008) and the ADWG (2004), DERM have defined the operational boundaries of each guideline. DERM have established that the AGWR (2008) will apply to barriers 1–5 inclusive, as defined in Section 4.2.4; barriers 6 and 7, inclusive of Lake Wivenhoe, Mid-Brisbane River and the Mt Crosby Esk and Lowood WTPs, fall entirely under the jurisdiction of the ADWG (2004). Each of the components of barriers 6 and 7 will need to explicitly address the twelve elements of the ADWG (2004) framework.

3.3 Queensland Water Quality Guidelines

The QWQG (2006) are intended to address the activities identified in the ANZECC 2000 Guidelines by:

- → Providing guideline values (numbers) that are tailored to Queensland regions and water types; and
- → Providing a process for deriving and applying local guidelines for water quality management in Queensland (i.e. more specific guidelines than those in the QWQG, 2006).

The *Environmental Protection (Water) Policy 1997* (LEG-00024) is subordinate legislation under the *Environmental Protection Act 1994* (LEG-00001), which outlines the process for determining the water quality guidelines (e.g. national, state, local) to use for water quality planning and decision making. Thus, in cases where the QWQG (2006) provide water quality guideline values for Queensland waters that are more localised than the ANZECC 2000 Guidelines, they will take precedence over the (broader) ANZECC 2000 Guidelines. For a number of indicators, however, particularly toxicants, there is little or no local information. For these indicators, the ANZECC 2000 Guidelines will remain the principal source of information.

The QWQG (2006) were used as a starting point for developing local EVs and draft WQOs. The following sub-section describes the rationale and process for developing these.

3.4 Local Environmental Values and Water Quality Objectives

Seqwater's current HACCP (Hazard Analysis and Critical Control Points) system for monitoring raw water quality is based entirely on the ability of treatment plants to remove individual contaminants; i.e. indicators (see Section 7.1). HACCP monitoring provides alerts to treatment plant operators for necessary process, storage and distributional changes, or flags events for which increased product sampling may be required (e.g. when treatment plants are under stress). However, because the ongoing supply of raw water quality heavily influences downstream product water quality, Seqwater recognizes that objectives are required for raw water quality based not only on the contaminant removal performance of relevant water treatment processes, but also on the sustainability requirements of the catchments and the long term supply of raw water for drinking and other needs; i.e. a healthy aquatic ecosystem is a prerequisite to maintaining suitable conditions for drinking water supply (see Section 4.3).

EVs and WQOs are being developed for Queensland waterways pursuant to the provisions of the *Environmental Protection (Water) Policy 1997* (LEG-00024). Useful definitions of EVs and WQOs are provided on the Department of the Environment, Water, Heritage and the Arts (DEWHA) website www.environment.gov.au (LEG-00121).

Environmental Values (EVs) are the qualities of waterways that need to be protected to ensure healthy aquatic ecosystems and waterways that are safe and suitable for community use. An EV is a quality, characteristic or attribute that is conducive to ecological health or any benefit to the community which requires protection from the effects of pollution, waste discharges and deposits. EVs are used to assist in the assessment of the current condition of catchments, identified risks and threats.

Water Quality Objectives (WQOs) are the levels of measurable outcomes that should ensure protection/maintenance of the EVs. WQOs may be defined for a range of physical parameters (e.g. turbidity, suspended solids and temperature), chemical parameters (e.g. phosphorus, nitrogen, biochemical oxygen demand and toxicants), and biological parameters (e.g. algae, diatoms, macro-invertebrates and fish), as well as other measures of catchment condition (e.g. erosion levels, riparian vegetation and channel morphology).

Seqwater has developed draft WQOs, derived from the EVs for Drinking Water Supply and Aquatic Ecosystem protection (see *Draft Environmental Values and Water Quality Objectives for Lakes Wivenhoe and Somerset, and the Mid-Brisbane River*; GDE-00011; and *Draft Proposed EV-WQO Framework (2008)*; GDE-00012). The draft WQOs were developed according to the DERM (formerly the Queensland Environmental Protection Authority) guideline *Establishing*

Draft Environmental Values and Water Quality Objectives (LEG-00143) and have been informed through existing guideline requirements including the ADWG (2004) and QWQG (2006). The draft WQOs are the most refined set of water quality guidelines to date; therefore, they are used increasingly by Seqwater for monitoring, risk assessment and management purposes. The WQOs are closely aligned with the targets and requirements of the WDWQMP and its associated management plans and procedures. They will also be incorporated into planning codes for Seqwater's water supply catchments to provide guidance in the development review and approvals processes for these catchments.

The proposed WQOs reflect the following considerations:

- → Relevant EVs and local catchment issues and contaminant sources;
- → Potential use of reference sites for the relevant water types;
- → Analysis of local data relating to water quality and flow regimes;
- → Comparison of observed data with the relevant guidelines for the Aquatic Ecosystem and Drinking Water Supply EVs;
- → Consideration of the likely loading from PRW;
- → Catchment and in-storage risk assessments for drinking water supply;
- → Required risk-based improvements to the catchments and waterways;
- → Assessments and EVs identified through stakeholder documents; and
- → Social and economic implications of proposed improvements to water quality.

Seqwater is currently reviewing the HACCP monitoring program (see Section 7.1.3) to align with the draft WQOs and thereby increase its utility (see *Draft Catchment Water Quality Monitoring Program*; PLN-00035). The new monitoring program and associated WQOs are scheduled for implementation by March 2011 (see Section 7.1.3 and *WDWQMP Improvement Plan*; Appendix H). As the new program is introduced, we will compare the monitoring data with the WQO indicators for the Drinking Water Supply and Aquatic Ecosystem EVs.

3.5 Queensland Water Recycling Guidelines

The *Queensland Water Recycling Strategy 2001* (LEG-00093) provides a framework to guide and support the implementation of water recycling programs that are efficient and without adverse health impacts, and are economically and environmentally sustainable. Similarly, the QWRG (2005) aim to encourage and support water recycling that is safe, environmentally sustainable and cost-effective. This will reduce pressure on existing potable water sources. The guidelines provide advice on recycling water **for non-potable reuse** that has been sourced from sewage treatment plant (STP) effluent, but not from other sources.

The QWRG (2005) are not intended to function as a manual, nor do they prescribe water quality standards or treatment requirements for every possible final use. Instead, they provide a risk management framework, combined with guidance on best practice to ensure that water recycling project planners and operators can match water quality to intended uses in the safest and most cost-effective manner.

The guidelines cover water recycling that uses effluent from wastewater treatment plants (WWTPs) that have the capacity to treat sewage from 21 or more equivalent persons, or approximately 5,250 L/day. This includes water mining from sewers. The guidelines also discuss use of effluent from on-site wastewater treatment systems, treated and untreated greywater, and other forms of wastewater.

The QWRG (2005) are not mandatory, though consideration is currently being given to the development of a state-based regulatory framework for the operation and management of recycled water infrastructure. This regulation will provide for the sustainable use of recycled water through the preservation of public health and environmental values.

3.6 Engaging Stakeholders

Seqwater recognises the importance of engaging stakeholders to successfully manage water quality; the key is to develop strong, supportive partnerships. The *Corporate Strategic Plan (2009-10 to 2013-14)* (PLN-00019) and *Draft Land and Water Quality Strategy* (POL-00024) set the framework for stakeholder engagement, the details of which are developed under Seqwater's annual operational plans. Seqwater's Stakeholder Support Initiative seeks to:

- Understand the needs of our regulators.
- Work with our partner Water Grid entities and agencies;
- Clarify our customer and partner expectations; and
- Establish appropriate financial and governance systems.

Several aspects of drinking water quality management require involvement between Seqwater and other agencies. Similarly, consultation with relevant health and other regulatory authorities is necessary for establishing many elements of drinking water quality management, such as monitoring and reporting requirements, and emergency response and communication plans. This is achieved using the following documents and actions:

- The *Compliance Obligations Register* (REG-00181) provides access (via *Q-Pulse Database*) to mandatory requirements and contractual agreements (e.g. water supply agreements). It also identifies the Queensland Government and Australian Government agencies that have jurisdiction over elements of Lake Wivenhoe. The register is kept up to date in accordance with the *Integrated Management System-Operational Manual* (MAN-00004. Formal research partnerships that Seqwater has developed are detailed in Section 12.3;
- The *Draft HACCP Customer Liaison Register* (HACCP General Folder) is a record of negotiations with raw water customers. The register includes a contact list of raw water customers, internal and external;
- The *Draft Wivenhoe System Communications Procedure* (PRO-00708) defines how and when upstream and downstream stakeholders (customers and water service providers) are to be contacted, and it defines the documentation requirements for stakeholder communications;
- The *Review, Distribution and Reporting of Water Quality Test Results Procedure* (PRO-00290) details the responsibilities for liaison with customers and agencies, and lists their contact details;
- Section 1.3.1 of the WDWQMP identifies the local governments that administer areas of the catchments;
- The *Draft Land and Water Quality Stakeholder Register* (REG-00003) outlines the roles and responsibilities of stakeholders including Seqwater staff, lists their contact details and provides a procedure for reviewing the register;
- Seqwater owns a fringe of land around Lake Wivenhoe, which is leased to third parties for agricultural purposes. The lessees of Seqwater land are an important stakeholder group, and a contact list is regularly updated by the Land Management Advisor; and
- The *Draft Water Source Protection Plan (2008)* (PLN-00018) puts in place a framework for the management of Seqwater land and for stakeholder engagement to achieve water quality management objectives. It also details priorities for raw water quality associated with farming and other land management activities in the catchments (see *Draft Action Plan for the Water Source Protection Plan*; PLN-00057).

3.6.1 Seqwater Catchments and Storages Report Card

As part of their partnership arrangement (see Section 12.3), Seqwater and CSIRO have recently developed the *Draft Seqwater Catchments and Storages Report Card* (BRO-00003), primarily as a public stakeholder engagement and reporting tool. The approach for developing the report card

and the methods for analysing the associated data are described in the *Draft Seqwater Report Card Manual* (PRO-00794).

The report card will provide a basis for keeping stakeholders and the public informed about whether the appropriate EVs are being maintained and, when necessary, alerting stakeholders to issues where action (e.g. land management) is required.

The *Draft Seqwater Report Card* shares many similarities with the *EHMP Report Card* (see Section 4.3.1); they both provide an easy-to-understand snapshot of the health of the water storages based on an 'A' to 'F' rating. However, the indicators and data analysis methods in the new report card have been tailored to large, lotic water bodies and are targeted towards assessment of the Drinking Water Supply and Aquatic Ecosystem EVs and their management. Data relating to catchment condition (e.g. riparian health, land use suitability) and resultant water quality is analysed to assess the risk of pollutant mobilisation, as well as whether the EVs were maintained during the reporting period. Scores are determined based on the state of the following attributes that reflect a 'healthy' storage:

- Good catchment condition with any land use appropriately managed;
- Minimal cyanobacteria algae blooms;
- Minimal incidence of bacteria and pathogens;
- Low suspended sediment and nutrient levels;
- Suitability for primary contact; and
- Healthy ecological condition.

The *Draft Seqwater Report Card* may incorporate local WQOs to enable site specific assessment of water quality risks in the storages and waterways, including maintenance of the EVs (see *WDWQMP Improvement Plan*; Appendix H).

4. Assessment of the Water Supply System

4.1 Context

A detailed analysis of the Wivenhoe system has recently been undertaken as part of the *Catchment and In-Storage Water Quality Risk Assessment (2007)* (RSK-00018), and the *Catchment and Water Quality Risk Assessment for Mid-Brisbane River (2008)* (RSK-00017). Detailed information within these documents includes:

- A description of the system including catchments, water sources, storages and processes;
- Water quality characteristics – chemical, microbiological and physical;
- Events that may impact upon water quality (see Sections 5 and 6);
- Operational challenges and threats (see Section 7); and
- Details of critical upstream and downstream processes that are relied upon to ensure the continuity and quality of water supply.

Further information on the catchments and processes that present a risk to water quality within the Wivenhoe system is provided in the *Draft Water Source Protection Plan (2008)* (PLN-00018). The flow chart in Figure 6 illustrates the key processes within the system including the monitoring points, barriers, transport systems and storages. The following sections describe these processes in detail.

4.2 Catchment Extent

In the context of catchment management for drinking water supply, the Wivenhoe catchment is the primary focus of the WDWQMP. Nevertheless, the Somerset catchment and Mid-Brisbane River catchment are included in the plan on the basis that releases from Lake Somerset are a significant inflow to Lake Wivenhoe, while Mid-Brisbane catchment inflows impact on water quality of Wivenhoe releases to the Mt Crosby Weir. Prioritisation of actions under the plan will consequently vary subject to the relative circumstances of these elements at any one time.

The physical extent of the Wivenhoe catchment is the land, watercourses and water bodies upstream of the dam wall for as far as natural inflows enter the lake, with the exception of the Stanley River catchment and other inflows upstream of the dam wall for Lake Somerset. The catchment drains a 5,554 km^2 area predominantly to the northwest of the reservoir. Although the extent of the catchment is within the scope of this plan, it is not under the direct control of Seqwater. Wivenhoe catchment is defined as an 'open' system (see Section 1.2) and, as such, it is not managed solely for drinking water supply. Seqwater owns land around the fringe of the lake, and manages activities within the lake itself. The areas under the direct control of Seqwater are identified on Seqwater's GIS database (GBM Software). Lake Wivenhoe is a natural system and although every effort is made to maintain and enhance water quality, the in-lake water is untreated and is therefore 'raw'.

The Somerset catchment drains a 1,503 km^2 (of the Wivenhoe system) area to the north and northeast of the reservoir. The catchment drains the catchments of the Stanley River to the northeast, the Sheep Station Creek to the northwest, and the Kilcoy and Sandy Creeks to the north. There are minor inflows from the sub-catchments to the east and west of the reservoir.

The Mid-Brisbane River catchment is approximately 563 km^2 and includes the sub-catchments of Spring Creek, Black Snake Creek, Branch Creek, Lake Manchester, Mt Crosby/Borallon and Mid-Brisbane River. Black Snake Creek and Spring Creek have been identified as having an impact on the water quality of the Mid-Brisbane River catchment. Black Snake Creek has elevated salinity levels and Spring Creek has been reported to have high turbidity. Lake Manchester sub-catchment is a largely forested catchment with an area of 74 km^2. Recreational use of this water storage is prohibited; however, the catchment is used by hikers (permitted only) and forestry operations. Downstream of Lake Manchester is the Mt Crosby/Borallon catchment.

Figure 6 Flow chart showing key processes within the Wivenhoe system including monitoring points, barriers, transport systems and storages.

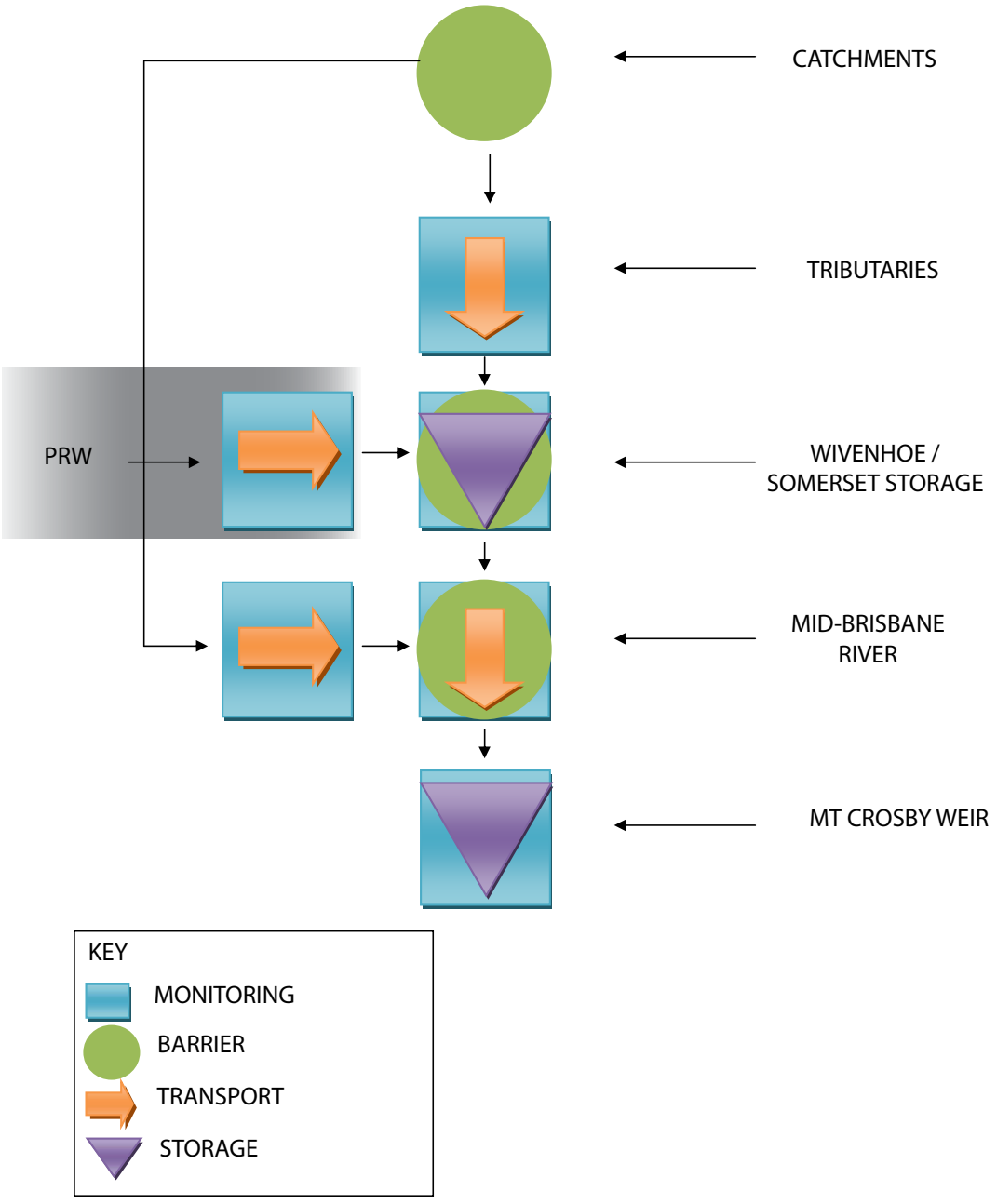
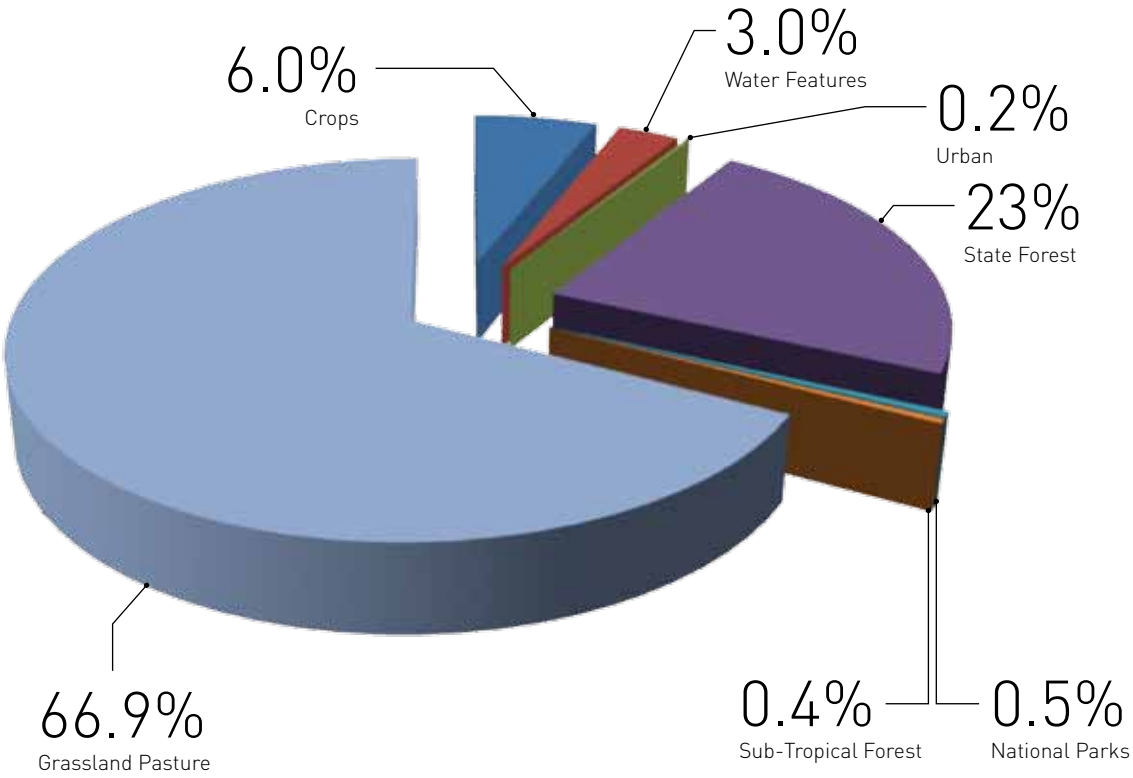


Figure 7 Land uses within the Wivenhoe catchment. The catchment has extensive rural-type land uses as well as a number of other uses and activities.



4.2.1 Catchment Land Use

Land uses and activities within the Wivenhoe catchment are varied. In addition to land-based uses and activities, the lake is used for water-based recreational activities including fishing, sailing and canoeing. The catchment has extensive rural-type land uses including:

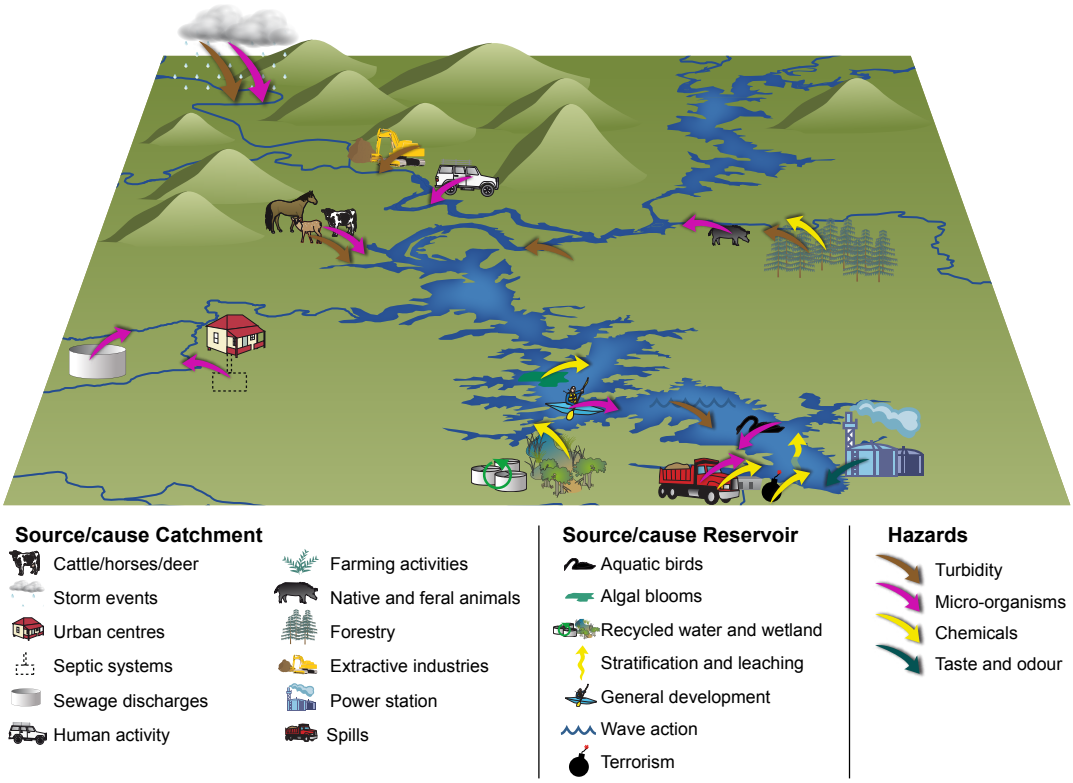
- Grazing (predominantly cattle);
- Agriculture;
- Animal husbandry (including intensive animal husbandry such as cattle feedlots); and
- Forestry.

Grazing of cattle and some horses on leasehold land occurs around the foreshores of Lake Wivenhoe. Grazing on cleared and semi-cleared land is the predominant land use in the catchment. Dairying is no longer carried out within the Wivenhoe catchment (see Figure 7).

While not having a significant physical footprint in terms of land area, a number of other uses and activities are undertaken in the Wivenhoe catchment that can affect water quality. These uses and activities include:

- Urban settlements;
- Rural residential development;
- Extractive industries (typically sand and gravel);
- Major utilities (such as power station and wastewater treatment plants);
- Commercial and industrial uses (usually with urban settlements);
- Rural industries (such as soil improvement);
- Tourism and recreation; and
- State Forest, Reserves and National Parks.

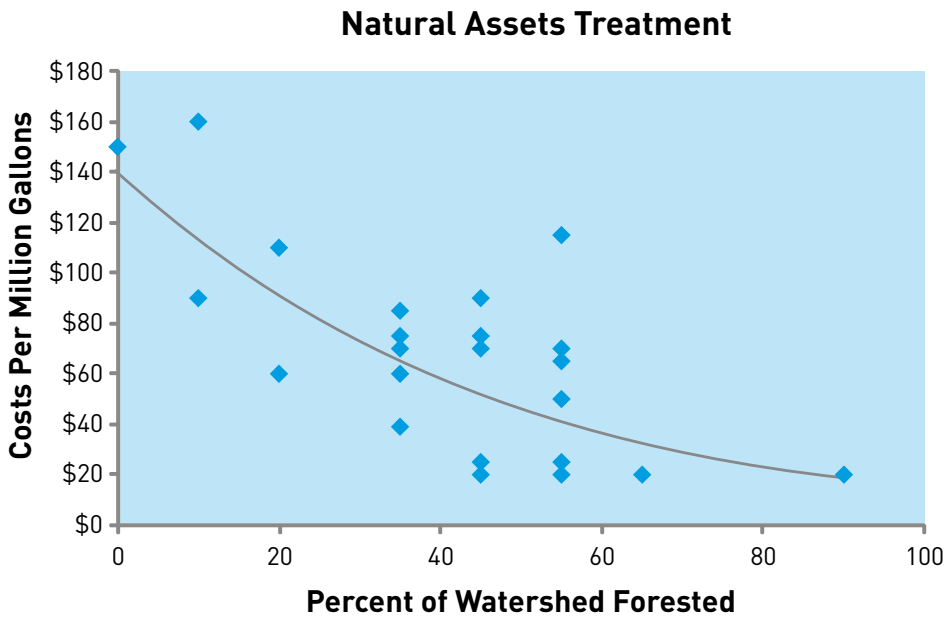
Figure 8 Potential hazards within the Wivenhoe catchment.



Land uses in the Wivenhoe catchment are changing, with significant landholder pressure to reduce rural lot sizes and increase resource access as in the case of water extractions, and sand and gravel extraction (including in-stream). Other rural industries in the catchment such as poultry farms and animal husbandry are likely to increase in intensity. There is also increasing urbanisation and housing development, particularly within the upstream Somerset catchment. It is possible that long term regional land use planning could identify areas around locations such as Esk as development areas for urban uses, particularly residential. Likewise, as the population in the region grows, there will be increasing demand for recreational activities offered by the lake and the surrounding landscape.

The relevance of land uses and activities to the WDWQMP is that they all have a potential impact on water quality and have varying levels of risk associated with them. These uses and activities are largely undertaken on land that is not directly controlled by Seqwater, and they are subject to varying degrees of management and monitoring. Likewise, certain uses and activities (particularly water orientated recreation uses) will be directly impacted by adverse water quality in Lake Wivenhoe. The land uses and other processes within the lake are part of the barriers treatment train. This highlights the intrinsic difference between the 'open' barriers and the other 'closed' (i.e. engineered) barriers in this multiple barriers water supply system (see Section 1.2). There are also other users of the lake who rely on good quality water (i.e. the wider community as recreational and tourist users of the lake), in addition to the downstream treatment plants (i.e. Mount Crosby WTP). Figure 8 illustrates some of the potential hazards in the Wivenhoe catchment.

Figure 9 An example of benefits to water quality from ecosystem services (American Water Works Association, 2005).



4.2.2 Ecosystem Services

A holistic approach to water resource management involves adopting preventive measures for water supply protection (see Section 6); these include the provision of ecosystem services that protect water quality and enhance catchment health. Ecosystem services are defined as the goods and services provided by ecosystems that benefit, sustain and support the wellbeing of people; e.g. filtering of runoff to supply high quality water for human consumption. (Note: EVs include the major types of ecosystem services and, as defined in Section 3.4, are used to assist in the assessment of the current condition of the catchments and storages). *The South East Queensland Ecosystem Services Framework* lists 28 ecosystem services, which include the production of food, provision of productive soils, recreational opportunities, and clean water and air. Sustainable management of water resources requires protection of the health of aquatic ecosystems so that these services can continue to meet human needs (*SEQ Regional Plan 2009-2031*; LEG-00120).

Maintaining healthy aquatic ecosystems and clean water in catchment waterways and dams ensures that a water supply is not only safer, but is also more economical to treat downstream. For example, the benefits of ecosystem services to water quality have been estimated for a number of US bulk water supply utilities (American Water Works Association, 2005; www.awwa.org/; REF-00013). The benefits of water quality enhancement are significant as a result of avoided costs, as well as cost reductions in water treatment processes (see Figure 9). Furthermore, ecosystem services such as forestation provide additional benefits such as carbon sequestration and habitat protection. A holistic approach requires an understanding of ecological processes as well as social and economic factors. It recognizes that natural ecosystems are interconnected systems, and that cooperation between landowners, government agencies and the community is essential for effective management of land and water resources.

The water quality of Lake Wivenhoe is reliant on the functioning of a large, productive catchment, and numerous ecosystem processes provide treatment services to inflows to the lake. The benefits of existing ecosystem services to catchment inflows in SEQ are summarised below:

- 1–3 log reductions of soluble nutrients and metals;
- 1–3 log reductions in turbidity; and
- 3–5 log reductions of the pathogens, *Escherichia coli and Crypotsporidium*.

The above log reductions were derived by comparisons of long term lake monitoring data from the offtake zones at Wivenhoe, North Pine and Hinze Dams with long term inflow data from the catchment inflow streams and rivers. Vegetative buffers substantially reduce suspended sediments loads in overland flows. Using soils from Wivenhoe catchment, flume experiments that simulated overland flows demonstrated a >99% (i.e. 2–4 log) reduction in *Crypotosporidium* oocytes when flows encountered a vegetated buffer (Hussein, J. et al. 2008). Additional log reductions waters are achieved in the storages through dilution, detention, partitioning and a range of other biological, physical and chemical processes.

4.2.3 Storage Characteristics and Waterways

This section provides details on the main waterways, dams and storage characteristics of the Wivenhoe system (see Figure 10). Wivenhoe Dam is built across the Brisbane River and forms Lake Wivenhoe, a 1,200 GL (full supply) plus 1,400 GL (flood storage) reservoir. The dam is located about 150 kilometres upstream from the mouth of the Brisbane River, and about 60 km upstream from Mt Crosby Weir. Lake Wivenhoe is the largest water storage in SEQ.

Somerset Dam is built on the Stanley River above the confluence of the Brisbane and Stanley Rivers. Lake Somerset has a 340 GL (full supply) plus 534 GL (flood storage) capacity. Lake Somerset is used primarily as an on-river storage for releasing water directly into Lake Wivenhoe via the Stanley River. Water is abstracted from Lake Somerset for both potable and agricultural supply, and the water in the reservoir is used directly for both agricultural and recreational use.

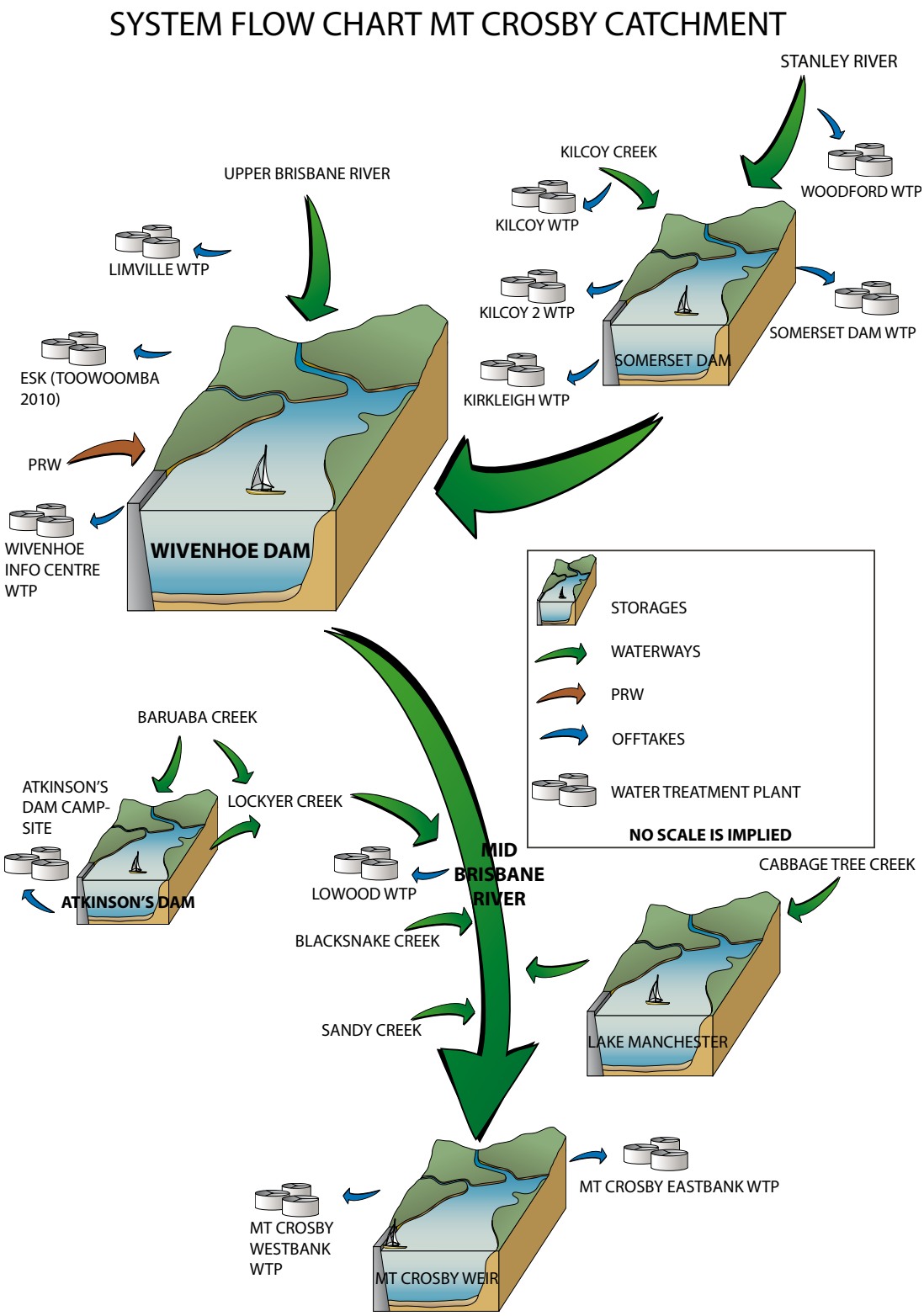
Seqwater's storages have all been built as water supply reservoirs. However, both Wivenhoe and Somerset Dams have headspace allocated to flood mitigation; for both dams, allocation for flood storage exceeds 50% of the total storage volumes. When flood waters are stored in Lakes Wivenhoe and Somerset, their management takes precedence over supply releases. The flood waters are managed using detailed flood management procedures (see Section 7.3), which are implemented and updated by Seqwater. These plans identify trigger values (i.e. concentrations that if exceeded, indicate a potential environmental problem and so 'trigger' a management response to water quality events; this ensures that associated preventive measures are performing and are adequate (see Section 6 and the *Australian Guidelines for Water Quality Monitoring and Reporting 2000*; LEG-00104) and the storage level requirements needed to achieve dam safety and flood mitigation targets.

A detailed analysis of inflows in the Wivenhoe system is provided in the *Draft Water Source Protection Plan (2008)* (PLN-00018). Inflows include wastewaters and recycled waters, and a range of contaminants can enter the system either directly, via tributaries, or throughout various stages in the water cycle. The major existing inflows that present a risk to water quality are summarised below:

- Rainfall in the catchments (i.e. direct rainfall, run-off and urban stormwater);
- Major inflows from the Brisbane River;
- Releases from Lake Somerset;
- Releases from Lake Manchester; and
- Recycled water (treated water from WWTPs upstream of Lake Wivenhoe).

Historically, average annual rainfall is approximately 940 mm for the Wivenhoe catchment and 1,230 mm for the Somerset catchment. Conversely, annual evaporation is 1,872 mm for the Wivenhoe catchment and 1,775 mm for the Somerset catchment. During the seven year 'millennium' drought, annual rainfall was about half the historic average; in 2005-06,

Figure 10 Schematic diagram of the Wivenhoe system showing the main waterways, storages and offtakes, and the water treatment plants.



Lake Wivenhoe recorded only 459 mm of rainfall and Lake Somerset recorded only 513 mm. The rainfall figures for 2004-05 were similar to those for 2005-06[5].

Reservoir refill is dependent not only on the amount of rain that falls, but also on the duration and the intensity of storm and rain events. Small storms producing up to 50 mm of rain result in minimal or no runoff from the catchment.

Rainfall events in 2009 and 2010 have resulted in replenishment of SEQ's water storages; i.e. in mid-March 2010, Lakes Wivenhoe and Somerset were approximately 95% and 100% full, respectively. Prior to this, the last significant rainfall occurred in 1999, when the storages filled and water was released into the river. The storages filled again in 2001; however, this event occurred from a base of 90% capacity in the storages. Hence, the ongoing lack of large rainfall events resulted in the drought conditions. This information highlights the vulnerability of Lake Wivenhoe to variability in seasonal and annual inflows. It highlights the intrinsic difference between the natural system elements in the water treatment train compared with other controlled elements; e.g. PRW (see Section 4.1.4).

The main inflows to Lake Wivenhoe are from the Brisbane River to the northwest, and the Stanley River and Somerset catchment to the northeast; there are also minor inflows from Byron, Reedy and Northbrook Creeks that drain the sub-catchments to the east. Water from Lake Wivenhoe discharges into a 60 km reach of the Mid-Brisbane River, which ends at Mt Crosby Weir.

The confluence of Lockyer Creek with the Brisbane River is about four kilometres downstream of the Wivenhoe Dam wall. Past events indicate the potential for significant flows to be derived from the Lockyer Creek under flood conditions. However, these events are irregular at best with little potential to augment supplies from the Wivenhoe system because of weir capacity. When inflows do occur, they are highly problematic, particularly with regard to turbidity as identified in the *Drought Water Quality Risk Assessment (2008)* (RSK-00015).

Water can also be released from Lake Manchester into the Mid-Brisbane River, a further 30 km downstream of the dam wall. Releases from the Lake Manchester system tend to be high in iron and manganese content and this has been problematic for the Mt Crosby treated water. The Mid-Brisbane River then flows to Mt Crosby Weir where water is abstracted for treatment at the two Mt Crosby WTPs.

4.2.4 Purified Recycled Water

Existing (and historical) inflow events to Lake Wivenhoe account for 100% of the storage volume of the lake. These inflows are expected to continue at a similar level following the commissioning of PRW returns; however, depending on any changes to the Queensland Government's policy decision on the dam levels at which PRW returns will commence, they will then account for 90% (or more) of the storage volume. Essential to the management of PRW returns is an appreciation that because of its drinking water specifications, the water quality characteristics of PRW will be quite different to those of the lake (see Section 5.2.1). Hence, management measures will need to maintain or enhance the ecosystem services that are now provided to the water body of the lake, and ensure that the 10% (or less) that will be derived from PRW returns is sustainably integrated. The management objectives for PRW returns are to:

1. Facilitate assimilation and mixing of PRW within the storage waters;
2. Maximise detention of of PRW within the storage waters;
3. Maintain and wherever possible improve the integrated in-storage water quality; and
4. Improve process understanding, and the effectiveness of catchment and storage management measures to facilitate the above objectives.

[5] Seqwater weather stations and Bureau of Meteorology.

The WDWQMP will allow for management actions that discriminate between PRW and the receiving lake waters, even if there is significant overlap in water quality risks between the two water types (see Section 5.2.1). To help inform these actions, Seqwater is assessing the existing ecosystem benefits that are provided to the downstream water treatment processes, and the catchment management actions that are needed to maintain or increase these benefits.

PRW returns will be a significant change to the sources of inflow to the lake; they will alter the role of the lake in terms of its delivery of water services. Moreover, PRW returns will introduce a different type of quantitative inflow compared to the inflows that the lake has experienced historically (see Section 5.2.1). PRW is likely to be at constant daily and annual volumes, which is significantly different to the variable seasonal and annual patterns of inflow normally affecting the lake. A 3D-hydrodynamic model has been developed to predict the circulation and mixing characteristics of PRW inputs to Lake Wivenhoe (see *Modelling Progress Report (January 2010)*; Research Plan Folder). A basic scoping-level ecosystem model of the response of the water column to nutrient inputs has also been developed. These models are used for scenario testing of planned PRW inputs (see Section 12).

With PRW returns, the lake will change from being solely a source of raw water and an early element of a 'linear' treatment train, to also being a receiver of PRW and a process element of a 'cyclical' treatment train (assuming the Mount Crosby WTP is the final element of the treatment train cycle). The key process barriers (i.e. critical treatment and quality control points) for the PRW cycle include (in process order):

Barrier 1:
- → Residential/Industrial Source Control (i.e. wastewater collection);

Barrier 2:
- → Wastewater Treatment (removes suspended solids, BOD and COD organics, nitrogron and phosphorous);

Barrier 3:
- → Microfiltration (removes turbidity, particles, bacteria, protozoa and viruses);

Barrier 4:
- → Reverse Osmosis (removes turbidity, inorganics, viruses, bacteria, protozoa and organics);

Barrier 5:
- → Ultra Violet Advanced Oxidation (removes organics, viruses, bacteria and protozoa);
- → De-chlorination (i.e. SBS treatment at Lowood);

Barrier 6:
- → Discharge into the Natural Environment (i.e. Lake Wivenhoe); and

Barrier 7:
- → Water Treatment Plants (i.e. disinfection/ distribution at Mt Crosby, Esk and Lowood WTPs).

Barrier 6 (discharge into the natural environment) includes water returns to Lake Wivenhoe and subsequent dilution and integration, residence time, and delivery via the Mid-Brisbane River to the Mount Crosby WTP.

The water quality of PRW inputs to Lake Wivenhoe will be reliant on the successful operation of the WCRWP Scheme. Figure 11A is a schematic diagram of the overall WCRWP Scheme including the potential upstream treatment plants, and the pump stations and pipeline infrastructure that will deliver PRW to Lake Wivenhoe. The treatment plants are managed using the Recycled Water Management Plans (RWMPs) identified in Section 6.1. Figure 11B shows the booster pump station at Lowood, and the PRW supply and risk transfer (i.e. interface point where the water quality risks are transferred from WaterSecure to Seqwater) points at Lake Wivenhoe.

The outlet for PRW returns is located in Logan's Inlet, adjacent to Coominya. This site is also the major recreation location on the lake. Hence, any visible indicators of the impact of PRW on water quality are likely to be seen, as they occur, by members of the public who use this location, and there is potential for public reaction to be a factor in managing PRW returns.

Because the regulatory and operational frameworks for PRW returns are still being progressively defined, a number of key assumptions have been made about the returns for the development of the WDWQMP. These are based on information from the WCRWP:

- Ultimate volumes of the scheme will be up to 230 ML/day;
- Return volumes in the first 12 months or more of operation are likely to be ~40–100 ML/day;
- Because of its drinking water specifications and notwithstanding the water quality parameters for PRW that are specified in the Grid Contracts, the water quality characteristics of PRW will not always meet the current environmental water quality parameters of Lake Wivenhoe; i.e. the water is treated primarily to health-based standards and not those described for the lake under the proposed WQOs (see Section 7.2);
- PRW return volumes will be continuous and consistent within timescales of one day or more, but may be variable on timescales of less than one day; and
- Data from routine monitoring of PRW to date (currently based on 220 parameters) indicates slight variation in water quality; however, water quality of PRW returns will not always be consistent in time and is expected to be subject to some diurnal, seasonal and climatic (e.g. storm) fluctuations.

A summary of water quality monitoring data from the last five to ten years for Lake Wivenhoe and Mid-Brisbane River, and estimates for PRW inflows following commissioning of the Swanbank storage release at the Bundamba AWTP are provided in Table 2.

Contaminants of potential concern in PRW returns are yet to be defined; however, they include a range of nutrients, which may cause changes to the ecological characteristics of Lake Wivenhoe, organochlorine compounds, industrial chemicals, pesticides, herbicides, PAHs, metals, pharmaceuticals, hormones, and selected bacteria and viruses. Monitoring of contaminants will be based on the following:

- Standards defined in the *Public Health Regulation 2005* (QLD) (LEG-00068); and
- Risk-based threshold limits as specified in the *PRW Quality Standard and Notification Triggers Table* (see Section 7.1.4), and as further defined by Seqwater and other state agencies for environmental and other purposes. Risks from PRW returns are discussed in Section 5.2.1.

4.2.5 QWC Expert Advisory Panel

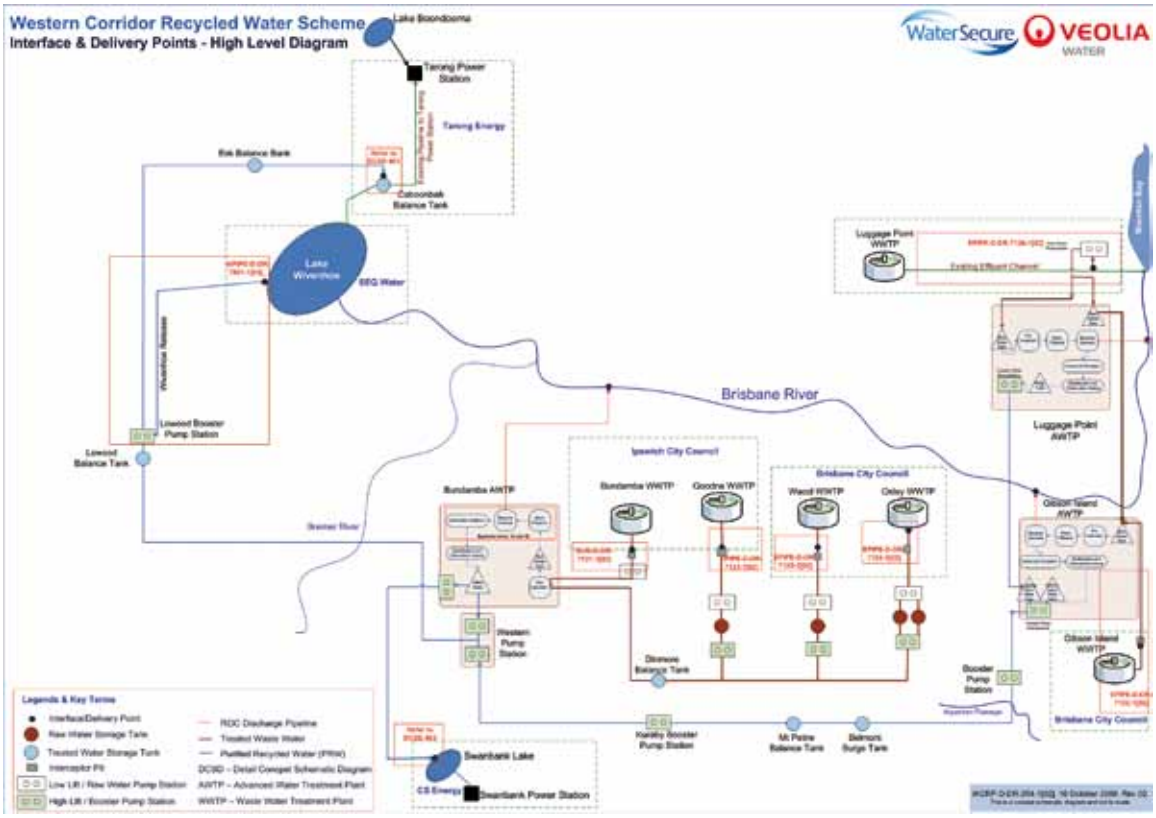
In early 2007, the QWC established an Expert Advisory Panel to provide advice on the treatment and management of PRW returns (see *QWC Expert Advisory Panel Interim Water Quality Report (2009)*; LEG-00102). The panel focuses on the delivery of advice to support best practice design and implementation of water supply management systems that have been developed for international systems. The advice is also intended to provide information on up to date developments in the water supply industry by engaging industry research experts.

A number of key elements of the WDWQMP have been discussed with the QWC Expert Advisory Panel, including:

- The scope of monitoring and research options;
- Progress on the development of management options including modelling;
- The WDWQMP water quality management framework (see Section 1.1);
- Additional water management options prior to delivery of PRW to Lake Wivenhoe such as wetlands;
- The location and engineering design specifications for PRW returns into Lake Wivenhoe;
- Detention times within Lake Wivenhoe for assimilation of PRW; and
- Risks from a limited number of PRW water quality parameters including nutrients, temperature, alkalinity and chlorine (see Section 5.2.1).

Figure 11 Western Corridor Recycled Water Project Scheme. (A) Scheme overview (B) Booster pump station at Lowood, and the PRW supply and risk transfer points at Lake Wivenhoe (WaterSecure).

A



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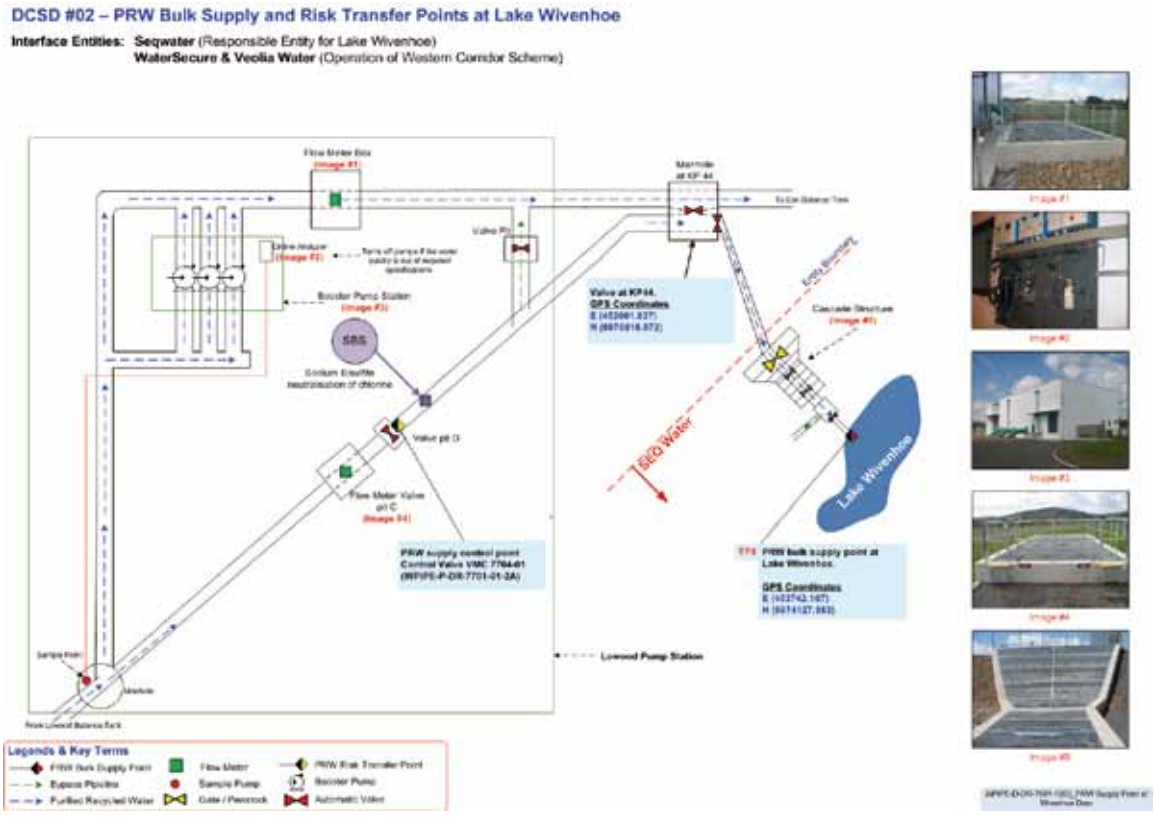


Table 2 Summary of water quality characteristics from the last five to ten years for Lake Wivenhoe and Mid-Brisbane River, and estimates for PRW following commissioning of the Swanbank storage release at Bundamba AWTP.

Water Quality Characteristic	Lake Wivenhoe			PRW	Mid-Brisbane River		
	Median	20th Percentile	80th Percentile		Median	20th Percentile	80th Percentile
Dissolved Oxygen (mg/L)	8.6	7.8	9.5	9.8	8.3	7.2	9.5
pH	8.3	7.7†	8.7†	7.2	8.0	7.75	8.2
Conductivity (µS/cm)	356	290	407	126	391	327	441.5
Turbidity (NTU)	3.1	1.6	5.8	0.4	3.3	1.8	5.0
Temperature (^{o}C)	19–25	nd	nd	21–27	nd	nd	nd
Crypto	0	0	0	0	nd	nd	nd
Giardia	0	0	0	0	nd	nd	nd
Total Phosphorus (mg/L)	0.018	0.014	0.026	0.016	0.021	0.018	0.029
Total Nitrogen (mg/L)	0.49	0.429	0.538	0.628	0.463	0.422	0.509
Soluble Phosphorus (mg/L)	0.002	<0.002†	0.005†	0.005–0.02	0.004	0.002†	0.006†
Soluble Nitrogen (mg/L)	0.015	0.004†	0.183†	0.628	nd	nd	nd
Algae Count (cells/ml)	105,966	46,760	177,006	0	5,615	3,615	30,812
E. Coli (CFU/100 ml)	3	1	9	0	12	6.3	24.8
Total Coliforms (CFU/100 ml)	43	4	520	0	67.7	27.9	297.4
Dissolved Fe (mg/L)	0.01	0.010	0.025	0.02	nd	nd	nd
Dissolved Mn (mg/L)	0.0010	0.01	0.01	<0.01	nd	nd	nd
Chlorophyll a (µg/L)	8.6	6.0	13.3	0.0	3.9	2.3	5.7
Alkalinity (mg/L $CaCo_3$)	78	64†	95†	50	nd	nd	nd
Free Chlorine (mg/L)	0.00	0.00	0.00	0.07*	nd	nd	nd

†Value represents the 10th rather than the 20th percentile, or the 90th rather than the 80th percentile. *Free chlorine in PRW at Bundamba AWTP (i.e. prior to chlorine removal process at Lowood). nd represents no suitable data available.

The outcomes of these discussions include:

- Agreement on the importance of the circulation and mixing model for Lake Wivenhoe, including recommendations on model improvement and resource needs to maintain the model;
- Agreement on a holistic management framework for Lake Wivenhoe incorporating the ADWG (2004) catchment to tap framework for managing water quality risks;
- Agreement on the broad categories of options for monitoring and management (under development and review);
- Acknowledgement of the risks from a limited number of PRW quality characteristics and their potential to generate hazards such as cyanobacterial bloom toxins;
- Agreement that wetlands be retained as a management option for PRW, depending on the results of future monitoring and confirmed water quality impacts;
- Agreement not to support a regulated six month detention period for PRW in all of Queensland's raw water storages, but to support a validation process to confirm the detention requirement for each individual raw water supply based on Seqwater modelling;
- Benchmarking of environmental contaminants; and
- Development of a contaminant decay model.

4.3 Catchment and Storage Condition

4.3.1 Healthy Waterways Report Card

Since 1999, the Ecosystem Health Monitoring Program (EHMP) has produced the annual *Ecosystem Health Report Card* to report on the health of SEQ's waterways. The report card is part of the programs managed under the South East Queensland Healthy Waterways Partnership. The report card provides an 'A' to 'F' rating for 19 catchments (including the Stanley River, Upper Brisbane and Mid-Brisbane catchments), 18 estuaries and nine zones within Moreton Bay, all within the SEQ region. The *2008 EHMP Report Card* is the most recent, and it is the culmination of monitoring at 381 freshwater, estuarine and marine sites from July 2007 to June 2008 (see *2008 EHMP Report Card* www.healthywaterways.org; LEG-00088).

The *2008 EHMP Report Card*, including comparisons with previous years, is summarised as follows:

- Stanley Catchment: grade IMPROVED from C+ (2006-07) to B+ (2007-08).
  Streams in good condition; improvements in physical, chemical and ecosystem processes, and in aquatic macroinvertebrate and fish indicators. Low scores for the nutrient cycling indicator in both years. An improvement on the previous year, and on the B- score of 2005-06. Conditions meet all of the set ecosystem health values in most of the reporting region; most key processes are functional and most critical habitats are intact.
- Upper Brisbane Catchment: grade IMPROVED from F (2006-07) to D- (2007-08).
  Streams in poor condition; substantial improvements in physical and chemical, ecosystem processes and aquatic macroinvertebrate indicators resulted in an increased grade; slight decrease in nutrient cycling and fish indicators, the fish indicator continues to score poorly. An improvement compared with the previous year, which scored F, but not as good as the D score of 2005-06. Conditions are unlikely to meet the set ecosystem health values in most of the reporting region; many key processes are not functional and many critical habitats are impacted.
- Mid-Brisbane Catchment: grade IMPROVED from B- (2006-07) to B (2007-08).
  Streams in very good condition (an A result indicates excellent); scores for the ecosystem processes indicator showed a considerable improvement compared with the previous year, and this is no longer the lowest scoring indicator; slight decline in the fish indicator. Conditions meet all of the set ecosystem health values; all key processes are functional and all critical habitats are in near pristine condition.

Overall, although the *2008 EHMP Report Card* shows a slight improvement in waterway ecosystem health compared with the previous year, it nevertheless indicates a high risk of adverse impacts to water quality in the Wivenhoe system, particularly in the Upper Brisbane Catchment. However, the EHMP has limited use for determining the health of Lakes Wivenhoe and Somerset and the Mid-Brisbane River, as well as for assessing whether the Drinking Water Supply EV is being maintained. There are two main reasons for this:

- The EHMP methods and sites in the Upper Brisbane catchment are specifically designed to assess freshwater streams and rivers, and have limited applicability to large, lotic water bodies such as Lakes Wivenhoe and Somerset; and
- Infrequent sampling and low spatial resolution of sampling; e.g. the EHMP sampling program for the Mid-Brisbane River is limited to monthly sampling at a single site.

Therefore, to encourage stakeholder engagement and facilitate internal management needs, e.g., prioritisation of resources for catchment management, a mechanism is required to communicate the results of Seqwater's catchment and storage monitoring programs. This will be achieved through development of the *Seqwater Report Card* (see Section 3.3.1).

4.3.2 Drinking Water Quality Monitoring Data

Review of historical water quality monitoring data assists in identifying hazards and those aspects of the drinking water system that require improvement. It improves the understanding of source water characteristics and system performance, both over time and following specific events such as heavy rainfall.

A six monthly review of the drinking water quality of the Wivenhoe system is regularly undertaken as part of Seqwater's certified HACCP system. The HACCP system aims to ensure quality assurance of drinking water, and therefore customer confidence. It is a process that attempts to reduce risk by providing a framework for the prevention of water quality degradation. The review is conducted in accordance with the *Draft HACCP Verification and Validation Schedule* (HACCP General Folder). It is undertaken by the HACCP team and is documented in the *Draft HACCP Team* (HACCP General Folder).

Historical laboratory monitoring data for the Wivenhoe system is held in Seqwater's QA/QC database. This is accessed using Seqwater's *TimeStudio* software (see *Environmental Database Operation Procedure*; PRO-00735) and will be available on Seqwater's new intranet (by 2011). Trending reports are produced in accordance with the *Draft HACCP Water Quality Reporting Procedure* (PRO-00294). A brief summary of reporting and review of water quality monitoring data is as follows:

- *Water Quality Trigger Value Reports* are reviewed at the fortnightly Water Quality Meeting;
- *Fortnightly Water Quality Reports* are produced for review at the monthly Managers Meeting;
- *Six Monthly Trending Reports* are produced (winter and summer) for the Seqwater Executive and other stakeholders; and
- *Annual Trending Reports*, including rainfall events and research and development findings, will also be produced for the Seqwater Executive and other stakeholders (see *WDWQMP Improvement Plan*; Appendix H).

The reports are kept on Seqwater's HACCP files, and will be available on Seqwater's new intranet (by 2011). Water quality monitoring data, trends and non-conformances are reviewed every six months in accordance with the *Draft HACCP Verification and Validation Schedule* (HACCP General Folder). The *Draft HACCP Customer Liaison Register* (HACCP General Folder) contains details of all exceedances of trigger values, as defined in the *Draft HACCP Customer Trigger Values Table* (HACCP General Folder).

5. Risk Assessment

5.1 Context

Effective risk management requires identification of all potential hazards and hazardous events, their sources and consequences, and an assessment of the perceived level of risk from each. A structured approach is important to ensure significant issues are not overlooked and areas of greatest risk are identified.

To facilitate continual improvement in risk management, Seqwater has developed a *Risk Management Policy* (PRO-00671) based on *AS/NZS 4360: Risk Management* (LEG-00029). Application of this policy includes undertaking risk assessments to improve understanding of the drinking water supply system. Seqwater's risk assessment procedure has been adapted and developed using the main components of *AS/NZS 4360: Risk Management* (LEG-00029) and is summarised in Appendix D (also see *Integrated Management Systems Risk Identification and Assessment*; PRO-00801). Enterprise wide risks to the organisation are identified and reviewed annually by the Seqwater Board and Executive. These risks form the basis of the business risk profile for the Seqwater and are listed in the *Enterprise Risk Register* (REG-00152).

The following risk assessments have recently been undertaken for the Wivenhoe system:

- *Catchment and In-Storage Water Quality Risk Assessment (2007)* (RSK-00018);
- *Catchment and Water Quality Risk Assessment for Mid-Brisbane River (2008)* (RSK-00017).
- *Drought Water Quality Risk Assessment (2008)* (RSK-00015); and
- *Toxic Cyanobacteria Risk Assessment (2007)* (RSK-00016);

These assessments were undertaken using guidance from the ADWG (2004), and define a number of risks to water supply quality, quantity and continuity. Specific outcomes sought by Seqwater to address these risks via the proposed WQOs (see Section 7.2) include:

1. Management of diffuse sources: improved riparian cover and vegetation structure to reduce overall contaminant input, including buffering the entry of pathogens and hazardous chemicals such as toxicants from agriculture, and accidental spills and releases. This will require actions such as:
    - Improved use of riparian filter strips to buffer the entry of pathogens and hazardous chemicals (such as toxicants);
    - Improved application of appropriate setback distances and riparian management practices for various types of land use in the catchment; and
    - Providing a means to better identify specific 'high risk' tributaries, and the basis for focusing management actions in these areas.
2. Management of point source discharges such as STP and PRW returns, by setting appropriate standards for water quality within appropriately sized mixing zones (see ANZECC 2000 Guidelines).
3. Where appropriate, identification of areas of High Environmental Value for additional protection status to better empower planning and management actions for maintaining water quality.

5.2 Hazard Identification

In the context of the HACCP system, the risk of concern is that of exceeding water quality targets. These targets are based on the quality of raw water that customers require, as described in Section 7.1.2; in addition to the WGM, the majority of the customer base is comprised of Seqwater's own WTPs (see Section 8.2). The targets have been negotiated with each customer/WTP as documented in the *Draft HACCP Customer Trigger Values Table* (HACCP General Folder). However, this is considered in combination with the *Draft HACCP Product Specification Statement* (HACCP General Folder), which iterates Seqwater's agreement with each customer/WTP.

Potential hazardous events are identified as part of Seqwater's risk assessment methods and are outlined in the following documents:

- *Integrated Management Systems Risk Identification and Assessment Procedure* (PRO-00801);
- *Environmental Risk Procedure and Register* (FRM-00002); and
- *Enterprise Risk Register* (REG-00152).

Hazardous events include, but are not limited to:

- Discharges and overflows;
- Other point sources releases including industry discharges;
- Potential leachates from septic tanks within catchments;
- Runoff from landfills and potential leachates;
- Runoff from grazing land – in relation to erosion and faecal matter;
- Runoff from cropped land;
- Runoff from land used for forestry operations;
- Urban stormwater runoff;
- Weed control around dams – spraying activities;
- Domestic and feral animals within a catchment area or dam;
- Human access and potential sabotage;
- Recreational activities that have potential to affect water quality; and
- Sand and gravel extraction.

For each hazardous event, a series of parameters have been identified to monitor water quality impacts as described in the *Draft HACCP Hazard-Parameter Table* (HACCP General Folder). Hazard likelihoods, consequences and risk rankings have been determined using the *Integrated Management Systems Risk Identification and Assessment Procedure* (PRO-00801), and are summarised in the following Hazard Assessment Ranking Tables:

- *Draft Wivenhoe Catchment Hazardous Events* (HACCP Plans Folder);
- *Draft Somerset Catchment Hazardous Events* (HACCP Plans Folder); and
- *Draft Lockyer and Mid-Brisbane Catchment Hazardous Events* (HACCP Plans Folder).

The hazards are regularly reviewed in accordance with the *Draft HACCP Verification and Validation Schedule* (HACCP General Folder).

5.2.1 Risks from Purified Recycled Water

Lake Wivenhoe is an existing (water storage) asset within a working catchment; in contrast, the PRW system is a built component. Hence, risks from PRW returns will be additional to or overlap with the existing water quality risks within the catchments and dams. Compounds from PRW returns that may present a risk include pathogens, pharmaceuticals, antibiotics, nutrients, water treatment additives, treatment residuals and others.

The origin of compounds in PRW will be confined to the PRW return point at Logan's Inlet adjacent to Coominya. In contrast, catchment sources of risk compounds are widespread, and include Coominya. Because PRW will be a key inflow to Lake Wivenhoe with unique characteristics and management requirements, the risks derived from the catchment must be discriminated from those derived from PRW. If the benefits of PRW treatment are to be fully realised for PRW returns to the lake, then those catchment sources that provide similar risks to PRW will need to be managed to equivalent best practice standards; management of PRW returns will be set within the context of managing all sources of inflow and their interrelated impacts.

5. Risk Assessment (continued)

In early 2007, and closely following the announcement of PRW returns to Lake Wivenhoe, Seqwater undertook the *Catchment and In-Storage Water Quality Risk Assessment (2007)* (RSK-00018). The intention of this risk assessment was to better understand the Wivenhoe/Somerset storage and its future management needs prior to commissioning of PRW returns into Lake Wivenhoe. This is the most current risk assessment for the Wivenhoe system, and it will be used to update the elements of the WDWQMP that are currently covered by the existing HACCP system (under review).

Although the risks from PRW returns are yet to be fully characterised and quantified, a risk profile for PRW returns (assuming returns are commissioned at 40% lake capacity) has been developed (see Table 3). It is based on the known background water quality characteristics of Lake Wivenhoe compared to those expected from PRW returns to the lake. The PRW characteristics and risks were derived from the findings of the Water Quality Risk Assessment Workshop for the WCRWP Scheme (November 2009; see *WCRWP Scheme Risk Register*; Hazard ID and Risk Assessment Folder), discussions with technical experts from the WCRWP Scheme and the QWC Expert Advisory Panel (see Section 4.2.5), and water quality monitoring data collected (twice weekly from June 2008 to September 2009) from the Bundamba AWTP.

The risks that have been identified for PRW returns into Lake Wivenhoe include the potential for direct impacts on human health, ecosystem impacts including those that may lead to a subsequent decline in drinking water quality, and impacts on other environmental values (e.g. recreational risks). With regard to the future needs of the catchment and in-storage management activities, the main risks include chlorine disinfection bi-products (e.g. chlorate), PRW temperature, nutrient loads for nitrogen and phosphorus, blue green algae blooms, pathogens, decreased alkalinity, metals and the potential impacts if dam levels fall below 10% capacity (for a summary of the results of PRW testing including validation and verification testing see *QWC Expert Advisory Panel Interim Water Quality Report (2009)*; LEG-00102).

Although the exact magnitudes of the risks from PRW are yet to be established, the Expert Advisory Panel agrees that:

- PRW returns will contain chlorine or chlorine disinfection bi-products from time to time;
- Soluble nutrient levels in PRW will be at least an order of magnitude greater than the background levels in Lake Wivenhoe,
- Alkalinity will be lower in PRW than in the receiving lake waters; and
- The temperature of PRW returns will be higher than that of the Lake Wivenhoe receiving waters.

There are unique risks for PRW returns that arise from both the continuity of the return flows and their specific character compared to the receiving water quality. The PRW water quality will not always meet the environmental water quality standards of the receiving lake waters. For instance, the median soluble phosphorus concentration in Lake Wivenhoe adjacent to the dam offtake, which releases into the Mid-Brisbane River, is 0.002 mg/L. It is expected that soluble phosphorus concentrations in PRW will be 0.005–0.02 mg/L (see Table 2); WaterSecure will notify Seqwater when total phosphorus concentrations ›0.15 mg/L (see Section 7.1.4 and *Seqwater-WaterSecure Operating Protocol*; PRO-00381).

There is also potential for chlorine residuals or by-products to be incorporated in releases into Lake Wivenhoe that currently have no chlorine residuals or chlorine residual source, other than the catchment-based STPs. While these differences are irrelevant to the drinking water standards, both have implications for the medium to long term management of Lake Wivenhoe and Mid-Brisbane River.

Although the PRW risk profile in Table 3 is the best available at this time, there is still substantial uncertainty regarding the characteristics of the PRW returns including, but not limited to: the potential for sediment and biological accumulation of contaminants, chronic toxicity impacts, ecosystem impacts, short circuiting of PRW through the reservoir, failures at the AWTPs, mixing and circulation impacts, and

changes to the alkalinity and buffering capacity of Lake Wivenhoe. This is partly because the PRW source water data is so far derived from only a limited number of WWTP sources and times. The introduction of Gibson Island and Luggage Point product waters, for instance, is expected to modify the final water PRW quality both immediately and seasonally. This is because:

- → Volumes change seasonally;
- → Water quality changes seasonally;
- → Treatment efficacy changes seasonally; and
- → Industry/commercial effluent changes seasonally; i.e. source loads.

Although many of the potential impacts of PRW returns are expected to be subtle, a level of risk will remain, particularly with regard to the long term sustainability of Lake Wivenhoe.

Importantly, there are additional risks to be considered including the potential for damage to the PRW pipeline infrastructure within the Wivenhoe and Mid-Brisbane catchments, which may lead to sudden impacts such as sediment inputs from erosion, and elevated nutrient and turbidity levels in the lake.

Another key consideration, which goes beyond impacts to drinking water quality and environmental and recreational values, is possible changes to the Queensland Government's current policy decision that PRW returns into Lake Wivenhoe will be commissioned when the total volume of Lakes Wivenhoe, Somerset and Samsonvale fall below 40%. For example, a decision to commission PRW returns in the near future may result in failure of Grid Participants to meet the regulatory and associated resourcing and training requirements for DWQMPs and RWMPs. In addition to the immediate requirement for a DWQMP for the Wivenhoe system, linked plans would also be required for the Mt Crosby, Esk and Lowood WTPs and Cressbrook Dam, and RWMPs would be required for the WCRWP Scheme.

Risk mitigation and management activities for future risks to the Wivenhoe system, including PRW returns to Lake Wivenhoe, will be based on outputs from the new *Catchment Water Quality Monitoring Program* (see Section 7.1.3), and those from the research and development programs that are currently underway (see Section 12). The outputs will be incorporated into the WDWQMP as part of a rolling review process, as they are completed over the next six to 36 months. In addition, the impacts of relevant contaminants must be managed in line with ANZECC 2000 Guidelines; e.g. the guidelines require mixing zones of limited size, and in order to protect the Aquatic Ecosystem EV, the stringent WQOs adopted for Total Nitrogen and Total Phosphorous may further limit the mass loads of these contaminants that are able to be safely included in PRW returns.

Table 3 Risk profile for PRW returns into Lake Wivenhoe (assuming returns at 40% lake capacity).

Hazard / Issue	Potential Impact	Likelihood	Consequence	Inherent Risk	Potential Management Measures	Residual Risk
Chlorine	→ Localised impacts (i.e. Logan's Inlet) → Indiscriminate ecosystem damage → Fish kills → Reduced recreational amenity	Unlikely	Moderate	Medium	→ Whole of Lake Wivenhoe: detention and integration → Assimilation by wetlands → Monitoring and feedback to WCRWP Scheme	Medium
Inorganic disinfection by-products (e.g. Chlorate, Chlorite, Perchlorate, Bromate)	→ Localised impacts (i.e. Logan's Inlet) → Indiscriminate ecosystem damage	Unlikely	Moderate	Medium	→ Whole of Lake Wivenhoe: detention and integration → Assimilation by wetlands → Monitoring and feedback to WCRWP Scheme	Medium
Organic disinfection by-products (e.g. NDMA, Chloroform)	→ Localised impacts (i.e. Logan's Inlet) → Indiscriminate ecosystem damage	Unlikely	Minor	Low	→ Whole of Lake Wivenhoe: detention and integration → Assimilation by wetlands → Monitoring and feedback to WCRWP Scheme	Low
De-chlorination by-products (e.g. Sodium bisulphate, Sulphuric acid, Citric acid)	→ Localised impacts (i.e. Logan's Inlet) → Indiscriminate ecosystem damage	Unlikely	Minor	Low	→ Whole of Lake Wivenhoe: detention and integration → Assimilation by wetlands → Monitoring and feedback to WCRWP Scheme	Low
Temperature	→ Indiscriminate ecosystem damage → PRW 'skating' → Water Anoxia → Extended periods of stratification	Almost Certain	Minor	High	→ Whole of Lake Wivenhoe: detention and integration → Temperature equilibration for all flows to Lake Wivenhoe → Recreational guidelines (e.g. closure of recreation sites) → Assimilation by wetlands → Monitoring and feedback to WCRWP Scheme	Low

Hazard / Issue	Potential Impact	Likelihood	Consequence	Inherent Risk	Potential Management Measures	Residual Risk
Nutrients (e.g. Ammonia, Nitrogen, Phosphorous)	→ Long term shift in storage from mesotrophic to eutrophic from accumulation over time	Possible	Major	High	→ Additional treatment at AWTPs to reduce chronic nutrient loads → Reduction of nutrients at dam to reduce short term impacts → Catchment management to reduce long term nutrient loads → Assimilation by wetlands	Medium
Blue green algae (i.e. from increased temperature and nutrients, and decreased pH/alkalinity)	→ Toxic algal blooms → Reduced recreational amenity → Water anoxia → Fish kills → Human health risks → Customer complaints (i.e. taste and odour issues)	Likely	Moderate	High	→ Additional treatment at Mt Crosby, Esk and Lowood WTPs to purify drinking water → Recreational guidelines (e.g. closure of recreation sites) → Catchment management measures	Medium
Turbidity	→ Some potential for increased toxic algal blooms.	Rare	Minor	Low	→ Short term flow diversion of PRW (e.g. to Tarong power station) → Detention and integration within Lake Wivenhoe (›2 months) → Catchment management Measures → Recreational guidelines (e.g. closure of recreation sites)	Low

Hazard / Issue	Potential Impact	Likelihood	Consequence	Inherent Risk	Potential Management Measures	Residual Risk
Pathogens (Bacteria, Viruses, Parasites) (i.e. directly from PRW or from increased temperature and nutrients, and decreased pH/alkalinity)	→ Human health risk → Reduced recreational amenity	Rare	Major	High	→ Short term flow diversion of PRW (e.g. to Tarong power station) → Detention and integration within Lake Wivenhoe (›12 months at 60% or more capacity) → Up to 2–4 log removal by storage → Recreational guidelines (e.g. closure of recreation sites) → Assimilation by wetlands	Low
pH / Decreased alkalinity	→ Increased algal blooms → Reduced capacity at Mt Crosby, Edk and Lowood WTPs	Possible	Moderate	High	→ Short term flow diversion of PRW (e.g. to Tarong power station) → Detention and integration within Lake Wivenhoe (›12 months) → Monitoring and feedback to WCRWP Scheme	Medium
Organic contaminants (e.g. Hormones, Fragrances, Pesticides and herbicides, Aldehydes, Pharmaceuticals)	→ Indiscriminate ecosystem damage from accumulation over time → Human health risk	Unlikely	Minor	Low	→ Detention and integration within Lake Wivenhoe (›12 months) → Catchment management measures → System benchmarking to confirm future trends → Monitoring and feedback to WCRWP Scheme → Recreational guidelines (e.g. closure of recreation sites)	Low
Inorganic anions (e.g. Bromide, Fluoride, Chloride, Iodide, Sulphide)	→ Indiscriminate ecosystem damage → Human health risk	Unlikely	Minor	Low	→ Detention and integration within Lake Wivenhoe (›12 months) → System benchmarking to confirm future trends → Monitoring and feedback to WCRWP Scheme	Low

Hazard / Issue	Potential Impact	Likelihood	Consequence	Inherent Risk	Potential Management Measures	Residual Risk
Metalloids (e.g. Arsenic, Boron)	→ Indiscriminate ecosystem damage from accumulation over time → Human health risk	Unlikely	Moderate	Medium	→ Detention and integration within Lake Wivenhoe (›12 months) → Catchment management measures → System benchmarking to confirm future trends → Monitoring and feedback to WCRWP Scheme	Low
Metals–divalent (e.g. Lead, Aluminium Manganese, Iron, Zinc, Copper, Mercury, Cadmium, Cobalt)	→ Indiscriminate ecosystem damage from accumulation over time → Human health risk	Possible	Minor	Medium	→ Detention and integration within Lake Wivenhoe (›12 months) → Catchment management measures → System benchmarking to confirm future trends → Monitoring and feedback to WCRWP Scheme	Low
Metals forming anionic complexes (e.g. Chromium, Molybdenum, Manganese)	→ Indiscriminate ecosystem damage from accumulation over time → Human health risk	Unlikely	Moderate	Medium	→ Detention and integration within Lake Wivenhoe (›12 months) → Catchment management measures → System benchmarking to confirm future trends → Monitoring and feedback to WCRWP Scheme → Recreational guidelines (e.g. closure of recreation sites)	Low
Contaminants added with ferric chloride (e.g. Manganese, Iron, Molybdenum, Zinc, Other trace metals)	→ Indiscriminate ecosystem damage from accumulation over time → Human health risk	Rare	Insignificant	Low	→ Detention and integration within Lake Wivenhoe (›12 months) → Catchment management measures → System benchmarking to confirm future trends → Monitoring and feedback to WCRWP Scheme	Low
Radionuclides (i.e. Gross alpha and beta)	→ Indiscriminate ecosystem damage from accumulation over time → Human health risk	Rare	Minor	Low	→ Detention and integration within Lake Wivenhoe (›12 months) → Recreational guidelines (e.g. closure of recreation sites)	Low

Hazard / Issue	Potential Impact	Likelihood	Consequence	Inherent Risk	Potential Management Measures	Residual Risk
Misc. contaminants from treatment process (e.g. Ammonia, Hydrogen peroxide, Sulphuric acid, Anti-scalant)	→ Indiscriminate ecosystem damage from accumulation over time → Human health risk	Rare	Minor	Low	→ Catchment management to reduce long term nutrient loads → Assimilation by wetlands	Low
Ancillary Hazards						
Dam levels fall below 10%	→ Indiscriminate Ecosystem damage → Fish kills → Reduced recreational amenity → Increased algal blooms → Long term shift in storage from mesotrophic to eutrophic → PRW 'skating' → Water anoxia → Extended periods of stratification	Possible	Moderate	High	→ Recreational guidelines (e.g. closure of recreation sites) → Research and education programs → Improved treatment at Mt Crosby	Medium

6. Multiple Barriers and Preventive Measures

6.1 Multiple Barriers

An important aspect of a holistic drinking water quality management system is application of the multiple barriers approach to prevent contaminants entering the potable water supply. The focus of this aspect of the WDWQMP is on raw water supply storage and distribution to the Mt Crosby, Esk and Lowood WTPs. The barriers (i.e. controls) in place for this component of the water supply system are based on the outcomes of monitoring and research. They are listed below and discussed in Section 6.2:

- Planning controls and regulation;
- Catchment management;
- Recreational and other access controls;
- Detention management within Lake Wivenhoe;
- Maintenance of storage and catchment ecosystem services;
- Wivenhoe Dam offtake management (not for Esk WTP);
- Variable flow management of PRW releases;
- Flow releases from the Somerset Dam system; and
- Flow releases from the Manchester Dam System (not for Esk and Lowood WTPs).

Barriers upstream are covered in the WCRWP Scheme RWMPs (see www.westerncorridor.com.au; LEG-00097), which include the following plans:

- Bundamba WWTP RWMP;
- Bundamba AWTP RWMP;
- Goodna WWTP RWMP;
- Gibson Island AWTP RWMP;
- Wacol Water Reclamation Plant (WRP) RWMP;
- Oxley WRP RWMP;
- Gibson Island WRP RWMP; and
- Luggage Point WRP RWMP.

Barriers downstream are covered in Seqwater's *Draft WTP Drinking Water Quality Management Plan* (PLN-00004), which includes the following sub-plans:

- Mt Crosby DWQMP;
- Esk DWQMP; and
- Lowood DWQMP.

The WGM is developing an overarching and coordinated management framework that links the above plans: this is the *SEQ Water Grid–Water Quality Management Plan* (REF-00011).

6.2 Preventive Measures

In order to ensure that hazards and hazardous events are managed effectively, measures need to be in place to eliminate or reduce the associated risks. The *Catchment and In-Storage Water Quality Risk Assessment (2007)* (RSK-00018) contains the following information that is relevant to this section of the WDWQMP:

- Significant risks, as discussed in Section 5.2 of the risk assessment report: Key Water Quality Risks Identified. The full results of the risk assessment that was carried out, observations, and comments made by stakeholders are detailed in Tables A9-A16 in Appendix E of the report;
- Existing preventive measures (and operational procedures) and their effectiveness, and changes to the risks as they are 'rolled through' the next downstream barriers are identified in Section 5.2 of the risk assessment report, and are detailed in Tables A9-A16 in Appendix E of the report; and
- Areas where risk management could be improved or better understood are discussed in Section 6 of the risk assessment report: Assessment of Controls.

A summary of significant sources of risk for the Wivenhoe catchment and storage as identified from the above risk assessment, and recommended additional preventive measures and areas where a better understanding of an issue would benefit risk management are provided in Appendix E. A similar summary is provided for the Somerset catchment and storage in Appendix F. The following sub-sections discuss the preventive measures (i.e. risk management options) and associated issues (e.g. management of PRW returns) that have been identified for the Wivenhoe system.

Significant sources of risk, preventive measures and the residual risks with controls for the Mid-Brisbane River catchment are described in the *Catchment and Water Quality Risk Assessment for Mid-Brisbane River (2008)* (RSK-00017) (see Section 3.5: Risk Register, and Appendix E of the risk assessment report). A summary of significant sources of risk that have been identified for the Mid-Brisbane River catchment is provided in Appendix G.

The existing controls identified for the Mid-Brisbane River catchment were judged by the risk assessment expert panel as being ineffective in terms of reducing the risks to an acceptable level. The sources of risk include climate change, high volume inflows from Black Snake Creek and Lockyer Creek, fauna kills, urban development, terrorism and lack of public awareness of the environmental value of the Mid-Brisbane River. The risk assessment identifies the following priority areas for risk management of water quality in the Mid-Brisbane River catchment:

- Development of a Mid-Brisbane River stakeholder engagement plan that identifies leading organisations and individuals responsible for driving water quality related projects within the Mid-Brisbane River catchment with the aim of formation and development of a Mid-Brisbane Partnership;
- Development of an Emergency Action Plan to define the actions to be taken and process to be followed for responding to any water quality related emergency that has potential to affect human health or the environment, or both;
- Development of managed incentives structures for landholders and community groups;
- A media and public awareness campaign to increase the profile and awareness of the Mid-Brisbane River catchment, its environmental values and protection status, and promotion of the Mid-Brisbane River as 'green' infrastructure; and
- On-going monitoring of water quality and ecosystem health of the Mid-Brisbane River catchment to secure a better understanding of the risks to a viable and secure raw water supply for SEQ.

6.2.1 Catchment Management Options

There is increasing evidence from various parts of Australia (Billington 2007; Mason et al. 2007) that investments in catchment management 'pay-off' in the long term through improved catchment health and better quality water from their watersheds. Catchment management is a core element of managing the quality of drinking water; it is achieved by managing existing uses, planning new development to manage risks and rehabilitating catchments (*SEQ Regional Plan 2009-2031;* LEG-00120). Both the ADWG (2004) and CRC for Water Quality and Treatment (LEG-00108) recognise and promote catchment management as a means of achieving water quality risk reduction.

Catchment management can involve activities ranging from constructing hard engineering structures and on-farm works (e.g. contour banks to reduce soil erosion, stream bank stabilisation, riparian revegetation, and restricting stock access by fencing, off-stream watering, improved buffer zones and providing shade trees away from waterways) to 'softer' solutions like management of household or industrial wastewater systems, community education and incentive schemes.

Experience from other parts of Australia shows that to be successful, catchment management initiatives need cooperation and collaboration of multiple stakeholders including local and state government agencies, state government-owned companies such as Seqwater, community groups and the general community of private land-owners. These groups can be united in their common goal to protect the health of drinking water supplies and recreational waters through both the healthy and sustainable catchments and waterways they generate, and the process of mutual recognition and support generated through such a shared goal and outcome. Catchment management options relevant to the Wivenhoe system include:

- Best practice farm planning, and land management plans;
- Incentive programs for implementation of best practice processes to protect water quality;
- Replanting and reforestation;
- Riparian restoration;
- Fencing and managing stock access to pasture and water;
- Maintenance of stock health and stock type;
- Water cycle management of catchment STPs, on-site sewage systems and urban stormwaters;
- Best practice pasture management, e.g., improving pasture species, cover crops, and weed, pest and fertiliser management;
- Biodiversity maintenance and protection;
- Erosion mitigation activities, e.g., sediment raps and farm dams;
- Management of built development and resource exploitation; and
- Management of human access to waterways including recreation.

6.2.2 Storage Management Options

There are only a few management options available to manage water quality within the Wivenhoe/ Somerset storage itself. Key storage management options are described below (refer to Section 7.3 for guidance on the decision making process for utilising these controls).

Use of the variable offtake at Wivenhoe Dam for water quality control

Selective Withdrawal – Active management of the depth from which water is harvested is an important control that can be applied in storages. Selective Withdrawal recognises that water quality is not uniform throughout the water column, and this allows selection of an offtake depth with the lowest contaminant concentrations in a storage. Having multiple or variable offtakes allows optimisation of overall water quality, even if individual parameters may be elevated.

Volume releases from Somerset Dam

Volume releases from Somerset Dam have the capacity to increase circulation within Lake Wivenhoe, raise the water level, and dilute or otherwise mitigate water quality conditions within the lake. As flow releases are variable it is also possible to manage and scale the implications of this management option.

Volume releases from Wivenhoe Dam

Releases from Lake Wivenhoe may be moderated or increased for specific circumstances, or be stopped altogether subject to water demand, water availability from other sources, or as a response to water quality conditions upstream or downstream of Wivenhoe Dam.

Volume releases from Manchester Dam

Releases from Lake Manchester can be used to replace or dilute flow releases from Lake Wivenhoe should the need arise. This provides an alternative and independent supply source for the Mt Crosby WTPs, which are typically sourced from Lake Wivenhoe.

Variable control of PRW release into Lake Wivenhoe

Flow releases of PRW are expected to be consistent in quantity over time, but not necessarily consistent in quality (see Section 4.2.4). This is a result of the shifting demands from other industrial users of PRW as well as the variability in the PRW source supply waters, which are affected by seasonal or regulated restrictions in water use. PRW is likely to shift the base characteristics of water quality in Lake Wivenhoe and may increase its sensitivity; therefore, more frequent preventive measures may be required. PRW flows can be regulated subject to the water quality requirements of the lake, water levels in the lake, or in response to a water quality variation in the PRW itself.

Predictive modelling in combination with the above

Effective water quality monitoring, and real-time modelling of storage stratification and inflow short-circuiting potential using computer models, such as DYRESM[6] and CAEDYM[7], are proving to be useful management tools at some storages (e.g. Myponga in South Australia). As mentioned in Section 4.2.4, the 3D-hydrodynamic model has been developed with the ability to predict inflow mixing, PRW skating, seasonal turnover and offtake optimization (see Section 12 and *Modelling Progress Report (January 2010)*; Research Plan Folder). The model has undergone external review and is currently being validated.

Use of the seasonal lake destratification and mixing process

Seasonal mixing of Lake Wivenhoe's stratified water column occurs annually between April and September. This mixing is sufficient to provide uniformity of water quality attributes across the entire system, so that they appear laterally and vertically integrated. This has the benefit of fully integrating waters from any preceding catchment inflow events as well as re-oxygenating the deeper water levels of the lake.

Potential for mixing devices in Wivenhoe Dam

At present, there are no destratification systems (e.g. aerators) in the Wivenhoe storage. To be effective, such a destratification system needs to be of sufficient size to always achieve a dissolved oxygen level of $\rightarrow$5 mg/L near the bottom of the storage. It would be important to consider the costs and benefits of destratification systems for the storage prior to installation, as the cost of air compressors and energy use would be substantial.

6.2.3 Planning

In response to development activities and intensification of land use within the region that have the potential to impact on water quality in the catchments, Seqwater has developed the *Development Guidelines for Water Quality Management in Drinking Water Catchments (2008)* (GDE-00001). These guidelines address types of development that may result in harm to water quality, public health or environmental values. Impacts on water quality from these activities may also result in interruption to or loss of water supply. The guidelines assist those involved in planning and development by providing information on how development can be undertaken in the catchments to recognise and manage impacts on water quality.

Seqwater does not determine land use decisions in the catchments; however, through the *Development Guidelines* and other means (e.g. education), Seqwater seeks to provide guidance on how development in water supply catchments should be undertaken to best manage potential impacts on water quality. These guidelines are intended to provide land users, land use decision makers and the community in the water supply catchments with guidance on how development can be undertaken to minimise impacts on water quality. The *Development Guidelines* will be used by Seqwater to:

[6] DYRESM- Dynamic Reservoir Simulation Model.
[7] CAEDYM- Computational Aquatic Ecosystem Dynamic Model.

- → Review development proposals that are referred to it via general enquiries, through development applications under the *Sustainable Planning Act (2009)* (SPA) (LEG-00127) and *Sustainable Planning Regulation (2009)* (SRA) (LEG-00155), or via other development assessment processes; and
- → Describe the additional considerations for development that occurs within the water supply catchments.

The guidelines are not intended to supersede provisions in local government planning schemes or other development regulating instruments, codes or policies. In general, Seqwater will seek to have development proposals demonstrate that the *Development Guidelines* are satisfied with regard to the proposal achieving the stated Development and Water Quality Vision:

> *Existing and future land uses, development and activities in water supply catchments are undertaken in a manner that contribute to maintaining and improving water quality in those catchments.*
>
> *Existing and future land uses, development and activities in water supply catchments are u ndertaken in a sustainable manner that will not have an adverse impact on the environment.*

The *SEQ Regional Plan 2009-2031* (LEG-00120) recognises the *Development Guidelines*' priorities for Water Management, and Drinking Water Catchment Protection (see Section 11.5 of the regional plan), and notes that *'These guidelines should be considered in planning and development assessment decisions for all land from which water flows to drinking water storages'*.

Seqwater has now implemented a tracking system to follow the uptake of advice provided to councils through the development application process, and the extent to which the guidelines are being considered by regional councils in their planning and development assessment decisions. Feedback on the tracking process will be provided to and discussed with councils at subsequent review meetings to assist with continual improvement.

In the context of the SPA and SPR, the Queensland Government has identified water quality as a matter of 'state interest' – that must be provided for in ongoing planning and development assessment by government at all levels. Furthermore, through the introduction of the *Environmental Protection Act 1994* (LEG-00001) and the SPA and SPR, all levels of government, industry and community have responsibility for taking all reasonable and practical measures to minimise or prevent environmental harm to waterways and water bodies.

DERM have developed the *Resource Planning Guidelines, Guideline F10, Policy & Code for Preserving Water Quality in Declared Catchment Areas* (LEG-00142). The development powers within this code are in the process of being formally devolved to Seqwater through the *Water Supply (Safety and Reliability) Act 2008* (LEG-00074), and the SPA and SPR. These powers will see Seqwater as a Concurrence Agency under the SPA and SPR for the six declared catchment areas, including Wivenhoe in the SEQ region; the code has limited application, mainly dealing with subdivision lot sizes, and on-site waste water treatment plants.

7. Operational Procedures

Operational procedures formalise activities that are essential to ensure the provision of consistently good quality water. Detailed operational procedures are required for all water quality management activities (both ongoing and periodic) including operational monitoring, verification procedures, preventive measures and maintenance requirements.

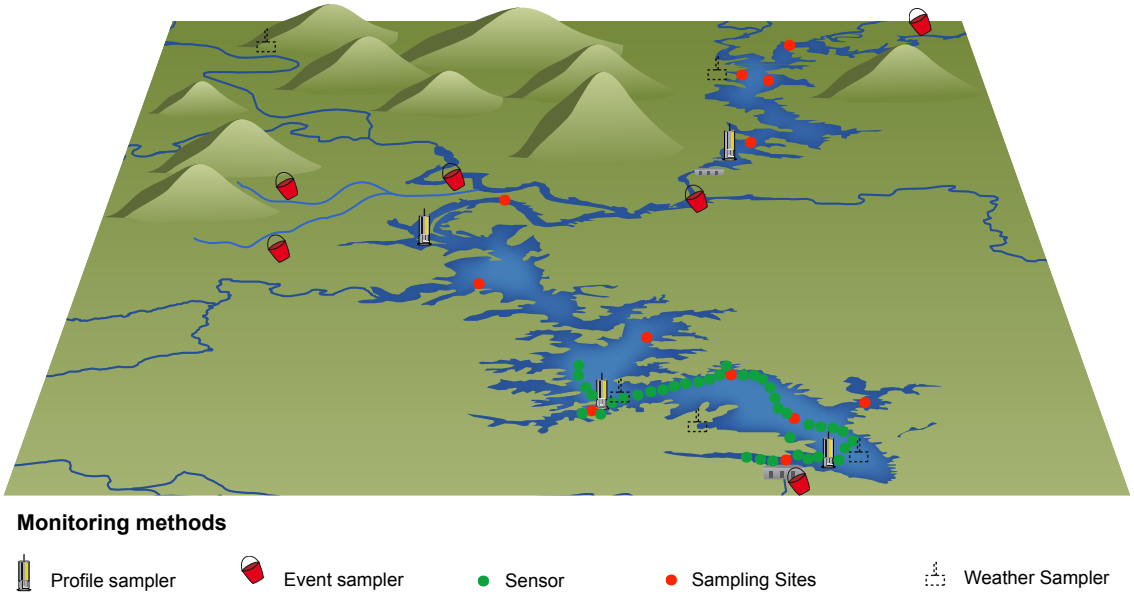
7.1 Operational Monitoring

7.1.1 Monitoring Program

Operational monitoring is the key driver for ensuring compliance with the ADWG (2004) and associated guidelines (see Section 3), and for gauging the success of the WDWQMP. There is an extensive (and growing) array of ongoing and periodic monitoring points on Lakes Wivenhoe and Somerset that are used to measure various water quality and quantity characteristics at various inflow and customer supply points (Figure 12).

The monitoring network allows real-time information to be collected and used as a basis for decision making, and it provides a means for validating model predictions. An on-line water quality profiler is shown in Figure 13. By implementing a reliable monitoring and reporting system, Seqwater has been able to establish a benchmark for water quality in the lake for the development of the EVs and draft WQOs (see Section 3.4), prior to the introduction of PRW.

Figure 12 Diagram showing the ongoing and periodic water quality monitoring points on Lakes Wivenhoe and Somerset, which are used to measure various water quality and quantity characteristics.



The monitoring systems have the capacity to monitor and provide results in real-time for characteristics such as water quality, flows, volumes, levels and temperature. Ongoing operational monitoring includes monitoring against HACCP levels, and in the near future against the EVs and WQOs.

The following research and monitoring activities assist in identifying changes to water quality in Lake Wivenhoe:

- Targeted nutrient monitoring and flux assessment;
- Tracking of bloom location, scale and duration;
- Daily, monthly and annual circulation modelling;
- Detention and dilution estimates at the dam offtake;
- Regular review of sediment contamination;
- Regular assessment of fish bioaccumulation;
- Passive sampling for CoC (chemicals of concern);
- Biotoxicity testing;
- Annual assessment of ecosystem health; and
- Water Quality Report Cards (see Sections 3.6.1 and 4.3.1).

Figure 13 One of Seqwater's telemetered water quality profiler and meteorological stations on Lake Wivenhoe.

Detailed information regarding the current operational monitoring program and the procedures required for its implementation are found in the following documents:

- *Draft Catchment Water Quality Monitoring Program* (PLN-00035);
- *Water Sample Collection, Storage and Preservation Procedure* (PRO-00296);
- *YSI Operation and Maintenance Procedure* (PRO-00291);
- *VPS Operation and Maintenance Procedure* (PRO-00720);
- *Determination of Algal Sample Frequency Procedure* (PRO-00292);
- *Operation and Maintenance of Weather Stations Procedure* (PRO-00626);
- *Routine Sampling Procedure* (PRO-00295);
- *Water Quality Event Monitoring Program* (MAN-00008);
- *Water Sample Delivery Procedure* (PRO-00293);
- *Sampling and Analysis Quality Control Procedure* (PRO-00706);
- *Environmental Database Operation Procedure* (PRO-00735);
- *Draft Wivenhoe HACCP Plan* (HACCP Plans Folder);
- *Draft Somerset HACCP Plan* (HACCP Plans Folder);
- *Draft Lockyer and Mid-Brisbane HACCP Plan* (HACCP Plans Folder);
- *Draft HACCP Verification and Validation Schedule* (HACCP General Folder);
- *Draft Water Quality Sampling Calendar* (PLN-00054); and
- *Draft Inter-Catchment WQ Monitoring and Research* (Monitoring Plan Folder).

7.1.2 Critical Control Points

For typical HACCP-type systems, monitoring plays a key role in risk management; however, for monitoring catchments, the focus shifts from reliance on end-product compliance testing verification to targeted verification and operational monitoring of Critical Control Points (CCPs) within the system. CCPs are illustrated on the *Draft HACCP Wivenhoe, Somerset, and Lockyer Mid-Brisbane Sampling Sites Maps* (HACCP Plans Folders). CCP critical limits, alerts and corrective actions are identified in the following HACCP Plans:

- *Draft Wivenhoe HACCP Plan* (HACCP Plans Folder);
- *Draft Somerset HACCP Plan* (HACCP Plans Folder); and
- *Draft Lockyer and Mid-Brisbane HACCP Plan* (HACCP Plans Folder).

A summary of the trigger values is also available in the *Draft HACCP Customer Trigger Values Table* (HACCP General Folder). The CCPs were identified in accordance with the following definition, which will be available on Seqwater's new intranet (by 2011):

> *The Critical Control Points (CCPs) are locations at which effective control of water quality is achievable, in particular for those parameters with direct or indirect effects on health of consumers.*

Based on this definition, the CCPs all correspond to the customer offtake points. Because the CCP trigger values relate to the ability to treat raw water at a particular downstream WTP, they have been set by negotiation with the treatment plant operators. Hence, the limits at each offtake vary. Details of discussions with the treatment plant operators are recorded in the *Draft HACCP Customer Liaison Register* (HACCP General Folder). For details regarding the ability of a WTP to treat raw water of a certain quality downstream, the respective WTP management plans must be referred to, as described in Section 6.1.

If a trigger level is exceeded, customers are contacted as directed in the HACCP Plans described above. For other issues and contact with external stakeholders, the *Draft Wivenhoe System Communication Procedure* (PRO-00708) is followed.

7.1.3 Monitoring Program Review

Seqwater is currently undertaking a review of the current monitoring program (see *Draft Catchment Water Quality Monitoring Program*; PLN-00035). The revised *Catchment Water Quality Monitoring Program* is expected to be implemented by March 2011. The current review is:

- → Validating the scale and scope of monitoring for the Wivenhoe system, and identifying data and management gaps;
- → Assessing data collection methods and data compatibility;
- → Reviewing changes and requirements of quality assurance programs (i.e. HACCP) as part of the current restructuring processs within Seqwater;
- → Aligning the new monitoring program with the principles and recommendations of the ADWG (2004);
- → Incorporating the principles of the NWQMS and the *Environmental Protection (Water) Policy 1997* in the establishment and maintenance of the EVs and WQOs.
- → Aligning the new monitoring program with the regulatory requirements of the *Draft Moreton Resource Operations Plan* (LEG-00058) for water quality;
- → Incorporating other requirements of the WDWQMP; and
- → Reviewing all associated procedures, documentation and reporting mechanisms (e.g. existing HACCP Plans will be incorporated into the *Draft Catchment Water Quality Monitoring Program*; PLN-00035).

7.1.4 Monitoring of Purified Recycled Water

Following commissioning of PRW returns into Lake Wivenhoe, regular monitoring of PRW water quality will be conducted by Veolia (under operational contract for WaterSecure) at Bundamba, Luggage Point and Gibson Island AWTPs. WaterSecure will also monitor conductivity, turbidity, ORP (Lowood balance tank only), temperature, Total Chlorine and pH online at the PRW risk transfer point (see Figure 11). Chlorine will also be monitored prior to de-chlorination at Lowood. WaterSecure will provide monitoring data to Seqwater on a quarterly basis (see *Seqwater-WaterSecure Operating Protocol*, PRO-00381; also see *Draft Wivenhoe System Communication Procedure*, PRO-00708).

WaterSecure (or its Scheme Manager on its behalf) will also use its best endeavours to notify Seqwater on a monthly basis of rolling annual 50th percentile limits (calculated monthly), and will notify Seqwater within 24 hours if the notification triggers in the *PRW Quality and Notifications Trigger Table* (WaterSecure) (Table 4) have been reached (see *Seqwater-WaterSecure Operating Protocol*, PRO-00381; also see *Draft Wivenhoe System Communication Procedure*, PRO-00708).

Critical to the process of defining the relative impacts of PRW and catchment inflows will be the establishment of event monitoring stations at major inflow locations on Lake Wivenhoe and the Mid-Brisbane River (see *Draft Event Sampling Procedure*; PRO-00678). Current monitoring encompasses major inflow locations on the Brisbane River and at Lockyer Creek on the Mid-Brisbane River. Additional sites are also under consideration for the Stanley River inflow from Lake Somerset, and for Coal and Candle Creeks along the lower western flank of Lake Wivenhoe. Measurements from these stations are expected to allow characterisation of inflow events, including PRW returns into Lake Wivenhoe. Parallel studies on catchment runoff water quality relative to catchment land uses and treatment by riparian buffer zones are expected to complement this ongoing *Water Quality Event Monitoring Program*.

Table 4 *PRW Quality and Notifications Trigger Table* (WaterSecure).

Parameter	PRW Quality Standard	Notification Trigger
Hardness as CaCO	50 to 125 mg/L	
Alkalinity	40 to 100 mg/L	Rolling annual 50th percentile value outside range
Turbidity	2 NTU	Rolling annual 50th percentile value above standard
Total Nitrogen 5 years after commencement of Proving Period	1.5 mg/L	Rolling annual 50th percentile value above standard
Total Phosphorous	0.15 mg/L	Rolling annual 50th percentile value above 0.02 mg/L
pH Range	6.5–8.5	Rolling annual 50th percentile value outside range
Total Dissolved Solids (TDS) **Maximum**	250 mg/L	Rolling annual 50th percentile value above standard
Manganese	‹0.05 mg/L	N/A
Copper	‹0.05 mg/L	N/A
Boron	‹0.37 mg/L	N/A
Aluminium	‹0.1 mg/L	N/A
Zinc	‹0.1 mg/L	N/A
Total Chlorine	No measurable residual	Daily average Total Chlorine ›0.2 (maximum)
Schedule 3B Public Health Regulation (2005)	No health standard exceeded	Any reported result in PRW exceeding health standard (maximum)

Seqwater will use its best endeavours to provide advice to WaterSecure within a reasonable timeframe on the likely fate after dispersion into Lake Wivenhoe of any parameter that has exceeded a health standard in Schedule 3B of the *Public Health Regulation 2005* (QLD) (LEG-00068) (see *Draft Wivenhoe System Communication Procedure*, PRO-00708; also see *Seqwater-WaterSecure Operating Protocol*, PRO-00381).

The accuracy and sensitivity of the 3D-hydrodynamic model for Lake Wivenhoe is improving; therefore it is able to provide increasingly reliable predictions of hydrodynamic and temperature variations in the lake. The model is also assisting in predicting the effects of planned or possible events including scenario testing of PRW returns and other inflows; e.g. identification and 'tracking' of inflows. Inflows to the lake do not disperse evenly, but travel defined paths. Modelling this type of information allows implementation of targeted preventive measures.

7.2 Corrective Actions

If operational monitoring reveals an exceedance, then the following procedures enable rapid reporting to customers and communication with other stakeholders:

- *Incident and Emergency Response Plan* (ERP-00001);
- *Draft Wivenhoe System Communication Procedure* (PRO-00708);
- *Review, Distribution and Reporting of Water Quality Test Results Procedure* (PRO-00290);
- *Draft HACCP Water Quality Reporting Procedure* (PRO-00294);
- *Issue Notification and Response Procedure* (PRO-00003);
- *Draft Public Area Closure Operational Procedure* (PRO-00719); and

- *Draft Public Warning of Blue Green Algae Procedure* (ERP-00016).

Implementation of these procedures is supported by the following documents:

- *Draft Wivenhoe HACCP Plan* (HACCP Plans Folder);
- *Draft Somerset HACCP Plan* (HACCP Plans Folder);
- *Draft Lockyer and Mid-Brisbane HACCP Plan* (HACCP Plans Folder);
- *Draft HACCP Verification and Validation Schedule* (HACCP General Folder);
- *Draft Water Quality Sampling Calendar* (PLN-00054);
- *Draft HACCP Product Specification Statement* (HACCP General Folder);
- *Draft HACCP Customer Trigger Limits Table* (HACCP General Folder);
- *Draft HACCP Records* (HACCP General Folder); and
- *Draft HACCP Customer Liaison Register* (HACCP General Folder).

The *Review, Distribution and Reporting of Water Quality Test Results Procedure* (PRO-00290) and the *Draft HACCP Water Quality Reporting Procedure* (PRO-00294) further assist operational control and the management of downstream processes (see Section 7.3).

As well as reactively responding to limit exceedances, Seqwater proactively reviews the catchment operational monitoring data to ensure the preventive measures are performing. Benchmark Draft WQOs have also been defined from the historical water quality monitoring database (Section 4.3.2). These results have been compared to estimates of the water quality of PRW returns and with other inflows, to identify potential changes to water quality in the lake.

Summaries of the proposed local WQOs for the Drinking Water Supply and Aquatic Ecosystem EVs for the Wivenhoe system are provided in Tables 5–7. These values are derived from guidelines and background levels, and will be used as trigger values. If a trigger value is exceeded, an immediate management response is required.

On the basis of these benchmark system assessments, where an indicator is below the threshold value or within the desirable range for its trigger value in a particular waterway, the risk to the protection of the environmental value is low[8]. Where an indicator is higher than the threshold value or outside the desirable range for its trigger value in a particular waterway, there may be a risk that the environmental value will not be protected. This may 'trigger' either:

- Immediate action to address the likely causes of the value not being met, or
- Further investigation to determine whether the trigger value is too conservative for local conditions or the local conditions influence the ambient levels and toxicity of the contaminant of concern.

In practice, it will often be most cost-effective (and precautionary) to take immediate action to address the causes of exceeding a trigger value, and maintain or restore the environmental values.

Where inflows are occurring, it is also possible to extrapolate the likely effect on water quality on the basis of the historical data, and to use predictive modelling. This allows rapid appreciation of the likely impacts and adoption of a pre-emptive response rather than a reactive one. For example, when a rainfall event occurs in the catchment, the immediate impact is a rise in stream levels and velocities. Based on past records of impacts from such inflows on nutrient levels or other water quality indicators, the potential impacts can be modelled and predicted.

[8] Department of Environment and Conservation NSW, 2008 Using the ANZECC Guidelines and Water Quality Objectives in NSW.

Table 5 Summary of proposed local WQOs for the Drinking Water Supply and Aquatic Ecosystem EVs for Lake Wivenhoe.

Indicator	Proposed Local WQO for Aquatic Ecosystem	Proposed Local WQO for Drinking Water Supply	Basis for WQO	Method for assessing compliance with WQO
DO (% sat)	90-110	Not Applicable	20/80 percentile of historical data	Median of previous twelve (monthly) sample data compared to WQO
Ammonia (mg/L)	0.025		80 percentile of historical data; aspirational element	Median of previous twelve (monthly) sample data compared to WQO
Total Nitrogen (mg/L)	0.5		80 percentile of historical data; aspirational element	Median of previous twelve (monthly) sample data compared to WQO
Nitrogen Oxides (mg/L)	0.01		80 percentile of historical data	Median of previous twelve (monthly) sample data compared to WQO
Total Phosphorous (mg/L)	0.025		80 percentile of historical data	Median of previous twelve (monthly) sample data compared to WQO
Filterable Reactive Phosphorous (mg/L)	0.004		80 percentile of historical data; aspirational element	Median of previous twelve (monthly) sample data compared to WQO
Chlorophyll a (µg/L)	Annual WQO: 9 µg/L Summer WQO: 13		Aspirational element	Median of previous twelve (monthly) sample data compared to WQO Summer WQO: Median of (monthly) sample data for summer compared to WQO
Sp. Conductivity (µS/cm)	417	475	Aquatic Ecosystem: 75 percentile of historical data DWS: 95 percentile of historical data Appendix G of QWQG	Median of sample data compared to WQO for Aquatic Ecosystem 95 percentile value from sample data compared to WQO for Drinking Water Supply
Turbidity (NTU)	6	18	Aquatic Ecosystem: 80 percentile of historical data DWS: 95 percentile of historical data	Median of sample data compared to WQO for Aquatic Ecosystem 95 percentile value from sample data compared to WQO for Drinking Water Supply
E.Coli (CFU/100mL)	Not Applicable	24	95 percentile of log transformed historical data	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
Coliforms (CFU/100mL)		800	HACCP	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference

Indicator	Proposed Local WQO for Aquatic Ecosystem	Proposed Local WQO for Drinking Water Supply	Basis for WQO	Method for assessing compliance with WQO
DO (mg/L)	Not Applicable	7.8/10.3	20/95 percentile value from historical data	20/95 percentile value from previous twelve (monthly) sample data compared to WQO
Suspended Solids (mg/L)		10	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Total Manganese (mg/L)		0.18	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Dissolved Manganese (mg/L)		0.046	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Dissolved Iron (mg/L)		0.075	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Total Algal Count (cells/mL)		31 500	95 percentile of historical data	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
Total Cyanophytes (cells/mL)		201 000	95 percentile of historical data	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
MIB (ng/L)		10	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
True Colour (Hazen Units)		21	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Cylindrospermopsis raciborskii (cells/mL)		52 000	95 percentile of historical data	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
Toxic Species (mm3/L)		0.62	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Microsystis Aeruginosa (cells/mL)		2200	95 percentile of historical data	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
Geosmin (ng/L)		2.5	95 percentile from historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO

Table 6 Summary of proposed local WQOs for the Drinking Water Supply and Aquatic Ecosystem EVs for Lake Somerset.

Indicator	Proposed Local WQO for Aquatic Ecosystem	Proposed Local WQO for Drinking Water Supply	Basis for WQO	Method for assessing compliance with WQO
DO (% sat)	83-108	Not Applicable	20/80 percentile of historical data	Median of previous twelve (monthly) sample data compared to WQO
Ammonia (mg/L)	0.025		80 percentile of historical data; aspirational element	Median of previous twelve (monthly) sample data compared to WQO
Total Nitrogen (mg/L)	0.5		80 percentile of historical data; aspirational element	Median of previous twelve (monthly) sample data compared to WQO
Nitrogen Oxides (mg/L)	0.01		80 percentile of historical data	Median of previous twelve (monthly) sample data compared to WQO
Total Phosphorpous (mg/L)	0.030		80 percentile of historical data;	Median of previous twelve (monthly) sample data compared to WQO
Filterable Reactive Phosphorous (mg/L)	0.005		80 percentile of historical data; aspirational element	Median of previous twelve (monthly) sample data compared to WQO
Specific Conductivity (µS/cm)	278	475	Aquatic Ecosystem: 75 percentile of historical data DWS: 95 percentile of historical data Appendix G of QWQG	Median of sample data compared to WQO for Aquatic Ecosystem 95 percentile value from sample data compared to WQO for Drinking Water Supply
Turbidity (NTU)	10	22	Aquatic Ecosystem: 80 percentile of historical data DWS: 95 percentile of historical data	Median of sample data compared to WQO for Aquatic Ecosystem 95 percentile value from sample data compared to WQO for Drinking Water Supply
E.Coli (CFU/100mL)	Not Applicable	60	HACCP	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
Total Coliforms (CFU/100mL)		800	HACCP	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
Dissolved Oxygen (mg/L)		7.1/10.3	20/95 percentile value from historical data	20/95 percentile value from previous twelve (monthly) sample data compared to WQO

Indicator	Proposed Local WQO for Aquatic Ecosystem	Proposed Local WQO for Drinking Water Supply	Basis for WQO	Method for assessing compliance with WQO
Suspended Solids (mg/L)	Not Applicable	10	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Total Manganese (mg/L)		0.14	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Dissolved Manganese (mg/L)		0.01	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Dissolved Iron (mg/L)		0.14	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Total Algal Count (cells/mL)		375 000	95 percentile of log transformed historical data	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
Total Cyanophytes (cells/mL)		307 000	95 percentile of log transformed historical data	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
MIB (ng/L)		0	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
True Colour (HU)		35	95 percentile from historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Cylindrospermopsis raciborskii (cells/mL)		38 000	95 percentile of log transformed historical data	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
Toxic Species (mm3/L)		1.1	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Microsystis Aeruginosa (cells/mL)		3370	95 percentile of log transformed historical data	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
Geosmin (ng/L)		0	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO

Table 7 Summary of proposed local WQOs for the Drinking Water Supply and Aquatic Ecosystem EVs for Mid-Brisbane River.

Indicator	Proposed Local WQO for Aquatic Ecosystem (Slightly to Moderately Disturbed)	Proposed Local WQO for Drinking Water Supply	Basis for WQO	Method for assessing compliance with WQO
DO (% sat)	88/106	Not Applicable	20/80 percentile of historical data	Percentiles from previous twelve (monthly) sampling data compared to WQO
Ammonia (mg/L)	0.010		80 percentile of historical data; slight aspirational element	Percentiles from previous twelve (monthly) sampling data compared to WQO
Total Nitrogen (mg/L)	0.50		80 percentile of historical data; slight aspirational element	Percentiles from previous twelve (monthly) sampling data compared to WQO
Nitrogen Oxides (mg/L)	0.062		80 percentile of historical data; slight aspirational element	Percentiles from previous twelve (monthly) sampling data compared to WQO
Total Phosphorous (mg/L)	0.028		80 percentile of historical data; slight aspirational element	Percentiles from previous twelve (monthly) sampling data compared to WQO
Filterable Reactive Phosphorous (mg/L)	0.006		80 percentile of historical data; slight aspirational element	Percentiles from previous twelve (monthly) sampling data compared to WQO
Chlorophyll a (µg/L)	5.5		80 percentile of historical data; slight aspirational element	Percentiles from previous twelve (monthly) sampling data compared to WQO
pH	7.75/8.2		20/80 percentile of historical data;	Percentiles from previous twelve (monthly) sampling data compared to WQO
Specific Conductivity (µS/cm)	418 (75 percentile)	503	Aquatic Ecosystem: See app.G- 75 percentile from long term data DWS: 95 percentile	Percentiles from previous twelve (monthly) sampling data compared to WQO for Aquatic Ecosystem 95 percentile value from sample data compared to WQO for Drinking Water Supply

Indicator	Proposed Local WQO for Aquatic Ecosystem (Slightly to Moderately Disturbed)	Proposed Local WQO for Drinking Water Supply	Basis for WQO	Method for assessing compliance with WQO
Turbidity (NTU)	4.9	15.1	Aquatic Ecosystem:80 percentile of historical data and slight aspirational element DWS: 95 percentile of historical data	Percentiles from previous twelve (monthly) sampling data compared to WQO for Aquatic Ecosystem 95 percentile value from sample data compared to WQO for Drinking Water Supply
E.Coli (CFU/100mL)	Not Applicable	60	HACCP	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
Coliforms (CFU/100mL)		800	HACCP	95 percentile value from previous twelve (monthly) sample data compared to WQO
DO (mg/L)		7.2/10.9	20/95 percentile value from historical data	20/95 percentile value from previous 12 (monthly) sample data compared to WQO
Suspended Solids (mg/L)		27.4	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Total Manganese (mg/L)		0.12	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Total iron		0.6	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO
Total Algal Count (cells/mL)		48500	95 percentile of historical data	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
Total Cyanophytes (cells/mL)		90 000	95 percentile of historical data	Logged 95 percentile value from previous twelve (monthly) sample data compared to logged WQO- exceedance indicated by more than 1 log value difference
True Colour (Hazen Units)		21	95 percentile of historical data	95 percentile value from previous twelve (monthly) sample data compared to WQO

7.3 Operational Controls

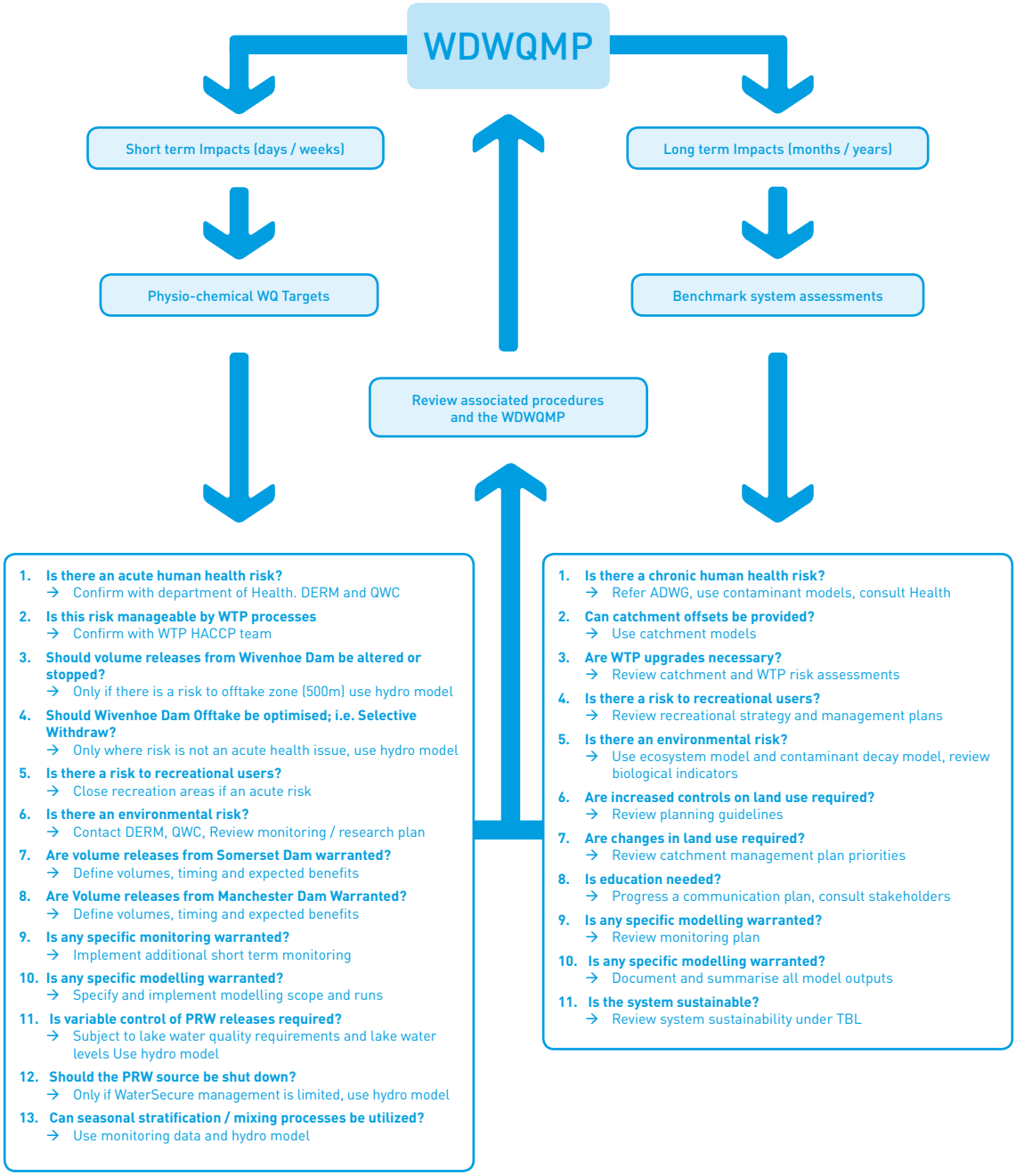
Management of the Wivenhoe system and operation of Wivenhoe Dam are given the upmost priority within Seqwater. All employees are appropriately trained to fulfil their duties. Operational procedures for the Wivenhoe system are listed below and are available on the *Q-Pulse Database* (see *Users Guide to Q-Pulse*; PRO-00031) and will also be available on Seqwater's new intranet (by 2011). The key operational controls for the management of the Wivenhoe system are as follows:

- *Recreation Management Framework* (PLN-00113) (and supporting documents; Community Involvement Folder);
- *Draft Catchment Water Quality Monitoring Program* (PLN-00035);
- *Operation and Maintenance of Weather Stations Procedure* (PRO-00626);
- *Event Station Maintenance Technical Manual* (MAN-00009);
- *Draft Operation and Maintenance Manuals for Wivenhoe Dam* (see *Draft Dams Operations and Maintenance 1.1 How to use this Manual*; Operational Controls Folder, and for the complete set of documents refer to Peter Allen, Director of Dam Safety, DERM);
- *Draft Operation and Maintenance Manuals for Somerset Dam* (see *Draft Dams Operations and Maintenance 1.1 How to use this Manual*; Operational Controls Folder, and for the complete set of documents refer to Peter Allen, Director of Dam Safety, DERM);
- *Draft Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam and Somerset Dam* (refer to Peter Allen, Director of Dam Safety, DERM);
- *Draft Procedure for Determining Routine Releases of Water from Wivenhoe Dam* (PRO-00713);
- *Wivenhoe Dam–Draft Standing Operating Procedures Manual* (MAN-00028) (Operational Controls Folder);
- *Somerset Dam–Draft Standing Operating Procedures Manual* (MAN-00024) (Operational Controls Folder);
- *Draft Operations Raw Water Intake Closure Procedure* (PRO-00718);
- *Draft Emergency Action Plan–Wivenhoe Dam (Infrastructure)* (PLN-00058); and
- *Draft Emergency Action Plan–Somerset Dam (Infrastructure)* (PLN-00055) (Emergency Actions Plans Folder).

In addition, record keeping of all event station activities is essential for tracing back to significant events or to problems that may not be immediately apparent at the time they are recorded. Not all unforseen problems can be documented; nevertheless, by instituting a rigorous record keeping procedure, many of the common problems can be resolved. All activities (e.g. event sampling, maintenance) are recorded on field sheets and stored in the appropriate event station folders.

Questions and answers to guide decision making for water quality events (i.e. short term impacts), and for interpreting the results of the benchmark system assessments (i.e. long term impacts), is provided in Figure 14.

Figure 14 Questions and answers to guide decision making for water quality events, and for interpreting the results of benchmark assessments.



7.4 Supporting Programs

Seqwater continues to implement a series of management and risk framework-based programs to support operational monitoring; these include monitoring and managing the water quality for specific locations and activities. These programs and associated management plans are essential for identifying and mitigating changes to water quality at key sources in the Wivenhoe system. The key supporting programs are listed below.

Storage and Catchment Risk Assessments

- *Catchment and Water Quality Risk Assessment for Mid-Brisbane River (2008)* (RSK-00017); and
- *Catchment and In-Storage Water Quality Risk Assessment (2007)* (RSK-00018).

Emergency Action Plans for Water Quality

- *Draft Emergency Action Plan for Water Quality–Wivenhoe Dam & Catchment* (ERP-00015);
- *Draft Emergency Action Plan for Water Quality–Somerset Dam and Catchment* (ERP-00017);
- *Emergency Action Plan for Water Quality–Mid-Brisbane and Catchment* (PLN-00007); and
- *Draft Recreational Water Quality Emergency Preparedness and Response Procedure* (ERP-00018).

Recreational Management Plans

- *Recreation Management Framework* (POL-00029) (and supporting documents; Community Involvement Folder).

Research Plan

- *Seqwater Research Plan (2009-12)* (PLN-00024) (see Section 12).

Recycled Water Management Plans

- WCRWP Scheme RWMPs (see www.westerncorridor.com.au, LEG-00097; and Section 6.1).

Land Use Planning and Regulations

- *Draft Water Source Protection Plan (2008)* (PLN-00018); and
- *Development Guidelines for Water Quality Management in Drinking Water Catchments (2008)* (GDE-00001).

Downstream Drinking Water Quality Management Plans

- *Draft WTP Drinking Water Quality Management Plan* (PLN-00004) (see Section 6.1).

7.5 Equipment Capability and Maintenance

Ensuring the capability of equipment is a necessary part of process control for a drinking water supply system. Equipment (and infrastructure) need to be adequately designed and of sufficient capacity (e.g. size, volume, deployment time) to handle all flow rates (peak and otherwise) without limiting equipment performance.

As a result of the institutional reforms, Seqwater has been given a significant infrastructure portfolio. An asset condition assessment (see *WDWQMP Improvement Plan*; Appendix H) is being undertaken to ascertain the current status of the equipment, and its capability to provide drinking water now and into the future. The outcome of this process has been the development of a capital expenditure program, which prioritises expenditure to ensure the continued safe supply of drinking water to the ADWG (2004) standard. The Wivenhoe Dam structure and equipment used in the operation of the water storage is strictly monitored and maintained in accordance with the requirements of the *Water Supply (Safety and Reliability) Act 2008* (LEG-00074). These requirements are identified in the *Compliance*

Obligations Register (REG-00181). The following documents have been prepared to ensure the equipment is maintained appropriately:

- *Operation and Maintenance of Weather Stations Procedure* (PRO-00626);
- *Draft Operation and Maintenance Manuals for Wivenhoe Dam* (see *Draft Dams Operations and Maintenance 1.1 How to use this Manual*; Operational Controls Folder, and for the complete set of documents refer to Peter Allen, Director of Dam Safety, DERM);
- *Draft Operation and Maintenance Manuals for Somerset Dam* (see *Draft Dams Operations and Maintenance 1.1 How to use this Manual*; Operational Controls Folder, and for the complete set of documents refer to Peter Allen, Director of Dam Safety, DERM);
- *YSI Operation and Maintenance Procedure* (PRO-00291);
- *VPS Operation and Maintenance Procedure* (PRO-00720); and
- *Event Station Maintenance Technical Manual* (MAN-00009.

7.6 Materials and Chemicals

The selection of materials and chemicals used in water systems is important as they have the potential to adversely affect drinking water quality. There is no active treatment of water in Lake Wivenhoe; any water quality enhancement is from the ecological processes in the storage.

However, glyphosate herbicides are used to control weeds in the water storage. The herbicides are applied in accordance with the *Job Analysis Procedures* (see *WDWQMP Improvement Plan*; Appendix H). The ADWG (2004) states a guideline drinking water value of 0.01 mg/L and a health value of 1 mg/L. The risk of exceeding these values is very low at the concentrations that the herbicides are used.

A risk assessment is undertaken before commencing any maintenance or operational activity to minimise the potential for raw water contamination.

Only chemicals and materials that are purchased in accordance with the *Procurement Policy* (POL-00026) are used in the maintenance of Lake Wivenhoe and Wivenhoe Dam. These will also be listed on the *Preferred Suppliers Register* (see *WDWQMP Improvement Plan*; Appendix H), All activities are undertaken in such as way as to minimise potential contamination of the water storage, as specified in the associated *Job Analysis Procedures* (see *WDWQMP Improvement Plan*; Appendix H). In the case of glyphosate, for instance, actual use is precluded by a risk assessment, and then its application is monitored so as to meet best practice requirements and to confirm that guideline trigger levels have not been exceeded. Over the 2008-09 weed treatment season, this approach has maintained glyphosate levels well below guidance requirements.

8. Verification of Drinking Water Quality

8.1 Verification Programs

The scope of this plan is the collection, storage and release of raw water from the Wivenhoe system to the WTPs. Verification of drinking water quality in the distribution network is therefore not within the scope of this plan. Verification of drinking water quality within the distribution network is the responsibility of LinkWater and Local Authority retail entities, and will be covered in the downstream DWQMPs, as identified in Section 6.1. However, the quality of raw water at the offtake points is monitored under the operational monitoring program (see Section 7.1), and is undertaken in accordance with the *Draft HACCP Verification and Validation Schedule* (HACCP General Folder).

Key programs for verification of raw water quality include:

- Catchment modelling;
- Daily, monthly and annual circulation modelling;
- Regular review of sediment contamination;
- Targeted nutrient monitoring and flux assessment;
- Detention and dilution estimates at dam offtake;
- Regular assessment of fish bioaccumulation;
- Passive sampling for CoC;
- Toxicity testing using bioassays; and
- *Monthly Water Quality Reports*.

8.2 Customer Satisfaction

Monitoring of consumer comments and complaints can provide valuable information on potential problems that may not have been identified by performance monitoring of the water supply system. Satisfaction with drinking water quality by consumers is largely based on a judgment that the aesthetic quality of tap water is 'good', which usually means that it is colourless, free from suspended solids, and has no unpleasant taste or odour.

Seqwater has no direct relationship with the consumer, and consumer complaints will be handled by the water retail entities. However, downstream water service providers will refer consumer complaints that may be a result of raw water quality to Seqwater. These will be handled through the *Issue Notification and Response Procedure* (PRO-00003).

Customer complaints regarding raw water quality are covered by the WDWQMP. In the context of this plan, the majority of the customer base comprises the WGM and Seqwater's own downstream WTPs. The WGM will provide feedback and complaints on the service provided.

A water quality specification has been established for each WTP that is supplied raw water, based on its treatment capacity, and these are shown in the *Draft HACCP Customer Trigger Limits Table* (HACCP General Folder). Where a complaint is received from a WTP regarding out of specification water, this is managed under the *Issue Notification and Response Procedure* (PRO-00003).

All customer correspondence is retained in accordance with the *Draft Wivenhoe System Communication Procedure* (PRO-00708).

8.3 Short Term Evaluation of Results

Short term performance evaluation entails the daily review of drinking water quality monitoring data and consumer satisfaction, to verify that the quality of water supplied to consumers conforms with the guideline values.

Details of operational monitoring are provided in Section 7.1. The monitoring program includes real-time monitoring of water quality as well as laboratory analyses. Results of the laboratory analyses are reviewed in accordance with the *Draft HACCP Water Quality Reporting Procedure* (PRO-00294).

9. Management of Incidents and Emergencies

Although preventive strategies are intended to prevent incidents and emergency situations, some events cannot be anticipated or controlled, or have such a low probability of occurring that providing preventive measures is cost prohibitive. For such events, there must be an adaptive capability to respond constructively and efficiently.

Considered and controlled responses to incidents and emergencies are essential for protecting public health as well as for maintaining consumer confidence and the organisation's reputation. The *SEQ Water Grid–Emergency Response Plan* (ERP-00014) is the overarching Emergency Response Plan for the Water Grid; it coordinates an effective response to emergencies across the Grid. The plan has been developed in accordance with *The Market Rules–SEQ Water Market* (LEG-00076) and it specifies the emergency reporting requirements, and the escalation and response protocols that the Water Grid Participants must follow. Each participant has its own internal Emergency Response Plan (see *Incident and Emergency Response Plan*; ERP-00001), which provides specific details on incident management and asset recovery procedures. At least once each year, all Emergency Response Plans must be reviewed against the requirements of the *SEQ Water Grid Emergency Response Plan* (ERP-00014).

Management of incidents and emergencies is given the highest priority by Seqwater. The *Incident and Emergency Response Plan* (ERP-00001) lays the foundation for a comprehensive whole of business response to emergency events, and demonstrates how the response processes align to the requirements of the WGM. The plan includes definitions on the severity of incident levels on a scale of 1 (least severe) to 5 (most severe), which are consistent with the *SEQ Water Grid Emergency Response Plan* (ERP-00014) and associated reporting procedures. Level 1 and 2 incidents are small scale events that do not typically have broader impacts and therefore are managed in accordance with Seqwater's *Incident and Emergency Response Plan* (ERP-00001). Level 3, 4 and 5 incidents can be expected to have broader impacts, and their management is subject to the requirements of the *SEQ Water Grid–Emergency Response Plan* (ERP-00014), including a compulsory requirement to report such incidents to and liaise with the WGM and other government agencies (e.g. DERM, Queensland Health, emergency services) as required.

For the management of the Wivenhoe system, there are two main categories of incidents and emergencies that can occur, as outlined below:

1. Direct impacts on water supply; i.e. Water Quality, Water Asset Failure, Water Quantity, and Security and Natural Disasters. For example, a blue-green algae bloom or major turbidity event whereby use of the supply source needs to be reduced (Level 2 incident), or a dam wall breach or where major works are required to re-establish water supply (Level 3 incidents).
2. Ancillary impacts associated with water supply; i.e. Health and Safety of Employees or Public, Environment, and Public Reassurance. For example, exceedance of a discharge licence whereby the discharge is likely to make its way into the drinking water source (Level 3 incident), or where a rapid decline in ecosystem health is expected to result in long term environmental impacts with the potential to affect water supply or cause adverse national or international attention (Level 5 incidents).

Seqwater documents that prescribe the management of incidents and emergencies as well as preparedness, communication and reporting procedures are as follows:

- *Incident and Emergency Response Plan* (ERP-00001);
- *Draft Wivenhoe System Communication Procedure* (PRO-00708);
- *Determination of Algal Sample Frequency Procedure* (PRO-00292);
- *Draft Emergency Action Plan for Water Quality–Somerset Dam and Catchment* (ERP-00017);
- *Draft Emergency Action Plan for Water Quality–Wivenhoe Dam and Catchment* (ERP-00015);
- *Emergency Action Plan for Water Quality–Mid-Brisbane and Catchment* (PLN-00007);

9. Management of Incidents and Emergencies (continued)

- *Emergency Action Plan–Wivenhoe Dam (Infrastructure)* (PLN-00058);
- *Emergency Action Plan–Somerset Dam (Infrastructure)* (PLN-00055);
- *Issue Notification and Response Procedure* (PRO-00003);
- *Draft Operations Raw Water Intake Closure Procedure* (PRO-00718);
- *Draft Public Area Closure Operational Procedure* (PRO-00719);
- *Safety-Emergency Procedures Manual* (MAN-00006);
- *Issue Notification Form* (FRM-00001);
- *Seqwater Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam* (refer to Peter Allen, Director of Dam Safety, DERM);
- *Seqwater Manual of Operational Procedures for Flood Mitigation for Somerset Dam* (refer to Peter Allen, Director of Dam Safety, DERM); and
- *Draft Recreational Water Quality Emergency Preparedness and Response Procedure* (ERP-00018).

Response and recovery plans have been developed in consultation with the relevant regulatory authorities and other key agencies. Dam (Infrastructure) Emergency Action Plans are written as a requirement of the *Queensland Water Act (2000)* (LEG-00025), and in consultation with the OWSR. HACCP and Water Quality Emergency Action Plans are communicated to relevant stakeholders when required, including the WGM, local councils and recreational users; they are also a requirement under the ADWG (2004). In addition, Seqwater has recently established the 1300 SEQWATER phone-line for handling public and media enquiries.

10. Employee and Awareness Training

The knowledge, skills, motivation and commitment of employees and contractors ultimately determine success when operating a water supply system. It is vital that awareness, understanding and commitment to performance optimisation and continuous improvement are developed and maintained within the organisation.

Employees and contractors who are responsible for water quality must be appropriately skilled and trained in the management and operation of water supply systems, as their actions can have a major impact on drinking water quality and public health. Also, an understanding of drinking water quality management is essential for empowering and motivating employees to make effective decisions. At Seqwater, staff and contractors are included in the *Water Quality and HACCP Staff Induction* (TRA-00009) process. Records of this training are documented in the *Draft HACCP Staff Training and Awareness Register* (Staff Training and Awareness Folder). This training and awareness session fulfils the ADWG (2004) requirement that all employees of the drinking water supplier are aware of the following:

- Seqwater's *Water Quality Policy* (POL-00012);
- Characteristics of the water supply system and preventive strategies in place throughout the system;
- Regulatory and legislative requirements;
- Roles and responsibilities of employees and departments; and
- How their actions can impact on water quality and public health.

This is reinforced through regular awareness sessions, historically run every six months. Employees are encouraged to participate in the continual improvement of water quality through the improvement request process, now incorporated in the *Issue Notification and Response Procedure* (PRO-00003). *Monthly Water Quality Reports* are emailed to relevant staff and other stakeholders, and regular information bulletins, called 'INFORM', are also e-mailed to employees and placed on notice boards. All company documents, including policies and procedures, will also be available to employees on Seqwater's new intranet (by 2011). Staff training for incidents and emergencies is based on the *Incident Management Training Presentation* (TRA-00008) and is documented using the *Training Attendance and Outcome Form* (FRM-00043). Polices are placed on notice boards throughout the organisation to ensure employees are fully aware of them. Seqwater's Business Review Meetings are also used to communicate information via group meetings.

All staff are required to have appropriate experience and training to fulfil their role. Every role has a position description that specifies the required experience and training required for that role. Performance management processes (see *WDWQMP Improvement Plan*; Appendix H) are used to ensure that employees receive appropriate ongoing training throughout their career with Seqwater. All training is recorded on the employee's personal file.

These activities are reviewed and audited under the following certifications:

- *ISO 9001:2008 Quality Management Systems–Requirements* (LEG-00061);
- *ISO 14001 (2004) Environmental Management Systems* (LEG-00006);
- Codex HACCP;
- *AS/NZS 4801:2001 Occupational Health and Safety Systems* (LEG-00071); and
- Use of Seqwater's Approved Contractor Panel to ensure that hired contractors have received all necessary training and induction requirements, as documented under the panel approval processes (see *WDWQMP Improvement Plan*; Appendix H).

11. Community Involvement and Awareness

The catchments within the Wivenhoe system have a large number of stakeholders, and Seqwater plays a prominent role in setting and leading community (and customer) expectations for sustainable water quality management. Community consultation, involvement and awareness can have a major impact on public confidence in water supply and the organisation's reputation.

The confidence of communities and businesses in Seqwater's performance is integral to the *Corporate Strategic Plan (2009-10 to 2013-14)* (PLN-00019), and Seqwater engages directly with catchment partners and landholders to advocate and deliver water quality programs; Seqwater also invests in capacity building of various external stakeholder groups. The strategic plan lists Seqwater stakeholder groups, and the required stakeholder contribution for the successful implementation of the *Draft Land and Water Quality Strategy* (POL-00024).

The *Draft Water Source Protection Plan (2008)* (PLN-00018) details the community communication and education requirements for successful land management to achieve the water quality objectives, and it details priorities for raw water quality associated with farming and other land management activities in the catchment (see *Draft Action Plan for the Water Source Protection Plan*; PLN-00057).

Seqwater recognises that an effective communication program is a long term commitment, including both consultation and education, and that it should be designed to provide an active, two-way exchange of information. This ensures that the needs and expectations of stakeholders are understood and are being satisfied.

Decisions on drinking water quality that are made by a drinking water supplier and the relevant regulatory authorities must be aligned with the needs and expectations of consumers. A central goal for Seqwater is the ability to work closely with its employees, contractors, suppliers, customers and other stakeholders to develop and implement agreed initiatives. The *Draft Wivenhoe System Communication Procedure* (PRO-00708) has been developed to achieve this goal through communication of operational performance.

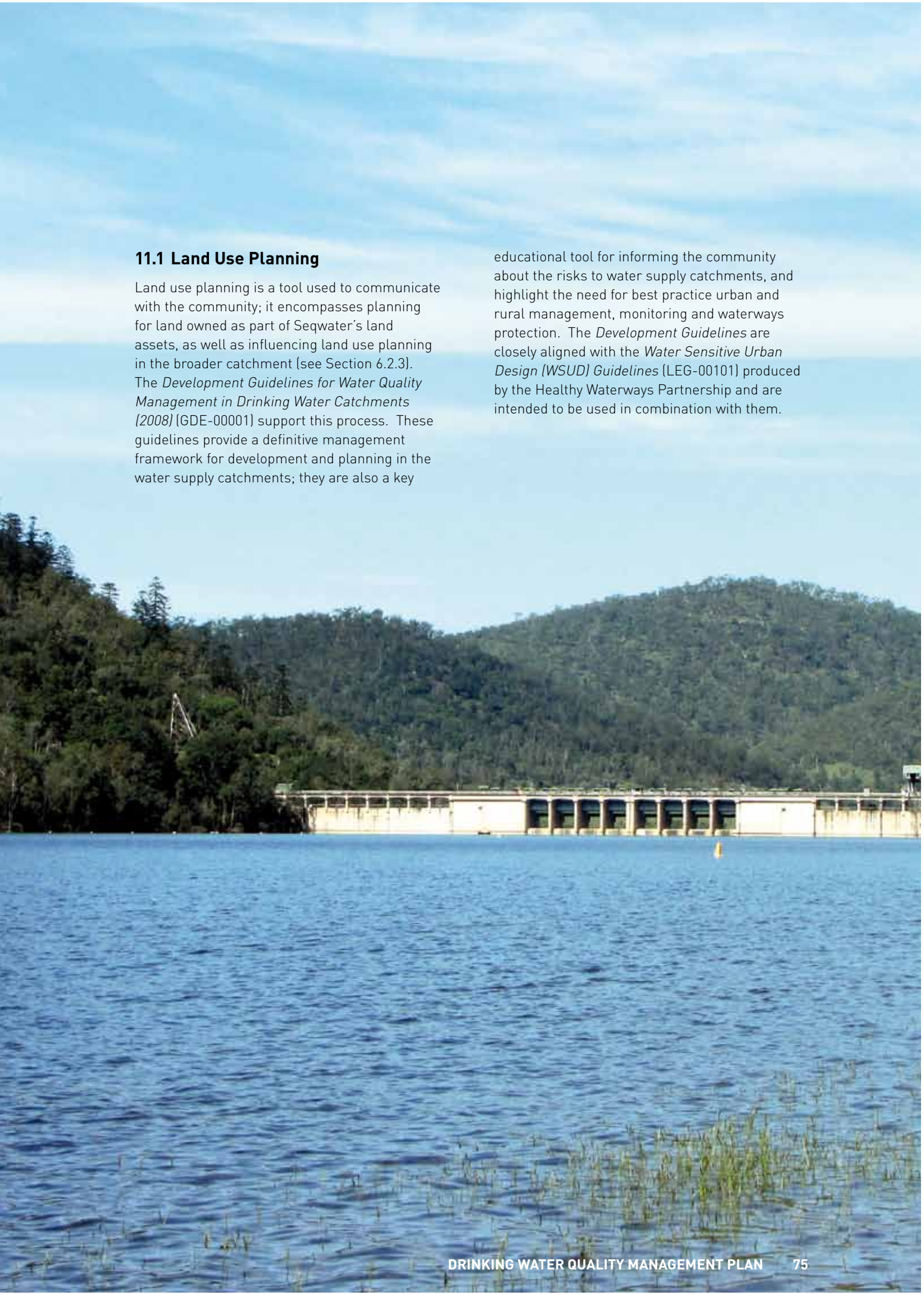
Education of and communication with the catchment community is an important management tool for Seqwater. Wivenhoe is an 'open' catchment and therefore the community and their activities in the catchment can significantly impact upon raw water quality. Effective communication to increase community awareness and knowledge of water quality issues and the various areas of responsibility is essential. Communication helps consumers to understand and contribute to decisions about the service provided and land-use constraints imposed in catchment areas. A thorough understanding of the diversity of views held by individuals in the community is necessary to satisfy community expectations. Community involvement and awareness in the management of Lake Wivenhoe and its catchment is implemented through the following:

- Information centre at Lake Wivenhoe;
- *Recreation Management Framework* (PLN-00113) (and supporting documents; Community Involvement Folder);
- The Seqwater website provides information on public activities, catchment and water quality, public notices, as well as current levels in storages;
- Wivenhoe Lessees Consultative Committee (meets quarterly);
- Informational displays at recreational areas;
- Information sessions are held for school and other community groups;
- Lessee newsletters, workshops and Catchment Advisory Groups;
- Support for catchment, Landcare and associated natural resource management groups; and
- Research partnerships (see Section 12.3).

Details of communications are retained by Seqwater in accordance with the *Draft Wivenhoe System Communication Procedure* (PRO-00708).

11.1 Land Use Planning

Land use planning is a tool used to communicate with the community; it encompasses planning for land owned as part of Seqwater's land assets, as well as influencing land use planning in the broader catchment (see Section 6.2.3). The *Development Guidelines for Water Quality Management in Drinking Water Catchments (2008)* (GDE-00001) support this process. These guidelines provide a definitive management framework for development and planning in the water supply catchments; they are also a key educational tool for informing the community about the risks to water supply catchments, and highlight the need for best practice urban and rural management, monitoring and waterways protection. The *Development Guidelines* are closely aligned with the *Water Sensitive Urban Design (WSUD) Guidelines* (LEG-00101) produced by the Healthy Waterways Partnership and are intended to be used in combination with them.



12. Research and Development

12.1 Research Strategy

Research is an ongoing activity that provides new knowledge by improving understanding of observed events as well as forecasting events. Research and development also provides innovative technologies and cost effective approaches to managing water quality in the lakes and surrounding catchment environs. The *Draft Land and Water Quality Strategy* (POL-00024) identifies the drivers, objectives and targets for water quality, and is a commitment to research and development to increase the understanding of the system. The main areas of research include the development and validation of:

- Circulation and mixing models;
- Ecosystem models and development of bioindicators;
- Passive samplers and bioaccumulation;
- Cyanobacterial growth and mitigation;
- Nutrient flux models;
- System benchmarking;
- Land use and water quality impacts;
- Climate change impacts; and
- Contaminant decay models.

These research areas are based on the requirements of the ADWG (2004), and the current and ongoing priorities established by the following risk assessments:

- *Catchment and In-Storage Water Quality Risk Assessment (2007)* (RSK-00018);
- *Catchment and Water Quality Risk Assessment for Mid-Brisbane River (2008)* (RSK-00017);
- *Drought Water Quality Risk Assessment (2008)* (RSK-00015); and
- *Toxic Cyanobacteria Risk Assessment (2007)* (RSK-00016).

These risk assessments incorporate implementation, calibration and validation strategies as part of their recommended programs.

12.2 Research Plan

Seqwater's future research needs for the Wivenhoe system are identified in the *Seqwater Research Plan (2009-12)* (PLN-00024). The research plan provides direction for research in four main areas:

Water Quality (Human Health)

- Pathogen quantification degradation and management.
  - Quantification of pathogen loads within the water supply system: this includes temporal and spatial trends as well as quantifying degradation rates and how environmental conditions impact on these variables.
  - Improving understanding of water circulation in Lake Wivenhoe to identify environmental characteristics that may lead to PRW or catchment runoff short-circuiting.
- Reducing pollutant transport to raw water supply.
  - Identifying catchment contaminants and factors that increase or decrease their transport to water supply reservoirs.
  - Developing risked based assessment process for chemicals of concerns entering raw water supply.
- Removing drinking water hazards.
  - Identifying treatment technologies that are required to deal with any reduction in water quality that may occur in the future, due to changes in catchment land use or climate change.
  - Managing disinfection by-products and other chronic contaminants in treated water.
- Managing algal blooms.
  - Identifying key drivers of algal growth in water storages, including the development of rapid techniques for the identification of algal toxins.

- Quantifying nutrient loads to storages as triggers for algal growth. (e.g. wet and dry Aeolian deposition), benthic flux, internal recycling and major pathways for nutrient uptake and incorporation).

Sustainable Ecosystems

→ Protecting biodiversity.

- Biodiversity protection involves the protection of endangered species as well as the protection of food-webs that support native flora and fauna. This area involves projects conducted in both the catchment and water reservoirs (e.g. frogs, lungfish, native fish).

→ Mitigating impacts of water infrastructure on aquatic ecosystems.

- Quantifying the transfer of fish past in-stream barriers – this research is required to meet regulatory requirements to manage and monitor the effectiveness of fish ladders.
- Determining the impact of flow regulation on downstream ecosystems and habitats (floral and faunal), including the impact of environmental flows to modify the total quantity of water and/or change seasonal discharge of rivers.

→ Quantifying and enhancing ecosystem services.

- Examining mixing effects within Lake Wivenhoe due to wind and overturn, and their impact on water quality.
- Quantifying carbon degradation pathways within the water column and sediment to provide whole of system oxygen and energy budgets. This research will also identify the relative importance of oxic and anoxic degradation pathways.

Business Efficiencies and Opportunities

→ Preparing for impacts of climate change.

- Climate Change Benchmarking – identifying the rate of change in key parameters (Source; soil moisture, catchment yield vs precipitation: Store; pH, Temp, DO, Chla: Supply; trends in raw water quality and impacts on treatment processes).
- Climate Change adaptation strategies – Once the potential impact of climate change on Seqwater assets and our ability to provide a safe and secure water supply are better defined, there will be a need to develop strategies that allow Seqwater to adapt to likely scenarios for the future.

→ Improving monitoring technologies.

- Design of new monitoring technologies (biological and technology based) to determine temporal and spatial variability of water quality parameters.
- Provide real-time data and an early warning system to improve the management of raw water supplies through informed operational adjustments (e.g. change in offtake level to obtain highest quality raw water; modify treatment processes to accommodate raw water with high concentrations of pollutants/turbidity).

→ Improving quality of drinking water supply.

- Identify key drivers of taste and odour producing compounds in raw water reservoirs.
- Identify improvement to treatment technology that enhance water quality (taste or colour).

→ Managing natural assets to enhance environmental outcomes and minimise cost.

- Quantifying the impact of adoption of best management practice (in the catchment) on the pollutant loads that reach waterways and reservoirs.

- Controlling terrestrial and aquatic weeds (pest species) that increase operational costs or pose water quality risks.

Synthesis and Knowledge Transfer

→ Statistical Analysis.

- Statistical analyses to quantify relationships between key parameters, and provide in-depth investigations of data that are relevant to management decision making.

→ Development of 3D-hydrodynamic and biochemical/ecological quantitative predictive models to synthesise our understanding of causal relationships in the storage that influence the likelihood of short-circuiting, algal blooms, pathogen transport, contaminant degradation, and taste and odour issues (see *Modelling Progress Report (January 2010)*; Research Plan Folder). A summary of predictions on the fate of PRW in Lake Wivenhoe is provided below:

> *Initial PRW simulation results suggest that the model is able to reasonably simulate the mixing and dilution dynamics of PRW with the reservoir. Simulation results suggest that both the PRW inflow rate and initial lake storage level can have a significant influence on PRW concentrations at the main dam wall offtake point. Simulated PRW concentrations at the main dam wall offtake point ranged from approximately 2–45% depending on the scenario under investigation. The simulated concentration of PRW at the Esk tower offtake point was below 1% for the duration of all scenarios. The simulation results also suggest that catchment inflows, Somerset releases and mixing induced by the Splityard Creek hydro-power station can significantly dilute the PRW.*

→ Development of a catchment model that can predict the impact of various land management scenarios on the mobilisation and transport of pollutants (nutrients, chemicals of concern and pathogens) during rain events of varying intensity.

→ Reporting and Communication.

- Provision of monthly updates to CEO and Communications for internal information and updates (e.g. website).
- Production of communication products appropriate to the audience (summary books/reports, scientific papers, conference presentations).
- *Seqwater Report Card* on the condition of Seqwater catchments and reservoirs (see Section 3.3.1).

12.3 Research Partnerships

Seqwater has defined and implemented a number of key stakeholder and community partnerships to both inform and progress the *Draft Land and Water Quality Strategy* (POL-00024) and its associated research programs. The partnerships themselves can be segregated into those managed through formal processes and agreements, and those established ad-hoc for project specific purposes. All of the partnerships and their outcomes can be linked to the key targets identified in the *Corporate Strategic Plan (2009-10 to 2013-14)* (PLN-00019) and the *Water Quality Policy* (POL-00012) (see Sections 2.1 and 2.2, respectively). These partnerships are intended to capture strategic areas of capacity or expertise both in Queensland and elsewhere.

While access to this capacity is a critical driver for forming such partnerships, they also provide a range of additional opportunities inclusive of, but not limited to:

→ Effective use of resources by jointly supporting programs;

→ Realignment of existing activities to enhance regional outcomes;

→ Building a skills base for organisational and long term succession management;

→ Shared understanding by partners of organisational priorities; and

→ Increased regional efficiencies in delivering programs with overlapping objectives.

To achieve these goals, Seqwater has established a number of research partnerships as identified in Table 8.

Table 8 Seqwater research partners and the strategic areas of capacity or expertise they contribute to Seqwater research programs.

Research Partner	Capacity / Expertise	Research Partner	Capacity / Expertise
Griffith University	→ Understanding phytoplankton and cyanobacterial growth → Identification of bioindicators → Ecosystems modelling → Fate modelling of contaminants → Understanding endocrine disruption → Toxicity database development	Queensland Health Scientific Services	→ Analytical Services and Quality Systems → Methodology review → System audits → PRW inflows and food web structure
University of Queensland	→ Hydrodynamic modelling → Monitoring tools for trace organics → Best e-journal library in SEQ → Understanding phytoplankton and cyanobacterial growth → Biogeochemical expertise → Technology development and support → Queensland cyber infrastructure facility	University of Adelaide	→ Predicting cyanobacterial bloom → Algorithm modelling and artificial neural networks
SEQ Catchments	→ Catchment Management → Large scale landscape management → GIS capacity	UTS	→ Zooplankton grazing
CSIRO	→ Data Management and Interpretation → System Modelling → Specialist hardware development → Contaminant fate characterisation	Pine Rivers Catchment Management Association	→ Catchment Management → Biological control agents
DPI Victoria	→ Benthic sediment nutrient fluxes	Monash University	→ Understanding cyanobacterial growth

12.4 Validation

Validation involves evaluating scientific and technical information on system processes and then undertaking investigations, where necessary, to validate system-specific operational procedures, trigger values and target criteria.

The aim of validation is to ensure effective operation and control. Historical data and operational experience can also be useful sources of information. Processes are revalidated on a regular basis or when variations occur (e.g. seasonally). Any new processes are tested using bench-top, pilot-scale or full-scale experimental studies to confirm that the processes and operational criteria produce the required results under the conditions specific to the individual water supply system.

Information used for validation includes:

- → Expert advice and third party review;
- → Scientific studies and verification results;
- → System observations;
- → Measurements; and
- → Evaluations.

Details of the validation undertaken as part of the HACCP process are in the *Draft HACCP Verification and Validation Schedule* (HACCP General Folder).

Trigger values, including alert and critical limits, have been set in negotiation with raw water customers, based on the ability of downstream WTPs to treat water of a particular quality. These negotiations have been recorded in accordance with the *Draft Wivenhoe System Communication Procedure* (PRO-00708), and are detailed in the *Draft HACCP Customer Liaison Register* (HACCP General Folder).

Current validation and refinement of the models for lake behaviour will provide a firm basis of ongoing management practices and will continue to reduce error in model predictions. Research and monitoring equipment (e.g. profilers) is calibrated and tested against existing equipment, or is operated according to the manufacturer's specifications.

13. Documentation and Reporting

Appropriate documentation provides the foundation for establishing and maintaining effective drinking water quality management systems. Documentation should:

- Demonstrate that a systematic approach is established and is implemented effectively;
- Develop and protect the organisation's knowledge base;
- Provide an accountability mechanism and tool;
- Facilitate review and audits by providing written evidence of the system; and
- Establish due diligence and credibility.

13.1 Management of Documentation and Records

The WDWQMP identifies all of the documents and records that are required for the management of the drinking water quality of the Wivenhoe system. As part of Seqwater's Integrated Management System, the *Q-Pulse Database* (see *Users Guide to Q-Pulse*; PRO-00031) and the following documents are central to managing documentation and reporting requirements:

- *Document and Records Management Procedure* (PRO-00001);
- *Procedure Template* (FRM-00111); and
- *Draft HACCP Records* (HACCP General Folder).

13.2 Reporting

Reporting includes the internal and external reporting of activities pertinent to the implementation and performance of drinking water quality management. The *Draft HACCP Water Quality Reporting Procedure* (PRO-00294) identifies the water quality reporting requirements, which include the following:

- All catchment issues are documented (Seqwater's G:\drive);
- *Weekly Water Quality Trigger Value Reports* produced and reviewed at the Water Quality Meeting;
- *Fortnightly Water Quality Report* produced for review at the Manager's meeting, and submitted to the Seqwater Executive;
- The CEO's *Monthly Board Report* includes reporting by exception on water quality issues;
- *Six Monthly Trending Reports* are produced (winter and summer); and
- *Annual Trending Reports*, including rainfall events and research and development findings, will also be produced for the Seqwater Executive and other stakeholders (see *WDWQMP Improvement Plan*; Appendix H).

The *Draft Wivenhoe System Communication Procedure* (PRO-00708) and the *Review, Distribution and Reporting of Water Quality Test Results Procedure* (PRO-00290) identify the external reporting requirements (see Figure 3).

As part of its obligations under the *The Market Rules–SEQ Water Market* (LEG-00076), Seqwater is required to provide to the WGM copies of any reports (e.g. incident and routine water quality reports) to the OWSR. Seqwater is also required to report to the WGM on relevant matters relating to the operation of the Water Grid. In addition, Seqwater has a contract obligation to notify the WGM if water quality deteriorates, and to provide water quality data to the WGM on request.

14. Evaluation and Audit

Long term evaluation of drinking water quality results and audits of drinking water quality management are required to determine whether preventive strategies are effective and whether they are being implemented appropriately. These reviews enable performance to be measured against objectives and help to identify opportunities for improvement.

The long term review of water quality monitoring is performed in accordance with the *Draft HACCP Verification and Validation Schedule* (HACCP General Folder) and the *Draft HACCP Water Quality Reporting Procedure* (PRO-00294).

Auditing is the systematic evaluation of activities and processes to confirm that objectives are being met. It includes assessment of the implementation and capability of management systems. Auditing provides valuable information on those aspects of the system that are effective, as well as identifying opportunities for improvement.

Audits are undertaken to systematically evaluate the effectiveness of water quality management. Internal audits are undertaken in accordance with the *Internal Audit Procedure* (PRO-00002), which references the following supporting documents:

- *Q-Pulse: Audits and Inspections Module*;
- *Issue Notification and Response Procedure* (PRO-00003); and
- *Issue Notification Form* (FRM-00001).

Seqwater holds certification to the following standards:

- *ISO 9001:2008 Quality Management Systems–Requirements* (LEG-00061);
- *ISO 14001 (2004) Environmental Management Systems* (LEG-00006);
- Codex HACCP; and
- *AS/NZS 4801:2001 Occupational Health and Safety Systems* (LEG-00071).

Certification is maintained through an external JAS-ANZ registered organisation. These systems are externally audited as required by the certification organisation.

Audit reports are stored in the *Q-Pulse Database* (*Users Guide to Q-Pulse*; PRO-00031). Outcome of the audits are reviewed at the monthly managers meeting. Actions out of external audits are managed using the *Issue Notification and Response Procedure* (PRO-00003).

In addition, ADWG (2004) audits are undertaken annually on selected elements of the WDWQMP to confirm compliance and improvements. These audits are documented in the *Q-Pulse: Audits and Inspections Module*.

15. Review and Continual Improvement

Senior executive support, commitment and ongoing involvement are essential to the continual improvement of the organisation's activities relating to drinking water quality. The senior executive should regularly review its approach to drinking water quality management, develop action plans and commit the resources necessary to improve operational processes and overall drinking water quality performance.

In order to ensure continual improvement, reviews of all elements of the Seqwater IMS are required by management in accordance with the *Integrated Management System-Corporate Manual* (MAN-00005).

A program for improvement of the WDWQMP including actions, accountabilities and dates for completion (or review) is provided in the *WDWQMP Improvement Plan* (Appendix H). The improvement plan has been developed to ensure continual improvement and compliance with the *Water Supply (Safety and Reliability) Reliability Act 2008* (LEG-00074), and the associated policy and standards framework including the twelve elements of the ADWG (2004) and associated guidelines.

The WDWQMP and improvement plan will be reviewed annually and resubmitted to the OWSR at that time.

Appendix A

List of Acronyms

ADWG	Australian Drinking Water Guidelines
AGWR	Australian Guidelines for Water Recycling
ANZECC	Australian and New Zealand Environment and Conservation Council
AWTP	Advanced water treatment plant
CCP	Critical Control Point
CoC	Chemicals of concern
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DERM	Department of Environment and Resource Management
DEWHA	Department of the Environment, Water, Heritage and the Arts
DWQMP	Drinking Water Quality Management Plan
EAP	Emergency Action Plan
EAP	Emergency Response Plan
EV	Environmental Value
EHMP	Ecosystem Health Monitoring Program
EPBC	Environment Protection and Biodiversity Conservation
GIS	Geographic Information Systems
HACCP	Hazard Analysis and Critical Control Points
IMS	Integrated Management System
LWQ	Land and Water Quality (Seqwater)
NRM	Natural Resource Management
NWQMS	National Water Quality Management Strategy
OWSR	Office of the Water Supply Regulator
PAH	Polycyclic Aromatic Hydrocarbons

PRW	Purified Recycled Water
SPA	Sustainable Planning Act
SPR	Sustainable Planning Regulation
QA/QC	Quality Assurance / Quality Control
QBWSA	Queensland Bulk Water Supply Authority
QLD	Queensland
QWC	Queensland Water Commission
QWQG	Queensland Water Quality Guidelines
QWRG	Queensland Water Recycling Guidelines
RWMP	Recycled Water Management Plan
SEQ	South East Queensland
STP	Sewage treatment plant
TBL	Triple bottom line
TMP	Total Management Planning
TRC	Toowoomba Regional Council
WCRWP	Western Corridor Recycled Water Project
WDWQMP	Wivenhoe Drinking Water Quality Management Plan
WGM	Water Grid Manager
WMS	Work Method Statement
WQ	Water quality
WQO	Water Quality Objective
WRP	Water reclamation plant
WSUD	Water Sensitive Urban Design
WTP	Water treatment plant
WWTP	Wastewater treatment plant

Appendix B

List of References

Legislation / Regulations

1. LEG-00103 South East Queensland Water (Restructuring) Act 2007
2. LEG-00074 Water Supply (Safety and Reliability) Act 2008 (QLD)
3. LEG-00141 Draft Water Quality and Reporting Guidelines for a Drinking Water Service (DERM Regulatory Guideline)
4. Environmental Protection Act 1994 (QLD) (LEG-00001)
5. Environmental Protection (Water) Policy 1997 (QLD) (LEG-00024)
6. Water Act 2000 (QLD) (LEG-00025)
7. Public Health Act 2005 (QLD) (LEG-00075)
8. Public Health Regulation 2005 (QLD) (LEG-00068)
9. Environment Protection and Biodiversity Conservation Act 1999 (Australian Government) (LEG-00119)
10. Sustainable Planning Act (2009) (LEG-00127)
11. Sustainable Planning Regulation (2009) (LEG-00155)

Government Strategies / Guidelines / SEQ Water Grid

12. Total Management Planning Guidelines 2001 (LEG-00107)
13. Australian Guidelines for Water Quality Monitoring and Reporting 2000 (LEG-00104)
14. National Water Quality Management Strategy (LEG-00082)
15. Guidelines for Water Quality Management in Drinking Water Catchments 2008 (GDE-00001)
16. Establishing Draft Environmental Values and Water Quality Objectives (LEG-00143)
17. Resource Planning Guidelines, Guideline F10, Policy & Code for Preserving Water Quality in Declared Catchment Areas (DERM Guideline) (LEG-00142)
18. Australian Drinking Water Guidelines 2004 (LEG-00004)
19. AS/NZS 4360: Risk Management (LEG-00029)
20. ISO 9001: 2008 Quality Management Systems–Requirements (LEG-00061)
21. ISO 14001: 2004 Environmental Management Systems (LEG-00006)
22. Standards Australia 2005, AS/ISO 22000: Food Safety Management systems–Analysis and Critical Control Points
23. AS/NZS 4801:2001 Occupational Health and Safety Systems (LEG-00071)
24. Guidelines for Managing Risks in Recreational Water 2008 (LEG-00089)

25. ANZECC 2000 Guidelines–Australian and New Zealand Environment and Conservation Council Guidelines for Marine and Fresh Water Quality 2000 (LEG-00090)
26. SEQ Water Grid–Corporate Profile (LEG-00098)
27. SEQ Water Grid–Water Quality Management Plan (REF-00011)
28. QWC Final Report to the Queensland Government: Urban Water Supply Arrangements in South East Queensland (LEG-00095)
29. Queensland Water Quality Guidelines 2006 (LEG-00085)
30. Australian Guidelines for Water Recycling 2008 (LEG-00091)
31. Queensland Water Recycling Guidelines 2005 (LEG-00092)
32. Queensland Water Recycling Strategy 2001 (LEG-00093)
33. South East Queensland Water Strategy 2009 (LEG-00094)
34. Water Sensitive Urban Design Guidelines (LEG-00101)
35. CRC for Water Quality and Treatment (LEG-00108)
36. SEQ Regional Plan 2009–2031 (LEG-00120)
37. Draft Moreton Resource Operations Plan (LEG-00058)
38. QWC Expert Advisory Panel Interim Water Quality Report 2009 (LEG-00102)
39. Western Corridor Recycled Water Project (www.westerncorridor.com.au) (LEG-00097);
40. Department of the Environment, Water, Heritage and the Arts (www.environment.gov.au) (LEG-00121)
41. QWC website (www.qwc.qld.gov.au). (LEG-00087)
42. 2008 EHMP Report Card (www.healthywaterways.org) (LEG-00088)
43. 2007 EHMP Report Card (www.healthywaterways.org) (LEG-00088)
44. SEQ Water Grid Manager (www.seqwgm.qld.gov.au) (LEG-00099)
45. Documents on institutional reform (www.qwc.qld.gov.au) (LEG-00087)
46. American Water Works Association (2005) (www.awwa.org/) (REF-00013)
47. Billington, K. 2007. Preventing Algal Blooms through Investment in Catchment Management. Proceedings of Ozwater 2007 Conference, Sydney, Paper o7123 (REF-00013).
48. Mason, H., Greene, R., Hocking, P., Vigneswaran, B. and Hart, M. 2007. Identifying the forms and mechanisms of Phosphorus transport from Agricultural Soils to adjacent waterways- Robertson, NSW. Proceedings of Ozwater 2007 Conference, Sydney, Paper o7401 (REF-00014).
49. Hussein, J., Ghadiri, H., Lutton, M., Smolders, A. and Schneider, P. 2008. The effect of flow impedance on deposition of Crypotosporidium parvum oocysts with or without a vetiver buffer strip. Soil Biology & Biochemistry 40: 2696–2698 (REF-00015).

Appendix C

Supporting Documents (Refer to CD-ROM)

Formal Requirements

REG-00181 Compliance Obligations Register

LEG-00076 The Market Rules–SEQ Water Market

GDE-00011 Draft Environmental Values and Water Quality Objectives for Lakes Wivenhoe and Somerset, and the Mid-Brisbane River

GDE-00012 Draft Proposed EV-WQO Framework (2008)

Corporate Commitment

PLN-00019 Corporate Strategic Plan (2009-10 to 2013-14)

POL-00012 Water Quality Policy

POL-00024 Draft Land and Water Quality Strategy

POL-00028 Sustainability Charter

PRO-00671 Risk Management Policy

Seqwater Organisational Structure

Org Charts 120210–EGM

Org Charts 120210–Organisational Development

Org Charts 120210–Business Services

Org Charts 120210–Water Delivery

Org Charts 120210–Asset Delivery

Stakeholder Engagement

BRO-00003 Draft Seqwater Catchments and Storages Report Card

PRO-00794 Draft Seqwater Report Card Manual

REG-00003 Draft Land and Water Quality Stakeholder Register

Hazard ID and Risk Assessment

PRO-00801 Integrated Management Systems Risk Identification and Assessment Procedure

REG-00152 Enterprise Risk Register

FRM-00002 Environmental Risk Procedure and Register

RSK-00015 Drought Water Quality Risk Assessment (2008)

RSK-00016 Toxic Cyanobacteria Risk Assessment (2007)

RSK-00017 Catchment and Water Quality Risk Assessment for Mid-Brisbane River (2008)

RSK-00018 Catchment and In-Storage Water Quality Risk Assessment (2007)

WCRWP Scheme Risk Register

Monitoring Plan

MAN-00008 Water Quality Event Monitoring Program

MAN-00009 Event Station Maintenance Technical Manual

PLN-00035 Draft Catchment Water Quality Monitoring Program

PLN-00054 Draft Water Quality Sampling Calendar

PRO-00290 Review, Distribution and Reporting of Water Quality Test Results Procedure

PRO-00291 YSI Operation and Maintenance Procedure

PRO-00292 Determination of Algal Sample Frequency Procedure

PRO-00293 Water Sample Delivery Procedure

PRO-00295 Routine Sampling Procedure

PRO-00296 Water Sample Collection, Storage and Preservation Procedure

PRO-00626 Operation and Maintenance of Weather Stations Procedure

PRO-00706 Sampling and Analysis Quality Control Procedure

PRO-00720 VPS Operation and Maintenance

PRO-00735 Environmental Database Operation Procedure

Draft Inter-Catchment WQ Monitoring and Research

Appendix C (continued)

HACCP General

PRO-00294 Draft HACCP Water Quality Reporting Procedure

Draft HACCP Hazard-Parameter Table

Draft HACCP Verification and Validation Schedule

Draft HACCP Product Specification Statement

Draft HACCP Customer Trigger Limits Table

Draft HACCP Records

Draft HACCP Team

Draft HACCP Customer Liaison Register

HACCP Plans

Draft Wivenhoe Sampling Sites Map

Draft Wivenhoe HACCP Plan

Draft Wivenhoe Catchment Hazardous Events

Draft Somerset HACCP Plan

Draft Somerset Sampling Sites Map

Draft Somerset Catchment Hazardous Events

Draft Lockyer and Mid-Brisbane HACCP Plan

Draft Mid-Brisbane Sampling Sites Map

Lockyer and Mid-Brisbane Catchment Hazardous Events

Operational Controls

MAN-00024 Somerset Dam–Draft Standing Operating Procedures Manual

MAN-00028 Wivenhoe Dam–Draft Standing Operating Procedures Manual

PRO-00713 Draft Procedure for Determining Routine Releases of Water from Wivenhoe Dams

PRO-00718 Draft Operations Raw Water Intake Closure Procedure

PRO-00719 Draft Public Area Closure Operational Procedure

Draft Manual of Operational Procedures for Flood Mitigation for Wivenhoe Dam (Peter Allen, Director of Dam Safety, DERM)

Draft Manual of Operational Procedures for Flood Mitigation for Somerset Dam (Peter Allen, Director of Dam Safety, DERM)

Draft Operation and Maintenance Manuals for Wivenhoe Dam (see Draft Dams Operations and Maintenance 1.1 How to use this Manual; Operational Controls Folder, and for the complete set of documents refer to Peter Allen, Director of Dam Safety, DERM)

Emergency Action Plans

ERP-00001 Incident and Emergency Response Plan

ERP-00014 SEQ Water Grid Emergency Response Plan

ERP-00015 Draft Emergency Action Plan for Water Quality–Wivenhoe Dam & Catchment

ERP-00016 Draft Public Warning of Blue Green Algae Procedure

ERP-00017 Draft Emergency Action Plan for Water Quality–Somerset Dam and Catchment

ERP-00018 Draft Recreational Water Quality Emergency Preparedness and Response Procedure

PLN-00007 Emergency Action Plan for Water Quality–Mid-Brisbane and Catchment

PLN-00055 Draft Emergency Action Plan–Somerset Dam (Infrastructure)

PLN-00058 Draft Emergency Action Plan–Wivenhoe Dam (Infrastructure)

Policy and Planning

GDE-00001 Development Guidelines for Water Quality Management in Drinking Water Catchments (2008)

Water Source Protection Plan

PLN-00018 Draft Water Source Protection Plan (2008)

PLN-00057 Draft Action Plan for the Water Source Protection Plan

Communication Plans

PRO-00381 Seqwater-WaterSecure Operating Protocol

PRO-00708 Draft Wivenhoe System Communication Procedure

Research Plan

PLN-00024 Seqwater Research Plan (2009-12)

Modelling Progress Report (January 2010)

Food Web Investigation of Lake Wivenhoe (March 2008)

Community Involvement

Recreation Management Framework (PLN-00113)

Seqwater Recreation Framework Nov 09

Recreation Framework Appendix 1 Recreation Management Individual Lakes

Recreation Framework Appendix 2 Legislation

Recreation Framework Appendix 3 Activities

Recreation Framework Appendix 4 Risk Management

Appendix C (continued)

Staff Training and Awareness

FRM-00043 Training Attendance and Outcome Form

TRA-00008 Incident Management Training Presentation

TRA-00009 Water Quality and HACCP Staff Induction

Draft HACCP Staff Training and Awareness Register

Evaluation and Audit

PRO-00002 Internal Audit Procedure

Q-Pulse: Audits and Inspections Module

Supporting Procedures

PRO-00031 Users Guide to Q-Pulse

POL-00026 Procurement Policy

MAN-00005 Integrated Management System-Corporate Manual

MAN-00004 Integrated Management System-Operational Manual

PRO-00001 Document and Records Management Procedure

FRM-00111 Procedure Template

PRO-00003 Issue Notification and Response Procedure

MAN-00006 Safety-Emergency Procedures Manual

FRM-00001 Issue Notification Form

PLN-00004 Draft WTP Drinking Water Quality Management Plan

Appendix D

Summary of Seqwater's risk assessment procedure

Likelihood Scale

Likelihood is defined as a general description of probability and/or frequency (AS/NZ 4360, 2004).

Level	Likelihood	Description
1	Rare	Will ONLY occur in exceptional circumstances
2	Unlikely	Could occur but not expected
3	Possible	Could occur at some time
4	Likely	Will probably occur in most circumstances
5	Almost Certain	Expected to occur in most circumstances

Consequence Scale

Consequence is defined as the outcome or impact of an event (AS/NZ4360, 2004). Applied to this project is:

- → Minor impact refers to aesthetic water quality impacts only
- → Major impact refers to any human health water quality impact.
- → Small population refers to ‹ 100 persons.
- → Large population refers to › 100 persons.

Level	Consequence	Description
1	Insignificant	Trivial environmental impact
2	Minor	Unreasonable interference with the environment (Minor impact and small population)
3	Moderate	Clearly visible impact to aquatic ecosystem (Minor impact and large population)
4	Major	Damage to the environment that requires remediation. (Major impact and large population affected and impact is reversible)
5	Catastrophic	Environmental damage is irreversible, of high impact or widespread. (Extensive part of catchment and river affected, major impact/s which are irreversible and large population affected)

Risk Rating Matrix

A combination of the consequences and likelihood assigned to each measure to calculate the overall risk rating.

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	High	High	Extreme	Extreme	Extreme
Likely	Medium	High	High	Extreme	Extreme
Possible	Low	Medium	High	High	Extreme
Unlikely	Low	Low	Medium	High	Extreme
Rare	Low	Low	Medium	High	Extreme

Appendix E

Summary of risks to water quality and recommended additional preventive measures for the Wivenhoe catchment and storage[9]

Item	Source of Risk	Most Significant Hazards	Risk Level	Sites at Most Risk	Comments
			WIVENHOE CATCHMENT		
1	Cattle/horses/pigs/deer (not including feral anim[a]als)	*Cryptosporidium/Giardia* Bacteria	Extreme	Recreation site drinking water; Drinking water for Seqwater, Esk and Toogoolawah WTPs	→ Monitor water quality at sub-catchment with high cattle levels compared to forested catchment
		Turbidity	Extreme		
2	Storm Events causing washing of high pollutant loads	*Cryptosporidium/Giardia* Bacteria; Viruses	Extreme	Recreation site drinking water (short circuiting conditions) Drinking water for Seqwater, Esk and Toogoolawah WTPs	→ Audit Recreation Esk and Toogoolawah WTPs (local plants) → Model Wivenhoe storage short circuiting
		Turbidity and sedimentation	Extreme		
3	On site waste water treatment systems (including septic systems) overflowing in storm events and system failure	*Cryptosporidium/Giardia* Bacteria; Viruses	Extreme	As above	→ Audit Local WTPs for adequacy of treatment processes → Model Wivenhoe storage short circuiting → Buy up shoreline land and revegetate especially near local WTP offtakes
4	WWTP discharges	*Cryptosporidium/Giardia* Bacteria; Viruses	Extreme	Recreation site drinking water; Drinking water for Seqwater, Esk and Toogoolawah WTPs	→ Audit all local WWTPs (Esk, Toogoolawah, Crows Nest) for treatment processes and improvements → Identify opportunities for wetland/detention basins → Monitor WQ in storm events at towns (e.g. Esk)
5	Human activity	*Cryptosporidium/Giardia*	High	As above	→ Enforce prohibited zones – fencing, gates, prosecution → Monitor water quality at sub-catchment with high cattle levels compared to forested catchment
6	Spills/Dumping	Chemicals	High	Local Drinking Water (Esk, Toogoolawah & Recreation sites)	→ Audit Local WTPs for adequacy of treatment processes → Audit adherence to code for low-level radioactive landfill → Collect evidence on septic cartage tankers (frequency, illegal dumping, accidents and routes)
		Cryptosporidium/Giardia Bacteria; Viruses	High		

[9] Adapted from *Catchment and In-Storage Water Quality Risk Assessment 2007* (RSK-00018).

Item	Source of Risk	Most Significant Hazards	Risk Level	Sites at Most Risk	Comments
7	Farming activities	Turbidity and sedimentation	**High**	Swimming at recreation sites (pathogens, toxins) Local Drinking Water Supplies	→ Monitor water quality at sub catchment with high cattle levels compared to forested catchment
8	Native and Feral animals	Bacteria	**High**	As above	→ Develop strategy for pig control
9	Forestry	Chemicals-Herbicides, pesticides	**High**	Swimming at recreation sites (pathogens, toxins) Local Drinking Water Supplies	→ Audit against code of practice → Event WQ monitoring of forestry sub catchments Investigate locations for wetlands and retarding basins → Collect information on pesticide usage
		Turbidity and sedimentation	**High**		
10	Extractive Industries	Turbidity and sedimentation	**High**		→ Audit against code of practice
11	Power station	Taste and Odour- Diesel fuel	**High**		→ Audit against code of practice
WIVENHOE STORAGE					
1	Aquatic Birds	Bacteria (Campylobacter, Salmonella)	**Extreme**	Esk and Toogoolawah WTPs Recreation sites around storage	→ Selective withdrawal available for Toogoolawah WTP → Powdered Activated Carbon dosing at WTP → Consider destratification → Consider local raw water basins (allows temporary shutdown)
2	Algal Blooms (normal operation)	Taste & Odour Compounds (MIB, Geosmin)	**Extreme**		→ Check draw off arrangements from Wivenhoe (adopt selective withdrawal) → Powdered Activated Carbon dosing at WTP → Consider destratification → Consider local raw water basins (allows temporary shutdown
		BGA Toxins	**Extreme**		

Appendix E (continued)

Item	Source of Risk	Most Significant Hazards	Risk Level	Sites at Most Risk	Comments
3	Recycled Water (see specific risk table below for additional risks)	Taste & Odour Compounds (MIB, Geosmin)	**Extreme**	Local Drinking Water Supplies Swimming at Recreation sites (pathogens)	→ MIB/Geosmin higher in Wivenhoe than in Somerset → Check draw off arrangements from Wivenhoe (adopt selective withdrawal) → Powdered Activated Carbon dosing at WTP → Consider destratification
		BGA Toxins	**Extreme**		
		Manganese	**High**		
4	Stratification and leaching	Manganese	**High**	WTPs Esk and Toogoolawah WTPs (pipe slime scour) Recreation sites around storage	→ Check draw off arrangements from Wivenhoe (adopt selective withdrawal) → Powdered Activated Carbon dosing at WTP → Consider destratification → Consider local raw water basins, for temporary shutdown)
5	General development around shoreline; recreation, boating, septic tank failure and spills at recreation WWTPs	*Cryptosporidium/Giardia* Bacteria; Viruses	**High**	Local Drinking Water Supplies Swimming at Recreation sites (pathogens)	→ R&D on actual shedding rates for primary contact recreating and which microorganisms. → Audit shoreline septics, leases (type, locations, number of animals); potential routes for contaminating water
6	Wave action	Turbidity	**High**		→ Considerable wave action in storage; less than in Somerset, because of large areas of shallows and less boat activity as well
7	Terrorism	Poisons	**High**		→ More secure fencing; increased surveillance; prosecution of illegal access

Appendix F

Summary of risks to water quality and recommended additional preventive measures for the Somerset catchment and storage[10]

Item	Source of Risk	Most Significant Hazards	Risk Level	Sites at Most Risk	Summary of Comments
SOMERSET CATCHMENT					
1	Cattle/horses/pigs/deer (not including feral animals)	*Cryptosporidium/Giardia* Bacteria	**Extreme**	Recreation sites on upper Stanley River Kilcoy drinking water	→ High intensity, very localised storms are frequent → Water quality event monitoring in high cattle catchment compared to forest catchment → Model Somerset dam for short circuiting
2	Storm Events causing washing of high pollutant loads	*Cryptosporidium/Giardia*	**Extreme**	Kilcoy 1.7 ML/d WTP (water supply) Kirkleigh recreation site (under storage stratification conditions)	→ Encourage finalisation of permanent raw water storage after weir offtake for Kilcoy → Upgrade Kilcoy WTP alarms and continuous monitors and duty/standby chemical dosing equipment and offsite alarms for process system failure → Upgrade Kirkleigh WTP alarms and continuous monitoring (eg. (e.g. turbidity after filters, pH at tube settlers after alarms at dosing)
		Bacteria; Viruses	**High**		
		Turbidity	**High**		
		Colour (THM causing compounds)	**High**		
3	Septic systems overflowing in storm events	*Cryptosporidium/Giardia* Bacteria; Viruses	**Extreme**	Kilcoy 1.7 ML/d WTP (water supply) Kirkleigh recreation site (under storage stratification conditions)	→ Sanitary Survey of septic tanks to confirm extent of the problem → WQ monitoring of septic tanks to understand potential micro-organism loads
4	STP discharges	*Cryptosporidium/Giardia* Bacteria; Viruses	**Extreme**		→ Audit Kilcoy and Woodford STPs to identify likelihood of discharge; Get all STPs to zero discharge; → Woodford STP has a reuse scheme after sand filtration of effluent; opportunity to improve recycle water system → Kilcoy STP is proposing a settling pond in the floodplain (not very good) → WQ monitoring in effluent to confirm composition
5	Spills and Dumping	*Cryptosporidium/Giardia* Bacteria; Viruses	**High**		→ Audit farms under code of practices → Improve referrals process to SEQ Water

[10] Adapted from *Catchment and In-Storage Water Quality Risk Assessment 2007* (RSK-00018).

Appendix F (continued)

Item	Source of Risk	Most Significant Hazards	Risk Level	Sites at Most Risk	Summary of Comments
SOMERSET CATCHMENT					
6	Native and Feral animals	*Cryptosporidium/Giardia* Bacteria	**High**	Kilcoy 1.7 ML/d WTP (water supply) Kirkleigh recreation site (under storage stratification conditions)	→ Water quality event monitoring in high cattle catchment compared to forest catchment (same storm events) → Develop strategy for pig control, because number of pigs is increasing
7	Forestry	Turbidity and sedimentation	**High**		→ Audit against code of practice; Event WQ monitoring of forestry sub catchments Investigate locations for wetlands and detention basins
8	Extractive Industries	Turbidity and sedimentation	**High**		
SOMERSET STORAGE					
1	Aquatic Birds	Bacteria (Campylobacter, Salmonella)	**Extreme**	Kilcoy and Kirkleigh WTPs Kirkleigh Recreation site; other sites along storage, where primary contact with water occurs	→ Obtain more evidence of bird numbers dynamics and contents of dropping; Consider destratification
2	Algal Blooms (normal operation)	Taste & Odour Compounds (MIB, Geosmin)	**Extreme**	Kilcoy and Kirkleigh WTPs Recreation sites in Wivenhoe (Algae nutrients from Somerset trigger further blooms in Wivenhoe storage) Kirkleigh Recreation site; other sites along storage, where primary contact with water occurs	→ Consider destratification systems for Somerset storage; Reduce source water inputs
		BGA Toxins	**Extreme**		
3	General development around shoreline; primary recreation, boating, septic tank failure and spills at recreation STPs	*Cryptosporidium/Giardia* Bacteria; Viruses	**High**		→ Relocate water supply offtake away from recreation site at Kirkleigh → Low flow switches on sewage rising main
4	Wave action	Turbidity	**High**	Kilcoy and Kirkleigh WTPs	→ Considerable wave action in storage; more boat activity as well
5	Terrorism	Poisons	**High**		→ More secure fencing; increased surveillance; prosecution of illegal access

Appendix G

Summary of risks to water quality and recommended additional preventive measures for the Mid-Brisbane River catchment[11]

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
Salinity	Both dry land and irrigation salinity can increase the amounts of dissolved salt entering adjoining rivers and streams.	Turbidity, chlorides, and colour	Major	Almost Certain	**Extreme**	No controls identified	Major	Almost Certain	**Extreme**	Specific investigation is recommended to determine the actual risk posed by dryland and irrigation salinity on water quality. Further investigation is required to identify high risk sites.	
Bush fire	Both controlled and uncontrolled bush fires. Increased turbidity associated with particulate matter fallout during fire and accelerated erosion post-bush fire. Increase organic matter and nutrients in run-off post fire. Potential for fauna kills during/post fire.	Organochlorine and Organophosphorus pesticides, microbiological, nutrients, turbidity and colour	Major	Rare	**High**	No controls identified	Major	Rare	**High**	Specific investigation is recommended to determine the frequency and extent of controlled and uncontrolled bush fires in the catchment and the locations of fire breaks. Loss of habitat biodiversity secondary aspect raised by participants.	
Inflows	Black Snake Creek (poor land management issues)	Turbidity, chlorides, and colour	Minor	Likely	**High**	No controls identified	Minor	Likely	**High**	Specific investigation is recommended to determine the frequency and volume of inflows from Black Snake Creek and determine the extent of mixing zone. Specific investigation is recommended to determine the capacity of riparian vegetation to buffer volume of inflows (and resultant concentrations of hazards).	
Inflows	Spring Creek	Organochlorine and Organophosphorus pesticides, nutrients, turbidity and colour	Major	Likely	**Extreme**	No controls identified	Major	Likely	**Extreme**	Specific investigation is recommended to determine the frequency and volume of inflows from Spring Creek. Capacity of riparian vegetation to buffer volume of inflows (and resultant concentrations of hazards) unknown.	

[11] From *Catchment and Water Quality Risk Assessment for Mid-Brisbane River 2008* (RSK-00017).

Appendix G (continued)

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
Inflows	Release of water from Wivenhoe Dam Bank stability eg. Sedimentation Accelerated erosion of banks and bank stability issues immediately down gradient of the Wivenhoe Dam wall due to flood releases in 1987 and 1988. Increased hydraulic loads immediately downstream of the dam wall.	Nutrients, turbidity and colour	Major	Possible	**Extreme**	No controls identified	Major	Possible	**Extreme**	The participants specifically bank slumping and instability as a result of the overflow from Wivenhoe Dam during 1987-1988 flood events. Specific investigation is recommended to determine the scale and extent of erosion or bank stability during high flow events.	
Inflows	Water quality downstream of Wivenhoe Dam wall immediately affected (ie. Cyanobacteria	Nutrients, turbidity and colour	Major	Possible	**Extreme**	Flood impact management and minimisation controls outlined in the Wivenhoe Dam Flood Management Manual.	Major	Unlikely	**High**		
Aquatic weeds	Introduced species of aquatic weeds (e,g. Water Hyancinth perifolation). River include Salvinia (*Salviia molesta*), Cabomba (*Cabomba carolinana*), Hymenachne (*Hymenache amplexicaulis*), water hyacinth (*Eichornia crassipes*) and anchored water hyacinth (*E.azurea*). Affects include blockage of Mt Crosby Weir offtake and irrigation offtakes, recreational amenity and fish habitat.	Increased BOD, low DO, pesticides, nutrients, turbidity and colour	Major	Almost Certain	**Extreme**	No controls	Major	Likely	**Extreme**	Specific investigation is recommended to determine the distribution and density of weed infestation. Participants were aware of ornamental weeds being harvested from the River but location unknown. Further investigation is required to determine suitable weed control chemicals are suitable for use in the waters and banks of the MBR.	To achieve a consistent approach to management of the Mid Brisbane River a single body must take ownership of the management of water quality in the Mid Brisbane River such as a stakeholder partnership (Mid Brisbane River Partnership). Proactive management measures required such as regular harvesting, spraying or booming to prevent spread, public awareness and education on weed transportation and consequences for water quality. Integrated approach to management of the issue within existing regulatory framework to ensure integrated approach to management), change from Liability to asset, load reductions in nutrients

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
Riparian weeds	Riparian weeds (eg chinese elm)	BOD, pesticides, nutrients, turbidity and colour	Major	Almost Certain	**Extreme**	Provisions of *Vegetation Management Act 1999*, local government planning scheme policies and codes, Natural Resource Management Plans.	Major	Possible	**Extreme**		Ownership/responsibility for riparian area required. Introduction of incentive programs (financial) for promotion of riparian rehabilitation or and erosion management controls.
Introduced species	Introduced species resulting from overflows of farm dams.	Turbidity and colour	Minor	Almost Certain	**High**	No controls identified	Minor	Almost Certain	**High**	Specific investigation is recommended to determine location, species type and population of introduced species within the MBR.	
Riparian vegetation loss	Loss of riparian vegetation potentially resulting in bank instability, accelerated soil erosion, increased ease of access to riparian areas by stock	Pesticides, nutrients, turbidity and colour	Catastrophic	Almost Certain	**Extreme**	No controls identified	Catastrophic	Almost Certain	**Extreme**		Ownership/responsibility for riparian area required. Long term management strategy required for whole extent of Mid Brisbane River to end the ad-hoc approach to management of environmental issues. Designated 'No Go' zones for stock (fencing/controlled grazing). Soils mapping within catchment to identify priority areas for erosion protection works will result in more appropriate allocation of funding. Education and awareness program. Introduction of incentive programs (financial) for promotion of riparian rehabilitation or and erosion management controls.

Appendix G (continued)

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
Agriculture within the catchments											
Live Stock Management	Unregulated live stock access to riparian areas, water barrages across the river in many locations for stock movement, bank instability, soil compaction associated with tramping effects, riparian vegetation used as feed by graziers, dead animal carcasses, erosion, accelerated run-off of nutrients, viruses, animal faecal contamination.	Organochlorine and Organophosphorus pesticides, microbiological, nutrients, turbidity and colour	Major	Almost Certain	**Extreme**	No controls identified	Major	Almost Certain	**Extreme**	Specific investigation is recommended to determine the grazing methods, waste management, feed management practices used in the MBRC.	
Intensive Agriculture	Brisbane Valley Feedlot located at Coominya, 30m from Spring Creek with @ 5,000 head of cattle. Biddeston Cattle Feedlot – 499 head of cattle. Diary (Lockyer Valley). Afc Abattoirs Pty Ltd at Coominya (now closed). Pasture growth. Horticulture. Issues: On-site storage of waste, effluent and wastewater management (overflow of dams), sediment, salinity, chemical residues, soil exposure, vegetation loss.	Pathogens[1], nitrates/ nitrites, ammonia, turbidity, colour.	Major	Almost Certain	**Extreme**	No official controls for pasture growth and horticulture. DNRW Farm Management Plans are only voluntary, The following Industry Environmental Codes are only voluntary: Queensland Farmers Federation's Environmental code of practice for agriculture, Queensland Fruit and Vegetable Growers - Sustainable fruit and vegetable production in Queensland, Queensland *Environmental code of practice for Queensland piggeries,* Queensland Dairy farmers Organisation & DPI Queensland dairy farming environmental code of practice. Herbicide application - Freshcare, Water Act 2000 - Water extraction requirements of the Water Regulation 2000.	Moderate	Possible	**High**	Controls are mostly voluntary and driven by farm economics Monitoring of farming Practices by DPIF and local government unknown. Buffer zones around farming areas Poultry farm in Coominya and abattoir understood to have separate disposal system for High-nutrient and pathogen laden waste. Compliance with DPIF and Environmental Protection Act 1994 licences unknown.	No stakeholders present from EPA or DPIF so uncertain what locations and what area of the catchment used for feedlots, dairy or poultry farming. ÐÐVolume and type of waste products and method of disposal unknown ÐÐUnderstand DPIF regulate farming operations and - Regular audit management practices

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
High Inflows Lockyer Creek (e.g. 1996 flood)	High inflows from the Lockyer Creek in 1996 and in early 2008. Increased salinity of groundwater and surface water. Agricultural runoff, weeds, topsoil movement.	pesticides, sediment, heavy metals, chemical residue, macrophytes	Major	Almost Certain	**Extreme**	Freshcare, HACCP, Property Planning, Weirs and Barriers.	Major	Almost Certain	**Extreme**	Weirs are not operated - IROL updated.	
Intensive Agriculture	Runoff from Poultry Farm (Sandy Creek)	Pathogens[1], nitrates/ nitrites, ammonia, turbidity, colour	Moderate	Likely	**High**	No controls identified	Moderate	Likely	**High**		
Forestry	Tree planting activities, maintenance activities (herbicides and insecticide application), runoff resulting in herbicide, pesticide, sediments loads and high turbidity, 44% of area forested within catchment comprises native forest. Brisbane Forest Park located North, North- East of Catchment	Organochlorine and Organophosphorus pesticides, nutrients, turbidity and colour	Moderate	Possible	**High**	No controls identified	Moderate	Possible	**High**		
Horticultural and agricultural chemical storage		Metals, nitrate/nitrite, organochlorine and organophosphorus pesticides, turbidity and colour , metals and COD	Major	Possible	**Extreme**	No controls identified	Major	Possible	**Extreme**		

Appendix G (continued)

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
Land use in the catchments											
Peri-urban development	Peri-urban- on-site systems- stormwater (eg. hard surfaces) water quality, illness (recreational uses), increased flow velocities, erosion, direction	Pathogens[1], metals, hydrocarbons, BTEX compounds, pesticides, nutrients, turbidity and colour	Major	Almost Certain	**Extreme**	*Integrated Planning Act 1997* - IDAS process and State Planning Policies, Provisions of *Vegetation Management Act 1999*, local government planning scheme policies and codes, Natural Resource Management Plans, EPA regulation of ERA's.	Major	Almost Certain	**Extreme**	Lack of ownership of water quality issues. Lack of awareness of how development adversely affects water quality. Barriers to effective controls - poorly managed planning/ regulation in region as a whole, limited public education, poor integration of services and programs, limited incentives, in-built competitive drivers.	A collaborative ownership of the management of water quality in the Mid Brisbane River. Stakeholder partnership for management of development impacts (Mid Brisbane River Partnership) Education and awareness program for broad spectrum of community. Remove competitive structures and improvement in coordination. Congruence and simplification of the planning and development assessment regulatory regime. Encourage self compliance.
Peri Urban Development - Clearing	Erosion, loss of remnant vegetation, habitat fragmentation.	Pesticides, nutrients, turbidity and colour	Major	Almost Certain	**Extreme**		Major	Almost Certain	**Extreme**		
Peri Urban Development - Construction	Sealed and unsealed road runoff, poor erosion and sediment control by builders, building waste.	Pathogens[1], metals, hydrocarbons, BTEX compounds, pesticides, nutrients, turbidity and colour	Major	Almost Certain	**Extreme**		Major	Almost Certain	**Extreme**		
Urban development	Increased runoff, erosion, lack of sediment control, litter, waste dumping, capacity of WWTP's, unsewered residential estates.	Pathogens[1], metals, hydrocarbons, BTEX compounds, pesticides, nutrients, turbidity and colour	Major	Almost Certain	**Extreme**	*Integrated Planning Act 1997* - IDAS process and State Planning Policies, Provisions of *Vegetation Management Act 1999*, local government planning scheme policies and codes, Natural Resource Management Plans, EPA regulation of ERA's.	Major	Likely	**Extreme**		Promotion of the Mid Brisbane River as "green" infrastructure. Commence consultation with new local governments. priority assigned by local and state governments to the protection of the Mid Brisbane River QLD Bulk Water Supply Authority to become a concurrence agency for planning and licensing of activities within catchment. Incentives and subsidies for sustainable housing development and communities with a focus on catchment water quality. Improved resourcing for local governments and EPA to enforce litter and water quality provisions of EP Regulation.

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
Storage management	Low oxygen and manganese concentrations from dams when water is released	Nutrients, algal blooms, turbidity and colour	Moderate	Almost Certain	**Extreme**	Operational procedures adequate for Wivenhoe, Somerset and North Pine, Lake Manchester, however no controls for farm dams in MBRC	Moderate	Almost Certain	**Extreme**	Flood Operations Manual determines release volume and velocity to limit downstream effects. Pondage, barrier and downstream effects associated with the impoundments on Lake Wivenhoe and Lake Somerset considered to have caused and will continue to cause on-going decline in channel morphology, sediment supply and low environmental flow. Moderate impact on downstream water quality. Management procedures for releases into the Mid Brisbane River adequate but overall landscape affects of the impoundments considered as on-going permanent impacts.	Land management and modelling for better procedures for release of water into Mid Brisbane River.
Transportation (e.g. Brisbane Valley Highway), vehicle accidents and road maintenance	Sealed and unsealed road construction (private and public roads) and spills of chemicals or regulated wastes associated with vehicle accidents.	Pathogens[1], metals, hydrocarbons, BTEX compounds, pesticides, nutrients, turbidity and colour	Catastrophic	Possible	**Extreme**	No controls identified	Catastrophic	Rare	**High**		
Recharge of groundwater through infiltration at the Lockyer Weirs	Additional water supply for irrigation above and below the Lockyer Weir (Mid Brisbane River likely to be affected during high intensity rainfall runoff).	Pesticides, nutrients, turbidity and colour	Insignificant	Rare	**Low**		Insignificant	Rare	**Low**	The weirs were considered to be a control measure.	
Squatting	Itinerant persons and backpackers have been known to reside on river banks unlawfully. Generate litter, clear vegetation, fires, unsewered areas, increased erosion, unlawful waste dumping.	Pathogens[1], metals, hydrocarbons, BTEX compounds, nutrients, turbidity and colour	Minor	Likely	**High**	No controls identified	Minor	Likely	**High**		

Appendix G (continued)

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
Change in land use	Catchment undergoing significant transition and landscape fragmentation Intensification of a land use. Expansion of existing residential land use in catchment, change in type of land use (i.e. agricultural to residential) and proliferation of that land use (e.g. Woolworths development at Fernvale potential to increase residential population).	Pathogens[1], metals, hydrocarbons, BTEX compounds, pesticides, nutrients, turbidity and colour	Minor	Almost Certain	**High**	No controls identified	Minor	Almost Certain	**High**		
Lack of public awareness that Mid-Brisbane River is a conduit for raw water supply	People undertake activities that they would not otherwise do if they knew it was raw water supply for SEQ's drinking water.	Pathogens[1], metals, hydrocarbons, BTEX compounds, pesticides, nutrients, turbidity and colour	Major	Possible	**Extreme**	No coordinated approach to public awareness of the environmental values (raw water supply) and protection status	Major	Possible	**Extreme**	Lack of planning for recreational use by local government. Ineffective assessment of water quality and protection during IDAS process for development approvals, EIS's, resource allocation assessments (hard rock and extractive industry). Local government have discretion to override planning scheme codes and policies to approval a development with little regard for consequences for water quality.	Media and public awareness campaign to increase the profile and awareness of the area, its environmental values (raw water supply) and protection status. Promotion of the Mid Brisbane River as "green" infrastructure. Commence consultation with new local governments. priority assigned by local and state governments to the protection of the Mid Brisbane River QLD Bulk Water Supply Authority to become a concurrence agency for planning and licensing of activities within catchment.
Bridges	Erosion of edges of bridges and runoff from sealed and unsealed river crossings and bridges into Mid Brisbane River. No barriers to hazards.	Metals, hydrocarbons, BTEX compounds, pesticides, nutrients, turbidity and colour	Major	Possible	**Extreme**	No controls identified	Major	Possible	**Extreme**		

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
Fauna kills	Baiting and shooting associated with hunting on private land within the catchment	BOD, nutrients, pathogens, colour, odour and turbidity	Major	Possible	**Extreme**	No controls identified	Major	Possible	**Extreme**		
Industrial development and use within catchments											
Extractive Industry	Sand and gravel extraction operations (small scale and large scale), bank instability, weed control, riparian vegetation clearing, accelerated erosion, poor management of excavation void - post extraction, ancillary activities (i.e. motor vehicle workshop and machine refuelling)	Metals, hydrocarbons, BTEX compounds, organochlorine and organophosphorus pesticides, turbidity and colour, BOD, low DO	Major	Rare	**High**	Regulatory controls over extractive industries dependent upon when the approval was granted. Old licenses/ development approvals not as prescriptive on rehabilitation and sediment control requirements.	Major	Rare	**High**	The location and scale of extractive industry operations within the catchment is unknown and difficult to target compliance activities by state government. Perception by panel members that the QLD EPA is not effectively regulating discharges from licensed extractive operations into the receiving environment and specifically to waters of the Mid Brisbane River. Perception that there are no controls in place to mitigate or reduce impacts to waters from extractive industries.	Consultation with EPA required identifying current licensed activities. Monitoring and auditing for compliance. Fines for non-compliance.
Extractive Industry	Extraction industries (e.g. Kholo) in bed and banks of Mid Brisbane River resulting in mobilisation of sediments.	Metals, organochlorine and organophosphorus pesticides, turbidity and colour, BOD, low DO	Major	Possible	**Extreme**	QLD EPA - Code of environmental compliance for certain aspects of extracting rock or other material (ERA 20) and relevant local government planning scheme codes and policies	Major	Possible	**Extreme**		
Industrial	Movie production and filming of accident scene in Mid Brisbane River (specific request made to SEQWater for approval of release of water from Wivenhoe Dam). Littering, clearing of vegetation, in-stream works.	Pathogens, metals, hydrocarbons, BTEX compounds, nutrients, turbidity and colour	Minor	Possible	**Medium**	No controls identified	Minor	Possible	**Medium**		

Appendix G (continued)

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
Fertiliser, herbicide and pesticide transportation	Transportation of herbicides, pesticides and fertiliser from areas outside the MBRC to storage locations and industries within the MBRC.	Nitrate/nitrite, organochlorine and organophosphorus pesticides, turbidity and colour , metals and COD	Major	Possible	**Extreme**	No controls identified	Major	Possible	**Extreme**		
Industry	Accidents at industrial facilities and chemicals and other contaminants washing into waterways. Use of Aqueous Fire Fighting Foam (containing perfluorooctanyl sulfonate and other solvents) in combating fire.	Metals, radionuclides, pathogens[1], hydrocarbons, PAHs, semi-volatile organic compounds, organic compounds, asbestos, pesticides, pH, nutrients, turbidity and colour	Major	Possible	**Extreme**	Department of Emergency Services incident response. Disaster Management Plans for local government. EPA Pollution Hotline for reporting incidents. Existing development approvals and planning controls do not consider impacts associated with accidents at small storage facilities or industry. Stanwell and Tarong Energy have emergency response plans.	Catastrophic	Rare	**High**	Engage with other stakeholders (e.g. SES, Department of Emergency Services, Police, local governments, EPA, industry). Lack of awareness of responsibility and notification procedures under existing plans and review of emergency response plans required.	QBWSA to develop Emergency Response Plan (ERP's) for environmental pollution incidents which have potential to adversely affect water quality in the Mid Brisbane River. Review of existing emergency response plans and monitoring protocol (i.e. Brisbane Water) to establish what exists. QBWSA will require stakeholder input of ERP's. Create communication channels through partnership arrangements to ensure all stakeholders feel confident to share information on risks to water quality in Mid Brisbane River. Local government and QBWSA to work with regulator to ensure the success of the Emergency Action Plans and to include the QLD Water Commission.
Major infrastructure development											
Infrastructure construction and maintenance	Western pipeline corridor, Power transmission corridor, Brisbane Valley Highway and road corridors. Gravel and sand extraction from borrow pits, contamination, minimal riparian zones, bank instability, carrying goods from outside catchment in, pollutant loads during operation	Metals, pathogens[1], hydrocarbons, PAHs, semi-volatile organic compounds, organic compounds, pesticides, pH, nutrients, turbidity and colour	Major	Almost Certain	**Extreme**	No controls identified	Major	Almost Certain	**Extreme**		

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
Operation of transport and utility service corridors (power and water)	Runoff increased due to cleared land and paved surfaces, spills of contaminants from vehicle accidents	Metals, pathogens[1], hydrocarbons, PAHs, semi-volatile organic compounds, organic compounds, pesticides, pH, nutrients, turbidity and colour	Catastrophic	Rare	**High**	No controls identified	Catastrophic	Rare	**High**		
Waste management and waste water treatment activities											
Waste management facility	Waste disposal and waste transfer facility management, leachate and surface water runoff	Metals, pathogens[1], hydrocarbons, PAHs, semi-volatile organic compounds, organic compounds pesticides, asbestos, pH, nutrients, turbidity and colour	Minor	Likely	**High**	No controls identified	Minor	Likely	**High**		
Municipal waste water treatment plants	Waste Water Treatment Plants in Loowood, Fernvale and Coominya servicing an increased population. Issues with peak design capacity, treatment capability and age of plants.	Pathogens[1], nitrates/nitrites, trihalomethanes, high BOD, turbidity and colour	Major	Likely	**Extreme**	Development approval/ environmental authority for ERA 15 administered by the EPA. Department of Natural Resources *Guidelines for Planning and Design of Sewerage Schemes* (Volumes 1 and 2). Queensland Department of Natural Resources (1996) *Interim Guidelines for Reuse or Disposal of Reclaimed Wastewater*.	Major	Likely	**Extreme**	Level of compliance with DA/EA unknown. Perception by panel members that the QLD EPA is not effectively regulating discharges from licensed WWTP operations into the receiving environment and specifically to waters of the Mid Brisbane River.	Specific investigation required to determine the volume or quality of wastewater discharged from each WWTP, level of treatment assumed to be primary or secondary WWTP, assumed no nitrogen removal or nitrification and determine the frequency and nature of overflows from pump stations and WWTP by-pass.
Municipal waste water treatment plants	Releases to MBR from Lowood and Fernvale	Pathogens[1], nitrates/nitrites, trihalomethanes, high BOD, turbidity and colour	Major	Likely	**Extreme**		Major	Likely	**Extreme**		

Appendix G (continued)

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
On-site domestic waste water treatment systems	Effluent from septic tanks in unsewered areas of the catchment with main concentrations at Lowood, Coominya and Fernvale. Soils with poor infiltration capacity. Septic systems are old and questionable treatment effectiveness.	Pathogens[1], nitrates/nitrites, trihalomethanes, high BOD, turbidity and colour	Moderate	Possible	**High**	Plumbing and Drainage Act 2002 – IDAS On-site Sewerage Code (Standard Sewerage Law) and the On-site Sewerage Facilities Guidelines for Vertical and Horizontal Separation Distance.	Moderate	Possible	**High**		
Unlawful waste dumping	Unlawful disposal of regulated waste, general waste (construction and demolition waste), domestic waste, medical waste within and adjacent to the MBR.	Metals, radionuclides, pathogens[1], hydrocarbons, PAHs, semi-volatile organic compounds, organic compounds, asbestos, pesticides, pH, nutrients, turbidity and colour	Major	Likely	**Extreme**	No controls identified	Major	Likely	**Extreme**		
Terrorism and/or sabotage											
Terrorism and/or sabotage	May include bomb, arson, terrorism threat, suspect articles, gas leaks, chemical leaks, biological or radiological incidents.	Metals, radionuclides, pathogens[1], hydrocarbons, PAHs, semi-volatile organic compounds, organic compounds, asbestos, pesticides, pH, nutrients, turbidity and colour	Catastrophic	Possible	**Extreme**	State Counter Terrorism Plan or National Counter Terrorism Plan.	Catastrophic	Possible	**Extreme**	No active measures in place to prevent acts of sabotage or terrorism.	QBWSA to examine its role in preventative management of acts of terrorism. Development of Emergency Action Plan for incidents which result in decline in water quality. This will require a review of the emergency response procedures which already exist for other stakeholders such as Department of Emergency Services, Queensland Police and EPA.

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
Climate Change											
Over grazing	To supply and demand for the growing population in SEQ leading to accelerated erosion and agricultural chemical contaminant inputs.	Salinity, pesticides, nutrients, turbidity and colour	Major	Possible	**Extreme**	Some government and independently funded riparian rehabilitation projects (e.g. Healthy Waterways and BCC). DPI/DNR/SEQCatchments training course on land management skills for stocking rates for graziers	Major	Possible	**Extreme**	Limited change, no extensive application, localised improvement projects only.	
Less available water for irrigation	More bare soil due to less planting of traditional high water demanding crops, increase erosion, higher pesticides/ herbicides inputs. Shift towards grazed pastures and intensive feedlots	Salinity, nutrients, turbidity and colour	Minor	Possible	**Medium**	Reduced water allocation for Mid Brisbane irrigators resulting in planting of drought tolerant pasture (i.e. potential positive influence on erosion issues during drought). Limited policing of water allocations.	Minor	Possible	**Medium**		
Increased raw water demand for domestic use	Increased population pressure in SEQ leading to increased water demand for consumption and municipal supply. Less water for natural resource management and natural processes.	Salinity, nutrients, turbidity and colour	Major	Almost Certain	**Extreme**	The QLD Water Commission 140L/day per household water conservation initiative Target 140.	Major	Almost Certain	**Extreme**		Recycling of water and water grid (currently being implemented) Water conservation targets
Increased duration between extreme rainfall events	Drying of soil, episodic wetting, erosion, salinity.	Salinity, nutrients, turbidity and colour	Catastrophic	Almost Certain	**Extreme**	No controls identified	Catastrophic	Almost Certain	**Extreme**	Erosion may be addressed in certain localities by riparian restoration projects. Not many controls in place. Long dry periods then high inflow events dependent upon land management skills.	Weirs on Lockyer Creek to assist in the setting out of turbidity associated with flood inflows into the Mid Brisbane River.

Appendix G (continued)

Source	Aspect	Hazard	Potential Risk			Current Operational Controls	Residual Risk			Comments Information Gaps	Proposed Future Controls
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
Recreational											
Camping	Bank stability, riparian vegetation removal, fuels, oils, fire damage	Metals, radionuclides, pathogens[1], hydrocarbons, PAHs, semi-volatile organic compounds, organic compounds, asbestos, pesticides, pH, nutrients, turbidity and colour	Major	Almost Certain	**Extreme**	Unregulated access through private land for access and egress to the river. Bollards used at public access areas such as Twin Bridges and Savages Crossing to reduce access to riparian areas. No designated or managed camping sites along the Mid Brisbane River. Penalty system exists but limited enforcement. Limited signage to inform camping is prohibited. No outdoor recreation strategy for the entire Mid Brisbane River.	Major	Likely	**Extreme**	Recreational use of the Mid Brisbane River (raw water supply) is prohibited under the Australian Drinking Water Guidelines and a key decision must be made by regulators as to whether recreational use of the Mid Brisbane River is appropriate as this water is SEQ drinking water supply. No recreational use guidelines for the entire reach of the Mid Brisbane River. The Mid Brisbane River passes through multiple jurisdictions and no unified recreational use management plan. Cost restrictions on management and enforcement of any recreational use guidelines. Public awareness of impacts of human use of the waterway is required via signage and information points. Increased public awareness of the Mid Brisbane River for recreational activities due to media reports results in increased visitation (i.e. Courier Mail article dated 18 April 2008).	A collaborative ownership of the management of water quality in the Mid Brisbane River. Stakeholder partnership for management of development impacts (Mid Brisbane River Partnership). Public awareness campaign to promote the impacts associated with recreational activities on water quality and environmental values of the Mid Brisbane River. Mid Brisbane River Recreation Management Plan was initiated in November 2004 but requires finalisation, ratification and implementation. Allocation of funding for establishment of infrastructure, rangers and permitting system under a final Mid Brisbane River Recreation Management Plan. Enforcement of final Mid Brisbane River Recreation Management Plan (i.e. fines, permits).
Infrastructure	Hazards related to the lack of infrastructure in riparian areas of the MBR used for recreation and issues include poor waste management, sediment laden runoff and bank erosion.	Pathogens[1], nutrients, turbidity and colour	Major	Almost Certain	**Extreme**		Major	Likely	**Extreme**		
Unrestricted access for recreation (entire MBRC)	Litter, erosion, sediment, riparian vegetation loss, weed transport, pathogens	Metals, radionuclides, pathogens[1], hydrocarbons, PAHs, semi-volatile organic compounds, organic compounds, asbestos, pesticides, pH, nutrients, turbidity and colour	Major	Almost Certain	**Extreme**		Major	Likely	**Extreme**		
Canoeing	Riparian vegetation loss, erosion, bank stability, hydrocarbons, litter	Metals, radionuclides, pathogens[1], hydrocarbons, PAHs, semi-volatile organic compounds, organic compounds, asbestos, pesticides, pH, nutrients, turbidity and colour	Major	Possible	**Extreme**		Major	Likely	**Extreme**		
Recreational vehicles - 4WD, dirt bikes, jet skiing, mountain bikes	Bank stability, litter, human waste, erosion, loss of riparian vegetation, hydrocarbons.	Metals, pathogens[1], hydrocarbons, semi-volatile organic compounds, nutrients, turbidity and colour	Major	Almost Certain	**Extreme**		Major	Likely	**Extreme**		

Appendix H

WDWQMP Improvement Plan

Actions	Accountability	Review	Status	Completion / Review
1. Implementation Requirements				
Implementation				
Submit draft WDWQMP and improvement plan to the WGM for review (as required under the *Market Rules*), and to WaterSecure to ensure consistency with the RWMP for PRW.	Peter Schneider (LWQ Manager) / Mike Taylor (Contractor–Risk Management)	Annual	Completed	Further review as required under the *Market Rules*, and ongoing consultation with Grid Participants
Submit final WDWQMP and improvement plan to the OWSR.	Peter Schneider (LWQ Manager) / Mike Taylor (Contractor–Risk Management)	Annual	Completed	Further review according to annual review cycle
Convene WDWQMP Staff Implementation and Stakeholder (other Water Grid entities) Workshops.	Peter Schneider (LWQ Manager) / Mike Taylor (Contractor–Risk Management)	Annual	Planning	March 2011
Further develop the risk management framework for Seqwater's DWQMPs. The goal is to further integrate LWQ functions relating to monitoring, research, catchment management and planning to ensure outcome delivery and ongoing compliance (see WDWQMP; Fig. 1): → Tabulate alignment and compliance with ADWG. → Convene workshop on application of risk management frameworks to SEQ catchments and storages (e.g. Pressure-Condition-Response Models). → Integrate with *SEQ Regional Plan 2009–2031* and other relevant planning mechanisms. → Maximise benefits through stakeholder engagement (e.g. *Seqwater Report Card* and other public reporting). → Application of relevant catchment/water quality management legislation. → Emphasis on developing feedback loops to ensure efficient targeting of management strategies. → Decision support systems (DSS), documentation and review.	Peter Schneider (LWQ Manager) / Mike Taylor (Contractor–Risk Management)	Ongoing	In progress	March 2011

Appendix H (continued)

Actions	Accountability	Review	Status	Completion / Review
Legal arrangements				
Establish contracts and other legal agreements: → PRW provider. → Commercial arrangements.	Jane Whipps (Principal Legal Adviser) John Nicolas (Consultant)	As required	In progress	June 2011
Establish procedure for annual reporting in according with the *Water Supply (Safety and Reliability) Act 2008*.	Rosemarie Webster (Compliance Manager)	Annual	Draft	June 2012
Contractors				
Establish procedure for identifying the Approved Contractor Panel including qualifications.	Peter Schneider (LWQ Manager)	Annual	In progress	March 2011
2. Corporate Commitment				
Implement Seqwater's new intranet featuring water quality and sustainability policies and other information for keeping Seqwater employees up to date with the requirements of the WDWQMP.	Arun Pratap (Manager, Asset & Corporate Management Systems)	Annual	In progress	June 2011
3. Regulatory and Formal Requirements				
Complete review of the *Compliance Obligations Register*.	Rosemarie Webster (Compliance Manager)	Annual	Completed	Further review included in annual review cycle
4. Stakeholder Engagement				
Implement stakeholder engagement initiatives from the *Draft Land and Water Quality Strategy*: → Initiate discussions with the Queensland Government on management of point sources (including WWTP discharges).	Peter Schneider (LWQ Manager)	Annual	Planning	June 2010
Seek Scheduling of Draft EVs and WQOs for Lakes Wivenhoe and Somerset, and Mid-Brisbane River under the *Environmental Protection (Water) Policy 2009*.	Jonathon Burcher (Water Quality Coordinator, Central Region)	4 years	Draft EVs and WQOs finalised	Scheduling in March 2010 (DERM/Parliamentary processes permitting)
Complete review of the *Draft Land and Water Quality Stakeholder Register*.	Peter Schneider (LWQ Manager / Mike Taylor (Contactor–Risk Management)	Annual	Draft	June 2010
Complete development and delivery of *Seqwater Report Card* for 2009-10.	James Udy (Principal Scientist)	Annual	Draft	October 2010

Actions	Accountability	Review	Status	Completion / Review
5. Hazard ID / Risk Assessment				
Convene workshop for evaluating uncertainty for risk assessments.	Belinda Reynolds (Senior Planner)	3 years	Completed	Included in 3 yr review cycle
Document process for incorporating extreme and high risks into the Seqwater *Enterprise Risk Register*.	Peter Schneider (LWQ Manager) Mike Taylor (Contractor–Risk Management) Jeff Lyddon (Risk Advisor)	Annual	In progress	March 2011
Review projected impacts of PRW, in light of: → Queensland Government policy decisions on when PRW will be added. → Results from the WCRWP Scheme Risk Assessment.	Peter Schneider (LWQ Manager) Mike Taylor (Contractor–Risk Management)	Annual	In progress	June 2010
Identification and review of preventive measures for significant risks: → Wivenhoe/Somerset storage. → PRW returns. → Catchments. → Water Source Protection Plan. → Operational controls: e.g. releases from Lake Wivenhoe to reduce impacts on Mt Crosby WTP (Appendix G).	Peter Schneider (LWQ Manager) Mike Taylor (Contractor–Risk Management)	Annual	In progress	June 2010
6. Catchment Water Quality Monitoring Program				
General information/flowchart on how monitoring is used, escalated and communicated (re *Catchment Water Quality Monitoring Program*) with links to appropriate documents.	Andrew Watkinson (Principal Catchment Water Quality Scientist) Mike Taylor (Contractor–Risk Management)	Annual	In progress	March 2011
Finalise and implement new *Catchment Water Quality Monitoring Program* (also see Research Plan section): → Event monitoring. → HACCP Team review. → Measures for exceedances, based on the WQOs, including how monitoring is increased including linkages to HACCP Plans. → Incorporate risk-based CCPs equivalents. → Incorporate WQO percentiles for 'warning' and 'act now' results. → Data processing / QA. → Reporting framework.	Andrew Watkinson (Principal Catchment Water Quality Scientist) Jonathon Burcher (Water Quality Coordinator, Central Region)	Annual	Draft	March 2011

Appendix H (continued)

Actions	Accountability	Review	Status	Completion / Review
Assess and report on data from the new *Catchment Water Quality Monitoring Program* against the EV and WQO indicators: → Short term 6 and 12 monthly trending analyses and reporting. → Adoption of methods consistent with the *Seqwater Report Card*.	Andrew Watkinson (Principal Catchment Water Quality Scientist)	Annual	Draft	March 2011
Identification and review of point source risks for licensed discharges: → WWTP discharges, bypass data (wet weather events).	Belinda Reynolds (Senior Planner)	Annual	Planning	June 2010
7. Operational Controls				
Review all relevant operational control procedures (load onto *Q-Pulse Database*): → Dam operations. → Release plan.	Rob Drury (Dam Safety and Source Operations Manager)	Annual	In progress	March 2011
Document process for assessing effectiveness of maintenance program.	Rob Drury (Dam Safety and Source Operations Manager)	Annual	In progress	June 2010
Prepare *Job Analysis Procedures* (Work Method Statements) for catchments and storages: → Pesticide usage in the storage. → *Job Analysis Procedures Register*.	Brad Heck (Land Management Coordinator) / James Udy (Principal Scientist)	Annual	In progress	June 2010
8. Emergency Action Plans				
Review EAPs for water quality.	Belinda Reynolds (Senior Planner)	Annual	Draft	June 2010
Review EAPs for dam infrastructure.	Rob Drury (Dam Safety and Source Operations Manager)	Annual	Draft	June 2010

Actions	Accountability	Review	Status	Completion / Review
9. Policy and Planning				
Review high risk developments in Wivenhoe, Somerset and Mid-Brisbane catchments.	Belinda Reynolds (Senior Planner)	3 years	In progress	June 2010
Implement relevant recommendations from the risk assessments: → *Catchment and In-Storage Water Quality Risk Assessment (2007).* → *Catchment and Water Quality Risk Assessment for Mid-Brisbane River (2008).*	Adrian Volders (Catchment Manager)	Annual	In progress	June 2010
10. Water Source Protection Plan				
Finalise *Draft Water Source Protection Plan* (load onto *Q-Pulse Database*): → Incorporate cost-benefit analysis into the preventive measures for catchment risks.	Adrian Volders (Catchment Manager) Belinda Reynolds (Senior Planner)	3 years	Draft	June 2010
Complete operational requirements for the *Draft Water Source Protection Plan* and associated procedures.	Adrian Volders (Catchment Manager)	Annual	In progress	June 2010
Finalise and schedule *Action Plan for the Water Source Protection Plan* (Wivenhoe, Somerset and Mid-Brisbane catchments) including how the *Water Source Protection Plan* and *Action Plan for the Water Source Protection Plan* will be reported on.	Adrian Volders (Catchment Manager) Belinda Reynolds (Senior Planner)	Annual	In progress	June 2010
Develop and finalise partnership arrangements: → Farm management.	Adrian Volders (Catchment Manager)	Annual	In progress	June 2010
11. Communication Plans				
Incident reporting				
Finalise *Draft Wivenhoe System Communication Procedure*: → Ensure all notification entities are included; e.g. WGM, LinkWater. → Progress MOU or similar for communications, provision of research services and data sharing with WaterSecure.	Peter Schneider (LWQ Manager) Terry Carter (Principal Coordinator, Incident & Emergence Response)	Annual	Draft	March 2011
Review the procedure for dissemination of water quality data to customers (and the community), and mechanisms for feedback and complaints from customers including the WGM.	Peter Schneider (LWQ Manager) Mike Taylor (Contractor–Risk Management)	Annual	In progress	March 2011
Draft procedure for review and trending of customer/WTP complaints.	Terry Carter (Principal Incident Coordinator)	Annual	In progress	June 2010

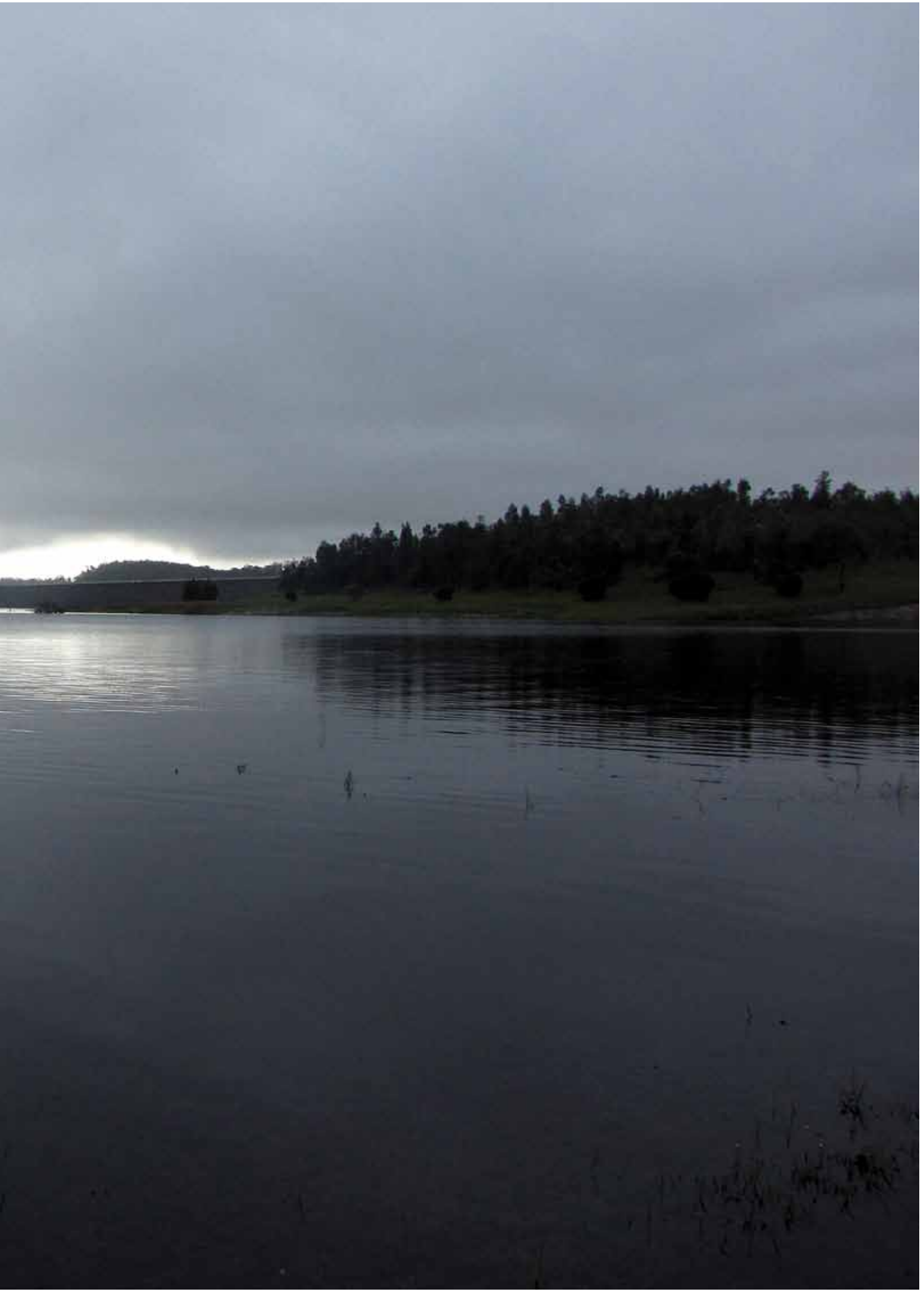
Appendix H (continued)

Actions	Accountability	Review	Status	Completion / Review
12. Research Plan				
Advice as required for development of the new *Catchment Water Quality Monitoring Program*: → Risk assessment review. → Conceptual models/system processes. → Development of suitable indicators; linkages to local EVs/WQOs; sampling frequencies; temporal/spatial components. → PRW monitoring targets: • Program design: data requirements, trending analyses, database development, data collection, and quality systems. • Develop *Catchment Water Quality Monitoring Program* system performance indicators. → Identify and implement emerging technologies; e.g. Microbial Source Tracking, PCR development, passive samplers, monitoring of trace contaminants. → Methods for assessing compliance.	James Udy (Principal Scientist)	Ongoing	In progress	March 2011
Further develop 3D-hydrodynamic and ecological, quantitative predictive model: → Characterise the nature of mixing effects within Lake Wivenhoe due to: • Wind overturn. • Splityard Creek. • PRW inflow. • Runoff events. → Improve understanding of water circulation / PRW short-circuiting.	James Udy (Principal Scientist)	Ongoing	In progress	June 2010
Incorporate EV and WQOs into hydrodynamic / ecosystem models.	James Udy (Principal Scientist) Coordinator, Central Region)	Ongoing	Planning	August 2010

Actions	Accountability	Review	Status	Completion / Review
Determine key drivers of algal growth in Lake Wivenhoe and Mid-Brisbane and seek to develop revised Local EV and WQO for key indicators.	James Udy (Principal Scientist)	Ongoing	In progress	August 2010
Develop new techniques for identifying periods of increased taste and odour risk as well as mitigation strategies	James Udy (Principal Scientist)	Ongoing	In progress	Dec 2010
Establish carbon degradation pathways within the water column and sediment.	James Udy (Principal Scientist)	Ongoing	In progress	June 2010
Review applicability of research outputs to the objectives of the WDWQMP.	James Udy (Principal Scientist) / Mike Taylor (Contractor–Risk Management)	Ongoing	In progress	June 2010
Establish and review research partnership arrangements.	James Udy (Principal Scientist)	Ongoing	In progress	June 2010
13. Supporting Procedures				
Complete reviews of Supporting Procedures to ensure all LWQ DWQMP requirements are met.	Peter Schneider (LWQ Manager) ./ Mike Taylor (Contractor–Risk Management)	Annual	Draft	March 2011
Complete the following supporting procedures: → *Preferred Suppliers Register.* → Asset condition assessment.	Seqwater Finance Group Peter Pennell (Manager, Strategic Maintenance, Planning & Renewal)	Ongoing	In progress	June 2010
14. Community involvement				
Participate in land use / community forums relevant to Wivenhoe system.	Adrian Volders (Catchment Manager)	Annual	In progress	Ongoing
Establish a procedure for community consultation including complaints.	Adrian Volders (Catchment Manager)	Annual	In progress	June 2010
15. Staff Training & Awareness				
Review staff performance review processes.	Imran Musa (Senior Human Resources Advisor)	Annual	In progress	June 2010
Targeted training of staff and contractors in specific requirements of the WDWQMP; e.g.: → Regulatory and legislative requirements. → Roles and responsibilities.	Peter Schneider (LWQ Manager) ./ Mike Taylor (Contractor–Risk Management)	Annual	Planning	March 2011

Appendix H (continued)

Actions	Accountability	Review	Status	Completion / Review
16. Documentation & Reporting				
Ensure contractual obligations are met to notify and report to the WGM: → If water quality deteriorates. → Provide water quality data on request.	Peter Schneider (LWQ Manager) Mike Taylor (Contractor–Risk Management)	Annual	In progress	March 2011
Review documentation management system (CIS project implementation).	Peter White (Senior Corporate Systems Coordinator)	Annual	In progress	June 2010
17. Evaluation & Audit				
Development of audit process for the WDWQMP.	Peter White (Senior Corporate Systems Coordinator).	Annual	In progress	June 2010
18. Review & Improvement				
Develop a review process for the WDWQMP when it is approved by the OWSR: → Maintain *WDWQMP Improvement Plan*. → Outcomes reported and reviewed. → WDWQMP endorsed by Seqwater Executive.	Peter Schneider (LWQ Manager) / Mike Taylor (Contractor–Risk Management)	Annual	In progress	June 2010



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