Queensland Water Quality Guidelines 2009

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Contents

Preface

Queensland's waters range from ephemeral inland streams to the great tidal rivers of the Wet Tropics. The state has a diverse network of streams and rivers, estuaries, wetlands, coastal bays and the World Heritage waters of the Great Barrier Reef.

All of these waters support diverse and essential ecosystems, but are, at the same time, subject to ever-increasing pressure to accommodate the various needs of the state's human population, including drinking water supply, agriculture and recreation.

Protecting the quality of the state's waters in the face of economic and population growth is a major priority for the Queensland Government.

National guidelines for water quality were published in 2000. These set benchmark values against which the quality of waters can be assessed. However, it is difficult for a national document to cover the vast range of water types found in Australia, and the national guidelines themselves recommend developing more regionally specific guidelines. The Queensland Water Quality Guidelines have been developed to deliver this regional focus.

Under the Environmental Protection (Water) Policy 2009 the Queensland Water Quality Guidelines inform the setting of water quality objectives required to protect or enhance environmental values for Queensland waters. They also provide government and the general community (including catchment/water managers, regulators, industry, consultants and community groups) guidelines for assessing and managing ambient water quality.

The first major version of the Queensland Water Quality Guidelines was released in 2006, with minor updates released in 2007. This 2013 edition includes updates and additional information, including a set of local water quality guidelines for the Mackay-Whitsunday region, which were developed by the region's NRM body. This version also provides linkages between the Queensland guidelines and the Great Barrier Reef Water Quality Guidelines recently drafted by the Great Barrier Reef Marine Park Authority.

The Queensland Water Quality Guidelines will continue to be a dynamic document. New information on the state's waters will be progressively incorporated into future versions of the guidelines so that they remain an up to date technical resource to help protect and manage Queensland's waters.

1 Introduction

1.1 National context and need for local guidelines

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (the ANZECC 2000 Guidelines) are a key technical component of Australia's National Water Quality Management Strategy (NWQMS). The NWQMS aims to achieve the sustainable use of Australia and New Zealand's water resources by protecting and enhancing their quality while maintaining economic and social development. The NWQMS is a strategy developed jointly by two ministerial councils: the Australian and New Zealand Environment and Conservation Council (ANZECC), and the Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ). The strategy now sits under the Environment Protection and Heritage Council (EPHC) and the Natural Resource Management Ministerial Council (NRMMC) with a secretariat in the Department of Environment, Water, Heritage and the Arts (DEHWA). In May 2009, the EPHC and NRMMC funded a three year program to update the ANZECC 2000 Guidelines.

The ANZECC 2000 Guidelines provide guideline values (numbers) or descriptive statements for different indicators to protect aquatic ecosystems and human uses of waters (e.g. primary recreation, human drinking water, agriculture, stock watering). For aquatic ecosystems, although the ANZECC 2000 Guidelines provide extensive default guideline values, they strongly emphasise the need to develop more **locally relevant** guidelines. The ANZECC 2000 Guidelines state: 'It is not possible to develop a universal set of specific guidelines that apply equally to the wide range of ecosystems in Australia and New Zealand. A framework is provided that allows the user to move beyond single-number, necessarily conservative values, to guidelines that can be refined according to local environmental conditions. This is the key message of the Guidelines.'

It is within this context that the Queensland Water Quality Guidelines have been initiated and will be progressively updated.

1.2 What are the Queensland Water Quality Guidelines?

1.2.1 Purpose

The Queensland Water Quality Guidelines (QWQG) are intended to address the need identified in the ANZECC 2000 Guidelines by:

- providing guideline values (numbers) that are tailored to Queensland regions and water types; and
- providing a process/framework for deriving and applying more locally specific guidelines for waters in Queensland.

1.2.2 Version and updating

This is the 2013 version of the Queensland Water Quality Guidelines (QWQG). Subsequent versions will be released as significant new material becomes available. The QWQG is available on the department's website www.ehp.qld.gov.au.

1.2.3 Extent of application

The QWQG applies to Queensland waters (including ground waters and waters within bed and banks). The spatial limits of the waters of Queensland are taken to be:

- **Land**: The state boundaries;
- **Marine**: The three nautical-mile limit of Queensland waters.

The Queensland Water Quality Guidelines are intended to apply to the above-defined waters.

For the waters within the Great Barrier Reef (GBR), the Great Barrier Reef Marine Park Authority (GBRMPA) has published *Water Quality Guidelines for the Great Barrier Reef Marine Park*. Following negotiation with GBRMPA, this version of the QWQG has been drafted to clarify the applicable water quality guidelines for different water types, particularly where there is potential for overlap. The decision rules governing this integration with GBR guidelines are detailed in section 2.3.4. The GBRMPA guidelines are available from the GBRMPA website..

1.2.4 Scope of the Queensland Water Quality Guidelines

The QWQG is a set of technical guidelines, primarily for the protection of Queensland aquatic ecosystems. The guidelines include locally and regionally relevant guideline values for fresh, estuarine and marine waters. EHP and Department of Natural Resources and Mines have been collecting water quality data from reference (unimpacted or minimally impacted) waterways since 1992. EHP has used this data, together with data collected throughout Queensland by other government agencies, tertiary institutions and other organisations, to derive the QWQG. Although the QWQG is primarily aimed at providing guidelines for aquatic ecosystems in Queensland, they also provide a limited range of state-specific guidelines for human use, including primary recreation and aquaculture. For example, undertaking aquaculture of a local species in far north Queensland might require some adjustment to the national guideline values, so local guidelines have been provided in this document.

More specifically, the main aspects covered in the QWQG (and the corresponding section number) are outlined below. The process for developing or selecting water quality guidelines is shown in Figure 2.1.1.

(a) Technical context for the guidelines (section 2)

This section introduces the following technical elements:

- the ANZECC 2000 framework for levels of ecosystem protection, with an explanation of how levels of protection influence the process of establishing guideline values for different waterways;
- the division of Queensland into regions (and in some cases, sub-regions), for which different water quality guidelines are established;
- the principal water types used in the guidelines, the approaches used to define/map these, and the source of guidelines used in this document (by each water type in each region);
- the relationship between the QWQG and the GBRMPA water quality guidelines;
- the scope of indicators to be addressed by guidelines; and
- discussion on the relationship of the guidelines to the prevailing stream flow characteristics.

(b) Queensland regional or sub-regional guideline values for aquatic ecosystem protection (section 3)

This section of QWQG provides water quality guideline values (i.e. numbers) for aquatic ecosystems for a range of defined Queensland regions. For other regions (e.g. Cape York), there is insufficient information at this time to provide regional guidelines. Where more detailed local data is available the QWQG provides guideline values for smaller sub-regional areas, e.g. segments of Moreton Bay.

The guidelines are based largely on good quality reference data collected throughout Queensland by a range of government agencies, tertiary institutions and other organisations. Where available, guidelines based on biological effects data are included.

The QWQG will focus on indicators that vary regionally and for which good quality data is available – particularly physico-chemical, biological and habitat indicators. The QWQG will also seek to provide guideline information for indicators not covered in the ANZECC 2000 Guidelines. For some types of indicators (e.g. toxicants) for which there is very limited local data, the ANZECC 2000 Guidelines will remain the main source of information.

The QWQG will be the primary source of aquatic ecosystem guideline material for water quality management purposes in Queensland. Where Queensland guideline values are not available, users should default to the ANZECC 2000 Guidelines or derive their own locally specific guidelines. On this matter, the QWQG provides guidance on how to derive local guidelines (refer to part (c) below).

Specific issues covered in section 3 include:

- water quality guidelines values (i.e. numbers) for various indicators and water types within each water quality region (‘regional guideline values’);
- as above but for more localised areas (‘sub-regional water quality guideline values’). Where available, these take precedence over the regional guideline values;
- supporting statements/explanatory notes and maps to facilitate understanding the guidelines; and
- supporting references/technical documents.

The QWQG also provides some technical information relating to management of riparian areas. In this version of the QWQG, the main technical source of riparian information is provided for the South-east Queensland (SEQ) region, based on work carried out for the Moreton Bay Waterways and Catchments Partnership. At the end of the SEQ section, there is a listing of riparian management source documents/guidelines, some of which have potential for application in other Queensland regions. As further technical information becomes available it will be included in future versions of these guidelines. For example, EHP is currently developing resource information to assist in identifying buffers/setbacks for wetland habitats in Queensland. The QWQG will provide additional information on riparian management as it becomes available.

(c) Procedures for deriving local guidelines for aquatic ecosystem protection (section 4)

Another key purpose of the QWQG is to provide guidance and procedures that will allow users, for example regional NRM bodies, to develop guidelines specific to their own waters (i.e. guidelines that are more localised than the QWQG and meet the QWQG's technical requirements for development of such guidelines). This may be necessary for a number of regions or water types where little previous data has been collected or where there are specific conditions that are not covered by the QWQG or ANZECC 2000 Guidelines.

Specific issues covered in section 4 include:

- general principles for deriving local guidelines;
- indicators;
- regions and water types (for the purposes of deriving and applying guidelines) and the rationale underlying these subdivisions;
- criteria for selecting reference sites;
- criteria to ensure reference data quantity and quality when deriving guidelines; and
- methods for deriving guideline numbers from reference data.

(d) Procedures for applying guidelines for aquatic ecosystem protection (section 5)

The QWQG contains guidance for the application of guideline values to water quality management in Queensland. Activities in which the guidelines could be used include assessments of waterway condition, processes for establishing environmental values and water quality objectives, and development assessments and licensing discharges (e.g. for activities under the *Environmental Protection Act 1994*). The QWQG provides links to other documents and guidelines to assist in this regard.

Specific issues covered in section 5 include:

- assessing test sites
  - quantity and quality requirements for data to compare with guidelines;
  - procedures for comparison with guidelines;
- using guidelines as an input to environmental values and water quality objectives processes; and
- development assessment, including licensing discharges.

(e) A compilation of reference data for Queensland aquatic ecosystems (section 6)

This section aims to provide reference condition data for a range of aquatic ecosystem indicators not included in the more formalised guideline tables. The purpose of this data is to provide a measure of 'normal' or 'typical' condition which can be used as a benchmark to compare with data from potentially impacted systems. While this information is used in a similar way to guidelines, the data on which it is based is less extensive and so the information should be regarded as advisory only. Some of this information may be upgraded to guideline status in the future. In version 3 of the QWQG, this section is limited to information on metals in oysters and mussels and information on biochemical oxygen demand (BOD) but it will be expanded in future versions of the guidelines.

It is one of the long term aims of the QWQG to capture as much of this type of data as possible. Compiling this type of data within a single document will make it more readily accessible to users.

(f) A compilation of guidelines relevant to human uses of water (section 7)

For most human uses of waters (e.g. drinking, recreation, irrigation) guideline values are generally applicable across all of Australia and therefore national guidelines for these uses will remain the main source of guideline information. This section contains a compilation of the relevant national guidelines for these types of uses. In some limited instances, there may be state guideline values set for these types of uses and another of the purposes of this section is to compile these state-level guidelines. These state-level guidelines would normally take precedence over national guidelines.

(g) Guidelines for urban stormwater (section 8)

This section contains:

- a compilation of information on 'typical' urban stormwater quality in existing urban areas; and
- guidelines for urban stormwater quality in new subdivisions

- The purpose of the information on typical urban stormwater quality is to provide a benchmark against which measurements of water quality in a specific urban catchment can be assessed. This would allow users to determine if anything unusual was occurring in such a catchment, i.e. something beyond normal urban contamination. The values in '1', however, should not be used to derive objectives for stormwater quality in new (or retrofitted) subdivisions. For this purpose, the guidelines under '2' should be referred to.

(h) National guidelines (section 9)

This section provides a listing of the main national guidelines applying to waterways in the absence of further information in these guidelines.

(i) Supporting technical information (appendices)

The appendices provide more detailed information on a range of issues, including water-type boundaries, mapping data sources, indicators and statistical protocols.

1.2.5 Relationship of ANZECC 2000 Guidelines and QWQG to *Environmental Protection (Water) Policy 2009*

Water quality guidelines can be developed at different spatial scales (e.g. national, state, local). The *Environmental Protection (Water) Policy 2009* outlines the process for determining which water quality guidelines (e.g. national, state, local) to use in water quality planning and decision making. In summary, where there is more than one set of applicable guidelines, the most locally accredited guideline information shall take precedence over broader guidelines. Thus, where the QWQG provides water quality guideline values for Queensland waters that are more localised than the ANZECC 2000 guidelines, the QWQG takes precedence over the (broader) ANZECC 2000 guidelines. However, for a number of indicators, notably toxicants, there is little or no local information. For these indicators the ANZECC 2000 Guidelines will remain the principal source of information.

Similarly, the QWQG provides a framework for establishing more localised guidelines than those currently provided in the QWQG. Where more locally relevant guidelines are appropriately developed and meet relevant technical requirements (e.g. those identified in this document), then they would in turn take precedence over the regional/sub-regional guidelines established in this document.

1.3 Queensland water quality management context

1.3.1 Links to environmental values and water quality objectives

The principal legislative basis for water quality management in Queensland is the *Environmental Protection (Water) Policy 2009* (EPP Water), which embodies the principles of the National Water Quality Management Strategy. The EPP Water includes a process for:

- identifying environmental values (EVs) of waterways, including both aquatic ecosystem values, and human use values. (The range of environmental values that may apply to waterways is summarised in Appendix H.); and
- establishing corresponding water quality objectives (WQOs) (also known as targets) to protect identified EVs. WQOs are established for different indicators of water quality such as pH, nutrients and toxicants. Achieving the identified WQOs for a waterway means the corresponding environmental values and uses of that waterway will be protected.

Technical water quality guidelines (such as the QWQG) form an important input to this EVs/WQOs process because they can be used as a starting point in setting WQOs. They also act as default WQOs in the absence of any scheduled EVs/WQOs. Because the EVs/WQOs process requires stakeholder input and the consideration of social/economic impacts, the finally adopted EVs/WQOs may differ from guideline values contained in the technical water quality guidelines. Where EVs/WQOs are included in Schedule 1 of the EPP Water, these take precedence over the values in the QWQG when making decisions under the EPP Water. Section 5.3 provides further detail on this issue.

Note that environmental values (EVs) and water quality objectives (WQOs) for a number of regions have been scheduled under the EPP (Water), with the QWQG acting as a primary technical input. Reference should be made to relevant EPP Water schedule 1 documents and accompanying plans, which are available on the department's website, for a comprehensive listing of EVs and WQOs.

For each area scheduled under the EPP Water, there is a document and a supporting plan.

1.3.2 Associated planning processes and related documents

Water quality: Management of water quality in Queensland is undertaken through a range of statutory and non-statutory processes. Some of the primary processes and planning frameworks are listed below:

- identification of EVs and WQOs for Queensland waters under the EPP Water (For more information on the EV setting process refer to the guideline Establishing draft environmental values and water quality objectives;
- development approvals, including point source discharges under the *Environmental Protection Act 1994* (for more information on the process of assessing point source discharges under the Environmental Protection Act refer to guideline Waste Water Discharge to Queensland Waters);
- coastal management plans under the Coastal Protection and Management Act 1995;
- local government planning under the Integrated Planning Act;
- South East Queensland Regional Plan;
- NAP and NHT regional natural resource management plans;
- Murray Darling Basin management plans;
- Reef Water Quality Protection Plan (2003, updated 2009);
- Water Quality Improvement Plans (WQIPs) developed for a range of GBR catchments under the Coastal Catchments Initiative; and
- other regional NRM body plans.

Water quantity: Management of water quantity is undertaken substantially through the provisions of the *Water Act 2000* and Water Resource Plans prepared under the Act. These are administered by the Department of Environment and Heritage Protection (previously by Natural Resources and Water). Certain sections of the Act, for example, sections dealing with the preparation of draft water resource plans, also require consideration of water quality, including EVs established under the EPP Water.

Riparian management: The QWQG provides a range of technical guidance source documents for riparian management. However, for statutory vegetation management (e.g. clearing of riparian areas), reference should be made to other information sources, including the relevant regional vegetation management codes under the Vegetation Management Act. EHP uses regional vegetation management codes to assess applications for clearing native vegetation. The vegetation management codes include riparian protection provisions in order to maintain values of watercourses including, for example, bank stability, water quality (by filtering sediments, nutrients and other pollutants), aquatic habitat, and terrestrial habitat. Further links to the vegetation management codes are provided in relevant sections of the QWQG. Background information on these codes (and access to the codes themselves) can be obtained from the department's website.

Queensland Wetlands Program: In 2003, the Australian and Queensland governments established a five-year Queensland Wetlands Program to protect wetlands in the Great Barrier Reef catchment and throughout Queensland.

The program is responsible for a number of projects that are delivering a range of new tools, including wetlands mapping throughout Queensland. Both the QWQG and Queensland Wetlands Program require the identification and classification of different water/wetland types (e.g. riverine, lacustrine, palustrine, estuarine, coastal) for their respective purposes. The decision rules/definitions and information used in mapping the respective wetland/water types have, to the greatest extent possible, been kept consistent/common to both the QWQG and the Queensland Wetlands Program. Some variations may occur between the two, for example, where sub-categorisation of water/wetland types was required for one but not the other, or where different mapping decision rules were applied. Further details on water types are provided later in the QWQG (refer section 2.4 – Water types and, in particular, Appendix B).

For the latest available information on the Queensland Wetlands Program (including the latest version of its technical report 'A *Wetland Mapping and Classification Methodology*', wetland definitions, supporting technical documents and mapping outputs), refer to the Wetland Info website.

Monitoring procedures: A companion document to the QWQG is the Queensland Monitoring and Sampling Manual. This manual provides detailed information on monitoring objectives, sampling approaches and analysis techniques, and should be referred to when undertaking monitoring for guideline development. It is available from the department's website at www.ehp.qld.gov.au

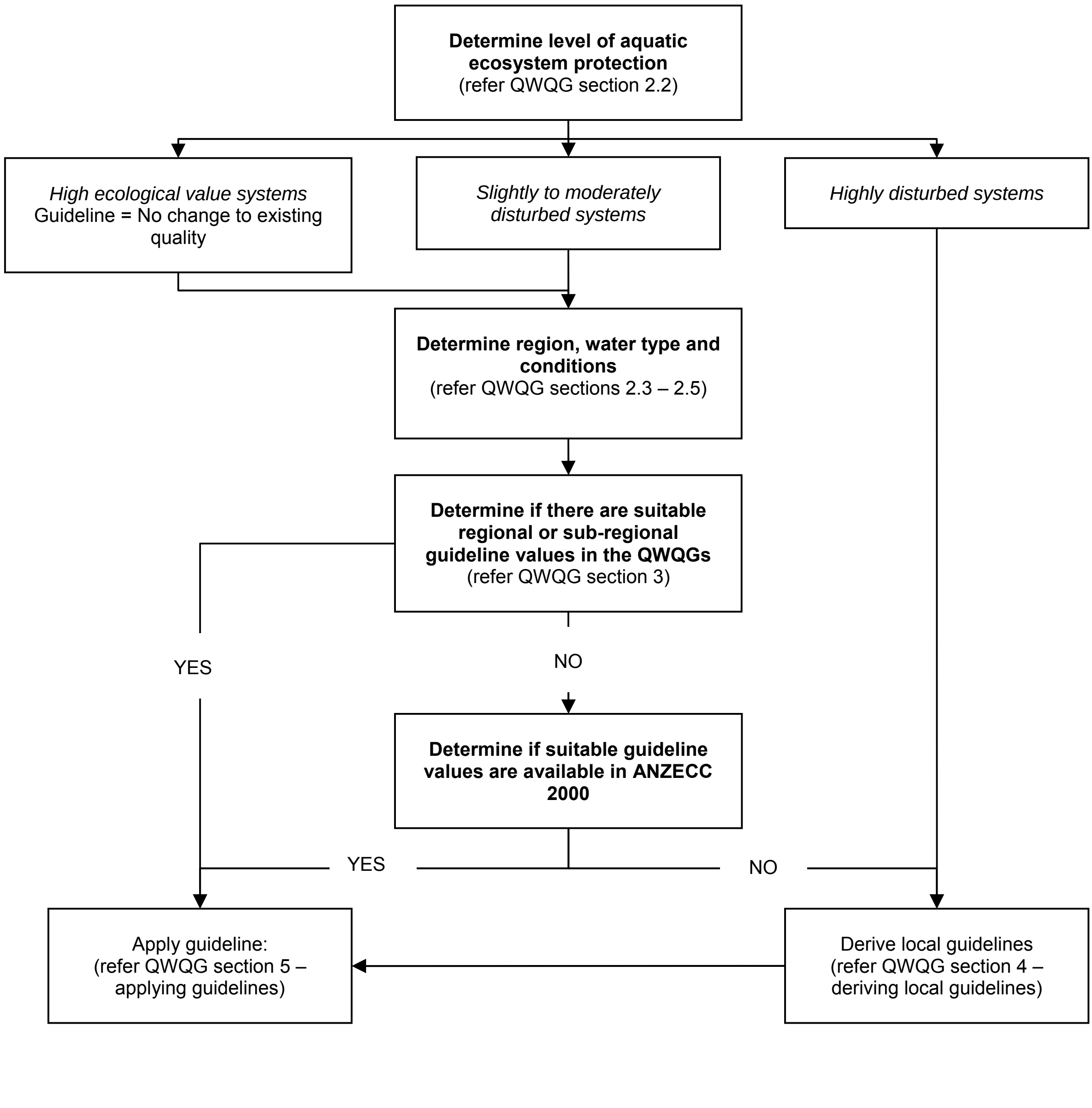
2 Technical context for the Queensland guidelines for aquatic ecosystem protection

2.1 Introduction

Guidelines for ecosystem protection can have varying levels of complexity. At their simplest, they can be single numbers that apply to all areas, all water types and under all flow regimes. While this approach does have the advantage of simplicity, it often results in entirely inappropriate numbers being applied to particular types of systems. To address this issue it is necessary to tailor guidelines more closely to each system type. The ANZECC 2000 Guidelines moved some way towards achieving this, particularly for physico-chemical indicators, through the definition of several regions and water types. One of the main purposes of the QWQG is to take this customisation process much further, with respect to Queensland's waters. This necessarily increases the complexity of the guidelines but results in much more appropriate numbers for individual situations.

This section is mainly concerned with describing the various factors that have been considered in the customisation of the guidelines for Queensland waters. These include level of protection, regions/sub-regions, water types and flow conditions (e.g. ambient vs 'event') under which the guidelines are meant to apply. In addition, this section includes some discussion of the scope of indicators for which it is appropriate to develop guidelines for ecosystem protection and the extent to which these are addressed in the QWQG. The overall process for developing or selecting water quality guidelines is provided in Figure 2.1.1 below (with cross-reference to relevant section numbers in the QWQG).

Figure 2.1.1: Process for developing or selecting water quality guidelines



2.2 Levels of aquatic ecosystem protection

2.2.1 Aquatic ecosystem condition

The ANZECC 2000 Guidelines establish a framework for developing water quality guideline values (numbers) based on the condition of aquatic ecosystems and the levels of protection provided to those ecosystems. This represents an important starting point in the process to derive water quality guidelines. The three levels of aquatic ecosystem condition are summarised in Table 2.2.1 below, and are:

- high ecological/conservation value systems (henceforth referred to as high ecological value systems);
- slightly to moderately disturbed systems; and
- highly disturbed systems.

Table 2.2.1: Definitions of aquatic ecosystem condition

Ecosystem condition	Definition
Level 1 High ecological/conservation value (HEV) ecosystems	'These are effectively unmodified or other highly valued systems, typically (but not always) occurring in national parks, conservation reserves or in remote and/or inaccessible locations. While there are no aquatic ecosystems in Australia and New Zealand that are entirely without some human influence, the ecological integrity of high conservation/ecological-value systems is regarded as intact.' (ANZECC 2000; 3.1–10)
Level 2 Slightly to moderately disturbed (SMD) ecosystems [1]	'Ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained. Typically, freshwater systems would have slightly to moderately cleared catchments and/or reasonably intact riparian vegetation; marine systems would have largely intact habitats and associated biological communities. Slightly to moderately disturbed systems could include rural streams receiving runoff from land disturbed to varying degrees by grazing or pastoralism, or marine ecosystems lying immediately adjacent to metropolitan areas.' (ANZECC 2000; 3.1–10) [1]
Level 3 Highly disturbed (HD) ecosystems	'These are measurably degraded ecosystems of lower ecological value. Examples of highly disturbed systems would be some shipping ports and sections of harbours serving coastal cities, urban streams receiving road and stormwater runoff, or rural streams receiving runoff from intensive horticulture. The third ecosystem condition recognises that degraded aquatic ecosystems still retain, or after rehabilitation may have, ecological or conservation values, but for practical reasons it may not be feasible to return them to slightly to moderately disturbed condition.' (ANZECC 2000; 3.1–10)

Source: (ANZECC, ARMCANZ: 2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality

Note 1: EPP Water 2009 recognises the potential to distinguish slightly from moderately disturbed systems and establish different management intents – see EPP Water and comments below.

The ANZECC 2000 Guidelines and the QWQG are primarily focussed upon deriving guideline values for slightly to moderately disturbed (level 2) aquatic ecosystems, as these are considered to represent a significant proportion of Australian waters (however, see comments below in relation to slightly modified systems). The QWQG also includes guideline values (numbers) for some high ecological value (level 1) waters within different regions of Queensland (for example, some waters within SEQ, Mary/Great Sandy region, Mackay-Whitsundays and Wet Tropics) where sufficient water quality data is available. High ecological value (HEV) waterways were identified under processes running parallel to the development of the QWQG (including in recent times, Water Quality Improvement Plans prepared for several GBR catchments, and EVs/WQOs scheduling projects under the EPP Water). These processes used a framework for identifying aquatic ecological values that was developed for Land and Water Australia (previously LWRRDC). The ecological values framework is included in the report *Guidelines for Protecting Australian Waterways* (2002), available for downloading from the Land and Water Australia website.

Figures 3.1.1(a–c) and 3.3.1 provide a broad outline of the waters identified as high ecological value in south-east Queensland and Douglas Shire (pre-amalgamation). For latest mapping in these regions refer to EPP Water schedule 1 maps and plans available for all regions from the department's website.

2.2.2 Guideline for aquatic ecosystems for different levels of protection

For each of the above levels of aquatic ecosystem, the ANZECC 2000 Guidelines provide corresponding guidance on the level of protection to apply. This is an important input to the QWQG, in that the level of protection influences the guideline values (numbers) developed for different waters. In effect, the ANZECC 2000 Guidelines recommend that stricter guideline values be developed for high ecological value (level 1) waters than other waters. The text box below summarises the main management-intent statements for high ecological value waterways contained in the ANZECC 2000 Guidelines.

What the ANZECC 2000 Guidelines say about high ecological value aquatic ecosystems.

'Some waters (e.g. many of those in national parks or reserves) are highly valued for their unmodified state and outstanding natural values. In many countries and in some Australian states these waters are afforded a high degree of protection by ensuring that there is no reduction in the existing water quality, irrespective of the water quality guidelines.' (2000; 3.1–11)

'The highest level of protection is for high conservation/ecological value systems where management would be expected to ensure there is no change in biological diversity relative to a suitable reference condition.' (2000; 2–9)

'The present guidelines recommend that for condition 1 ecosystems the values of the indicators of biological diversity should not change markedly….Any decision to relax the physical and chemical guidelines for condition 1 ecosystems should only be made if it is known that such degradation in water quality will not compromise the objective of maintaining biological diversity in the system.' (2000; 3.1–11)

'For condition 1 ecosystems, the Guidelines advise that there should be no change from ambient conditions, unless it can be demonstrated that such change will not compromise the maintenance of biological diversity in the system.' (2000; 3.3–6)

The ANZECC 2000 Guidelines provide further direction on how to derive water quality guidelines for different water quality indicator groups according to the level of protection identified for a waterway (refer Table 2.2.2).

In short, the recommended degree of change from reference condition will increase as the level of ecosystem protection declines.

Table 2.2.2: ANZECC (2000) default-effect sizes for different levels of protection

Indicator class	Effect size or departure from reference by level of ecosystem protection		
	High ecological value systems	**Slightly to moderately disturbed systems**	**Highly disturbed systems**
Toxicants in water	No change to natural values	95% species protected with 50% certainty	80–90% species protected with 50% certainty
Toxicants in sediments	No change to natural values	>95%ile of values complies with ISQG* low	Metals: <3xnatural background Toxicants: <3x ISQG low
Physico-chemical	No change to natural values	Median lies within $20^{th}/80^{th}$ percentile of reference range	Locally determined, e.g. $10^{th}/90^{th}$ percentile of reference range
Biological	No change to natural values	Median lies within $20^{th}/80^{th}$ percentile of reference range	Locally determined, e.g. $10^{th}/90^{th}$ percentile of reference range

* Refer to ANZECC (2000) sediment guidelines.

ANZECC (2000) makes a number of points about the three levels of protection and ecosystem condition outlined above, recognising that the classification is one way of representing a continuum of ecosystem conditions. Indeed the three categories identified in the ANZECC (2000) guidelines were an advancement on the two categories recognised in the previous (1992) ANZECC guidelines. Extracts from ANZECC (2000) are reproduced below:

'The three levels of protection described above form one practical but arbitrary approach to viewing the continuum of disturbance across ecosystems.' (ANZECC, 2000; 3.1-12)

'The concept of three ecosystem conditions in section 3.1.3 (of ANZECC) is for management guidance only. Users need to view these as examples that represent a continuum of ecosystem conditions.'

(ANZECC, 2000; 3.4-14)

'Local jurisdictions may negotiate alternative site-specific levels of protection after considering factors such as….perceived conservation/ecological values of the system additional to those recognised in the simple classification.' (ANZECC, 2000; 3.1-12)

(For toxicants) 'In most cases, the 95% protection level trigger values (ANZECC Table 3.4.1) should apply to ecosystems that could be classified as slightly–moderately disturbed, although a higher protection level could be applied to slightly disturbed ecosystems where the management goal is no change in biodiversity.'

(ANZECC, 2000; 3.4-3)

'Even though a system is assigned a certain level of protection, it does not have to remain 'locked' at that level in perpetuity. The environmental values and management goals (including level of protection) for a particular system should normally be reviewed after a defined period of time, and stakeholders may agree to assign it a different level of protection at that time. However, the concept of continual improvement should be promoted always, to ensure that future options for a water resource are maximised and that highly disturbed systems are not regarded as "pollution havens".' (ANZECC, 2000; 3.1-12)

Consequently, the QWQG and the *Environmental Protection (Water) Policy 2009* recognise the potential to provide further specification of the levels of ecosystem condition for which different levels of protection can be applied. A first stage in this process is the potential to distinguish slightly disturbed from moderately disturbed systems and levels of protection. This provides scope to refine management goals and guideline values for these systems. For example, some systems currently identified as slightly modified systems may be more readily improved to natural condition/high ecological value than systems in a more modified state. At this stage the QWQG does not specify detailed guideline values for the slightly disturbed level of protection, however future versions may do so depending on available information. Hence, version 3 of the QWQG has adopted the ANZECC 2000 Guidelines approach for physico-chemical indicators as identified above and has derived water quality guideline values (numbers) based on the rules in Table 2.2.3.

Table 2.2.3: Recommended basis for determining Queensland guideline values for waters at different levels of protection

Level of protection	Basis for guideline value
High ecological value systems	No change to natural values
Slightly to moderately disturbed systems[1]	Guideline based on 20th and/or 80th percentiles of reference data from good quality reference sites
Highly disturbed systems	Guideline locally derived based on: a less stringent percentile, e.g. 10th/90th or reference data from more impacted but still acceptable reference sites

Note 1: EPP Water 2009 recognises the potential to distinguish slightly from moderately disturbed systems and establish different management intents – see EPP Water

For high ecological value systems, the 'no-change' requirement implies there should be no change to any of the natural attributes of the system. This includes physico-chemical, biological and habitat attributes. In this context, 'no change' means there should be no change to the natural range of values of any given indicator. As a practical means of testing for no change, it is recommended that change to the 20th, 50th and 80th percentiles of the natural values all be tested. If all three percentiles pass the 'no change' test, then the overall range is deemed to have experienced no change. A method for assessing 'no change' against these three percentiles is given in Appendix D. In line with this approach to testing no change, guidelines for HEV waters (when data on natural condition is available) include values for all three percentiles. If data on natural condition is unavailable, then it will need to be acquired before any guideline can be established.

For slightly to moderately disturbed systems, the QWQG is based on application of the 20th and/or 80th percentiles of reference data approach. Refer to Appendix A for details of how this approach was applied to derive the QWQG.

For highly disturbed (HD) systems a less stringent local guideline can be derived using different percentiles or different reference data, as indicated in the above table. However, no guideline values for HD waters are included in the QWQG at this stage.

2.3 Regionalisation of guidelines

2.3.1 Regional and sub-regional guidelines

One of the aims of the QWQG is to provide a mechanism to tailor guidelines to better address the natural regional and local variability in water quality across the state. The ANZECC 2000 Guidelines addressed this issue (with respect to physico-chemical indicators) by defining four regions across Australia and six water types (e.g. upland streams, lowland streams, estuaries, etc) within each region. The QWQG takes the regionalisation approach two levels further by allowing creation of not only **regional guidelines within Queensland** but also **sub-regional (local) guidelines within Queensland regions.** These are defined below:

Regional guidelines: These are based on a set of major biogeographic regions that have been defined for Queensland – see section 2.3.2. Within each region a number of water types will be defined. Most water types are common across all regions but there may be a few types specific to a particular region. The main water types are defined in Appendix B. The long term aim will be to develop guidelines that can be applied to each water type within each region. The regional guidelines would be applied as a default to all parts of the region **except** where more detailed (i.e. more local) sub-regional guidelines have been defined (see below).

Sub-regional (local) guidelines: Where sufficient spatially detailed data is available, more locally specific guidelines will be developed. Under this approach guidelines would be defined for areas smaller than the region. This would be achieved by first defining one or more sub-regions. Sub-regional guidelines would then be developed for each defined sub-region. These sub-regions would be defined in terms of mapped boundaries.

The sub-regional approach is not limited to any one level of protection. The QWQG at this stage has established sub-regional (local) guidelines values for areas identified as high ecological value (e.g. areas within Noosa River estuary, eastern Moreton Bay, Great Sandy Strait, Mackay-Whitsunday, and Wet Tropics), and some slightly to moderately disturbed waters (e.g. Central Moreton Bay).

2.3.2 Queensland regions for water quality

There are a number of ways to break up the state into regions. It has been determined that for water-related issues, the division of Queensland into regions or zones would be most appropriately based on the AWRC (the former Australian Water Resources Council) defined major drainage divisions and, at the next level down, on the AWRC-defined catchment basins.

Queensland contains four major drainage divisions: Gulf Rivers, Lake Eyre, Murray Darling and Bulloo, and East Coast. These have been adopted in the QWQG with two main changes. (Refer Figure 2.3.1.)

Firstly, the Bulloo drainage division was combined with the Murray Darling.

Secondly, the East Coast drainage division is so large that the QWQG divides it into four sub-regions (South-east, Central, Wet Tropics, Cape York), based on climatic zones in Queensland.

Reference to Table 2.3.1 below shows the relationship of drainage divisions, regions adopted for the QWQG, and the basins within each region. For example, the East Coast drainage division contains four regions of which one, South-east Queensland, incorporates basins 137–146. Reference to the AWRC-defined Queensland basin map (Figure 2.3.2) indicates these basins extend from the Burrum basin in the north to the NSW border in the south. Water quality guidelines developed for the south-east Queensland region therefore apply to waters within these basins, unless more detailed sub-regional (local) guidelines have been established and included in the QWQG. Similarly, the table and map show that the basins within Central region (basins 117–136) extend from the Black River basin in the north (basin 117) to the Burnett River basin in the south (basin 136).

Table 2.3.1: Regions adopted for Queensland guidelines

Drainage division	Adopted region	Basins in region
Gulf	Gulf	910–927, 105
Lake Eyre	Lake Eyre	1–4
Murray Darling (and Bulloo)	Murray Darling	Basins 416, 417, 422, 423, 424, 11
East Coast	East Cape York	Basins 101–104, 106
	Wet Tropics	Basins 107–116
	Central	Basins 117–136
	South-east	Basins 137–146

Further subdivision of these regions (i.e. creation of sub-regions) can be undertaken if studies establish clear differences in water quality between different parts of a region.

Similarly, waters on the boundaries of regions may exhibit features characteristic of both regions, so some discretion is required in applying guidelines solely on the basis of the boundaries provided. For example, the Black River (Basin 117) is the northernmost system in the Central Coast region. However, some of its freshwaters have features more typical of the adjacent Wet Tropics region, and in this case use of Wet Tropics guideline values could be appropriate for some of these particular streams. If users of these guidelines have information on streams that suggests they belong to a region other than indicated in this document, they can email the QWQG team on epa.ev@ehp.qld.gov.au.

Figure 2.3.1: Regions adopted for the Queensland Water Quality Guidelines

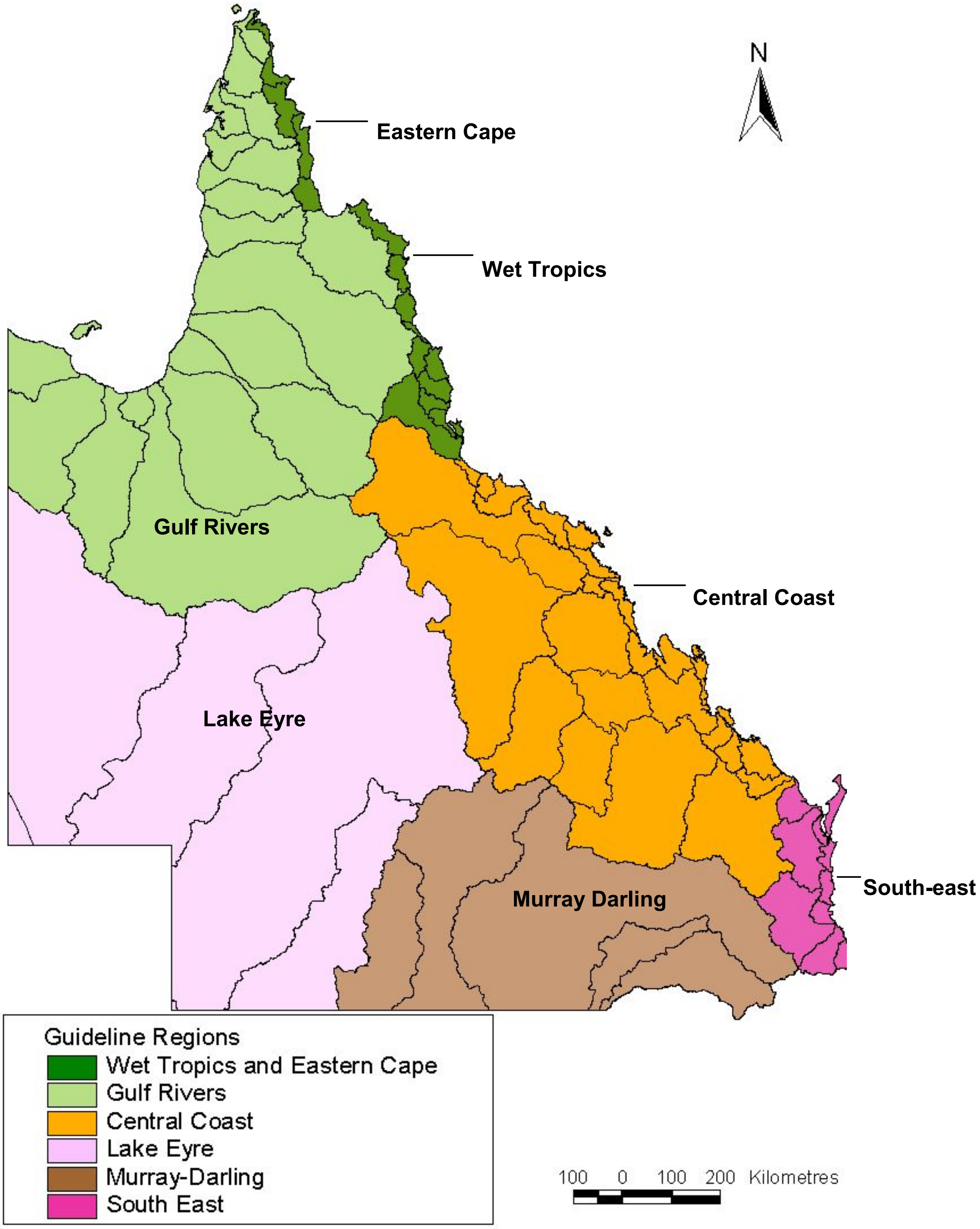
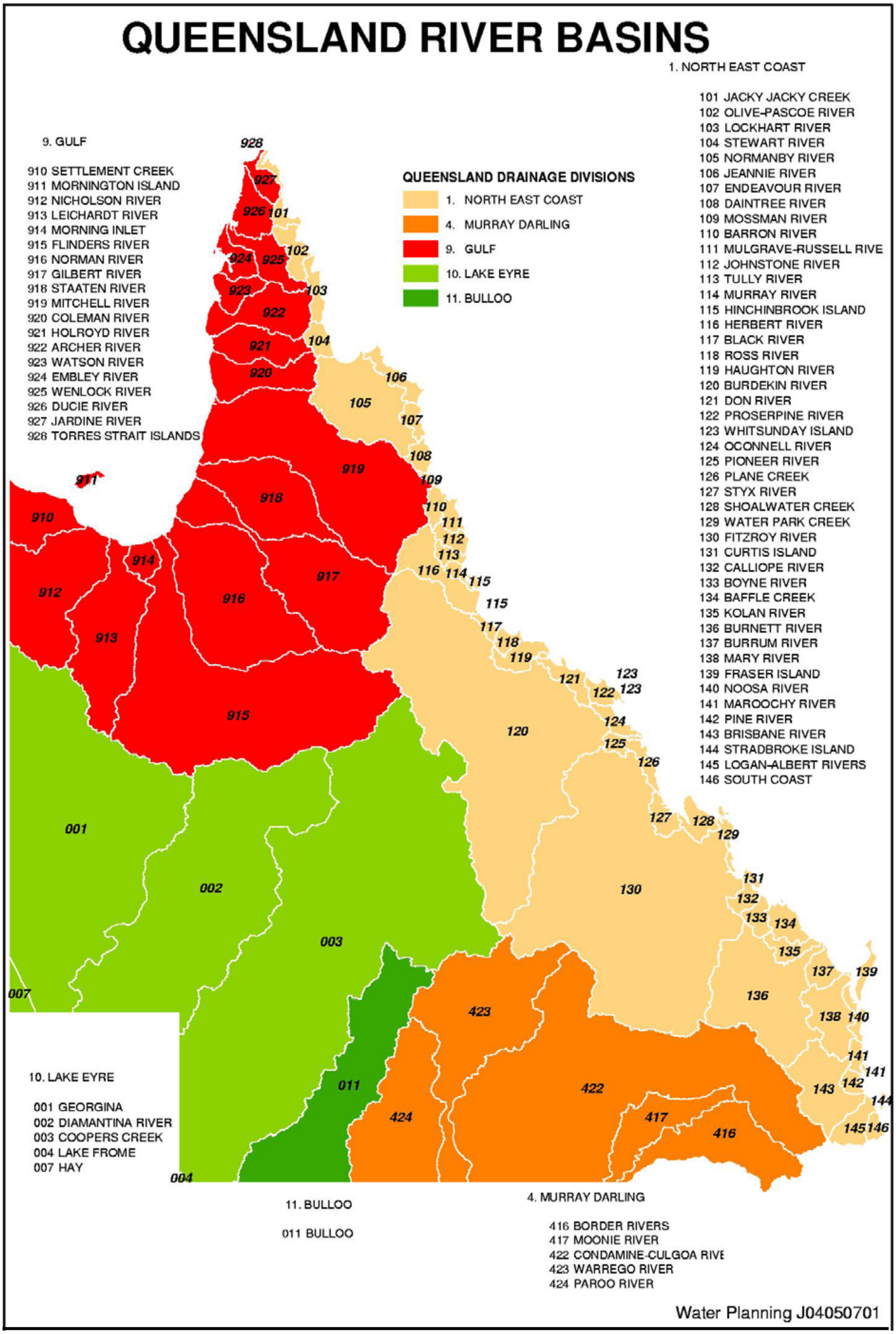


Figure 2.3.2: Queensland river basins

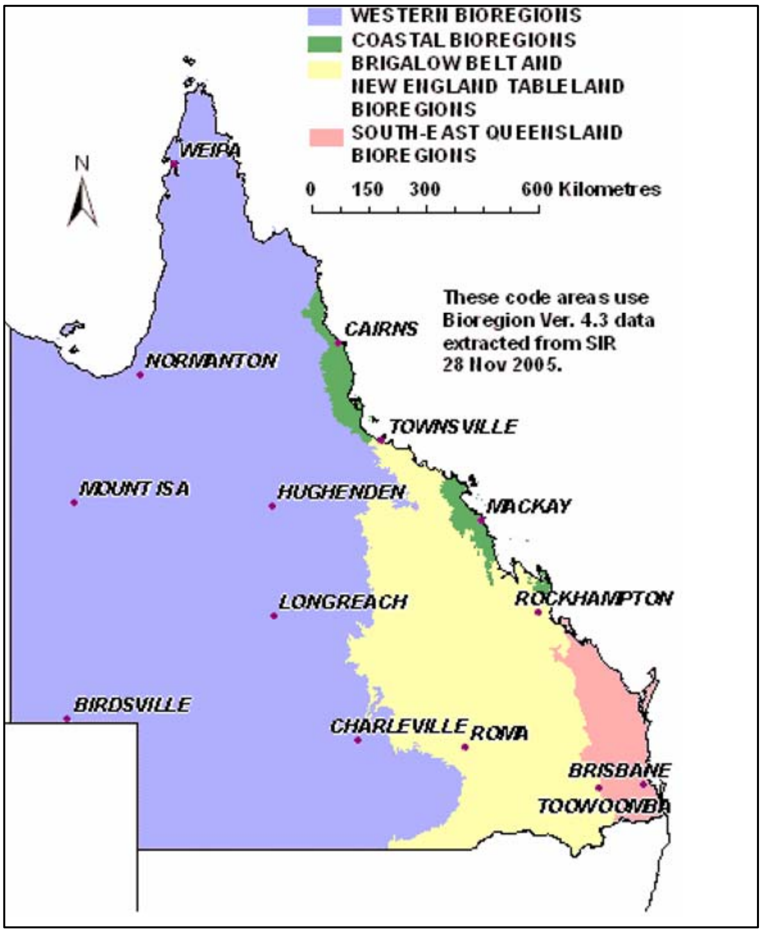


2.3.3 Relationship of QWQG regions for water quality to regionalisation under vegetation management codes

The QWQG provides some technical guidance on riparian management, primarily in the SEQ region. However, for statutory purposes, EHP uses regional vegetation management codes to assess applications for clearing native vegetation. The vegetation management codes include riparian protection provisions in order to maintain values of watercourses including, for example, bank stability, water quality (by filtering sediments, nutrients and other pollutants), aquatic habitat, and terrestrial habitat. The boundaries and names of the regional vegetation management codes are based on bioregions. These are outlined on the department's website and are reproduced in Figure 2.3.3.

These boundaries are different from the boundaries/names of water quality regions used in the QWQG (as shown in Figure 2.3.1). Hence, within each QWQG water quality region there may be one or more corresponding vegetation management codes. Reference is made to the relevant vegetation management codes in each of the main QWQG regional water quality guideline sections. For the latest background information on the vegetation management codes (including regional boundaries and the codes themselves), refer to the department's website.

Figure 2.3.3: Queensland Vegetation Management Bioregions



2.3.4 Relationship of QWQG regions and guidelines to Great Barrier Reef Marine Park waters and guidelines

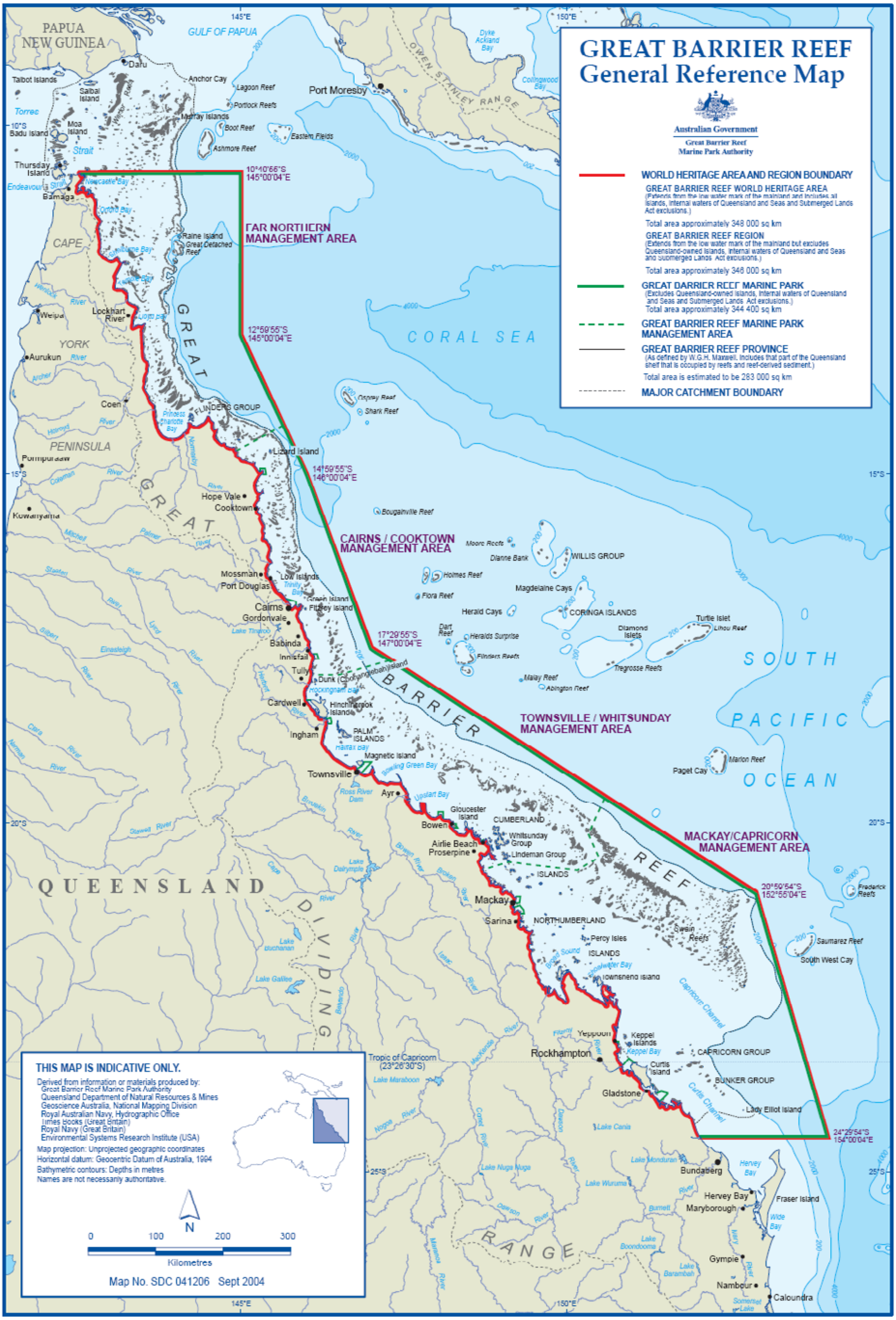
Draft water quality guidelines for the Great Barrier Reef Marine Park have recently been released by the Great Barrier Reef Marine Park Authority (GBRMPA), and can be downloaded from the GBRMPA website.

Much of the Great Barrier Reef Marine Park (refer Figure 2.3.4) lies beyond Queensland state waters but, in inshore coastal waters, there is an area of overlap. This occurs because the waters of the Great Barrier Reef Marine Park extend inshore to the landward low water mark while Queensland waters extend three nautical miles offshore.

In order to avoid conflict within this area of overlap, the following protocols have been agreed with GBRMPA:

- Queensland guidelines are to be adopted for all waters inshore of and within the Enclosed Coastal zone. This is a defined water zone used in the Queensland guidelines (see section 2.4 below and Appendix B for a detailed definition). In brief, it covers the more enclosed inshore waters, e.g. western parts of Moreton Bay or the Hinchinbrook channel.
- The only exception to the above is guidelines for pesticides for waters within the GBR Marine Park. Because there are no Queensland guidelines for pesticides, the GBR Marine Park water quality guidelines for pesticides will be adopted in all waters of the Marine Park, including the Enclosed Coastal zone.
- Offshore from the Enclosed Coastal zone and within waters of the GBR Marine Park, the GBR guidelines will apply, even if the boundary of the Enclosed Coastal zone lies inside the three nautical mile zone. The GBRMPA guidelines define a series of water types with the GBR and these are described in section 2.4 below, with more detail in Appendix B.
- Where there are no Great Barrier Reef Marine Park water quality guidelines provided for a specific indicator, the QWQG (as shown in relevant tables in section 3) will apply in the Marine Park.
- In coastal areas of Queensland not covered by the Great Barrier Reef Marine Park (e.g. south-east Queensland), the Queensland guidelines will apply up to the three nautical mile limit. Outside of this limit the default ANZECC 2000 guidelines would apply.

Figure 2.3.4: Boundaries of the Great Barrier Reef Marine Park



2.4 Defining water types for guidelines

The aim of defining water types is to create groupings within which water quality (or biological condition) is sufficiently consistent that a single guideline value can be applied to all waters within each group or water type. The ANZECC 2000 Guidelines defined a set of broad water types for physico-chemical indicators, which are useful as a default. These include:

- upland freshwaters;
- lowland freshwaters;
- lakes;
- wetlands (palustrine);
- estuaries; and
- marine – inshore and offshore.

As with regionalisation, the Queensland Water Quality Guidelines allow this process to be taken one or two steps further. However, the extent to which further subdivision of water types can be taken in practice depends on availability of data. Currently, there is sufficient data available to define some more detailed water types for estuarine and coastal waters in the South-east, Central Coast and Wet Tropics regions. In summary, the changes to estuary/marine water types include:

- a division of estuary into sub-components (upper, mid, lower) for South-east and Central Coast regions; and
- a division of inshore marine waters into 'enclosed coastal' and 'open coastal' waters.

The Great Barrier Reef Marine Park Authority has released guidelines for the Marine Park and have defined four water types covering waters offshore from the Enclosed Coastal zone and out to the Coral Sea; these are open coastal, midshelf, offshore and the Coral Sea (however, no guidelines are proposed for the Coral Sea zone). A detailed description of these and their relation to QWQG water types is given in Appendix B, section B.2.4.2 and they are outlined in Table 2.4.1 below. The Marine Park waters and guidelines are included in the guideline tables in section 3.

For freshwaters, the QWQG generally defaults to the ANZECC 2000 Guidelines categories of upland and lowland freshwaters. The ANZECC Guidelines suggest a cut-off of 150m to differentiate between lowland and upland waters. As a default this is adopted by the QWQG but in some areas this is not particularly appropriate. For example, the water quality improvement plan for the Ross-Black catchments around Townsville proposes a cut-off of around 80m as a more appropriate demarcation between the flood plain and steeper parts of the catchments. In other areas different cut-offs may be designated in the future.

In the South-east Queensland region (from Noosa south to the border) there has been further work undertaken as part of the Ecosystem Health Monitoring Program (EHMP) to identify local freshwater types and establish biological guidelines relevant to these water types. For example, this work has identified coastal wallum streams as a particular water type and has derived biological guideline values appropriate to wallum habitats. Therefore, for biological indicators in south-east Queensland, the QWQG has adopted the EHMP water types (and includes ecological guidelines based on EHMP work). Refer to section 3.1.3.1 for EHMP water types in south-east Queensland).

There are several regions (e.g. Gulf Rivers, eastern Cape York) for which there is little or no local water quality data, and for which local water types have not yet been defined. For the Gulf and Lake Eyre regions it is considered that the ANZECC default freshwater types are not particularly useful and so no water types have been defined for these regions yet. No guideline values are provided in this document for these areas. The alternatives for users are to default to the ANZECC 2000 Guidelines (for the most similar water type) or to develop local guidelines (see section 4). It should be noted that for many of these areas the ANZECC 2000 Guidelines may not be particularly appropriate and the collection of at least some local data is strongly recommended.

The water types applied in this version of the QWQG are detailed in Table 2.4.1. It shows the base ANZECC water types in the left-hand column while the column for each region indicates additional water types that have been defined for Queensland waters in the QWQG with links to the GBR water quality guidelines where applicable.

Definitions of all water types and the methods used to derive the Queensland-specific water types are detailed in Appendix B. This also explains links to wetlands mapping under the Queensland Wetlands Program. (Also refer to notes after Table 3.1.6 for EHMP freshwater water types in south-east Queensland.)

Table 2.4.1: Water types adopted by QWQG for Queensland regions

	Queensland region water types						
ANZECC base water types1	**SE Qld**	**Central Qld**	**Wet Tropics**	**Eastern Cape York**	**Gulf**	**Lake Eyre**	**Murray Darling**
Upland freshwater	A/EHMP	A	A	A	X	X	A
Lowland freshwater	A/EHMP	A	A	A	X	X	A
Lakes	A	A	A	A	X	X	A
Wetlands	A	A	A	A	X	X	A
Estuaries	Upper estuary	Upper estuary	n/a	A	A	n/a	n/a
	Mid-estuary	Mid-estuary	Mid-estuary				
Inshore marine	Enclosed coastal/ lower estuary	Enclosed coastal/ lower estuary	Enclosed coastal/ lower estuary	Enclosed coastal/ lower estuary	Enclosed coastal/ lower estuary	n/a	n/a
	Open Coastal	Open Coastal[3]	Open Coastal[3]	Open Coastal[3]	Open Coastal		
Offshore marine	Note 2	Midshelf [3]	Midshelf [3]	Midshelf [3]	Note 2	n/a	n/a
	Note 2	Offshore[3]	Offshore[3]	Offshore[3]	Note 2	n/a	n/a
Note 1	A = adopt default ANZECC 2000 Guidelines water type X = no types defined n/a = not applicable						
Note 2	Offshore marine areas are outside the limit of Queensland waters (three nautical miles). Refer to ANZECC 2000 Guidelines.						
Note 3	Refer to GBRMP Guidelines for guideline values but see also tables 3.2.1b (Central Coast) and 3.3.1b (Wet Tropics). See section B.2.4.2 for detailed definition of water types within the GBR Marine Park.						

2.5 Guidelines under baseflow and non-baseflow conditions

Water quality has a strong dependence on flow. During and shortly after high-flow events, when much of the streamflow has been derived from overland flow, water quality is generally poor and also highly temporally variable. Under these conditions, the water contains high levels of suspended solids and associated pollutants washed off from land surfaces. Under baseflow conditions, when most of the flow is derived from sub-surface seepage or groundwater inflows, quality is generally much better and also relatively stable. Under very low or nil flows, water quality is often poor and also variable due to the effects of stagnation.

These different flow regimes can be identified on a flow duration curve which shows flow on the Y axis and, on the X axis, the percentage of the time when flow is greater than the graphed value. Figure 2.5.1 shows a generic figure of this type. This shows the short-lived high flows, longer periods of baseflow and some period of nil flow. The shape of the curve will vary depending on the flow regime. Wet Tropics streams would show a shape like Figure 2.5.1 with some flood flows, long periods of baseflow and only occasional nil flows. At the other extreme, ephemeral western streams would look more like Figure 2.5.2 with short-lived high flows, almost no baseflow and long periods of nil flow. In contrast to freshwater streams, estuarine and coastal waters obviously experience no nil flow periods and generally only short periods of being affected by high flows. As a result, water quality in these waters is much less variable than in most freshwaters.

Figure 2.5.1: Generic flow duration curve for stream in a wetter coastal area of Queensland

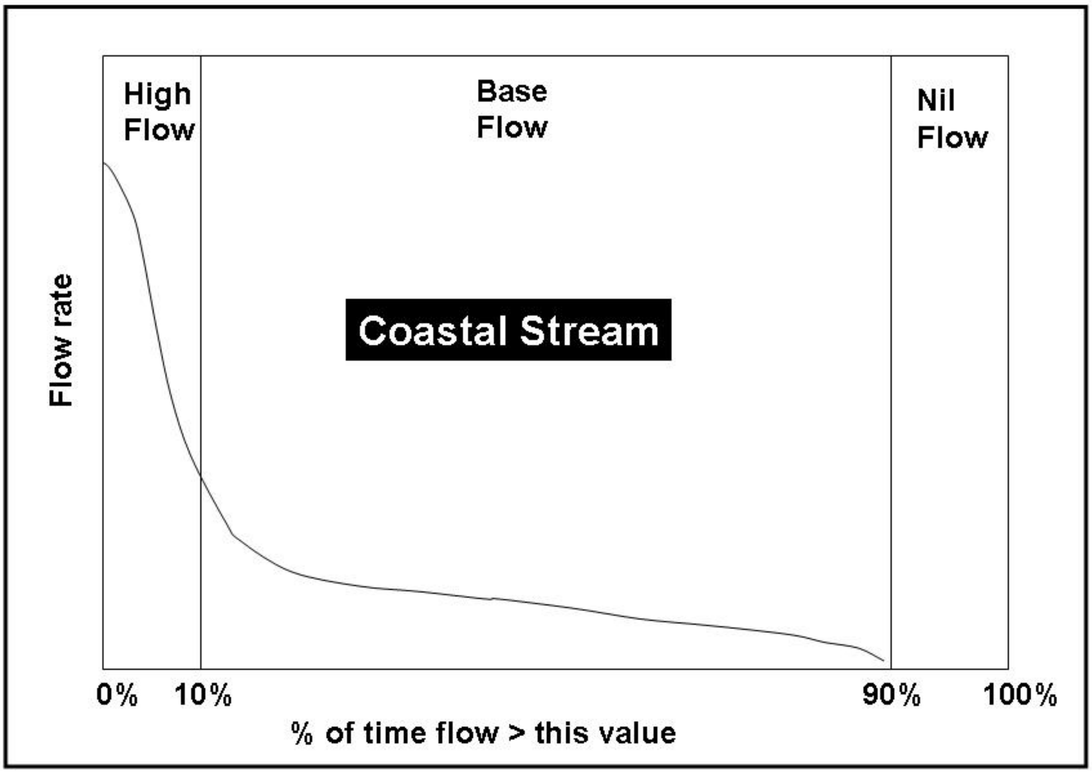
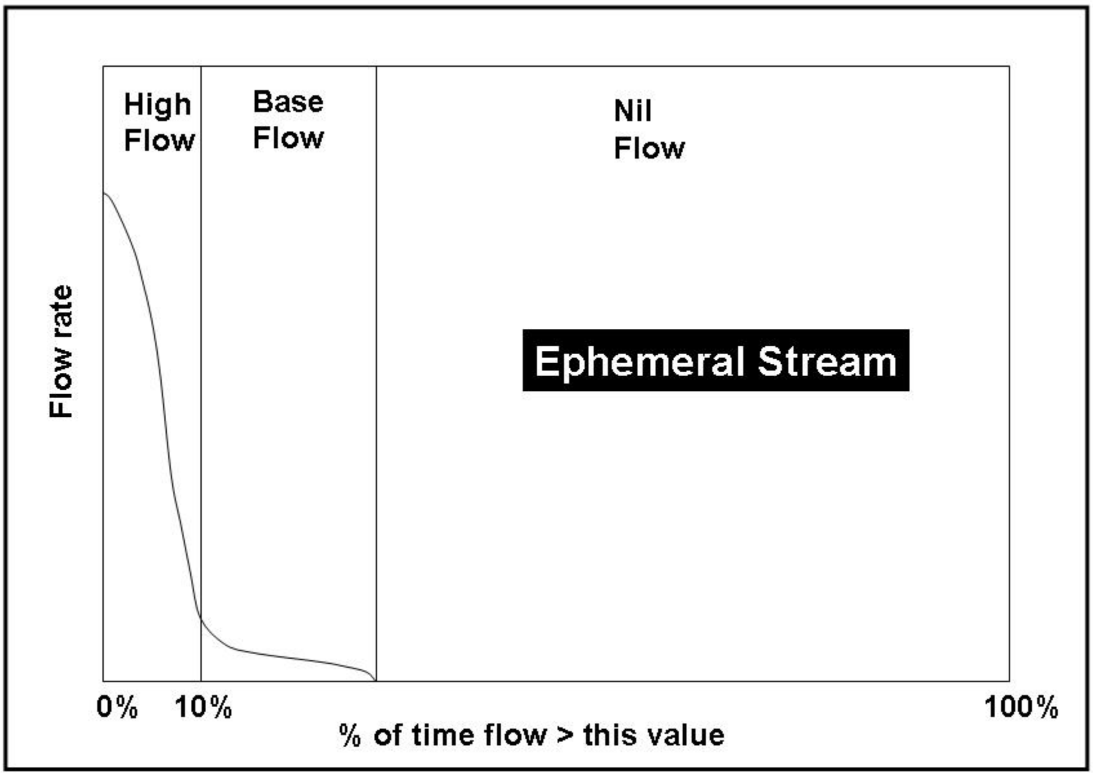


Figure 2.5.2: Generic flow duration curve for an ephemeral stream in Queensland



Because water quality differs under these three types of flow regimes, there should ideally be separate guidelines for each. However, currently, both the ANZECC and the QWQG guidelines are largely based on data collected during baseflow (ambient) periods. These guidelines are generally appropriate in estuarine and marine waters and for freshwaters under baseflow conditions. However, problems arise when guidelines derived in baseflow periods are applied to high flow or nil flow periods because water quality in these times is naturally different. Some more detailed discussion of this issue is contained in section 5.2. The more ephemeral the stream, the more significant this problem becomes.

One way to address this issue is to collect water quality data from reference streams during flood periods or nil flow periods and use this data to derive guidelines that can be applied during these flow regimes. This is logistically difficult to do and there are issues around the high level of variability, particularly in high flows. As a result, this approach has not been commonly applied. However, this has been attempted for the Mackay-Whitsunday region of Queensland. The Mackay-Whitsunday Regional NRM Group collected data from several reference streams during high flows and have used this to derive guidelines expressed as event mean concentrations (EMC) as part of their development of the Mackay-Whitsunday Water Quality Improvement Plan. This is the first time this has been done on a significant scale in Queensland. These guideline values are presented in the sub-regional guidelines tables for the Mackay-Whitsunday area, under the Central Queensland region. More details on the Mackay-Whitsunday WQIP are available from: www.reefcatchments.com.au.

2.6 Indicators

Water quality guidelines have traditionally been focussed on physico-chemical or toxicant indicators. However, in more recent times there has been a shift to more holistic management of aquatic ecosystems. The index of stream condition (Ladson et al 1999) was one of the first attempts to develop this type of approach. This considered five stream attributes, namely hydrology, physical form, streamside zone, water quality and aquatic life, and defined a set of indicators for each.

Biological indicators are important because they provide a direct measure of ecosystem health. However, where a decline in ecosystem health is detected, biological indicators are often unable to attribute this to a specific cause. Therefore, in order to be able to pinpoint the cause of the decline, it is also important to measure indicators of these potential causes. Water quality may be an issue in some situations but in many Australian waters, changes to hydrology, habitat or physical form may be having greater impacts on ecosystem health. Indicators of all these attributes are therefore important. Some examples which illustrate the potential scope of indicators of each of these attributes are given below:

- **Water quality**: physical measures such as dissolved oxygen, chemical measures such as nitrogen or phosphorus and measures of toxicants – pesticides and heavy metals;
- **Physical form**: measures such as bank stability, bed aggradation and degradation and presence of woody debris;
- **Habitat**: measures of the health of the riparian zone such as width, continuity, species composition;
- **Hydrology**: measures of alteration to flow, including gross reduction, changes to peak or baseflows, changes in seasonality; and
- **Aquatic life**: can include both measures of structure, e.g. populations of macroinvertebrates or fish and measures of function, e.g. benthic dissolved oxygen (DO) cycles or algal growth rates.

The main indicators addressed in this version of the QWQG are summarised in Table 2.6.1. These are largely physico-chemical, but as data becomes available, guidelines for biological and habitat indicators will be progressively included. For south-east Queensland waters from Noosa south to the border, biological and riparian habitat indicators (and water quality guidelines) have been established as part of the Ecosystem Health Monitoring Program (EHMP), and are also included in the QWQG. These include guideline values for fish and macroinvertebrates, among other indicators. Further details and explanations of the main physico-chemical and biological indicators are included in Appendix E.

Guideline values for toxicant indicators in water and sediment will continue to be largely sourced from the ANZECC 2000 Guidelines, although where local toxicant-effects data becomes available this will be incorporated into the QWQG. The Great Barrier Reef Marine Park Guidelines contain extensive guideline values for pesticides and these have been adopted by the QWQG for enclosed coastal waters in the GBR Marine Park zone.

Table 2.6.1: Main water quality indicators addressed in the QWQG

Guideline indicators
Nitrogen (ammonia, oxidised, organic, total)
Phosphorus (filterable reactive, total)
Chlorophyll-a
Turbidity
Secchi depth
DO
pH
Conductivity
Temperature

Guideline indicators
EHMP ecological indicators (SE Qld)

Note: refer to Appendix E for further explanation of the indicators used

2.7 Groundwater

These guidelines do not specifically address groundwater. However, the comments in the ANZECC 2000 Guidelines about the applicability of the guidelines to groundwater are equally valid with respect to the Queensland guidelines. These comments are reproduced in their entirety below:

'Groundwater is an essential water resource for many aquatic ecosystems, and for substantial periods it can be the sole source of water to some rivers, streams and wetlands. Groundwater is also very important for primary and secondary industry as well as for domestic drinking water, particularly in low rainfall areas with significant underground aquifers. Generally these Guidelines should apply to the quality both of surface water and of groundwater since the environmental values which they protect relate to above-ground uses (e.g. irrigation, drinking water, farm animal or fish production and maintenance of aquatic ecosystems). Hence groundwater should be managed in such a way that when it comes to the surface, whether from natural seepages or from bores, it will not cause the established water quality objectives for these waters to be exceeded, nor compromise their designated environmental values. An important exception is for the protection of underground aquatic ecosystems and their novel fauna. Little is known of the lifecycles and environmental requirements of these quite recently-discovered communities, and given their high conservation value, the groundwater upon which they depend should be given the highest level of protection.

As a cautionary note the reader should be aware that different conditions and processes operate in groundwater compared with surface waters and these can affect the fate and transport of many organic chemicals. This may have implications for the application of guidelines and management of groundwater quality.' (ANZECC 2000).

3 Queensland guideline values

This section contains the QWQG values (numbers) for Queensland waters. It comprises seven sub-sections that address each of the seven major regions defined in section 2.3.2 (South-east, Central Coast, Wet Tropics, etc).

The guideline values for each region are detailed in tables in sections 3.1–3.7. Notes are attached to each table to provide guidance on the application and limitations of the guideline values.

In the long term it is intended that each regional sub-section will contain:

- **Regional guidelines**: these are default guidelines for each water type within the region. They apply to all areas of the region **except** where more detailed sub-regional (local) guidelines have been defined (see below). Typically the regional guidelines are set at the slightly to moderately disturbed level of protection.
- **Sub-regional (local) guidelines**: guidelines specific to defined sub-regional areas. This mechanism will allow tailoring of guideline values to more localised areas in cases where this is found to be necessary and/or useful. Sub-regional guidelines have been developed for high ecological value (level 1) waters, and also for some slightly to moderately disturbed waters.

The development of both regional and sub-regional guidelines is entirely dependent on the availability of suitable reference data. Reflecting current data availability, this version of the QWQG contains no guideline values at all for the eastern Cape York, Gulf, Lake Eyre and Murray Darling Regions. For the Wet Tropics and Central Coast regions there are regional guidelines for physico-chemical indicators but only limited sub-regional guidelines, while for the South-east region (Burrum River basin south to the NSW border) there are both regional and sub-regional guidelines, and a much broader range of indicators is addressed.

For slightly to moderately disturbed (SMD) waters, the guideline values should be compared with the *median* of values at a test site – see section 5 for details on applying the guidelines. Guideline values for these waters are either single number values or in some cases (e.g. pH) are upper and lower bounds.

Within some regions a number of high ecological value (HEV) waters have been identified by processes running parallel to the development of the QWQG (e.g. EHP, WQIPs). Each of these waters is treated as a separate sub-region, which may contain one or more water types. Physico-chemical guideline values for these waters are expressed differently from those for slightly to moderately disturbed waters. They comprise three numbers (based on the 20th, 50th and 80th percentiles of the natural values in these waters or comparable waters) rather than a single number. Guideline values for high ecological value waters are only provided where adequate baseline data is available. Methods for testing against these guidelines are contained in Appendix D. Where high ecological value waters have been identified but there is no guideline value identified (e.g. because there is insufficient data) section 4 outlines requirements for data to derive local guidelines for high ecological value waters.

For highly disturbed (HD) waters, no values are provided in the QWQG, and local guidelines would need to be developed. Such less stringent guidelines may be based on (a) different reference data percentiles, e.g. 10th and 90th; (b) reference data from sites that are more impacted but that are still considered to have significant ecological value; or (c) other local information.

3.1 South-east Queensland region

The scope of the water quality guidelines for the South-east region includes:

- section 3.1.1: regional guidelines for physico-chemical indicators (for slightly to moderately disturbed waters) – in the absence of more localised values (see below), these regional numbers apply;
- section 3.1.2: sub-regional (local) guidelines for physico-chemical indicators – specified waters (refer list below). Where available, these are used instead of the regional guideline values for physico-chemical indicators;
- section 3.1.3: regional guidelines for biological indicators (adapted from EHMP process: Noosa – south to NSW border);
- section 3.1.4: regional guidelines for riparian zones (adapted from EHMP process: Noosa – south to NSW border); and
- section 3.1.5: guidelines (statewide) for fisheries habitat.

Note that where waters have been included under schedule 1 of the EPP (Water), the EVs and WQOs in schedule 1 documentation/mapping should be used when making planning or other decision making under the EPP Water. These documents are available on the department's website.

Sub-regional guidelines (physico-chemical indicators) have been prepared for the following waters:

- Great Sandy Strait: high ecological value;
- Fraser Island waters: high ecological value;
- Noosa estuary: high ecological value;
- Noosa estuary (remainder): slightly to moderately disturbed;
- Pumicestone Passage (north): high ecological value;
- Eastern Moreton Bay: high ecological value;
- Waterloo Bay: high ecological value;
- Central Moreton Bay: slightly to moderately disturbed;
- Southern Moreton Bay (Jumpinpin): high ecological value;
- Southern Moreton Bay (remainder): slightly to moderately disturbed;
- Broadwater: slightly to moderately disturbed;
- North Stradbroke Island selected waters: high ecological value; and
- Gold Coast hinterland freshwaters (based on guideline values for mid–upper Coomera): high ecological value.

Where high ecological value waters have been identified, but there is no guideline value identified (usually because there is insufficient data) the intent is to maintain current water quality and biodiversity as outlined in section 2.2. Examples of these waters include eastern reef waters (east of Moreton Island), mainland freshwater reaches (various), and Moreton/Stradbroke Island freshwater reaches (various).

3.1.1 South-east Queensland regional guideline values for physico-chemical indicators (slightly to moderately disturbed waters)

Table 3.1.1 below outlines the regional physico-chemical guideline values for south-east Queensland waters (extending from the NSW border to Burrum – refer section 2.3.2). Note that where sub-regional (i.e. more localised) water quality guidelines have been developed (refer section 3.1.2), they are to be given precedence. Refer to Figure 3.1.1 (three maps) for an outline of the water types in the South-east region. The median water quality value of test sites is to be compared and assessed against the numbers in this table (refer section 5 and Appendix D). (EVs and WQOs have been scheduled under the EPP Water for a number of waters in this region, using these WQ guideline values as a technical input. The scheduled EVs/WQOs and supporting mapping are available from the department's website and should be referred to for planning/decision making under the EPP Water.)

Table 3.1.1: Regional guidelines for physico-chemical indicators – South-east region

South-east region water type	Physico-chemical indicator (refer Appendix E) and guideline value[9] (slightly to moderately disturbed systems)														
	Amm N	Oxid N	Org N[6]	Total N	Filt R P	Total P	Chl-a	DO (% sat[n])[1,2,3]		Turb	Secchi	SS	pH[4,5]		Cond	Temperature[10]
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	lower	upper	NTU	(m)	(mg/L)	lower	upper	(µS/cm)	°C
Open coastal	6	3	130	140	6	20	1.0	95	105	1	5.0	10.0	8.0	8.4	n/a	Managers need to define their own upper and lower guideline values, using the 80th and 20th percentiles, respectively, of ecosystem temperature distribution (ANZECC 2000).
Enclosed coastal	8	3	180	200	6	20	2.0	90	105	6	1.5	15	8.0	8.4	n/a	
Mid-estuarine and tidal canals, constructed estuaries, marinas and boat harbours	10	10	280	300	6	25	4.0	85	105	8[8]	1.0[8]	20[8]	7.0	8.4	n/a	
Upper estuarine	30	15	400	450	10	30	8.0	80	105	25[8]	0.5[8]	25[8]	7.0	8.4	n/a	
Lowland streams	20	60	420	500	20	50	5.0	85	110	50	n/a	6	6.5	8.0	See Appendix G	
Upland streams	10	40	200	250	15	30	2.0	90	110	25	n/a	6	6.5	8.2	See Appendix G	

South-east region water type	Physico-chemical indicator (refer Appendix E) and guideline value[9] (slightly to moderately disturbed systems)															
	Am m N	Oxid N	Org N[6]	Tot al N	Filt R P	Total P	Chl-a	DO (% sat[n])[1,2,3]		Tur b	Secc hi	SS	pH[4,5]		Cond	Temperature[10]
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	lower	upper	NTU	(m)	(mg/L)	lower	upper	(µS/cm)	°C
Freshwater lakes/ reservoirs	10	10	330	350	5	10	5.0	90	110	1–20	nd	nd	6.5	8.0	See Appendix G	
Wetlands[7]	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	

Note 1	Note that DO guidelines (% saturation) for freshwaters should only be applied to flowing waters, including those with significant sub-surface flows. Stagnant pools in intermittent streams naturally experience values of DO below 50% saturation.	
Note 2	DO Guideline values in the table above apply to daytime conditions. Lower values may occur at night but this should not be more than 10% –15% less than daytime values.	
Note 3	DO values as low as 40% may occur in estuaries for short periods following material inflow events after rainfall. DO values consistently <50% are likely to significantly impact on the ongoing ability of fish to persist in a water body. DO values <30% saturation are toxic to some fish species. These DO values should be applied as absolute lower limit guidelines for DO – see also section 5.2. Very high DO (supersaturation) values can be toxic to some fish as they cause gas bubble disease. See Butler and Burrows (2007) for detailed report on effects of low DO on fish.	
Note 4	During flood events or nil flow periods, pH values should not fall below 5.5 (except in wallum areas) or exceed 9.	
Note 5	In wallum areas, waters contain naturally high levels of humic acids (and have a characteristic brown ti-tree stain). In these types of waters, natural pH values may range from 3.6 to 6.0.	
Note 6	During periods of low flow and particularly in smaller creeks, build up of organic matter derived from natural sources (e.g. leaf litter) can result in increased organic N levels (generally in the range of 400 to 800µg/L). This may lead to total N values exceeding the QWQG values. Provided that levels of inorganic N (i.e. NH_3 + oxidised N) remain low, then the elevated levels of organic N should not be seen as a breach of the guidelines, provided this is due to natural causes.	General abbreviations nd = no data; n/a = not applicable
Note 7	For Wetlands in SEQ region the ANZECC 2000 guidelines do not provide any guideline values.	
Note 8	These guideline numbers apply to estuaries less than 40km in length. Longer estuaries have naturally higher turbidity levels (and corresponding higher suspended solids and lower Secchi values) due to the longer retention times for suspended particulates and also to the continual re-suspension of fine particles by high tidal velocities. Values are variable and site specific. However, most values are <100NTU and very few values are >200NTU.	
Note 9	For information on general application of these guideline values, on their application under different flow conditions and on approaches to assessing pulse inputs of pollutants, see section 5 and Appendix D of the QWQG.	
Note 10	Temperature varies both daily and seasonally, is depth dependent and is also highly site specific. It is therefore not possible to provide simple generic water quality guidelines for this indicator. The recommended approach is that local guidelines be developed. Thus guidelines for potentially impacted streams should be based on measurements from nearby streams that have similar morphology and which are thought not to be impacted by anthropogenic thermal	

South-east region water type	Physico-chemical indicator (refer Appendix E) and guideline value[9] (slightly to moderately disturbed systems)															
	Am m N	Oxid N	Org N[6]	Tot al N	Filt R P	Total P	Chl-a	DO (% sat[n])[1,2,3]		Tur b	Secc hi	SS	pH[4,5]		Cond	Temperature[10]
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	lower	upper	NTU	(m)	(mg/L)	lower	upper	(µS/cm)	°C
	influences. From an ecological effects perspective, the most important aspects of temperature are the daily maximum temperature and the daily variation in temperature. Therefore measurements of temperature should be designed to collect information on these indicators of temperature and, similarly, local guidelines should be expressed in terms of these indicators. Clearly, there will be an annual cycle in the values of these indicators and therefore a full seasonal cycle of measurements is required to develop guideline values.															

3.1.2 South-east Queensland sub-regional guideline values for physico-chemical indicators (specific waters)

The following tables provide sub-regional guideline values for specific waters in south east Queensland. Guideline values are provided for waters identified as high ecological value (HEV), and for slightly to moderately disturbed (SMD) waters. Note that sub-regional water quality guidelines in this section are to be given precedence over the regional guidelines in the previous section. Where waters are not specified in these tables, the regional guideline values above (Table 3.1.1) can be used.

Table 3.1.2 below outlines the sub-regional physico-chemical guideline values for **specific** estuarine and coastal waters in south-east Queensland. Table 3.1.3 provides sub-regional physico-chemical guideline values for **specific** freshwaters in south-east Queensland (primarily in western and Gold Coast hinterland catchments). Table 3.1.4 includes additional specific guideline values for a number of Fraser Island lakes (all at high ecological value protection level). Table 3.1.5 provides specific water quality guideline values for Blue Lake and Brown Lake on North Stradbroke Island. (EVs and WQOs have been scheduled under the EPP Water for a number of waters in this region, using these WQ guideline values as a technical input. The scheduled EVs/WQOs and supporting mapping are available from the department's website and should be referred to for planning/decision making under the EPP Water.)

For high ecological value waters, the 20th, 50th and 80th percentile water quality values of test sites are to be compared and assessed against the corresponding percentile values in this table (refer section 5 and Appendix D). For slightly to moderately disturbed systems, the test site median is compared against the 80th percentile value shown in the tables (refer section 5 and Appendix D).

Refer to Figure 3.1.1 (three maps: a, b, c) for an outline of the water types (and the location of identified high ecological value waters) in the South-east region. (More detailed water type mapping in SEQ is provided in plans supporting EPP Water Schedule 1 documents, available from the department's website. These should be referred to for the most current/detailed boundaries.)

Table 3.1.2: Sub-regional guidelines for physico-chemical indicators – South-east region estuarine and coastal waters6

Sub-region[1]	Water type[3]	Protection level[2]	Physico-chemical indicator (refer Appendix E) and percentile value (20th, 50th, 80th percentile)[4, 5]																																			
			Amm N			Oxid N			Org N			Total N			FiltR P			Total P			Chl-a			DO			Turb			Secchi			SS			pH		
			(µg/L)			(µg/L)			(µg/L)			(µg/L)			(µg/L)			(µg/L)			(µg/L)			(% satn)			(NTU)			(m)			(mg/L)					
Estuary/ marine			20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80
Great Sandy Strait	EC	HEV	2	7	10	2	2	3	100	100	150	110	115	160	2	2	3	6	10	14	0.6	0.8	1.3	90	95	100	1	2	4	1.8	2.9	4.3	4	9	13	8.1	8.2	8.4
Noosa River	EC	SMD			15			6			220			240			2			15			1.8	90		105			4	1.8					15	8.0		8.4
Noosa River[7]	ME	HEV	7	15	32	2	5	15	130	210	320	150	240	380	2	2	2	10	13	16	0.8	1.5	2.5	85	95	105	2	5	8	1.1	1.6	2.0				8.0	8.1	8.3
Noosa River	UE	HEV	10	26	72	3	10	43	300	400	640	320	440	750	2	2	2	10	15	20	1.4	2.2	5.0	85	95	105	8	12	22	0.5	0.7	1.0				7.4	7.9	8.1
Pumice-stone Passage outer	EC	HEV & SMD	2	4	6	2	2	3	150	180	210	150	190	220	4	5	7	15	18	25	1.0	1.6	2.5	90	95	105	2	4	6	1.4	1.8	2.5	6	12	16	8.0	8.2	8.3
Pumice-stone Passage central[7]	ME	HEV	2	4	9	2	2	9	210	250	310	210	260	330	2	2	2	13	17	23	1.3	2.7	4.0	95	100	105	5	7	10	0.8	1.0	1.4	nd	nd	nd	8.0	8.1	8.3
Central Moreton Bay	OC	HEV & SMD	2	3	5	2	2	2	100	120	150	110	130	160	3	5	8	12	15	20	0.5	0.8	1.0	95	100	105	<1	1	5	2.7	4.5	6.0	nd	nd	nd	8.2	8.2	8.4

Sub-region[1]	Water type[3]	Protection level[2]	Physico-chemical indicator (refer Appendix E) and percentile value (20th, 50th, 80th percentile)[4, 5]																																				
			Amm N (µg/L)			Oxid N (µg/L)			Org N (µg/L)			Total N (µg/L)			FiltR P (µg/L)			Total P (µg/L)			Chl-a (µg/L)			DO (% satn)			Turb (NTU)			Secchi (m)			SS (mg/L)			pH		
Eastern Moreton Bay – North	OC	HEV & SMD	2	3	5	2	2	3	100	120	150	100	120	160	2	3	5	9	12	16	0.5	0.6	1.0	95	100	105	<1	<1	1	5.5	8.5	11.4	nd	nd	nd	8.2	8.3	8.4
Eastern Moreton Bay – Central	OC	HEV & SMD	2	3	5	2	2	3	100	120	150	100	120	160	2	3	5	9	12	16	0.5	0.6	1.0	95	100	105	<1	<1	1	3.5	4.0	5.0	nd	nd	nd	8.2	8.3	8.4
Eastern Moreton Bay – South	OC	HEV & SMD	2	3	5	2	2	3	100	120	150	100	120	160	2	3	5	9	12	16	0.5	0.6	1.0	95	100	105	<1	<1	1	1.5	2.1	3.1	nd	nd	nd	8.2	8.3	8.4
Western Bays (Waterloo, Bramble & Deception	EC	HEV & SMD	2	3	5	2	2	2	110	150	190	120	150	200	6	10	14	15	22	30	0.5	1.0	1.6	95	100	105	1	3	6	1.3	2.0	3.0	nd	nd	nd	8.1	8.2	8.4
Southern Moreton Bay	EC	HEV & SMD	2	3	5	2	2	2	110	150	190	120	150	200	3	4	8	12	16	24	0.60	1.2	2.0	95	100	105	2	4	7	1.2	1.8	2.7	nd	nd	nd	8.1	8.2	8.4
Broadwater	EC	HEV & SMD	2	4	8	2	2	4	120	140	180	130	150	190	3	4	6	14	17	22	1.3	1.8	2.5	90	95	105	2	4	6	1.5	2.0	2.7	nd	nd	nd	8.0		8.4

Notes:

The location and boundaries of the sub-regional waters identified in this table are shown in Figure 3.1.1a. If a waterway is not specified in this table, then default to the regional water quality guidelines (Table 3.1.1) for slightly to moderately disturbed (SMD) waters.

Protection level: HEV = high ecological value; SMD = slightly to moderately disturbed. Many sub-regional waters contain some areas of HEV waters and some areas of SMD waters. For sub-regions containing HEV waters, the 20th, 50th and 80th percentiles are all given. In sub-regions with only SMD waters, only the 80th and/or 20th percentile values are provided.

Water type: OC = open coastal; EC = enclosed coastal; UE = upper estuarine; ME = mid-estuarine.

Water quality indicators (refer Appendix E): Amm N = ammonia nitrogen; Oxid N = oxidised nitrogen; Org N = organic nitrogen; Total N = total nitrogen; FiltR P = filterable reactive phosphorus; Total P = total phosphorus; Chl-a = chlorophyll-a; DO = dissolved oxygen (percent saturation); Turb = turbidity; Secchi = Secchi depth; SS = suspended solids.

5. nd = no data available. n/a = not applicable

6.Notes on Table 3.1.1 also apply.

7.Mid-estuarine (ME) guidelines for Noosa River and Pumicestone Passage Central can also be used for tidal canals, constructed estuaries, marinas and boat harbours.

Table 3.1.3: Sub-regional guidelines for physico-chemical indicators – South east Queensland upper catchments and major storages

Sub-region[1]	Water type[2]	Protection level [3]	Physico-chemical indicator[4, 11]														
			Amm N	Oxid N	Org N	Total N[8]	FiltR P[10]	Total P[9]	Chl-a	DO (% satn)[6]		Turb[5]	SS	pH[7]		Cond	Sulphate
Freshwater			(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	Lower	Upper	(NTU)	(mg/L)	Lower	Upper	(µS/cm)	(mg/L)
Stanley River	UF	SMD	10	40	200	250	15	30	2.0	90	110	5	6	6.5	8.2		
	LF	SMD	20	60	420	500	20	50	5.0	85	110	10	6	6.5	8.0		
Upper Brisbane River	UF	SMD	10	40	200	250	15	30	2.0	90	110	5	6	6.5	8.2	750	
	LF	SMD	20	60	420	500	20	50	5.0	85	110	10	6	6.5	8.0	750	
Lockyer Creek	UF	SMD	10	40	200	250	15	30	2.0	90	110	5	6	6.5	8.2	1200	
	LF	SMD	20	60	420	500	20	50	5.0	85	110	10	6	6.5	8.0	1200	
Mid Brisbane River	UF	SMD	10	40	200	250	6	30	2.0	90	110	5	6	6.5	8.2	380	
	LF	SMD	10	60	420	500	6	28	5.0	85	110	5	6	6.5	8.0	380	
Bremer River	UF	SMD	10	40	200	250	15	30	2.0	90	110	17	6	6.5	8.2	770	

Sub-region[1]	Water type[2]	Protection level [3]	Physico-chemical indicator[4, 11]														
			Amm N	Oxid N	Org N	Total N[8]	FiltR P[10]	Total P[9]	Chl-a	DO (% satn)[6]		Turb[5]	SS	pH[7]		Cond	Sulphate
Freshwater			(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	Lower	Upper	(NTU)	(mg/L)	Lower	Upper	(µS/cm)	(mg/L)
and incl.	LF	SMD	20	60	420	500	20	50	5.0	85	110	17	6	6.5	8.0	770	
Warrill Cr	UF	SMD	10	40	200	250	15	30	2.0	90	110	5	6	6.5	8.2	500	
	LF	SMD	20	60	420	500	20	50	5.0	85	110	5	6	6.5	8.0	500	
Deebing Cr	UF	SMD	10	40	200	250	15	30	2.0	90	110	17	6	6.5	8.2	770	50
	LF	SMD	20	60	420	500	20	50	5.0	85	110	17	6	6.5	8.0	770	50
Bundamba Cr	UF	SMD	10	40	200	250	15	30	2.0	90	110	17	6	6.5	8.2	770	50
	LF	SMD	20	60	420	500	20	50	5.0	85	110	17	6	6.5	8.0	770	50
Logan River	UF	SMD	10	40	200	250	15	30	2.0	90	110	5	6	6.5	8.2	780	
	LF	SMD	20	60	420	500	20	50	5.0	85	110	10	6	6.5	8.0	780	
Albert River	UF	SMD	10	40	200	250	15	30	2.0	90	110	5	6	6.5	8.2		
	LF	SMD	20	60	420	500	20	50	5.0	85	110	10	6	6.5	8.0		

Sub-region[1]	Water type[2]	Protection level [3]	Physico-chemical indicator[4, 11]														
			Amm N	Oxid N	Org N	Total N[8]	FiltR P[10]	Total P[9]	Chl-a	DO (% satn)[6]		Turb[5]	SS	pH[7]		Cond	Sulphate
Freshwater			(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	Lower	Upper	(NTU)	(mg/L)	Lower	Upper	(µS/cm)	(mg/L)
Gold Coast hinterland streams[3]	UF	HEV	4 5 7	4 10 22	95 115 180	104 130 207	13 18 23	19 26 41	0.6 0.8 1.5	98	102 108	1 2 4	-	7.6 7.9	8.2	-	-
Fraser Island Lakes	Lake	HEV	Refer Table 3.1.4 for Fraser Island HEV lakes – Benaroon, Birrabeen, Boomanjin, Jennings, Mackenzie, Ocean and Wabby Lakes.														
Stradbroke Island Lakes	Lake	HEV, SMD	Refer Table 3.1.5 for Blue Lake (HEV) and Brown Lake (SMD) on North Stradbroke Island.														
SEQ Storages Somerset Dam	Lake		10	10	nd	350	5	30	Annual: 9 Summer: 13	90	110	10	nd	6.5	8.5	280	nd
Wivenhoe Dam	Lake		10	10	nd	350	4	30	Annual: 9 Summer: 13	90	110	6	nd	6.5	8.5	420	nd

Notes:

If a waterway is not specified in this table, then default to the regional water quality guidelines (Table 3.1.1) for slightly to moderately disturbed (SMD) waters.

Water type: UF = upper catchment freshwater, LF = lower catchment freshwater

Protection level: HEV = high ecological value; SMD = slightly to moderately disturbed. Many sub-regional waters contain some areas of HEV waters and some areas of SMD waters. For sub-regions containing HEV waters, the 20th , 50th and 80th percentiles are all given. At this stage HEV values are only specified for Gold Coast hinterland waters. In sub-regions with only SMD waters, only the 80th and/or 20th percentile values are provided.

Water quality indicators (refer Appendix E): Amm N = ammonia nitrogen; Oxid N = oxidised nitrogen; Org N = organic nitrogen; Total N = total nitrogen; FiltR P = filterable reactive phosphorus; Total P = total phosphorus; Chl-a = chlorophyll-a; DO = dissolved oxygen (percent saturation); Turb = turbidity; SS = suspended solids; Cond = Conductivity

Turbidity – higher turbidity levels will occur during flood flows and generally in small drying waterholes but turbidity levels in large waterholes should not vary greatly from 5 and 10 NTU for upland and lowland waters respectively.

Dissolved Oxygen – much lower DO values can occur naturally in nil flow situations. Generally DO should be greater than 40% saturation in large waterholes with no flow. However, smaller waterholes or holes that are drying up can naturally experience even lower levels of DO.

pH – lower values down to 4.0 occur in waters with high levels of humic material.

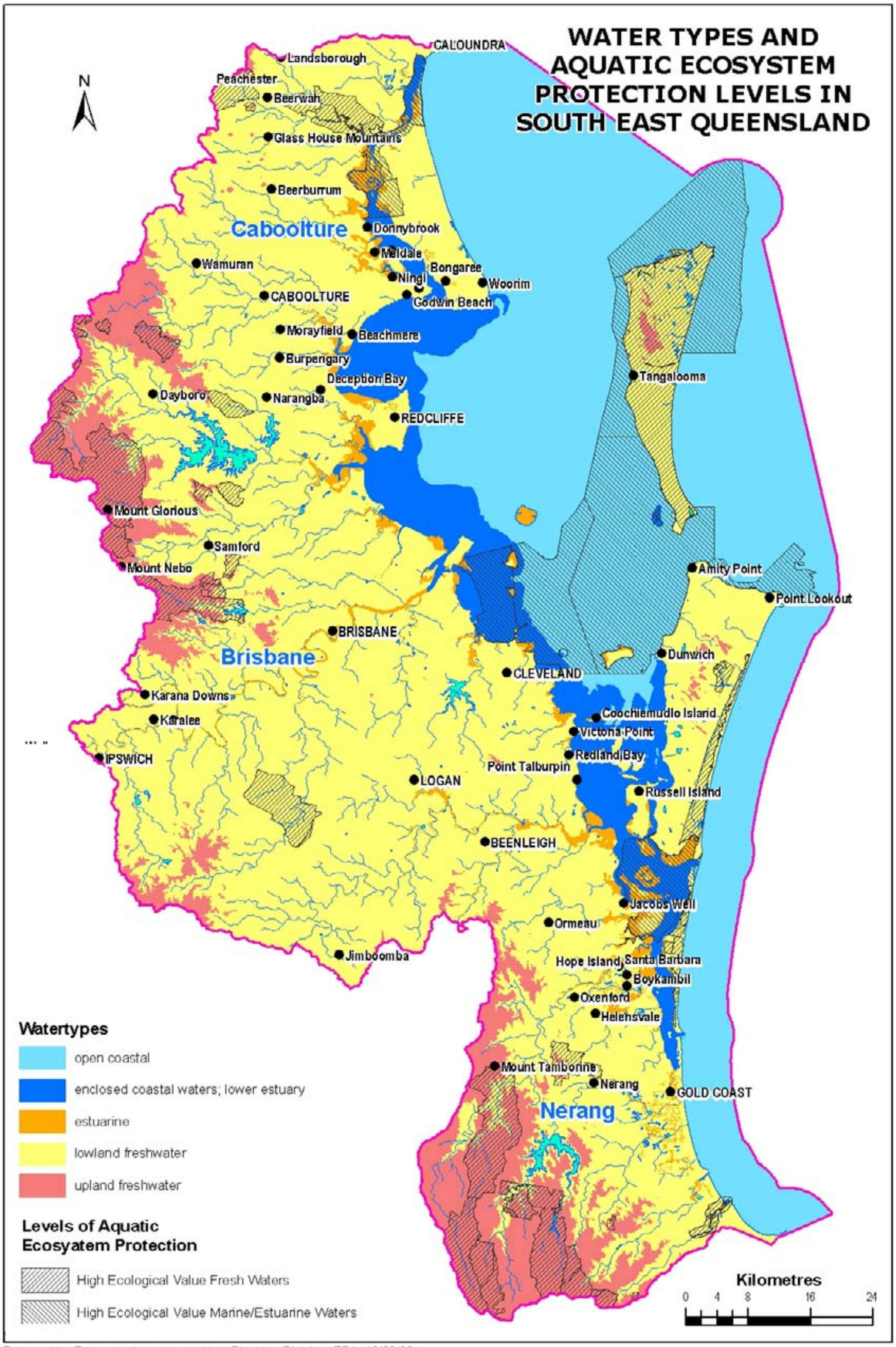
Total Nitrogen – the guideline values may be exceeded in small drying waterholes or waterholes with high levels of leaf litter.

Total Phosphorus – levels seem to be significantly dependent on catchment soil types. For example, values in the very clean Canungra Creek exceed the upland guidelines for no obvious reason except for that soils in that area have a high phosphorus content.

Filterable Reactive Phosphorus – as with total phosphorus, FRP levels seem dependent on local catchment soil types in some cases.

Additional information is provided in the source report by MWH (2009): EVs and guidelines to support development of WQOs for SEQ upper catchments, March 2009.

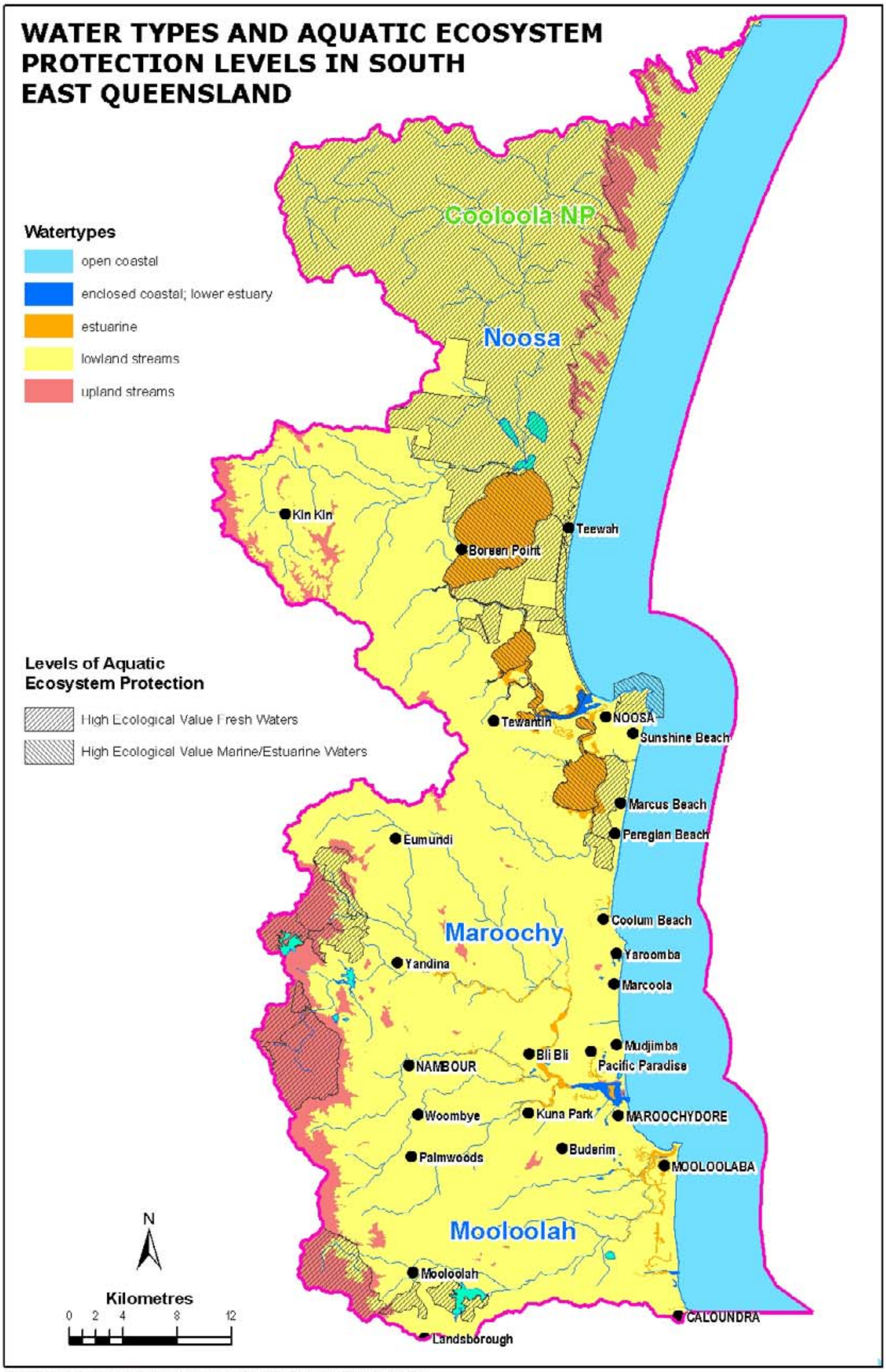
Figure 3.1.1a



Prepared by Resource Assessment Unit, Planning Division, EPA. 10/02/06.

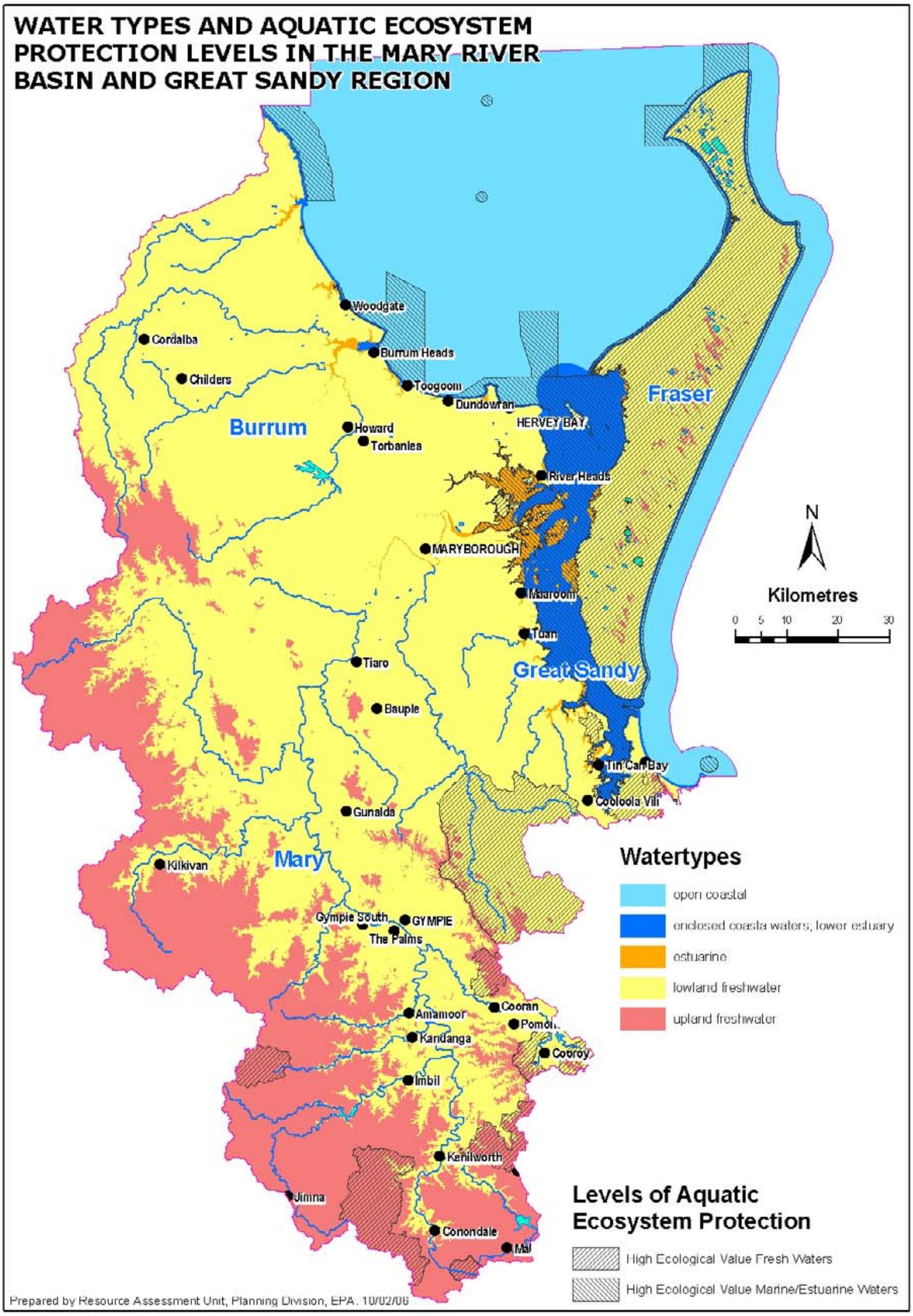
Boundaries in the above plan are indicative only. EVs and WQOs have been scheduled under the EPP Water for a number of waters in this region. The scheduled EVs/WQOs and supporting mapping delineating water types and level of aquatic ecosystem protection should be referred to for planning/decision making under the EPP Water. Scheduled EVs/WQOs and supporting mapping (plans) are available from the department's website. Spatial (GIS) 'read only' data sets of the plans are available on CD-ROM ('Environmental Values Schedule 1 Database, March 2007' and subsequent updates) and can be requested via email to data.coordinator@ehp.qld.gov.au. Hard copies of plans can be viewed under arrangement at 400 George Street, Brisbane. Refer to Figure 2.3.1 for the geographic scope of application of the QWQG in South-East Queensland Region.

Figure 3.1.1b



Refer to Figure 2.3.1 for the geographic scope of application of the QWQG in South-east Region. Refer to notes accompanying Figure 3.1.1a for further details on interpretation of mapping.

Figure 3.1.1c



Refer to Figure 2.3.1 for the geographic scope of application of the QWQG in South-east Queensland/Central Coast Regions. Refer to notes accompanying Figure 3.1.1a for further details on interpretation of mapping.

Table 3.1.4: Sub-regional water quality guidelines for physico-chemical indicators – Fraser Island lakes

Lake (all HEV level 1)[1,2]	%ile	Physico-chemical water quality indicator (refer Appendix E) and value[3]						
		pH	Cond[4] (µS cm)	DO (mg/L)	DO %sat	Secchi (m)	Total P (µg/L)	Chl-a (mg/m)
Benaroon	20%	3.8	90	7.0	87	1.5	1.3	1.8
	50%	4.0	97	7.8	93	1.6	2.0	2.3
	80%	4.3	110	8.2	95	1.9	3.2	3.0
Birrabeen	20%	4.0	90	7.1	85	3.6	1.0	0.8
	50%	4.1	96	8.2	94	4.6	1.3	1.4
	80%	4.5	110	8.4	99	5.4	2.9	2.2
Boomajin	20%	3.8	110	7.2	88	0.8	1.2	0.4
	50%	4.1	127	7.8	93	1.0	2.0	0.7
	80%	4.3	140	8.3	96	1.0	2.8	1.1
Jennings	20%	3.6	85	6.5	80	1.0	1.3	0.6
	50%	3.9	95	7.1	90	1.2	3.0	1.1
	80%	4.2	105	7.9	93	1.2	3.7	1.3
Mackenzie	20%	4.1	95	7.5	89	5.6	1.0	0.4
	50%	4.4	100	8.0	95	9.0	1.0	0.8
	80%	4.8	105	8.4	101	9.0	1.7	1.3
Ocean	20%	5.4	330	7.4	88	0.9	10.4	7.1
	50%	5.9	355	7.8	94	1.0	16.0	8.9
	80%	6.2	380	8.0	99	1.1	19.0	11.8
Wabby	20%	5.5	170	8.2	95	1.6	4.8	4.3
	50%	5.7	178	9.1	114	2.2	7.0	7.4
	80%	5.9	185	10.0	121	2.5	9.3	11.7

Notes:

Protection level: HEV = high ecological value. All lakes identified as HEV.

Other Fraser Island waters have been identified by EHP studies as high ecological value, where the intent is to maintain current water quality/biodiversity (no guideline values derived).

Water quality indicators (refer Appendix E): Cond = conductivity; DO = dissolved oxygen; Secchi = Secchi depth; Total P = total phosphorus; Chl-a = chlorophyll-a.

Note that conductivity data in this version of the QWQG has been updated based on more reliable data.

Table 3.1.5: Sub-regional water quality guidelines for physico-chemical indicators – North Stradbroke Island lakes

Lake /protection level[1]	Percentile	Physico-chemical indicator[2] (refer Appendix E) and value						
		pH	Cond (µS/cm)	Secchi (m)	DO (%sat)	FRP (µg/L)	Total P (µg/L)	Chl-a (µg/L)
Blue (HEV)	20%	4.9	90	4.9	86	2	2	0.6
	50%	5.1	90	5.8	90	2	4	1.2
	80%	5.2	90	6.9	95	2	6	2.4
Brown (SMD)	20/80%	4.6–5.0	90	0.7	90–99	2	15	14

Lake /protection level [1]	Percentile	Physico-chemical indicator [2] (refer Appendix E) and value					
		Temp (Deg C)	Turbidity (NTU)	Amm N (µg/L)	Org N (µg/L)	Oxid N (µg/L)	Total N (µg/L)
Blue (HEV)	20%	19	<1	2	56	6	90
	50%	23	<1	4	80	21	100
	80%	26	1	7	100	37	130
Brown (SMD)	20/80%	19–26	9	9	500	3	500

Notes:

Protection level: HEV = high ecological value; SMD = slightly to moderately disturbed.

Water quality indicators (refer Appendix E): Cond = conductivity; Secchi = Secchi depth; DO = dissolved oxygen; FRP = filterable reactive phosphorous; total P = total phosphorus; Chl-a = chlorophyll-a; Temp = temperature; Amm N = ammonia nitrogen; Oxid N = oxidised nitrogen; Org N = organic nitrogen; Total N = total nitrogen.

3.1.3 South-east Queensland regional guideline values for biological indicators (slightly to moderately disturbed waters)

3.1.3.1 Freshwaters: regional biological guidelines

The following table applies to freshwaters from Noosa River basin south to the NSW border and is based on information collected in the freshwater Ecosystem Health Monitoring Program (EHMP) of the Healthy Waterways Partnership. It provides ecological indicators and guideline values for a number of water types in south-east Queensland. (Note that the values have been updated from QWQG 2006 in order to align with the current EHMP guideline values.) The indicators (including fish and macroinvertebrates) differ from the physico-chemical indicators used in previous sections, and are explained further in Appendix E. Water types used for EHMP are also different from the generic ANZECC 2000 Guidelines freshwater types, in that they provide a more detailed breakdown of water types. They are defined in the table below. Water type mapping linked to EPP Water scheduling documents is available from the department's website.

The guideline values in Table 3.1.6 are for application to slightly to moderately disturbed waters. Any waters identified as high ecological value may require more stringent guideline values. These values are yet to be determined.

Table 3.1.6: Regional guidelines for biological indicators – South-east Queensland freshwaters

Indicator[1]	Percentile used	Water type [3]				Oper-ant[2]	Units
		Wallum /tannin stained freshwater	Lowland freshwater	Upland fresh-water	Coastal freshwater		
Fish							
PONSE	Original guideline	100	100	100	100	>=	%
O/E	Used for all	1	1	1	1	>=	ratio (number)
% Alien	Fish indices	0	0	0	0	=	%
Invertebrates							
No. taxa	20th	11	22	22	22	>=	number
PET	20th	3	4	5	4	>=	number
SIGNAL score	20th	4	4	4.6	4	>=	number
Ecological processes	80th						
GPP	80th	0.5	0.5	0.25	0.5	<=	$gC/m^2/day$
R24	80th	0.35	0.35	0.15	0.35	<=	$gC/m^2/day$
Del ^{13}C	20th	–28	–28	–28	–28	>=	delta units
Chl-a	80th	12	12	8	12	<=	mg Chl-a/m^2/day
Nutrient cycling							
Algal bioassay (N+P)/C	80th	4	4	4	4	>=	ratio (number)
Del ^{15}N	80th	5	5	5	5	<=	delta units

Notes:

Descriptions of indicators are contained in Appendix E.

For each indicator the operant denotes whether test-site values should be higher or lower than the guideline number to achieve compliance.

Water types:

Upland freshwater – small (first, second and third order) upland streams (surrogate = altitude >250m). Moderate-to-fast flowing due to steep gradients. Substrate usually cobbles and bedrock, sometimes gravel, rarely sand or mud.

Lowland freshwater – larger (third, fourth and fifth order), slow-flowing and meandering streams and rivers. Gradient very slight. Substrates sometimes cobble and gravel but more often sand, silt or mud.

Coastal freshwater – between Nambour and NSW border. Does not include upland streams that feed these systems. Mix of small and larger slow-flowing lowland streams in this region, not including wallum.

Wallum/tannin stained freshwater – sandy, tea-coloured stained water, low pH coastal streams draining through wallum vegetation.

(Water type mapping is included in EPP Water scheduling documents accessible from the department's website.)

3.1.3.2 Freshwaters: sub-regional biological guidelines

Pine Rivers Shire: For this area of south-east Queensland, users should refer to the biological indicators and guidelines contained in the document, 'The Stream Health Manual, Pine Rivers Shire Council (Loose & Nolte 2004)'. Where there is inconsistency between regional biological guidelines and the Pine Rivers Shire guidelines, the Pine Rivers Shire guidelines should take precedence. The Pine Rivers Shire Stream Health Manual is available from Moreton Bay Council's website at <http://www.moretonbay.qld.gov.au/uploadedFiles/moretonbay/environment/waterways/Stream-Health-Manual.pdf>.

3.1.3.3 Estuarine and marine waters: biological guidelines

Seagrass Depth Limit

The following table refers to estuarine and marine waters of Moreton Bay and Pumicestone Passage and is based on information collected under the estuarine and marine component of the Ecosystem Health Monitoring Program (EHMP). It provides a guideline value for the depth to which the seagrass, *Zostera muelleri,* should grow to below mean sea level. Mean sea level approximates 0m AHD. See Table E.3 for further explanation of this indicator.

The guideline values in Table 3.1.7 are based on the 50th percentile of reference condition and apply to high ecological value waters and to waters that are slightly to moderately disturbed.

Table 3.1.7: Sub-regional guidelines for seagrass depth limit in south-east Queensland

Sub-region	Water type	Protection level	Z. muelleri depth (metres below AHD)
Pumicestone Passage	EC	HEV	-0.8
Pumicestone Passage	EC	SMD	-1.2
Deception Bay (north section)	EC	SMD	-3
Waterloo Bay	EC	HEV	-1.9
Central Bay	EC	HEV	-2.2
Central Bay	EC	SMD	-2.2
Eastern Bay	OC	HEV	-3.5
Eastern Bay	EC	SMD	-2.2
Southern Bay	EC	HEV	-1.3
Southern Bay	EC	SMD	-1.3
Broadwater	EC	HEV	-1.3
Broadwater	EC	SMD	-1.9

Note: AHD refers to Australian Height Datum.

3.1.3.4 Guidelines for nitrogen stable isotopes as indicators of sewage and other nitrogen rich wastes in the aquatic environment

Nitrogen loading to aquatic ecosystems from sewage is recognised worldwide as a growing problem. The use of nitrogen stable isotopes can act as a means of discerning sewage nitrogen in the aquatic environment from other sources of nitrogen (e.g fertiliser). The technique is based upon two naturally occurring atomic forms of nitrogen ^{14}N and ^{15}N. During the sewage treatment process, bacteria digest nitrogen, thereby reducing its concentration in the effluent and minimising environmental impact. Typically, the bacteria will have an enzymatic preference towards ^{14}N over the ^{15}N as ^{14}N is lighter and easier to metabolise. Hence, the remaining nitrogen in sewage effluent is enriched with ^{15}N and aquatic plants (macroalgae, seagrasses and mangroves), utilising nitrogen compounds from the sewage effluent will also contain more of this ^{15}N, resulting in a tissue ^{15}N to ^{14}N ratio ($\delta^{15}N$) above control values. Elevated $\delta^{15}N$ levels in marine plants (typically ~10 ppt) have been found in plants growing or incubated near sewage outfalls in Moreton Bay with values typically below 4 ppt in areas unaffected by sewage.

This technique can be applied to tracing other nitrogen sources in which ^{15}N has been enriched relative to ^{14}N e.g. aquaculture effluent. However, the increases in ^{15}N to ^{14}N ratios in aquatic plants close to these sources may be slightly different to those found in plants adjacent to sewage discharges.

3.1.4 South-east Queensland guidelines for management of riparian zones

The material for management of riparian zones in this document comprises non-statutory guidelines containing information from the Southeast Queensland Regional Water Quality Management Strategy (2001) and a series of technical references on a range of aspects of riparian management.

For statutory riparian vegetation management, reference should be made to the relevant regional vegetation management codes under the Vegetation Management Act. These codes cover all aspects of vegetation management and include riparian protection provisions (including required widths to be preserved) in order to maintain values of watercourses. Background information on these codes (and the codes themselves) can be downloaded from the department's website.

The boundaries and names of the regional vegetation management codes are different from the boundaries/names of water quality regions used in this guideline (as shown in Figure 2.3.3). Hence, within each QWQG region there may be one or more corresponding vegetation management codes. For the SEQ region, the primary corresponding vegetation management code (South-east Queensland bioregion) is available from the department's website.

The non-statutory riparian guideline information from the Southeast Queensland Regional Water Quality Management Strategy (2001) is summarised in Table 3.1.8 below and the related figures 3.1.2, 3.1.3 and 3.1.4. Riparian guideline technical references are listed at the end of this section.

Table 3.1.8: South-east region guidelines for riparian areas [1]

Water type	Riparian function		
	Ecological processes	**Habitat**	**Bed and bank stability**
Upland freshwater	**Perennial** (see Figure 3.1.2) Maintain or restore vegetation to achieve 70% canopy shade in streams less than 10m wide. This will achieve: • moderation of temperature and dissolved oxygen extremes; • organic cycling of leaf litter for nutrients and energy; and • transformation of diffuse nitrogen inputs. **Ephemeral** (see Figure 3.1.3) As above.	**Perennial** (see Figure 3.1.2) Eradicate weeds and maintain or restore: • in-stream large woody debris for fish and invertebrates; • native trees, shrubs and ground cover on the banks; and • tree roots to provide stable undercut banks. This also assists in maintaining biodiversity. **Ephemeral** (see Figure 3.1.3) As above.	**Perennial** (see Figure 3.1.2) Maintain or restore bank vegetation to minimise erosion. Maintain large woody debris for channel shape and form. Manage cattle access. **Ephemeral** (see Figure 3.1.3) Maintain or restore bed and

Water type	Riparian function		
	Ecological processes	Habitat	Bed and bank stability
	Gullies Not applicable.	Gullies Not applicable.	bank vegetation to minimise erosion during wet weather flows. Manage cattle access. Gullies Maintain low vegetation to minimise erosion during wet weather flows.
Lowland freshwater	Perennial (see Figure 3.1.4) Maintain or restore vegetation to achieve: • shade over near-bank areas; • some moderation of temperature and dissolved oxygen extremes; and • transformation of diffuse nitrogen inputs.	Perennial (see Figure 3.1.4) Eradicate weeds and maintain or restore: • in-stream large woody debris for fish and invertebrates; • native trees, shrubs and ground cover on the banks; and • tree roots to provide stable undercut banks. This also assists in maintaining biodiversity.	Perennial (see Figure 3.1.4) Maintain or restore bank vegetation. Maintain large woody debris for channel shape and form. Manage cattle access.

Table 3.1.8 (cont.) South-east Queensland guidelines for riparian areas

Water type	Riparian function		
	Ecological processes	Habitat	Bed and bank stability
Tannin stained and coastal fresh-waters	**Perennial** Maintain or restore vegetation to achieve: • 70% canopy shade in streams less than 10m wide; and • shade over near-bank areas in wider streams. This will achieve: • moderation of temperature and dissolved oxygen extremes; and • transformation of diffuse nitrogen inputs.	**Perennial** Eradicate weeds and maintain or restore: • in-stream debris, riffles and pools; and • native trees, shrubs and ground cover on the banks. This also assists in maintaining biodiversity.	**Perennial** Maintain or restore bank vegetation. Manage cattle access.

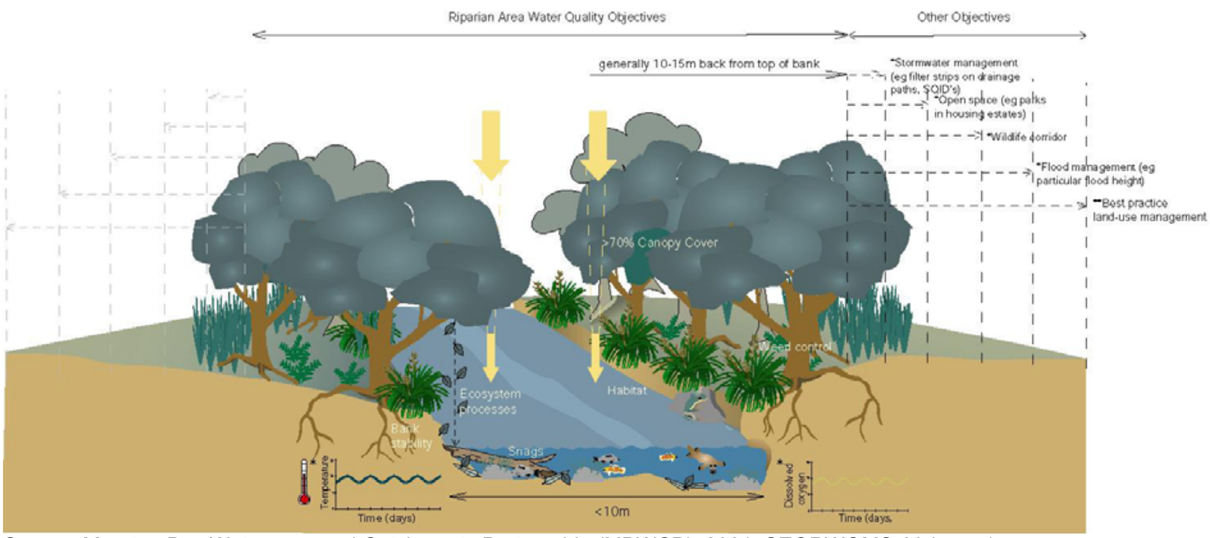
Water type	Riparian function		
	Ecological processes	**Habitat**	**Bed and bank stability**
Estuarine	Maintain or restore marine plants[2] to achieve: • shade over near-bank areas; • moderation of temperature and dissolved oxygen extremes; • organic cycling of leaf litter for nutrients and energy; and • transformation of diffuse nitrogen inputs.	Eradicate weeds and maintain or restore: • in-stream debris; and • marine plants[2], trees, shrubs and ground cover on the banks.	Maintain and restore bank vegetation to minimise erosion.
Coastal foreshores	Maintain or restore marine plants[2] to achieve: • shade over near-shore areas; • moderation of temperature and dissolved oxygen extremes; • organic cycling of leaf litter for nutrients and energy; and • transformation of diffuse nitrogen.	Eradicate weeds and maintain or restore marine plants[2], trees, shrubs and ground cover, and restore tidal regimes where appropriate.	Maintain or restore shoreline vegetation (such as mangroves, salt marshes and seagrass) to minimise erosion.

Notes:

A listing of further technical information on riparian guidelines is provided after Figure 3.1.4. This is not meant to be comprehensive, however it indicates some of the sources of more detailed information on riparian management issues.

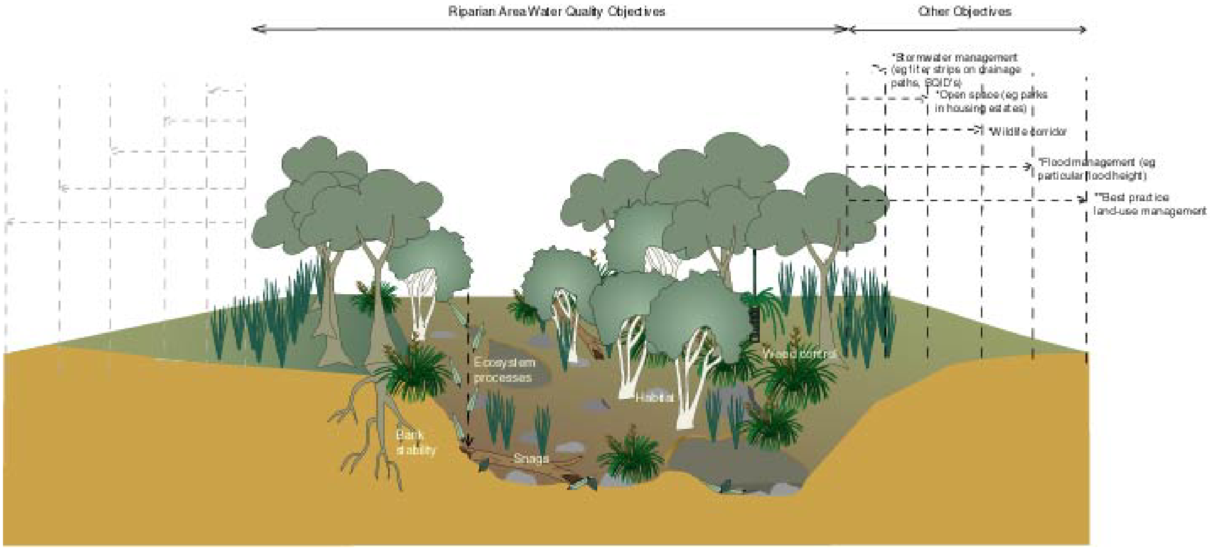
Marine plants include mangroves, salt marshes and seagrass.

Figure 3.1.2: Conceptual model for perennial upland freshwater stream <10 metres wide



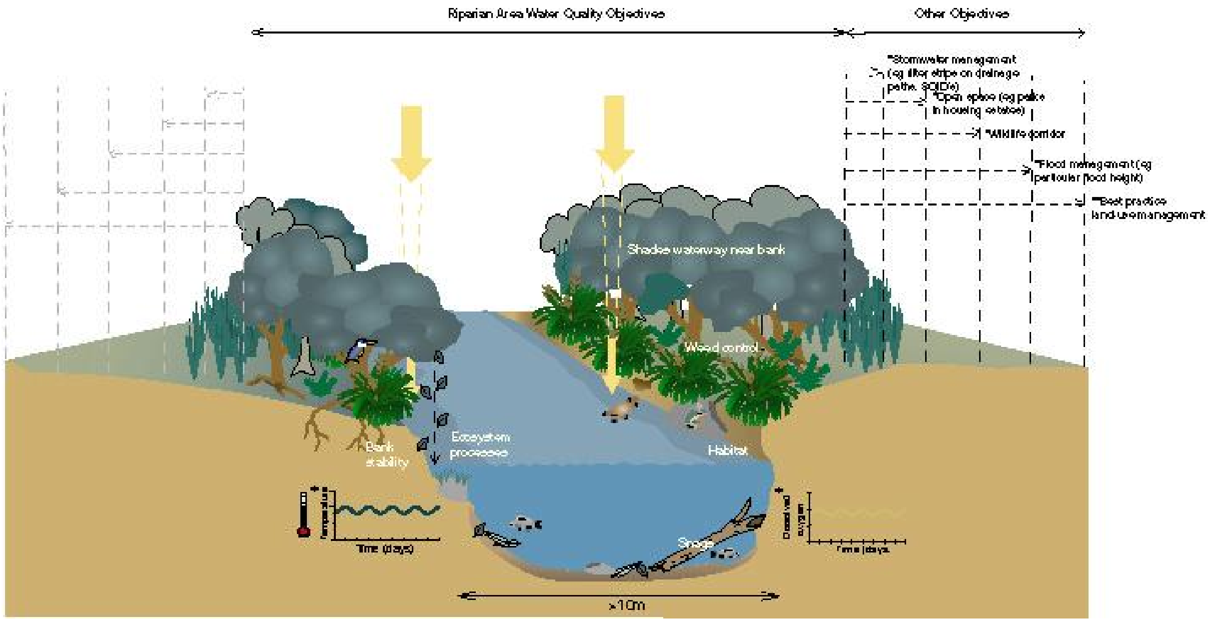
Source: Moreton Bay Waterways and Catchments Partnership (MBWCP), 2001, SEQRWQMS, Volume 1

Figure 3.1.3: Conceptual model for ephemeral freshwater stream



Source: Moreton Bay Waterways and Catchments Partnership (MBWCP), 2001, SEQRWQMS, Volume 1

Figure 3.1.4: Conceptual model for perennial lowland freshwater stream >10 metres wide



Source: Moreton Bay Waterways and Catchments Partnership (MBWCP), 2001, SEQRWQMS, Volume 1

A list of available technical guidelines for managing riparian zones is given below. These cover a range of aspects of riparian management and provide ample information on how to adequately protect the riparian zones of watercourses.

- *Principles for riparian lands management*, Land and Water Australia, 2007 (Eds: Lovett and Price).
- Managing riparian lands to improve water quality: optimising nitrate removal via denitrification, Coastal CRC. 2006 (Hunter et al). Technical Report 57. Available from:
- http://www.clw.csiro.au/publications/science/2006/tr57-riparian_guidelines.pdf.
- *Managing riparian widths to achieve multiple objectives,* fact sheet 13, Land and Water Australia, Australian Government, 2004.
- *Managing high in-stream temperatures using riparian vegetation*, Land and Water Australia technical guideline 5 (Davies et al), 2004.
- *Improving water quality,* fact sheet 3, Land and Water Australia, Australian Government, 2002.
- *Maintaining in-stream life,* fact sheet 4, Land and Water Australia, Australian Government, 2002.
- *Managing riparian land*, fact sheet 1, Land and Water Australia, Australian Government, 2002.

- *Streambank stability*, fact sheet 2, Land and Water Australia, Australian Government, 2002.
- *Guidelines for stabilising streambanks with riparian vegetation* (Queensland focus), CRC for Catchment Hydrology, September 1999 (Abernethy, Rutherfurd), Technical Report 99/10.
- Riparian land management technical guidelines, volume 1, Principles of sound management, Land & Water Resources Research & Development Corporation (LWRRDC), November 1999
- (Eds: Lovett and Price).
- *Riparian land management technical guidelines, volume 2, On-ground management tools and techniques,* November 1999*,* Land & Water Resources Research & Development Corporation (LWRRDC), November 1999 (Eds: Price and Lovett).
- *Managing stock*, fact sheet 6, Land and Water Australia, Australian Government, 2002.
- *Managing woody debris in rivers*, fact sheet 7, Land and Water Australia, Australian Government, 2002.
- *Guidelines for riparian filter strips for Queensland irrigators*, CSIRO Land and Water, September 1999 (Karssies, Prosser), Technical Report 32/99. Available from:
- www.clw.csiro.au/publications/technical99/tr32-99.pdf
- *A rehabilitation manual for Australian streams, volumes 1 & 2.* (Rutherfurd, Jerie & Marsh 2000), Cooperative Research Centre for Catchment Hydrology & Land and Water Resources Research and Development Corporation..

3.1.5 Guidelines for fisheries habitat

A range of guidelines relating to fisheries habitat are available from the Department of Agriculture, Fisheries and Forestry.

- Cotterell, EJ 1998. *Fish passage in streams: Fisheries guidelines for design of stream crossings*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 001, 37pp.
- Hopkins, E, White, M and Clarke, A 1998. *Restoration of fish habitats: Fisheries guidelines for marine areas*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 002, 44pp.
- Bavins, M, Couchman, D and Beumer, J 2000. *Fisheries guidelines for fish habitat buffer zones*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 003, 39pp.
- Clarke, A and Johns, L 2002. *Mangrove nurseries: Construction, propagation and planting: Fisheries guidelines*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 004, 32pp.
- Challen, S and Long, P 2004. *Fisheries guidelines for managing ponded pastures*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 005, 27pp.
- Derbyshire, K 2006. *Fisheries guidelines for fish-friendly structures*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 006, 64pp.
- Lawrence, M, Sully, D, Beumer, J and Couchman, D 2009. *Fisheries guidelines for conducting an inventory of instream structures in coastal Queensland*, Department of Primary Industries and Fisheries, Fish Habitat Guideline FHG 007, 72pp.

3.2 Central Coast Queensland region

3.2.1 Central Coast Queensland regional guideline values for physico-chemical indicators (slightly to moderately disturbed waters)

Tables 3.2.1a and 3.2.1b below outline the regional physico-chemical guideline values for Central Coast Queensland waters (extending north from the Burnett River basin to the Black River basin – refer section 2.3.2). Note that where sub-regional (i.e. more localised) water quality guidelines are developed, they are to be given precedence. At this stage the QWQG provide sub-regional guidelines for streams in the Mackay-Whitsunday area in the following table. The median value of water quality at test sites is to be compared and assessed against the numbers in this table (refer section 5 and Appendix D).

Table 3.2.1a: Regional guideline values for physico-chemical indicators – Central Coast region fresh and estuarine waters

Central region water type	Physico-chemical indicator (see Appendix E) and guideline[9] value (slightly to moderately disturbed systems)															
	Amm N	Oxid N	Org[6] N	Total N	FiltR P	Total P	Chl-a	DO (% sat[n])[1,2,3]		Turb	Secchi	SS	pH[4,5]		Conductivity	Temperature[11]
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	lower	upper	(NTU)	(m)	(mg/L)	lower	upper	(µS/cm)	(°C)
Open coastal, midshelf & offshore	See Table 3.2.1b which covers guidelines for these waters, which are within the Great Barrier Reef Marine Park.															Managers need to define their own upper and lower guideline values, using the 80th and 20th percentiles, respectively, of ecosystem temperature distribution (ANZECC 2000).
Enclosed coastal	8	3	180	200	6	20	2.0	90	100	6	1.5	15	8.0	8.4	n/a	
Mid-estuarine and tidal canals, constructed estuaries, marinas and boat harbours	10	10	260	300	8	25	4.0	85	100	8[8]	1.0[8]	20[8]	7.0	8.4	n/a	
Upper estuarine	30	15	400	450	10	40	10.0	70	100	25[8]	0.4[8]	25[8]	7.0	8.4	n/a	
Lowland streams[10]	20	60	420	500	20	50	5.0	85	110	50	n/a	10	6.5	8.0	See Appendix G	
Upland streams[10]	10	15	225	250	15	30	n/a	90	110	25	n/a	–	6.5	7.5	See Appendix G	
Freshwater lakes/ reservoirs	10	10	330	350	5	10	5.0	90	110	1–20	nd	nd	6.5	8.0	See Appendix G	
Wetlands [7]	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	

Central region water type	Physico-chemical indicator (see Appendix E) and guideline[9] value (slightly to moderately disturbed systems)															
	Amm N	Oxid N	Org[6] N	Total N	FiltR P	Total P	Chl-a	DO (% sat[n])[1,2,3]		Turb	Secchi	SS	pH[4,5]		Conductivity	Temperature[11]
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	lower	upper	(NTU)	(m)	(mg/L)	lower	upper	(µS/cm)	(°C)

Note 1	Note that DO guidelines (% saturation) for freshwaters should only be applied to flowing waters, including those with significant sub-surface flows. Stagnant pools in intermittent streams naturally experience values of DO below 50% saturation.	
Note 2	DO Guideline values in the table above apply to daytime conditions. Lower values may occur at night but this should not be more than 10% –15% less than daytime values.	
Note 3	DO values as low as 40% may occur in estuaries for short periods following material inflow events after rainfall. DO values consistently <50% are likely to significantly impact on the ongoing ability of fish to persist in a water body. DO values <30% saturation are toxic to some fish species. These DO values should be applied as absolute lower limit guidelines for DO – see also section 5.2. Very high DO (supersaturation) values can be toxic to some fish as they cause gas bubble disease. See Butler and Burrows (2007) for detailed report on effects of low DO on fish.	
Note 4	During flood events or nil flow periods, pH values should not fall below 5.5 (except in wallum areas) or exceed 9.	
Note 5	In wallum areas, waters contain naturally high levels of humic acids (and have a characteristic brown ti-tree stain). In these types of waters, natural pH values may range from 3.6 to 6.0.	
Note 6	During periods of low flow and particularly in smaller creeks, build up of organic matter derived from natural sources (e.g. leaf litter) can result in increased organic N levels (generally in the range of 400 to 800µg/L). This may lead to total N values exceeding the QWQG values. Provided that levels of inorganic N (i.e. NH3 + oxidised N) remain low, then the elevated levels of organic N should not be seen as a breach of the guidelines, provided this is due to natural causes.	General abbreviations nd = no data; n/a = not applicable
Note 7	For Wetlands, see ANZECC 2000 Guidelines.	
Note 8	These guideline numbers apply to estuaries less than 40km in length. Longer estuaries have naturally higher turbidity levels (and corresponding higher suspended solids levels and lower Secchi depth values) due to the longer retention times for suspended particulates and also to the continual re-suspension of fine particles by high tidal velocities. Values are variable and site specific. However, most values are <100NTU and very few values are >200NTU.	
Note 9	For information on general application of these guideline values, on their application under different flow conditions and on approaches to assessing pulse inputs of pollutants – see section 5 and Appendix D of the QWQG.	
Note 10	In the absence of better data, the guidelines adopted for freshwaters are for the most part the default ANZECC 2000 Guidelines. It is acknowledged that these need to be updated with local data as soon as this is available.	

Central region water type	Physico-chemical indicator (see Appendix E) and guideline[9] value (slightly to moderately disturbed systems)															
	Amm N	Oxid N	Org[6] N	Total N	FiltR P	Total P	Chl-a	DO (% sat[n]) [1,2,3]		Turb	Secchi	SS	pH[4,5]		Conductivity	Temperature[11]
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	lower	upper	(NTU)	(m)	(mg/L)	lower	upper	(µS/cm)	(°C)
Note 11	Temperature varies both daily and seasonally, is depth dependent and is also highly site specific. It is therefore not possible to provide simple generic water quality guidelines for this indicator. The recommended approach is that local guidelines be developed. Thus, guidelines for potentially impacted streams should be based on measurements from nearby streams that have similar morphology and which are thought not to be impacted by anthropogenic thermal influences. From an ecological effects perspective, the most important aspects of temperature are the <u>daily maximum temperature</u> and the <u>daily variation in temperature</u>. Therefore measurements of temperature should be designed to collect information on these indicators of temperature and, similarly, local guidelines should be expressed in terms of these indicators. Clearly, there will be an annual cycle in the values of these indicators and therefore a full seasonal cycle of measurements is required to develop guideline values.															

Abbreviations:

Water type: OC = open coastal; EC = enclosed coastal; UE = upper estuarine; ME = mid-estuarine.

Water quality indicators (refer Appendix E): Amm N = ammonia nitrogen; Oxid N = oxidised nitrogen; Org N = organic nitrogen; Total N = total nitrogen; FiltR P = filterable reactive phosphorus; Total P = total phosphorus; Chl-a = chlorophyll-a; DO = dissolved oxygen (percent saturation); Turb = turbidity; Secchi = Secchi depth.

Table 3.2.1b: Regional guideline values for physico-chemical indicators – Central Coast region coastal waters. (based on the GBRMPA and the QWQG guidelines)

Water type[5]	Physico-chemical indicators (see Appendix E) and their guideline[1] values (slightly to moderately disturbed systems)														
	Amm N	Oxid N	Particulate N[3]	Total N	FiltR P	Particulate P[3]	Total P	Chl-a[2]	TSS[3]	Turb	Secchi[4]	pH		DO (% satn)	
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(NTU)	(m)	lower	upper	lower	upper
Open Coastal	4	3	20	140	6	2.8	20	0.45	2	1	10	8.1	8.4	95	105
Midshelf	4	2	20	140	6	2.8	20	0.45	2	<1	10	8.1	8.4	95	105
Offshore	2	2	17	120	5	1.9	12	0.4	0.7	<1	17	8.1	8.4	95	105

Water type[5]	Physico-chemical indicators (see Appendix E) and their guideline[1] values (slightly to moderately disturbed systems)													
	Amm N	Oxid N	Particulate N[3]	Total N	FiltR P	Particulate P[3]	Total P	Chl-a[2]	TSS[3]	Turb	Secchi[4]	pH		DO (% satn)	
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(NTU)	(m)	lower	upper	lower	upper
Note 1	Guideline values for PN, PP, Chl a, Secchi and TSS should be compared to mean values rather than median values (see GBRMPA Guidelines, accessible at the following web link: http://www.gbrmpa.gov.au/corp_site/key_issues/water_quality/draft_water_quality_guidelines).														
Note 2	Chlorophyll values are ~40% higher in summer (0.63µg/L) and ~30% lower in winter (0.32µg/L) than mean annual values. Both the annual mean and these seasonal mean values should be regarded equally as guideline values for assessment purposes.														
Note 3	Seasonal (winter/summer) adjustments for TSS, PN and PP guidelines are approximately ±20% of the annual mean values.														
Note 4	Guideline trigger values for water clarity need to be decreased by 20% for areas with greater than 5m tidal ranges.														
Note 5	Water types for the GBR Marine Park are described in Appendix B.														

3.2.2 Sub-regional guidelines for the Mackay-Whitsunday region

A Water Quality Improvement Plan (WQIP) for the Mackay Whitsunday region was published in 2008. The main report and supporting technical reports are available from the web site: www.reefcatchments.com.au .

The WQIP contains recommended long-term water quality objectives for all of its defined catchment management areas. The freshwater long term water quality objective values for each management area have been adopted as sub-regional (i.e. local) guidelines by the QWQG. These values have been derived using appropriate methodologies and are clearly the most appropriate values for these waters. The Mackay-Whitsunday WQIP also sets shorter term target values for water quality. These are less stringent than the long term objectives but may be achievable with measures that can be practically applied in the next few years. However, guidelines are designed to provide a measure of natural condition and this is why the QWQG have adopted the WQIP's long term water quality objectives, which are primarily based on data from largely undisturbed sites.

In addition to baseflow or ambient guidelines, the Mackay-Whitsunday Water Quality Improvement Plan has also developed guidelines for event flows. Like the baseflow guidelines, these are based on data from reference creeks but collected during flow events rather than under baseflow – see Table 3.2.4.

For estuary and enclosed coastal waters of the Mackay-Whitsunday region, it is recommended that users should revert to the QWQG numbers for the Wet Tropics (see section 3.3) as no sub-regional data is available. For marine waters, users should refer to the GBRMPA guidelines. However, the Mackay-Whitsunday WQIP does provide some guidelines for event water quality in inshore waters and these should be referred to for assessment of event conditions.

Further details on the tables are provided below.

Table 3.2.2 of the QWQG provides sub regional physico chemical water quality guidelines for freshwaters under baseflow (i.e. normal/ambient) conditions. For the high ecological value (HEV) waters the intent is to maintain current water quality, habitat, biota, flow and riparian areas condition. This is assessed by methods described in Appendix D (2.1). Where water quality data are available, this is based on 20th, 50th and 80th percentiles of reference site water quality (derived from 12 months of sampling under baseflow conditions from several Mackay Whitsunday reference sites, namely Impulse Creek, Finch Hatton Creek, St Helens Creek, Basin Creek, and Andromache

River - Refer Table 17 of the Mackay Whitsunday WQIP). The relevant 'source' reference site for each catchment management area is provided in the Mackay Whitsunday NRM region document "Turning environmental values into water quality objectives and targets" (Table 30). If no water quality data is available for particular HEV waters, then a statement is provided in the table.

For most slightly to moderately disturbed (SMD) waters, guideline values are derived from the 80th &/or 20th percentiles of data from reference sites. However, for some SMD waters, existing water quality was comparable to adjacent HEV waters and therefore, although the level of protection is designated as SMD, the intent is to preserve existing water quality. For these streams, guidelines are therefore based on the same approach as that for HEV waters i.e. no change 20th, 50th and 80th percentiles. This means that guidelines for these waters include all three percentile values. Waters for which the "no change" approach has been taken are identified in the table.

Table 3.2.3 provides baseflow guideline values for agricultural herbicides, again based on the objectives in the Mackay Whitsunday WQIP.

Table 3.2.4 provides event quality guidelines for freshwaters – water quality during high flow events. The event quality objectives are based on data collected from reference sites under event flow conditions. There were several events monitored at each reference site. The event water quality objective values are expressed as Event Mean Concentrations (EMC) i.e. the total event load divided by the total event volume. This is one of the first times this type of objective has been derived for Queensland waters. Because of the highly variable nature of water quality during events, the confidence intervals around these numbers are inevitably large. Nevertheless, these values are a significant step forward in that they provide a benchmark against which quality during events can be assessed. Using ambient guidelines for this purpose is inappropriate.

Table 3.2.2: Mackay-Whitsunday sub-regional baseflow (ambient) guidelines for physico-chemical indicators – freshwaters

Sub-region (catchment management area)[1]	Water type [2]	Protection level [3]	Physico-chemical indicator (refer Appendix E) and percentile value (20th, 50th, 80th percentile) [4, 5]																											
			DIN (µg/L)			PN (µg/L)			FRP (µg/L)			PP (µg/L)			TSS (mg/L)			DO[8] (% sat)				pH			EC µS/cm			Other indicators[6]		
			20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	NF 20	F 20	NF 80	F 80	20	50	80	20	50	80	20	50	80
Alligator Creek		HEV	No HEV freshwaters identified to date. Refer SMD row below																											
Alligator Creek		SMD			30			110			15			20			5	40	85	120		7.3		7.5			527			
Andromache River		HEV	9	18	46	21	39	62	12	22	28	4	9	13	0	1	1	50	90	120	105	8	8.2	8.3	320	483	600			

Sub-region (catchment management area)[1]	Water type [2]	Protection level [3]	Physico-chemical indicator (refer Appendix E) and percentile value (20th, 50th, 80th percentile) [4, 5]																											
			DIN			PN			FRP			PP			TSS			DO[8]				pH			EC			Other indicators[6]		
			(µg/L)			(µg/L)			(µg/L)			(µg/L)			(mg/L)			(% sat)							µS/cm					
Andromache River [7]		SMD	9	18	46	21	39	62	12	22	28	4	9	13	0	1	1	50	90	120	105	8		8.3	320	483	600			
Bakers Creek		HEV	No HEV freshwaters identified to date. Refer SMD row below.																											
Bakers Creek		SMD			30			150			20			20			4	40	85	120		6.8		7			390			
Basin Creek			See listing under Gillinbin Creek area																											
Blackrock Creek (based on Andromache R HEV)		HEV	9	18	46	21	39	62	12	22	28	4	9	13	0	1	1	50	90	120	105	8	8.2	8.3	320	430	600			
Blackrock Creek		SMD			10			142			6			20			4	40	85	120		7.6		7.9			697			
Blacks Creek (based on Basin Ck HEV)		HEV	4	9	13	39	58	152	1	2	3	6	12	22	1	2	4	50	90	120	105	6.7	6.9	7.1	130	190	350			
Blacks Creek[7]		SMD	4	9	13	39	58	152	1	2	3	6	12	22	1	2	4	50	90	120	105	6.7		7.1	130	190	350			
Cape Creek (based on Basin Ck HEV)		HEV	4	9	13	39	58	152	1	2	3	6	12	22	1	2	4	50	90	120	105	6.7	6.9	7.1	130	190	350			

Sub-region (catchment management area)[1]	Water type [2]	Protection level [3]	Physico-chemical indicator (refer Appendix E) and percentile value (20th, 50th, 80th percentile) [4, 5]																											
			DIN			PN			FRP			PP			TSS			DO[8]				pH			EC			Other indicators[6]		
			(µg/L)			(µg/L)			(µg/L)			(µg/L)			(mg/L)			(% sat)							µS/cm					
Cape Creek[7]		SMD	4	9	13	39	58	152	1	2	3	6	12	22	1	2	4	50	90	120	105	6.7		7.1	130	190	350			
Carmila Creek		HEV	No HEV freshwaters identified to date. Refer SMD row below																											
Carmila Creek		SMD			8			78			5			10			3	40	85	120		7.3		7.8			279			
Constant Creek (based on St Helens Ck HEV)		HEV	8	11	17	21	32	81	4	5	9	3	4	5	0	1	1	50	90	120	105	7.4	7.6	7.8	60	60	70			
Constant Creek		SMD			10			142			6			20			4	40	85	120		7.6		7.9			697			
Eden Lassie Creek		HEV	Maintain existing water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas. Note: there is insufficient information available to establish current water quality for these waters. Refer to section 4 of the QWQG for details on how to establish a minimum water quality data set for deriving local 20th, 50th and 80th percentiles using good quality reference sites.																											
Eden Lassie Creek		SMD			18			39			22			9			1	40	85	120		6.5		7.5			483			
Finch Hatton Creek			See listing under Upper Cattle Creek area																											
Flaggy Rock Creek		HEV	4	9	13	39	58	152	1	2	3	6	12	22	1	2	4	50	90	120	105	6.7	6.9	7.1	130	190	350			

Sub-region (catchment management area)[1]	Water type [2]	Protection level [3]	Physico-chemical indicator (refer Appendix E) and percentile value (20th, 50th, 80th percentile) [4, 5]																											
			DIN			PN			FRP			PP			TSS			DO[8]				pH			EC			Other indicators[6]		
			(µg/L)			(µg/L)			(µg/L)			(µg/L)			(mg/L)			(% sat)							µS/cm					
Flaggy Rock Creek		SMD			8			78			5			10			3	40	85	120		7.3		7.8			279			
Gillinbin Creek (including and based on Basin Ck HEV)		HEV	4	9	13	39	58	152	1	2	3	6	12	22	1	2	4	50	90	120	105	6.7	6.9	7.1	130	190	350			
Gillinbin Creek[7]		SMD	4	9	13	39	58	152	1	2	3	6	12	22	1	2	4	50	90	120	105	6.7		7.1	130	190	350			
Gregory River (based on Impulse Ck HEV)		HEV	10	20	31	10	16	52	9	10	15	4	10	17	1	2	3	50	90	120	105	7.2	7.3	7.6	180	260	780			
Gregory River		SMD			30			43			6			6			2	40	85	120		7.2	8.1				580			
Impulse Creek			See listing under Repulse Creek area																											
Lethe Brook (based on Andromache R HEV)		HEV	9	18	46	21	39	62	12	22	28	4	9	13	0	1	1	50	90	120	105	8	8.2	8.3	320	430	600			
Lethe Brook		SMD			8			101			8			18			3	40	85	120		7.5		7.8			463			
Mackay City		HEV	No HEV freshwaters identified to date. Refer SMD row below																											

Sub-region (catchment management area)[1]	Water type [2]	Protection level [3]	Physico-chemical indicator (refer Appendix E) and percentile value (20th, 50th, 80th percentile) [4, 5]																											
			DIN			PN			FRP			PP			TSS			DO[8]				pH			EC			Other indicators[6]		
			(µg/L)			(µg/L)			(µg/L)			(µg/L)			(mg/L)			(% sat)							µS/cm					
Mackay City		SMD			30			110			15			20			5	40	85	120		7.3		7.5			527			
Marion Creek (based on Basin Ck HEV)		HEV	4	9	13	39	58	152	1	2	3	6	12	22	1	2	4	50	90	120	105	6.7	6.9	7.1	130	190	350			
Marion Creek		SMD			8			78			5			10			3	40	85	120		7.3		7.8			279			
Murray Creek (based on Andromache R HEV)		HEV	9	18	46	21	39	62	12	22	28	4	9	13	0	1	1	50	90	120	105	8	8.2	8.3	320	430	600			
Murray Creek[7]		SMD	9	18	46	21	39	62	12	22	28	4	9	13	0	0	1	50	90	120	105	8		8.3	320	430	600			
Myrtle Creek (based on Impulse Ck HEV)		HEV	10	20	31	10	16	52	9	10	15	4	10	17	1	2	3	50	90	120	105	7.2	7.3	7.6	180	260	780			
Myrtle Creek		SMD			30			112			25			20			5	40	85	120		7.2		7.3			654			
O'Connell River (based on Andromache R HEV)		HEV	9	18	46	21	39	62	12	22	28	4	9	13	0	1	1	50	90	120	105	8	8.2	8.3	320	430	600			

Sub-region (catchment management area)[1]	Water type [2]	Protection level [3]	Physico-chemical indicator (refer Appendix E) and percentile value (20th, 50th, 80th percentile) [4, 5]																											
			DIN (µg/L)			PN (µg/L)			FRP (µg/L)			PP (µg/L)			TSS (mg/L)			DO[8] (% sat)				pH			EC µS/cm			Other indicators[6]		
O'Connell River		SMD			30			43			6			6			2	40	85	120		7.2		8.1			580			
Pioneer River - Main Channel (based on upper Cattle Ck HEV)		HEV	5	8	13	6	13	26	2	3	6	1	3	5	0	1	1	50	90	120	105	7.4	7.4	7.5	40	40	50			
Pioneer River - Main Channel		SMD			8			102			5			20			5	40	85	120		7.4		8.3			183			
Plane Creek		HEV	No HEV freshwaters identified to date. Refer SMD row below																											
Plane Creek		SMD			8			101			8			18			3	40	85	120		7.5		7.8			463			
Proserpine River - Main Channel		HEV	Maintain existing water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas. Note: there is insufficient information available to establish current water quality for these waters. Refer to section 4 of the QWQG for details on how to establish a minimum water quality data set for deriving local 20th, 50th and 80th percentiles using good quality reference sites.																											
Proserpine River - Main Channel		SMD			30			150			25			20			5	40	85	120		6.9		7.5			270			
Reliance Creek (based on St Helens CK HEV)		HEV (the Leap)	8	11	17	21	32	81	4	5	9	3	4	5	0	1	1	50	90	120	105	7.4	7.6	7.8	60	60	70			

Sub-region (catchment management area)[1]	Water type [2]	Protection level [3]	Physico-chemical indicator (refer Appendix E) and percentile value (20th, 50th, 80th percentile) [4, 5]																												
			DIN			PN			FRP			PP			TSS			DO[8]				pH			EC			Other indicators[6]		
			(µg/L)			(µg/L)			(µg/L)			(µg/L)			(mg/L)			(% sat)							µS/cm					
Reliance Creek		Other HEV	Maintain existing water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas. Note: there is insufficient information available to establish current water quality for these waters. Refer to section 4 of the QWQG for details on how to establish a minimum water quality data set for deriving local 20th, 50th and 80th percentiles using good quality reference sites.																												
Reliance Creek		SMD			30			110			15			20			5	40	85	120		7.3		7.5			527			
Repulse Creek (including and based on Impulse Ck HEV)		HEV	10	20	31	10	16	52	9	10	15	4	10	17	1	2	3	50	90	120	105	7.2	7.3	7.6	180	260	780			
Rocky Dam Creek (based on Basin/Gillinbin HEV)		HEV	4	9	13	39	58	152	1	2	3	6	12	22	1	2	4	50	90	120	105	6.7	6.9	7.1	130	190	350			
Rocky Dam Creek		SMD			10			142			6			20			4	40	85	120		7.6		7.9			697			
Sandy Creek (based on Basin Ck HEV)		HEV	4	9	13	39	58	152	1	2	3	6	12	22	1	2	4	50	90	120	105	6.7	6.9	7.1	130	190	350			
Sandy Creek		SMD			30			110			15			20			5	40	85	120		7.3		7.5	`		527			
Sarina Beaches		HEV	No HEV freshwaters identified to date. Refer SMD row below																												

Sub-region (catchment management area)[1]	Water type [2]	Protection level [3]	Physico-chemical indicator (refer Appendix E) and percentile value (20th, 50th, 80th percentile) [4, 5]																													
			DIN			PN			FRP			PP			TSS			DO[8]				pH			EC			Other indicators[6]		
			(µg/L)			(µg/L)			(µg/L)			(µg/L)			(mg/L)			(% sat)							µS/cm					
Sarina Beaches		SMD			9			58			2			12			2	40	85	120		6.7		7.1			194			
St Helens Creek		HEV	8	11	17	21	32	81	4	5	9	3	4	5	0	1	1	50	90	120	105	7.4	7.6	7.8	60	60	70			
St Helens Creek		SMD			10			142			6			20			4	40	85	120		7.6		7.9			697			
Thompson Creek		HEV	Maintain existing water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas. Note: there is insufficient information available to establish current water quality for these waters. Refer to section 4 of the QWQG for details on how to establish a minimum water quality data set for deriving local 20th, 50th and 80th percentiles using good quality reference sites.																											
Thompson Creek		SMD			10			142			6			20			4	40	85	120		7.6		7.9			697			
Upper Cattle Creek (including and based on Finch Hatton Ck HEV)		HEV	5	8	13	6	13	26	2	3	6	1	3	5	0	1	1	50	90	120	105	7.4	7.4	7.5	40	40	50			
Upper Cattle Creek		SMD			8			78			5			10			3	40	85	120		7.3		7.8			279			
Upper Proserpine River		HEV	9	18	46	21	39	62	12	22	28	4	9	13	0	1	1	50	90	120	105	6.5		8.5	320	483	600			

Sub-region (catchment management area)[1]	Water type [2]	Protection level [3]	Physico-chemical indicator (refer Appendix E) and percentile value (20th, 50th, 80th percentile) [4, 5]																												
			DIN (µg/L)			PN (µg/L)			FRP (µg/L)			PP (µg/L)			TSS (mg/L)			DO[8] (% sat)				pH			EC µS/cm			Other indicators[6]		
Upper Proserpine River[7]		SMD	9	18	46	21	39	62	12	22	28	4	9	13	0	1	1	50	90	120	105	6.5		8.5	320	483	600			
Waterhole Creek		HEV	No HEV freshwaters identified to date. Refer SMD row below																											
Waterhole Creek[7]		SMD	9	18	46	21	39	62	12	22	28	4	9	13	0	1	1	50	90	120	105	6.5		8.5	320	483	600			
West Hill Creek (based on Basin Ck HEV)		HEV	4	9	13	39	58	152	1	2	3	6	12	22	1	2	4	50	90	120	105	6.7	6.9	7.1	130	190	350			
West Hill Creek[7]		SMD	4	9	13	39	58	152	1	2	3	6	12	22	1	2	4	50	90	120	105	6.7		7.1	130	190	350			
Whitsunday Coast (based on Impulse Ck HEV)		HEV	10	20	31	10	16	52	9	10	15	4	10	17	1	2	3	50	90	120	105	7.2	7.3	7.6	180	260	780			
Whitsunday Coast[7]		SMD	10	20	31	10	16	52	9	10	15	4	10	17	1	2	3	50	90	120	105	7.2	7.3	7.6	180	260	780			

Notes:

Sub region: Listed alphabetically. The location and boundaries of the subregional waters/catchment management areas identified in this Table are shown the *Mackay-Whitsunday Water Quality Improvement Plan*, available from the following web site: www.reefcatchments.com.au .

Water types. The guidelines in this table relate to riverine freshwaters. If a waterway/water type is not specified in this table, then default to the regional water quality guidelines for slightly to moderately disturbed (SMD) waters for other water types (eg lakes, estuaries). Generally areas identified for HEV level of protection are upland freshwater. Areas identified for SMD level of protection are primarily lowland freshwaters. Exceptions are Basin and Gillinbin Creek lowland, Thompson Creek lowland and Black Creek lowland all of which are HEV. Further details on the water types and decision rules are provided in the Mackay Whitsunday NRM region document “Turning environmental values into water quality objectives and targets” (Table 30), available from the following web site: www.reefcatchments.com.au.

Protection level: HEV = high ecological value (management intent: to maintain current condition); SMD = slightly – moderately disturbed. Many of the catchment management areas/subregional waters contain some areas of HEV waters and some areas of SMD waters, so for each sub region both HEV and SMD rows are provided. For subregions containing HEV waters, the intent is to maintain current water quality (20th, 50th and 80th percentiles of reference site water quality where sufficient information is available), habitat, biota, flow and riparian areas condition. Where information is not available, a management intent statement is provided. In subregions with only SMD waters, only the 80th &/or 20th percentile values of reference sites are provided. (However, refer to additional comments under note 7 for SMD waters where current condition is better than long term guideline value). Further information on the methods used to derive these values is provided in the *Mackay-Whitsunday Water Quality Improvement Plan* and supporting technical documents, available from the following web site: www.reefcatchments.com.au .

Values for indicators were calculated based on ambient freshwater sampling from reference (HEV) catchments in the Mackay Whitsunday region (in particular, sites at Impulse Creek, Finch Hatton Creek, St Helens Creek, Basin Creek, and Andromache River.) (Refer Table 17 of the Mackay Whitsunday WQIP.)

Water quality indicators (refer Appendix E): DIN = dissolved inorganic nitrogen; PN = particulate nitrogen; FRP = filterable reactive phosphorus; PP = particulate phosphorus; TSS = total suspended solids; DO = dissolved oxygen (percent saturation); pH = pH; EC = electrical conductivity.

For other physico-chemical indicators not listed in this table, refer to relevant regional water quality guidelines.

For these SMD waters, the intention is preserve existing water quality and therefore guidelines are based on “no change” to the 20th,50th or 80th percentiles (Mackay-Whitsunday WQIP, p 28: ‘If current condition is better than the long term ‘guideline’ WQO, then the Target and WQO adopted is equal to Current Condition (50th percentile) so water quality does not degrade.’).

Dissolved oxygen values in streams during non-flow (stagnant) periods tend to naturally vary more widely than in flow periods. Minimum values are lower (due to the effects of stagnation) while maximum values are commonly higher (due to increased algal activity). For this reason DO guidelines are provided for both flow and non-flow conditions. Thus “F” denotes a guideline for flow periods and “NF” denotes a guideline for nil flow periods.

Table 3.2.3: Mackay-Whitsunday sub-regional baseflow (ambient) guidelines for agricultural herbicides – freshwaters

Sub-region (catchment management area)[1]	Water type[2]	Protection level[3]	Agricultural herbicide indicator[4, 5]				
			Ametryn (µg/L)	Atrazine (µg/L)	Diuron (µg/L)	Hexazinone (µg/L)	Tebuthiuron (µg/L)
Alligator Creek		HEV	No HEV freshwaters identified to date. Refer SMD row below.				
Alligator Creek		SMD	0.02	0.09	0.19	0.20	<LOD [5]
Andromache River		HEV	<LOD [5]	<LOD [5]	<LOD [5]	<LOD [5]	<LOD
Andromache River		SMD	<LOD	<LOD	<LOD	<LOD	<LOD
Bakers Creek		HEV	No HEV freshwaters identified to date. Refer SMD row below.				
Bakers Creek		SMD	0.01	0.17	0.11	0.14	<LOD
Basin Creek			See listing under Gillinbin Creek area.				
Blackrock Creek (based on Andromache Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD

Sub-region (catchment management area)[1]	Water type[2]	Protection level[3]	Agricultural herbicide indicator[4, 5]				
			Ametryn	Atrazine	Diuron	Hexazinone	Tebuthiuron
			(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Blackrock Creek (based on Rocky Dam Ck)		SMD	0.02	<LOD	0.07	0.13	<LOD
Blacks Creek (based on Basin Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Blacks Creek		SMD	<LOD	<LOD	<LOD	<LOD	<LOD
Cape Creek (based on Basin Ck HEV + all SMD<LOD)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Cape Creek		SMD	<LOD	<LOD	<LOD	<LOD	<LOD
Carmila Creek		HEV	No HEV freshwaters identified to date. Refer SMD row below.				
Carmila Creek		SMD	<LOD	<LOD	<LOD	0.01	<LOD
Constant Creek (based on St Helens Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Constant Creek		SMD	0.02	<LOD	0.07	0.13	<LOD
Eden Lassie Creek (based on all SMD<LOD)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Eden Lassie Creek		SMD	<LOD	<LOD	<LOD	<LOD	<LOD
Finch Hatton Creek			See listing under Upper Cattle Creek area.				
Flaggy Rock Creek (based on Basin Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Flaggy Rock Creek		SMD	<LOD	<LOD	<LOD	0.01	<LOD

Sub-region (catchment management area)[1]	Water type[2]	Protection level[3]	Agricultural herbicide indicator[4, 5]				
			Ametryn	Atrazine	Diuron	Hexazinone	Tebuthiuron
			(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Gillinbin Creek (including, and based on, Basin Creek HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Gillinbin Creek (including Basin Creek)		SMD	<LOD	<LOD	<LOD	<LOD	<LOD
Gregory River (based on Impulse Ck HEV+ all SMD<LOD)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Gregory River		SMD	<LOD	<LOD	<LOD	<LOD	<LOD
Impulse Creek			See listing under Repulse Creek area.				
Lethe Brook (based on Andromache R HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Lethe Brook		SMD	<LOD	<LOD	0.01	0.04	<LOD
Mackay City		HEV	No HEV freshwaters identified to date. Refer SMD row below.				
Mackay City		SMD	0.02	0.09	0.19	0.20	<LOD
Marion Creek (based on Basin Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Marion Creek		SMD	<LOD	<LOD	<LOD	0.01	<LOD
Murray Creek (based on St Helens Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Murray Creek		SMD	<LOD	<LOD	<LOD	<LOD	<LOD
Myrtle Creek (based on Impulse Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD

Sub-region (catchment management area)[1]	Water type[2]	Protection level[3]	Agricultural herbicide indicator[4, 5]				
			Ametryn	Atrazine	Diuron	Hexazinone	Tebuthiuron
			(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Myrtle Creek		SMD	0.04	0.11	0.11	0.08	<LOD
O'Connell River (based on Andromache R HEV + all SMD<LOD)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
O'Connell River		SMD	<LOD	<LOD	<LOD	<LOD	<LOD
Pioneer River - Main Channel (based on Upper Cattle Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Pioneer River - Main Channel		SMD	<LOD	0.02	0.02	0.02	<LOD
Plane Creek		HEV	No HEV freshwaters identified to date. Refer SMD row below.				
Plane Creek		SMD	<LOD	<LOD	0.01	0.04	<LOD
Proserpine River - Main Channel (based on Eden Lassie Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Proserpine River - Main Channel		SMD	0.04	0.11	0.11	0.08	<LOD
Reliance Creek (based on St Helens Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Reliance Creek		SMD	0.02	0.09	0.19	0.20	<LOD
Repulse Creek (including and based on Impulse Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Rocky Dam Creek (based on Basin Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Rocky Dam Creek		SMD	0.02	<LOD	0.07	0.13	<LOD

Sub-region (catchment management area)[1]	Water type[2]	Protection level[3]	Agricultural herbicide indicator[4, 5]				
			Ametryn	Atrazine	Diuron	Hexazinone	Tebuthiuron
			(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Sandy Creek (based on Basin Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Sandy Creek		SMD	0.02	0.09	0.19	0.20	<LOD
Sarina Beaches		HEV	No HEV freshwaters identified to date. Refer SMD row below.				
Sarina Beaches		SMD	<LOD	<LOD	<LOD	<LOD	<LOD
St Helens Creek		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
St Helens Creek		SMD	0.02	<LOD	0.07	0.13	<LOD
Thompson Creek (based on Gregory River HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Thompson Creek		SMD	0.02	<LOD	0.07	0.13	<LOD
Upper Cattle Creek (including and based on Finch Hatton Ck HEV)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Upper Cattle Creek (including Finch Hatton Ck SMD)		SMD	<LOD	<LOD	<LOD	0.01	<LOD
Upper Proserpine River (based on all SMD<LOD)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Upper Proserpine River		SMD	<LOD	<LOD	<LOD	<LOD	<LOD
Waterhole Creek		HEV	No HEV freshwaters identified to date. Refer SMD row below.				
Waterhole Creek		SMD	<LOD	<LOD	<LOD	<LOD	<LOD

Sub-region (catchment management area)[1]	Water type[2]	Protection level[3]	Agricultural herbicide indicator[4, 5]				
			Ametryn	**Atrazine**	**Diuron**	**Hexazinone**	**Tebuthiuron**
			(µg/L)	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**
West Hill Creek (based on Basin Ck HEV + all SMD<LOD)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
West Hill Creek		SMD	<LOD	<LOD	<LOD	<LOD	<LOD
Whitsunday Coast (based on Impulse Ck HEV + all SMD<LOD)		HEV	<LOD	<LOD	<LOD	<LOD	<LOD
Whitsunday Coast		SMD	<LOD	<LOD	<LOD	<LOD	<LOD

Notes:

Sub region: Listed alphabetically. The location and boundaries of the sub-regional waters/catchment management areas identified in this table are shown the *Mackay-Whitsunday Water Quality Improvement Plan,* available from the following website: www.reefcatchments.com.au.

The guidelines in this table relate to riverine freshwaters. Generally, areas identified for HEV level of protection are upland freshwater. Areas identified for SMD level of protection are primarily lowland freshwaters. Exceptions are Basin and Gillinbin Creek Lowland, Thompson Creek lowland and Black Creek lowland all of which are HEV. Further details on the water types and decision rules are provided in the Mackay Whitsunday NRM region document "Turning environmental values into water quality objectives and targets" (Table 30), available from the following website: www.reefcatchments.com.au.

Protection level: HEV = high ecological value; SMD = slightly to moderately disturbed. For HEV waters the management intent and guidelines value are <LOD. For SMD waters the guideline value varies according to the area concerned. Further information on the methods used to derive these values is provided in the *Mackay-Whitsunday Water Quality Improvement Plan* and supporting technical documents, available from the following website: www.reefcatchments.com.au.

Water quality indicators (refer Appendix E): Agricultural herbicides as named.

LOD is limit of detection, which is currently 0.01 µg/L for all herbicides in this table.

Table 3.2.4: Mackay-Whitsunday regional event-based freshwater guidelines[1]

Sub-region (catchment management area)[2]	Indicators[3, 4]									
	Physico-chemical					Agricultural herbicide				
	DIN	PN	FRP	PP	TSS	Ametryn	Atrazine	Diuron	Hexazinone	Tebuthiuron
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Alligator Creek	300	340	30	70	87	0.07	0.74	1.2	0.5	<LOD [5]
Andromache River	300	340	27	70	200	<LOD [5]	0.02	<LOD [5]	<LOD [5]	<LOD
Bakers Creek	300	340	30	70	57	0.08	0.83	1.4	0.56	<LOD
Basin Creek	Refer Gillinbin Creek									
Blackrock Creek	300	263	30	70	33	0.06	0.55	0.91	0.37	<LOD
Blacks Creek	300	340	30	70	183	<LOD	<LOD [5]	0.06	0.03	<LOD
Cape Creek	48	152	3	37	66	<LOD	0.02	0.05	<LOD	<LOD
Carmila Creek	300	256	30	53	39	<LOD	0.04	0.46	0.23	<LOD
Constant Creek	300	279	30	66	64	0.05	0.24	0.75	0.29	<LOD
Eden Lassie Creek	213	327	30	70	141	<LOD	<LOD	0.06	<LOD	<LOD
Finch Hatton Creek	Refer Upper Cattle Creek									
Flaggy Rock Creek	300	340	30	70	200	<LOD	0.03	0.12	0.02	0.05
Gillinbin Creek	48	152	3	37	66	<LOD	0.02	0.05	<LOD	<LOD
Gregory River	300	254	30	57	42	<LOD	0.06	0.31	0.04	<LOD
Impulse Creek	Refer Repulse Creek									
Lethe Brook	300	120	30	28	38	0.04	0.21	0.66	0.25	<LOD

Sub-region (catchment management area)[2]	Indicators[3, 4]									
	Physico-chemical					Agricultural herbicide				
	DIN	PN	FRP	PP	TSS	Ametryn	Atrazine	Diuron	Hexazinone	Tebuthiuron
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Mackay City	300	198	30	51	39	0.08	0.75	1.3	0.51	<LOD
Marion Creek	300	340	30	70	122	<LOD	0.18	0.56	0.21	<LOD
Murray Creek	300	206	30	48	67	0.05	0.25	0.75	0.3	<LOD
Myrtle Creek	300	340	30	70	40	0.12	0.94	1.5	0.49	<LOD
O'Connell River	300	340	30	70	158	<LOD	0.06	0.28	0.04	0.16
Pioneer River - Main Channel	300	340	30	70	198	0.03	0.43	0.75	0.19	<LOD
Plane Creek	300	178	30	61	200	<LOD	0.17	0.51	0.14	<LOD
Proserpine River - Main Channel	300	340	30	70	200	<LOD	0.26	1	0.19	0.42
Reliance Creek	300	274	30	70	42	0.06	0.61	1	0.41	<LOD
Repulse Creek	256	261	27	31	8	<LOD	<LOD	<LOD	<LOD	<LOD
Rocky Dam Creek	300	340	30	70	122	0.04	0.27	0.75	0.55	<LOD
Sandy Creek	300	340	30	70	71	0.02	0.4	0.75	0.41	<LOD
Sarina Beaches	300	340	30	70	95	<LOD	0.04	0.46	0.23	<LOD
St Helens Creek	300	121	30	33	45	<LOD	0.04	0.46	0.23	<LOD
Thompson Creek	300	67	30	15	22	<LOD	0.15	0.46	0.17	<LOD
Upper Cattle Creek	300	118	30	53	43	<LOD	0.14	0.43	0.16	<LOD

Sub-region (catchment management area)[2]	Indicators[3, 4]									
	Physico-chemical					**Agricultural herbicide**				
	DIN	**PN**	**FRP**	**PP**	**TSS**	**Ametryn**	**Atrazine**	**Diuron**	**Hexazinone**	**Tebuthiuron**
	(µg/L)	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(mg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**
Upper Proserpine River	300	20	27	31	10	<LOD	<LOD	<LOD	<LOD	<LOD
Waterhole Creek	289	173	30	42	74	<LOD	0.03	0.11	0.02	0.04
West Hill Creek	300	340	30	70	156	<LOD	0.17	0.54	0.2	<LOD
Whitsunday Coast	256	261	27	31	8	<LOD	<LOD	<LOD	<LOD	<LOD

Notes:

This table shows end of system event water quality values for each catchment management area in the Mackay-Whitsunday region, based on the *Mackay-Whitsunday Water Quality Improvement Plan*. Further information on the methods used to derive these values is provided in the *Mackay-Whitsunday Water Quality Improvement Plan*, available from the following website: www.reefcatchments.com.au.

Sub region: Listed alphabetically. The location and boundaries of the sub-regional waters/catchment management areas identified in this table are shown the *Mackay-Whitsunday Water Quality Improvement Plan,* available from the above web link.

Water quality indicators (refer Appendix E): DIN = dissolved inorganic nitrogen; PN = particulate nitrogen; FRP = filterable reactive phosphorus; PP = particulate phosphorus; TSS = total suspended solids; agricultural herbicides as named.

Values for indicators were calculated based on end of catchment event mean concentration (EMC) using both monitored and modelled results. Further information on the methods used to derive these values is provided in the *Mackay-Whitsunday Water Quality Improvement Plan* and supporting technical documents, available from the following website: www.reefcatchments.com.au.

LOD is limit of detection which is currently 0.01 µg/L for all herbicides in this table.

3.2.3 Central Coast Queensland region biological guidelines

3.2.3.1 Freshwaters: macroinvertebrate guidelines

Guidelines for some common indicators of freshwater macroinvertebrate health have been developed by EHP over the past year. These can be applied as default values to the whole of the Central Region. However, where resources permit, development of sub-regional guidelines may provide more locally relevant numbers.

The guideline values are summarised in Table 3.2.5 below. Following the table, detailed definitions of the indices and explanations of the basis and derivation of the guideline values are provided. These guidelines are only for the SMD level of protection and additional work would be required to derive HEV guideline values. The median value of biological indices at SMD test sites is to be compared and assessed against the numbers in this table.

Table 3.2.5: Freshwater macroinvertebrate guideline values for SMD waters in the Central Region

Index	Habitat	Number of samples	20^{th} %ile	80^{th}%ile
Taxa richness	Composite	21	12	21
	Edge	22	23	33
PET taxa richness	Composite	21	2	5
	Edge	22	2	5
SIGNAL	Composite	21	3.33	3.85
	Edge	22	3.31	4.20
% tolerant taxa	Composite	21	25	50
	Edge	22	44	56

Habitat

Samples were taken in two habitat types. Edge is habitat along the stream bank and composite is a mixture of all bed habitats within the site (e.g. sandy pool, rocky pool, riffle, run, cascade).

Taxa richness

Taxa richness is the number of macroinvertebrate taxa collected in a sample. This index is commonly used by most monitoring programs. Its use is generally based on the premise that the better the condition of a site, the more taxa will be found; however, inflated numbers may also result at sites with higher than normal levels of flow and nutrient levels.

PET taxa Richness

PET Taxa Richness (or EPT) is the number of families from the three orders of aquatic insects: Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Macroinvertebrates belonging to these three orders are considered to be sensitive to changes in their environment, and therefore PET taxa richness can be used to assess degradation of habitat.

SIGNAL index

The SIGNAL index (stream invertebrate grade number – average level), was developed for the bio-assessment of water quality in Australia. A SIGNAL score gives an indication of water quality in the river from which the sample was collected. Rivers with high SIGNAL scores are likely to have low levels of salinity, turbidity and nutrients such as nitrogen and phosphorus, and are also likely to be high in dissolved oxygen.

Each macroinvertebrate family has been allocated a sensitivity grade number based on how sensitive it is to various pollutants and other physical and chemical factors. The SIGNAL index value is calculated by averaging the sensitivity grade numbers of the families of macroinvertebrates present at a site.

Reference sites

Reference sites were initially selected for sampling based on a technical spatial sampling design (generalised random tessellation strategy) which incorporated the available road network (accessibility) and stream order levels (i.e. larger stream orders were weighted higher for selection to account for the higher probability of randomly selecting low order streams – which are more likely to be dry). Further investigation of sites for selection was undertaken using desktop and field vetting techniques which scored sites on the 10 reference criteria categories (types of human impact). Sites that scored 4 or 5 as a minimum for each criterion were considered as 'best available' reference, and sampled.

Calculation of reference range values

20^{th} percentile and 80^{th} percentile values were calculated for each of the indices from values at the number of sites listed in the table. These calculations were undertaken using the Statistica software program.

3.2.4 Central Coast Queensland region habitat guidelines

3.2.4.1 Riparian vegetation guidelines

Technical guideline information relating to management of riparian areas was included in the guidelines for South-east Queensland (section 3.1.4) and should be referred to for all other regions.

For statutory guidelines for riparian habitat in Central Queensland, reference should be made to the relevant regional vegetation management codes under the Vegetation Management Act. The codes include riparian protection provisions in order to maintain values of watercourses. Background information on these codes (and the codes themselves) can be obtained from the department's website.

The boundaries and names of the regional vegetation management codes are different from the boundaries/names of water quality regions used elsewhere in this guideline (as shown in Figure 2.3.3). Hence, within each QWQG region there may be one or more corresponding vegetation management codes. The QWQG Central Coast region overlaps with several of the regional vegetation management codes, depending on the particular location concerned. Two of these include the Brigalow Belt/New England Tablelands and the coastal bioregions vegetation management codes. Links to these are available opn the department's website.

3.2.4.2 Fisheries habitat guidelines

A range of guidelines relating to fisheries habitat are available from the Department of Agriculture, Fisheries and Forestry.

- Cotterell, EJ 1998. *Fish passage in streams: Fisheries guidelines for design of stream crossings*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 001, 37pp.
- Hopkins, E, White, M and Clarke, A 1998. *Restoration of fish habitats: Fisheries guidelines for marine areas*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 002, 44pp.
- Bavins, M, Couchman, D and Beumer, J 2000. *Fisheries guidelines for fish habitat buffer zones*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 003, 39pp.
- Clarke, A and Johns, L 2002. *Mangrove nurseries: Construction, propagation and planting: Fisheries guidelines*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 004, 32pp.
- Challen, S and Long, P 2004. *Fisheries guidelines for managing ponded pastures*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 005, 27pp.
- Derbyshire, K 2006. *Fisheries guidelines for fish-friendly structures*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 006, 64pp.
- Lawrence, M, Sully, D, Beumer, J and Couchman, D 2009. *Fisheries guidelines for conducting an inventory of instream structures in coastal Queensland*, Department of Primary Industries and Fisheries, Fish Habitat Guideline FHG 007, 72pp.

3.3 Wet Tropics Region

3.3.1 Wet Tropics regional guideline values for physico-chemical indicators (slightly to moderately disturbed waters)

Tables 3.3.1a and 3.3.1b below outline the regional physico-chemical guideline values for Wet Tropics region waters (extending north from the Herbert River basin to the Endeavour River basin – refer section 2.3.2). Note that where sub-regional (i.e. more localised) water quality guidelines are developed, they are to be given precedence. Refer to Figure 3.3.1 for water-type boundaries and HEV areas for part of the Wet Tropics region. The median value at a test site is to be compared and assessed against the numbers in this table (refer section 5 and Appendix D). (EVs and WQOs have been scheduled under the EPP Water for a number of waters in this region, using these WQ guideline values as a technical input. The scheduled EVs/WQOs and supporting mapping are available from the department's website and should be referred to for planning/decision making under the EPP Water.)

Table 3.3.1a: Regional guideline values for physico-chemical indicators – Wet Tropics region fresh and estuarine waters

Wet Tropics region water type	Physico-chemical indicators and guideline values[8] (slightly to moderately disturbed systems)															
	Amm N	Oxid N	Org N[6]	Total N	FiltR P	Total P	Chl-a	DO (% sat[n])[1,2,3]		Turb	Secchi	SS	pH[4,5]		Conductivity	Temperature[9]
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	lower	upper	(NTU)	(m)	(mg/L)	lower	upper	(µS/cm)	°C
Open coastal, midshelf & offshore	See Table 3.3.1b which covers guidelines for these waters, which are within the Great Barrier Reef Marine Park.															Managers need to define their own upper and lower guideline values, using the 80th and 20th percentiles, respectively, of ecosystem temperature distribution (ANZECC 2000).
Enclosed coastal	15	10	135	160	5	20	2.0	85	105	10	1.0	nd	7.5	8.4	n/a	
Mid-estuarine and tidal canals, constructed estuaries, marinas and boat harbours	15	30	200	250	5	20	3.0	80	105	10	1.0	nd	6.5	8.4	n/a	
Lowland streams	10	30	200	240	4	10	1.5	85	120	15	na	–	6.0	8.0	See Appendix G	
Upland streams	6	30	125	150	5	10	0.6	90	100	6	na	nd	6.0	7.5	See Appendix G	
F/water lakes/reservoirs	10	10	330	350	5	10	3	90	120	2–200	nd	nd	6.0	8.0	See Appendix G	
Wetlands[7]	10	10	330	350–	5–25	10–50	10	90	120	2–	na	nd	6.0	8.0	nd	

			– 1180	1200						200						

Note 1	Note that DO guidelines (% saturation) for freshwaters should only be applied to flowing waters, including those with significant sub-surface flows. Stagnant pools in intermittent streams naturally experience values of DO below 50% saturation.	
Note 2	DO guideline values in the table above apply to daytime conditions. Lower values may occur at night but this should not be more than 10% –15% less than daytime values.	
Note 3	DO values as low as 40% may occur in estuaries for short periods following material inflow events after rainfall. DO values <50% are likely to significantly impact on the ongoing ability of fish to persist in a water body. DO values <30% saturation are toxic to some fish species. These DO values should be applied as absolute lower limit guidelines for DO – see also section 5.2. Very high DO (supersaturation) values can be toxic to some fish as they cause gas bubble disease. See Butler and Burrows (2007) for detailed report on effects of low DO on fish.	
Note 4	During flood events or nil flow periods, pH values should not fall below 5.5 (except in wallum areas) or exceed 9.	
Note 5	In wallum areas, waters contain naturally high levels of humic acids (and have a characteristic brown ti-tree stain). In these types of waters, natural pH values may range from 3.6 to 6.0.	
Note 6	During periods of low flow and particularly in smaller creeks, build up of organic matter derived from natural sources (e.g. leaf litter) can result in increased organic N levels (generally in the range of 400 to 800µg/L). This may lead to total N values exceeding the QWQG values. Provided that levels of inorganic N (i.e. NH_3 + oxidised N) remain low, then the elevated levels of organic N should not be seen as a breach of the guidelines, provided this is due to natural causes.	General abbreviations nd = no data; n/a = not applicable
Note 7	Wetlands guidelines for most indicators are based on ANZECC 2000. Guideline values for organic nitrogen calculated as Total N minus (Amm N + Oxid N).	
Note 8	For information on general application of these guideline values, on their application under different flow conditions and on approaches to assessing pulse inputs of pollutants – see section 5 and Appendix D of the QWQG.	
Note 9	Temperature varies both daily and seasonally, is depth dependent and is also highly site specific. It is therefore not possible to provide simple generic water quality guidelines for this indicator. The recommended approach is that local guidelines be developed. Thus guidelines for potentially impacted streams should be based on measurements from nearby streams that have similar morphology and which are thought not to be impacted by anthropogenic thermal influences. From an ecological effects perspective, the most important aspects of temperature are the daily maximum temperature and the daily variation in temperature. Therefore measurements of temperature should be designed to collect information on these indicators of temperature and, similarly, local guidelines should be expressed in terms of these indicators. Clearly, there will be an annual cycle in the values of these indicators and therefore a full seasonal cycle of measurements is required to develop guideline values.	

Table 3.3.1b: Regional guideline values for physico-chemical indicators – Wet Tropics region open coastal, midshelf and offshore waters. (based on the GBRMPA and the QWQG guidelines)

Water type[5]	Physico-chemical indicators (see Appendix E) and their guideline[1] values (slightly to moderately disturbed systems)														
	Amm N	Oxid N	Particulate N[3]	Total N	FiltR P	Particulate P[3]	Total P	Chl-a[2]	TSS[3]	Turb	Secchi[4]	pH		DO (% sat[n])	
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/L)	(NTU)	(m)	lower	upper	lower	upper
Open Coastal	2	2	20	140	4	2.8	20	0.45	2	1	10	8.15	8.4	95	105
Midshelf	2	2	20	140	4	2.8	20	0.45	2	<1	10	8.15	8.4	95	105
Offshore	2	2	17	130	4	1.9	10	0.4	0.7	<1	17	8.15	8.4	95	105
Note 1	Guideline values for PN, PP, Chl-a, Secchi and TSS should be compared to mean values rather than median values (see GBRMPA Guidelines, accessible at the following web link: http://www.gbrmpa.gov.au/corp_site/key_issues/water_quality/draft_water_quality_guidelines).														
Note 2	Chlorophyll values are ~40% higher in summer (0.63µg/L) and ~30% lower in winter (0.32µg/L) than mean annual values. Both the annual mean and these seasonal mean values should be regarded equally as guideline values for assessment purposes.														
Note 3	Seasonal (winter/summer) adjustments for TSS, PN and PP guidelines are approximately ±20% of the annual mean values.														
Note 4	Guideline trigger values for water clarity need to be decreased by 20% for areas with greater than 5m tidal ranges.														
Note 5	Water types for the GBR Marine Park are described in Appendix B.														

3.3.2 Wet Tropics sub-regional guideline values for physico-chemical indicators (specific waters)

Table 3.3.2 below outlines the sub-regional physico-chemical guideline values for identified high ecological values (HEV) and slightly to moderately disturbed (SMD) waters in the Wet Tropics. Note that water quality guidelines in this table are to be given precedence over the regional guidelines in the previous section. Where waters are not specified in this table the regional guideline values (Table 3.3.1) should be applied. For high ecological value waters, the 20th, 50th and 80th percentile water quality values of test sites are to be compared and assessed against the corresponding percentile values in this table (refer section 5 and Appendix D). The median value of water quality at SMD test sites is to be compared and assessed against the SMD numbers in this table (refer section 5 and Appendix D). EVs and WQOs have been scheduled under the EPP Water for a number of waters in this region, using these WQ guideline values as a technical input. (The scheduled EVs/WQOs and supporting mapping are available from the department's website and should be referred to for planning/decision making under the EPP Water).

Refer to Figure 3.3.1 for an outline of the water types, and the location of identified high ecological value (HEV) waters, in the Wet Tropics region. (More detailed water type mapping for the waters shown in this figure is provided in plans supporting EPP Water Schedule 1 documents, available from the department's website. These should be referred to when the most current/detailed boundaries are required.)

Table 3.3.2: Sub-regional guidelines for physico-chemical indicators – Wet Tropics region

Sub-region[1]	Water type[3]	Protection level[2]	Physico-chemical indicator (refer Appendix E) and percentile value (20th, 50th, 80th percentile)[4]																																			
			Amm N (µg/L)			Oxid N (µg/L)			Org N (µg/L)			Total N (µg/L)			FiltR P (µg/L)			Total P (µg/L)			Chl-a (µg/L)			DO (% satn)			Turb (NTU)			Secchi (m)			SS mg/L			pH		
Estuary/ marine			20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80	20	50	80
Daintree	ME	HEV	5	10	15	2	15	30	100	100	200	110	130	250	2	3	5	10	15	20	1.0	2.0	3.0	80	85	105	2	5	10	1.0	1.5	2.0	nd	nd	nd	6.5		8.4
Endeavour	ECLE	SMD			10			10			nd			200			3			15			2	80		105			10			1.0			nd	6.5		8.4
	ME	SMD			20			40			nd			300			3			20			3	75		105			10			1.0			nd	6.5		8.4
Freshwater																																						

Sub-region[1]	Water type[3]	Protection level[2]	Physico-chemical indicator (refer Appendix E) and percentile value (20th, 50th, 80th percentile)[4]																																			
			Amm N (µg/L)			Oxid N (µg/L)			Org N (µg/L)			Total N (µg/L)			FiltR P (µg/L)			Total P (µg/L)			Chl-a (µg/L)			DO (% satn)			Turb (NTU)			Secchi (m)			SS mg/L			pH		
All identified HEV waters in the former Douglas Shire	UF	HEV	3	4	6	10	15	30	75	100	125	90	120	150	3	4	5	5	7	10	<0.5	<0.5	0.5	90	95	100	<1	2	5	nd	nd	nd	nd	nd	nd	6	6.5	7.5

Notes:

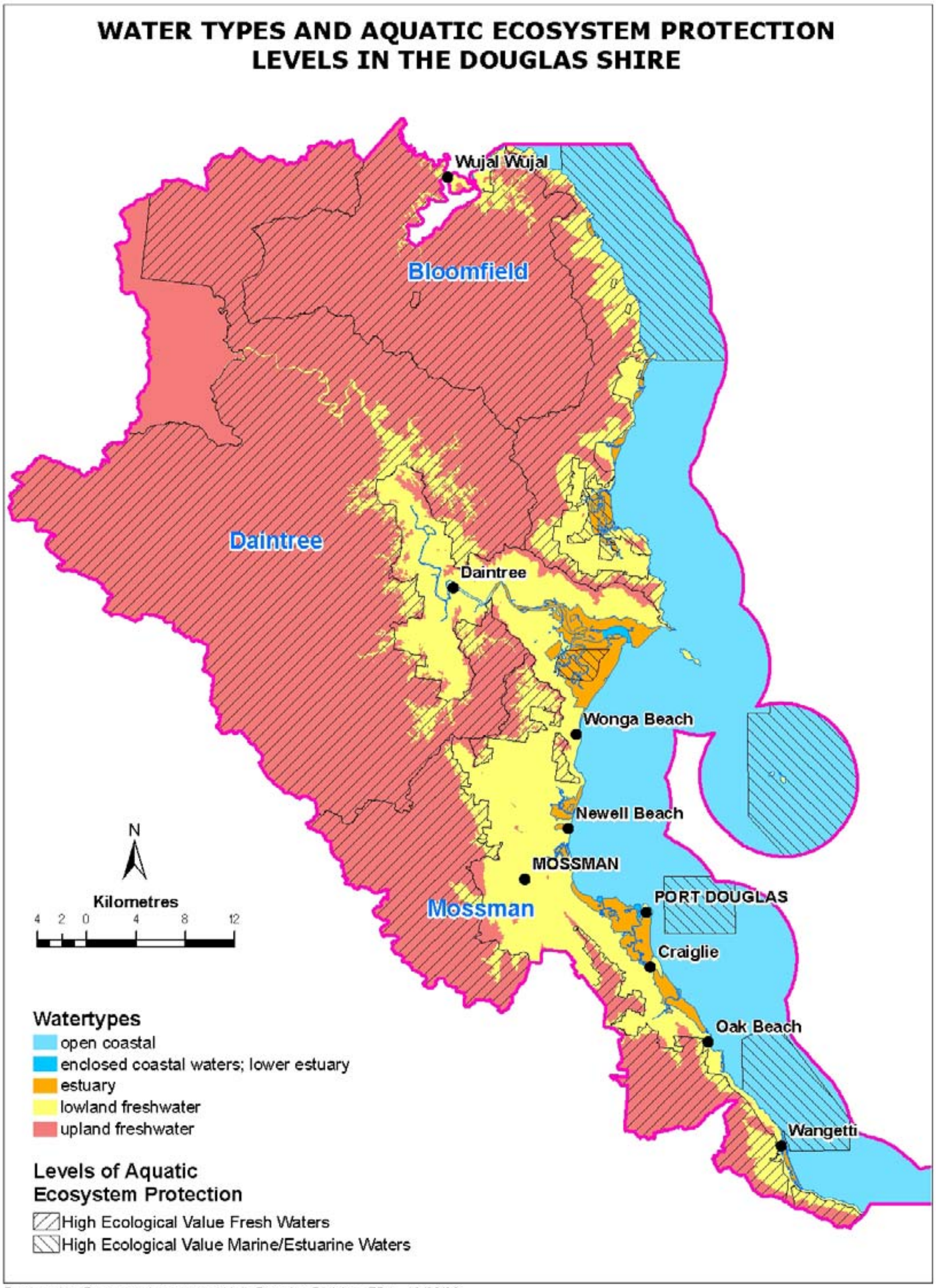
The location and boundaries of the sub-regional waters identified in this table are shown in Figure 3.3.1. If a waterway is not specified in this table, then default to the regional water quality guidelines (Table 3.3.1) for slightly to moderately disturbed (SMD) waters.

Protection level: HEV = high ecological value; SMD = slightly to moderately disturbed. Many sub-regional waters contain some areas of HEV waters and some areas of SMD waters. For sub-regions containing HEV waters, the 20th, 50th and 80th percentiles are all given. In sub-regions with only SMD waters, only the 80th and/or 20th percentile values are provided.

Water type: OC = open coastal; EC = enclosed coastal; UE = upper estuarine; ME = mid-estuarine.

Water quality indicators (refer Appendix E): Amm N = ammonia nitrogen; Oxid N = oxidised nitrogen; Org N = organic nitrogen; Total N = total nitrogen; FiltR P = filterable reactive phosphorus; Total P = total phosphorus; Chl-a = chlorophyll-a; DO = dissolved oxygen (percent saturation); Turb = turbidity; Secchi = Secchi depth; SS = suspended solids; nd = no data.

Figure 3.3.1



Produced by Resource Assessment Unit, Planning Division, EPA. 10/02/06.

Boundaries in the above plan are indicative only. EVs and WQOs have been scheduled under the EPP Water for a number of waters in this region. The scheduled EVs/WQOs and supporting mapping delineating water types and level of aquatic ecosystem protection should be referred to for planning/decision making under the EPP Water. Scheduled EVs/WQOs and supporting mapping (plans) are available from the department's website. Spatial (GIS) 'read only' data sets of the plans are available on CD-ROM ('Environmental Values Schedule 1 Database, March 2007' and subsequent updates) and can be requested via email to data.coordinator@ehp.qld.gov.au. Hard copies of plans can be viewed under arrangement at 400 George Street, Brisbane.. Refer to Figure 2.3.1 for the geographic scope of application of the QWQG in the Wet Tropics Region.

3.3.3 Wet Tropics habitat guidelines

3.3.3.1 Riparian vegetation guidelines

Technical guideline information relating to management of riparian areas was included in the guidelines for South-east Queensland (section 3.1.4) and should be referred to for all other regions.

For statutory guidelines for riparian habitat in the Wet Tropics, reference should be made to the relevant regional vegetation management codes under the Vegetation Management Act. The codes include riparian protection provisions in order to maintain values of watercourses. Background information on these codes (and the codes themselves) can be obtained from the department's website.

The boundaries and names of the regional vegetation management codes are different from the boundaries/names of water quality regions used elsewhere in this guideline (as shown in Figure 2.3.3). Hence, within each QWQG region there may be one or more corresponding vegetation management codes. For the QWQG Wet Tropics region, a primary corresponding vegetation management code (coastal bioregions) is available from the department's website.

Fisheries habitat guidelines

- A range of guidelines relating to fisheries habitat are available from the Department of Agriculture, Fisheries and Forestry.
- Cotterell, EJ 1998. *Fish passage in streams: Fisheries guidelines for design of stream crossings*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 001, 37pp.
- Hopkins, E, White, M and Clarke, A 1998. *Restoration of fish habitats: Fisheries guidelines for marine areas*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 002, 44pp.
- Bavins, M, Couchman, D and Beumer, J 2000. *Fisheries guidelines for fish habitat buffer zones*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 003, 39pp.
- Clarke, A and Johns, L 2002. *Mangrove nurseries: Construction, propagation and planting: Fisheries guidelines*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 004, 32pp.
- Challen, S and Long, P 2004. *Fisheries guidelines for managing ponded pastures*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 005, 27pp.
- Derbyshire, K 2006. *Fisheries guidelines for fish-friendly structures*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 006, 64pp.
- Lawrence, M, Sully, D, Beumer, J and Couchman, D 2009. *Fisheries guidelines for conducting an inventory of instream structures in coastal Queensland*, Department of Primary Industries and Fisheries, Fish Habitat Guideline FHG 007, 72pp.

3.4 Eastern Cape York

There are no QWQG guidelines for Eastern Cape York. Users may default to the ANZECC 2000 Guidelines or alternatively apply the QWQG for the Wet Tropics. For information on deriving local guidelines, refer section 4.

3.5 Gulf Rivers

There are no QWQG for the Gulf Rivers. Users may default to the ANZECC 2000 Guidelines, although these are unlikely to be appropriate, particularly for intermittent and ephemeral inland streams. Users are strongly encouraged to collect local data and develop local guidelines. For information on deriving local guidelines, refer section 4.

3.6 Lake Eyre

There is very little water quality information available for the Lake Eyre basin. Default ANZECC 2000 Guidelines are very unlikely to be appropriate for the ephemeral streams of the region. Users are strongly encouraged to collect local data and develop local guidelines. For information on deriving local guidelines, refer section 4.

3.7 Murray Darling

There is some information available for this basin but insufficient to set reliable Queensland guidelines. Users may default to the ANZECC 2000 Guidelines, although these are unlikely to be appropriate for the flood-plain reaches of these rivers and users are encouraged to develop local guidelines. For information on deriving local guidelines, refer section 4.

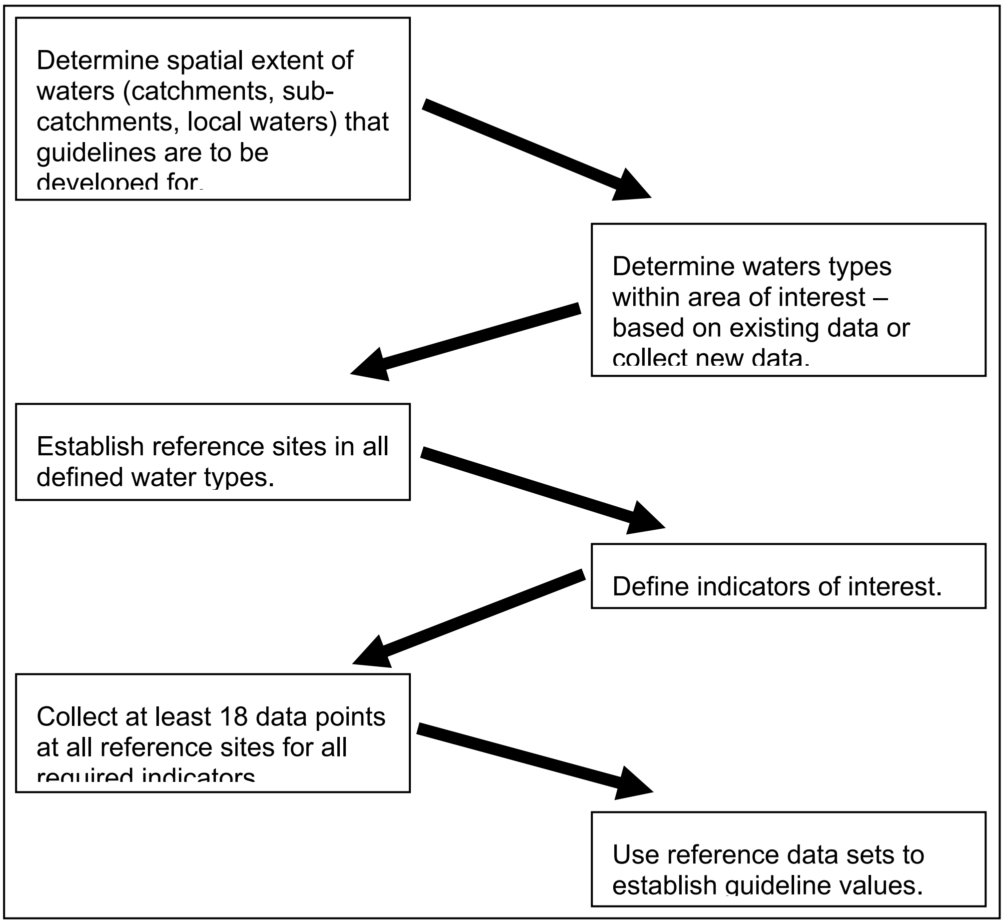
4 Procedures for deriving regional or sub-regional guidelines for aquatic ecosystem protection

4.1 Introduction

This section of the Queensland Water Quality Guidelines outlines procedures for deriving water quality guidelines at both a regional and a sub-regional level. Matters covered include definition of water types, selection of indicators, selection of reference sites, collection of reference data and derivation of guideline values based on reference data.

An overall process for developing guidelines is outlined in Figure 4.1.1 below, but note that a more detailed process for developing sub-regional guidelines is described in sections 4.4.5 and 4.4.6.

Figure 4.1.1: Process for determining guidelines



Water types

A first step in deriving a guideline is to define the water type to which the guideline will apply. This is necessary because there is considerable natural variation in water quality, and biological condition, between different water types, including lakes, streams, estuaries and coastal waters. There may also be differences within the major water types so that, for example, stream-water quality could vary between upland, mid-catchment and lowland reaches.

From a guideline perspective the aim is to define water type(s) within which natural (reference) water quality is reasonably consistent. This then allows the setting of single guideline values that can reasonably be applied across all sites within each defined water type. If there is too much variation within a defined water type, then a single guideline value could be too stringent for some sites or too lenient for others. This risk can be minimised by setting up more water types but this can result in too much complexity. Thus, the number of water types has to be a compromise between usability and variability.

To take an example, a first step would be to determine what natural variation in water quality occurred across the catchment. This determination could be based on existing water quality data or might require the collection of new data from sites across the catchment. The next step would be to divide the catchment into water types that best represent the range of natural variation. One possible outcome might see the catchment divided into faster-flowing stony/sandy upland streams and slow-flowing more turbid streams on the flood plains with perhaps another category for billabongs. There might be further subdivisions related to the flow regime or to the effects of geology on water quality. Once the water types were established, reference sites representative of each type would be set up and collection of reference data undertaken, as described in sections 4.4.2 and 4.4.3. This process is outlined in Figure 4.1.1.

One issue that arises is that a set of water types suitable for one indicator may not fit so well with other indicators. To avoid the complexity of setting up a different set of water types for each indicator, it may be desirable to devise a compromise set of water types that are reasonably applicable to all indicators. However, in the longer term, more complex water-type classifications may become practical for users through the use of computer-based expert systems.

In the case of sub-regional guidelines, these may apply to relatively limited areas, in which case there may not be any need to define water types. In this situation, a sub-regional guideline would be defined as applying to a named water body (e.g. a lake on Fraser Island – see Table 3.1.4) or to a defined reach of a water body. However, where sub-regional guidelines are required to cover larger areas, there may then be a need to either (a) define water types within that sub-region and derive separate guideline values for each or (b) to break the area up into zones based on defined geographic boundaries and derive guidelines for each defined zone. Option (b) would obviously be based on the premise that each zone contains internally consistent water quality.

4.2 Selecting indicators

Guidelines are values designed to protect environmental values (EVs) or management goals. However, when assessing the extent to which an environmental value is protected, the issue arises as to which indicators need to be assessed to determine if the value is in fact protected.

In theory, complete protection of an environmental value requires that levels of all relevant indicators comply with guideline values. However, for each EV and particularly for aquatic ecosystem protection, there are large numbers of potential indicators, for example, concentrations of a wide range of toxicants or numerous possible biological indicators. Monitoring all these is impractical and there needs to be a process for selecting the most relevant and cost effective indicators.

Indicator selection will depend on the purpose of an assessment. If a specific issue or risk is being investigated then the indicators will relate very specifically to that. For example, if there is extensive use of two or three pesticides in a particular area then the indicators might include measures of these particular compounds in water, sediment or biota. Alternatively, if, say, the protection of the Mary River cod was the issue, then indicators might include presence of large pools with snags or availability of breeding sites.

If the purpose of an assessment is a more general assessment of ecosystem condition it is both impractical and unnecessary to assess all possible indicators in the first instance. In this situation it will be necessary to focus on some broader indicators of condition. An example of this is the use of fish and macroinvertebrate indicators in the Sustainable Rivers Audit program used to assess the health of the Murray Darling system. These indicators provide a good overview of river health but, where health impacts are noted, these general indicators do not necessarily provide specific information on the cause of the impacts. To determine causes it will usually be necessary to monitor some more specific indicators that are linked to potential causes.

It is beyond the scope of this guideline document to provide detailed discussion of indicator selection, although some further information is provided in section 4.3.1 below and Appendix E. In conclusion, users are encouraged to think carefully about which indicators are most relevant to their issue rather than simply monitor a range of ‘traditional’ indicators. However, where more innovative indicators are employed, there will of course be a need to develop corresponding guideline values.

4.2.1 Indicators for aquatic ecosystem protection

Achieving protection of aquatic ecosystems entails not only managing traditional water quality (water chemistry) but also managing other attributes of the system, in particular habitat and flow. Further, it is now recognised that assessing ecosystem health is best achieved through direct measurement of biological indicators rather than through indirect assessment via system stressors such as water quality. However, measurement of ecosystem stressors remains important in determining causes of detected changes to biological attributes.

This more holistic approach to ecosystem health assessment and management has been captured in the Victorian index of stream condition protocol (Ladson et al 1999). This protocol encompasses the following attributes:

- water quality (ecosystem stressor);
- flow (ecosystem stressor);
- habitat – streamside and instream (ecosystem status and stressor); and
- biota (Ecosystem status).

Variations on this approach have been applied in the Sustainable Rivers Audit (Murray Darling Basin Commission) and in the freshwater Ecological Health Monitoring Program (EHMP) in south-east Queensland. For EHMP, refer to web link below:

http://www.healthywaterways.org/EcosystemHealthMonitoringProgram/Home.aspx.

These approaches have been developed for freshwater ecosystems. For estuarine and coastal systems there has been less work done. Ward et al (1998) listed a wide range of potential indicators but a framework is lacking. A publication of the Coastal CRC, *Users' Guide for Estuarine, Coastal and Marine Indicators for Regional NRM Monitoring* (http://www.ozcoasts.org.au/pdf/CRC/Indicators/Executive_summary.pdf) provides a framework for deriving indicators for estuary and coastal areas. The Ecological Health Monitoring Program (EHMP) in south-east Queensland has also defined a set of indicators for estuary and coastal areas (www.healthywaterways.org).

Tables 4.3.1 and 4.3.2 provide sets of basic indicators for freshwaters and estuaries that are commonly applied in the southern part of Queensland. These are not mandatory but are provided for information. Descriptions of these indicators are provided in Appendix E.

Table 4.3.1: Commonly applied indicators for freshwater ecosystems

Attribute	Indicator
Water quality	Conductivity
	Temperature, including maxima and minima
	TN, TP, NO3, FRP
	pH
	DO
	DO diel cycle
	Turbidity
Habitat	To be determined
Flow	To be determined
Biota	Macroinvertebrates – SIGNAL family richness
	Benthic algae biomass (shallow-flowing streams) Chl-a (deeper slow-flowing streams)

Table 4.3.2: Commonly applied indicators for estuary/coastal areas

Attribute	Indicator
Water quality	Conductivity
	Temperature
	TN, TP, NO3, FRP
	pH
	DO
	Turbidity
	Secchi depth
Habitat	Extent of mangroves and seagrass compared to pre-development
	Seagrass max depth range
Flow	To be determined
Biota	Chl-a

In the longer term it is intended to move towards an agreed group of priority indicators that would be applied as defaults in most general-assessment monitoring programs. Part of this process will be the development of suitable indicators for the wide range of Queensland regions and water. For example, there are currently no good biological indicators of overall health for estuaries in Queensland. Another example is the need to develop better biological indicators and guidelines for ephemeral streams, which make up a significant proportion of Queensland's inland waters.

4.3 Deriving guideline values

4.3.1 General approaches

The two main approaches to deriving guideline values are based on:

1. **Direct measurement of biological impacts.** Under this approach guideline values are based on the results of direct testing of the impacts of a stressor on a target organism. An example would be testing the effects of a particular toxicant on fish and other aquatic species. This approach is appropriate for stressor indicators that have direct measurable impacts on the biota, e.g. toxicants, dissolved oxygen, and light attenuation. It is less appropriate for indicators such as nutrients whose threshold impacts are indirect and more complex.
2. **Acceptable departure from natural or reference condition.** This approach is based on the premise that some small departure from natural baseline or reference condition is acceptable. It is suitable for biological condition indicators and also for indirect stressor indicators such as nutrients. This approach requires a good knowledge of reference condition and a value judgement on the extent of an acceptable departure.

The Queensland Water Quality Guidelines will contain guidelines based on both approaches. Guidelines based on direct measurement of biological impacts are normally derived from the results of scientific studies. These require specific expertise and knowledge and are unlikely to be undertaken by regional or local groups.

However, many guidelines will be based on use of the departure from reference approach. The rest of this section describes methods for deriving guidelines based on this approach. These methods can be applied by regional or local bodies to derive their own local guidelines if required.

These methods cover:

- criteria for identifying reference sites in the relevant water type (section 4.4.2);

- collecting adequate reference data to derive guidelines (section 4.4.3); and
- deriving guideline values from reference data (section 4.4.4).

4.3.2 Reference site criteria

A **reference site** is a site whose condition is considered to be a suitable baseline or benchmark for assessment and management of sites in similar water bodies. The condition of the site is **reference condition** and values of individual indicators at that site are the **reference values**. Note that reference values can encompass not only physico-chemical characteristics but also the biological and habitat characteristics of a system.

Most commonly, reference condition refers to sites that are subject to minimal/limited disturbance. The criteria adopted by the Queensland Water Quality Guidelines for minimally disturbed reference sites are shown in Table 4.4.1. These are based in part on the criteria developed under the National Monitoring River Health Initiative (www.environment.gov.au/water/publications/environmental/rivers/nrhp/bioassess.html).

Table 4.4.1: Criteria for reference sites for physico-chemical indicators

	Freshwaters
1	No intensive agriculture within 20km upstream. Intensive agriculture is that which involves irrigation, widespread soil disturbance, use of agrochemicals and pine plantations. Dry-land grazing does not fall into this category.
2	No major extractive industry (current or historical) within 20km upstream. This includes mines, quarries and sand/gravel extraction.
3	No major urban area (>5000 population) within 20km upstream. If the urban area is small and the river large this criterion can be relaxed.
4	No significant point source wastewater discharge within 20km upstream. Exceptions can again be made for small discharges into large rivers.
5	Seasonal flow regime not greatly altered. This may be by abstraction or regulation further upstream than 20km. Includes either an increase or decrease in seasonal flow.
	Estuaries
1	No significant point source wastewater discharge within the estuary or within 20km upstream. Exceptions can again be made for small discharges into large rivers.
2	No major urban area (>5000 population) within 20km upstream. If the urban area is small and the river large this criterion can be relaxed.

Note that the criteria in Table 4.4.1 are for physico-chemical indicators. Additional criteria may be required for some biological indicators. The criteria seek that sites have minimal impact from human activities (e.g. absence of intensive agriculture, wastewater discharges).

The reference condition concept can also be applied to more disturbed systems. For example, in an urban situation it might be useful to use the least disturbed urban creek sites to derive reference values and guidelines to be applied to other urban creeks. This would provide a realistic expectation of quality in an urban situation whereas use of largely undisturbed reference sites for highly disturbed systems might create unachievable water quality expectations.

Although the criteria in Table 4.4.1 are recommended, there are some regions (e.g. South-east Queensland) and some water types (e.g. lowland rivers) where it may be difficult to find any sites that fully comply with these criteria. In this situation it may be necessary to use lesser quality or best available sites. Based on local knowledge, judgements will have to be made as to which sites in an area exhibit the least deviation from the criteria in Table 4.4.1.

Through existing state government monitoring programs, a number of minimally disturbed reference sites have already been identified throughout Queensland. These are listed in Appendix F.

4.3.3 Reference data requirements

4.3.3.1 Reference data quantity

Data collected from reference sites is used to estimate percentile values, which in turn are used to derive guidelines. For slightly to moderately disturbed waters (the category into which most waterways would fall) the 20th and 80th percentiles of reference site values are used. To be confident in such guidelines we need to be sure they are based on percentile estimates that reflect the true population values. For high ecological value waters, 20th, 50th and 80th percentiles are required (see Appendix D).

Indicator values at reference sites vary naturally, the extent of variation being dependent on the indicator and also the water type. Like most statistical measures, errors in percentile estimates will reduce with increasing sample size. The magnitude of errors in percentile estimates based on different sample sizes were assessed using a statistical re-sampling technique (akin to bootstrapping) applied to long term (>6 years) EHP monthly data sets. Details of this approach are described in Negus et al (in preparation).

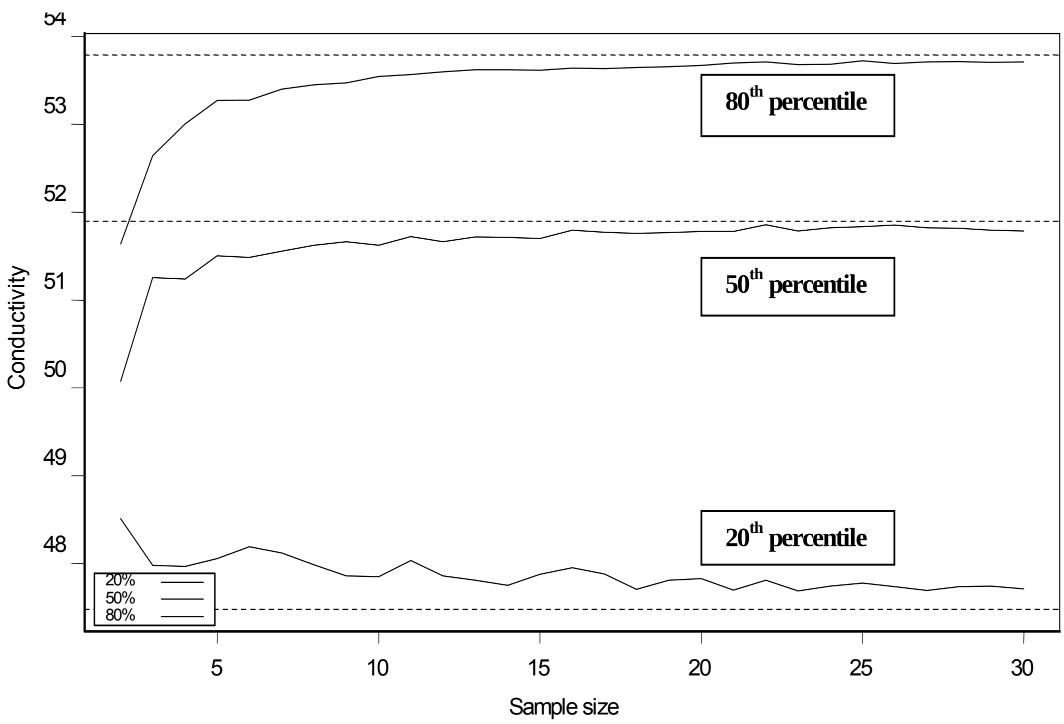
An example result is shown below in Figure 4.4.1. This shows how percentile estimates move towards the true value (based on the total data set; usually >70 results) with increasing sample size. Results are shown for three different percentile values. For the 20th and 80th percentile values, error values tend to level off at around 15–20 data values, suggesting this number of samples is sufficient to provide a reasonable estimate of the true percentile value. The range of 15–20 data values was applicable to most indicators. This sample size is reasonably close to the ANZECC 2000 Guidelines recommendation of 24 data values.

The analysis also shows that use of a smaller number of data values results in percentile estimates that lie inside the true percentile values. Thus, in practice, percentiles based on small numbers of samples would give rise to more stringent guidelines. Note, however, that sample sizes less than about five tend to give rise to very inaccurate results.

Based on these analyses it is recommended that, for one to two reference sites, estimates of 20th or 80th percentiles at a reference site should be based on a minimum of 18 samples collected at each site over at least 12 and preferably 24 months (in order to capture two complete annual cycles). For 50th percentiles a smaller minimum number of samples (~ 10–12) would be adequate but in most situations it would be necessary to collect sufficient data for the 20th and 80th percentiles anyway. (Ideally, there should be three or more reference sites for each water type.)

Given that such large data sets are rarely available outside government agencies, percentile estimates based on eight or more samples could be used to derive interim guidelines on the understanding that further data would be collected and guideline values updated accordingly.

Figure 4.4.1: Relationship between sample size and the error in estimation of percentile values for the indicator conductivity



Another source of variability in estimating percentiles is that even within the same water type, different reference sites usually give different percentile estimates. This is mainly due to natural variability between sites. In flowing streams or estuary/marine waters this variation is often quite small. However, in more ephemeral streams this variability can become very significant. In any exercise aimed at deriving percentile-based guidelines, the natural variability between reference sites must be taken into account. It is therefore recommended that at least two (and preferably more) reference sites are used to derive guidelines for each water type. If the minimum two sites give obviously different results then further reference sites need to be included. In the event that three or more reference sites give widely varying results (which is most likely to occur in ephemeral systems) it may be necessary to assume this is a natural effect. Guideline values would have to be tailored to take account of the wide range of natural variability. However, assumptions about natural variability should only be arrived at after a careful review of the suitability of the selected reference sites.

Where two or more reference sites are being sampled and are giving consistent results the data should be pooled to give a percentile estimate – see section 4.4.5 for methods of combining data from different sites.

Assuming consistent data is being collected from two or more reference sites, it may reasonable to derive an interim estimate of percentiles based on a minimum number of samples at each site of eight. However, ongoing sampling to check the validity of this result must be carried out. Recommendations for reference data requirements are summarised in Table 4.4.2.

Table 4.4.2: Reference data requirements for estimating 20th, 50th and 80th percentiles

Reference site criteria	Number required	Minimum time period
Recommended minimum number of reference sites	2 or more depending on local variability[1]	
Recommended minimum data set per site:		
1–2 reference sites	18/site	12 months (preferably 24 months)
3 or more reference sites	12/site	12 months (preferably 24 months)
Minimum interim data set (subject to further data collection)	8/site	12 months

Note: 1. It is recommended that there should be at least 2 and ideally three or more reference sites for each water type.

4.3.3.2 Reference data quality

Sampling errors can potentially contribute significantly to the overall errors in percentile estimates. Therefore, all reference data monitoring programs must have quality assurance programs in place that:

- are well documented;
- keep sampling errors at a minimum; and
- allow these errors to be quantified.

As part of the quality assurance procedure, data collection should be consistent with the Queensland Monitoring and Sampling Manualavailable from the department's website.

If an assessment of sampling errors cannot be made then the data should not be used for deriving guidelines. If the errors are quantified but found to be a significant component of the overall error then, again, use of the data should be carefully assessed.

Table C.1 in Appendix C provides some recommendations on the desired quality of data for deriving guidelines.

4.3.4 Deriving guideline values from reference data

Guidelines are based on some acceptable effect size. If the guideline is being derived from measurement of direct effects or impacts on biota (e.g. effects of toxicants) then the effect size is based on a level of the stressor that is not having a significant effect on the survival and reproduction of the test organism. Judgements on what level of effect constitutes a significant effect on survival must be based on expert opinion.

If the guideline is being derived based on some departure from reference condition, then similarly a decision has to be made on what is an acceptable departure. In either case the acceptable-effect size will be related to the level of protection that is required for the ecosystem.

As explained in detail in section 2, the ANZECC 2000 Guidelines define three levels of protection, namely:

- high ecological value systems;
- slightly to moderately disturbed systems; and
- highly disturbed systems.

The ANZECC 2000 Guidelines have defined acceptable-effect sizes for each level of protection for different indicator types. These are summarised in Table 4.4.3.

Table 4.4.3: ANZECC 2000 default effect sizes for different levels of protection

Indicator class	**Effect size or departure from reference by level of ecosystem protection**		
	High ecological value systems	Slightly to moderately disturbed systems	Highly disturbed systems
Toxicants in water	No change to natural values	95% species protected with 50% certainty	80–90% species protected with 50% certainty
Toxicants in sediments	No change to natural values	>95%ile of values complies with ISQG* low	Metals: <3xnatural background Toxicants: <3x ISQG low
Physico-chemical	No change to natural values	Median lies within $20^{th}/80^{th}$ percentile of reference range	Locally determined, e.g. $10^{th}/90^{th}$ percentile of reference range
Biological	No change to natural values	Median lies within $20^{th}/80^{th}$ percentile of reference range	Locally determined, e.g. $10^{th}/90^{th}$ percentile of reference range

* Refer to ANZECC (2000) sediment guidelines.

The Queensland Water Quality Guidelines have adopted the ANZECC 2000 Guidelines approach for physico-chemical indicators as identified in Table 4.4.4.

Table 4.4.4: Recommended basis for determining Queensland guideline values for waters at different levels of protection

Level of protection	**Basis for guideline value**
High ecological value systems	No change to natural values
Slightly to moderately disturbed systems	Guideline based on 20^{th} and/or 80^{th} percentiles of reference data from good quality reference sites
Highly disturbed systems	Guideline locally derived based on: a) a less stringent percentile, e.g. $10^{th}/90^{th}$ or b) reference data from more impacted but still acceptable reference sites

For high ecological value systems the no-change requirement implies there should be no change to any of the natural attributes of the system. This includes physico-chemical, biological, habitat and flow attributes. A method for assessing no change is given in Appendix D.

The QWQG values are based on application of the 20^{th} and/or 80^{th} percentiles of reference data approach. Details of how this approach was applied to derive the Queensland guidelines are given in Appendix A. These guideline values, like the ANZECC 2000 Guidelines, are applicable to waters that are identified as slightly to moderately disturbed systems.

For highly disturbed (HD) systems a less stringent guideline can be derived at a local level as outlined in Table 4.4.4. The QWQG does not at this stage provide any specific guideline values for HD waters.

4.3.5 Deriving sub-regional water quality guidelines (SMD waters)

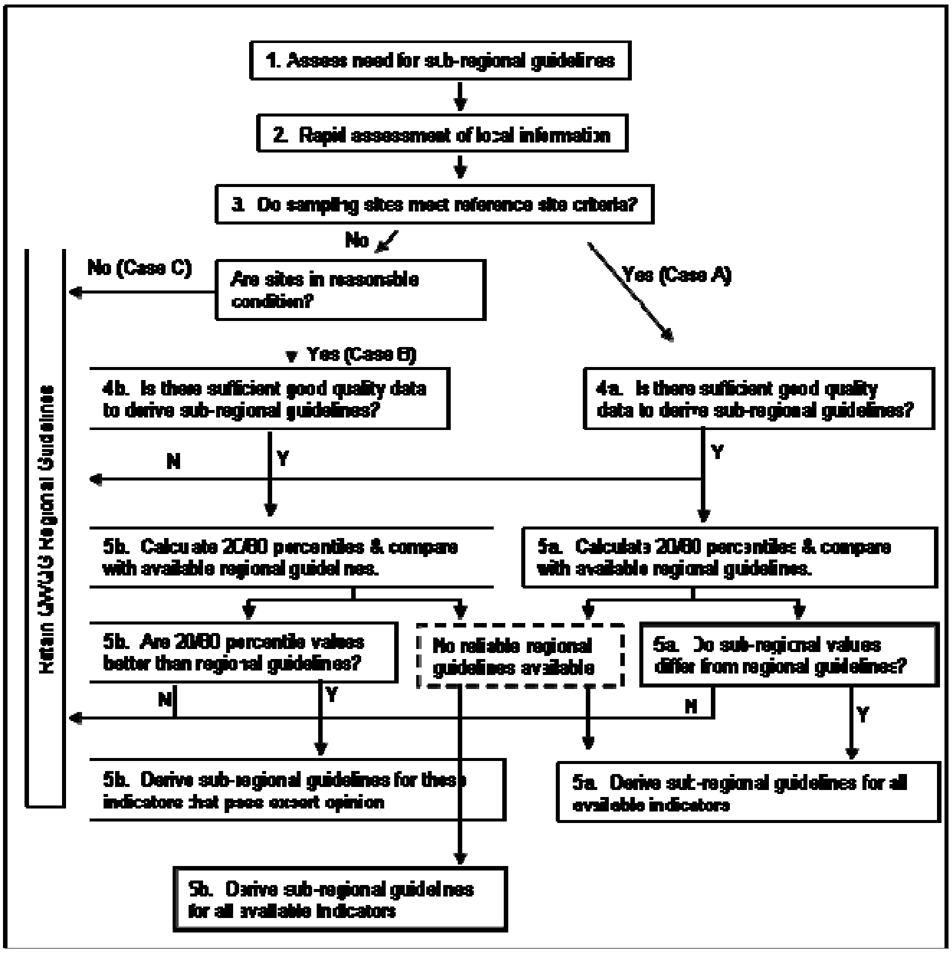
The concept of sub-regional guidelines was described in section 2.3.1. These are guidelines that apply to a defined area which may be part of a water body, an entire water body or a group of water bodies within a region. Sub-regional guidelines can be specified to apply to particular water types within the defined water body/ies but they may often be applied to the defined water body/ies without reference to water types, provided that is appropriate.

Their purpose is to provide guideline values that are specifically tailored to the defined waters and which therefore provide more appropriate management goals than the generic regional guidelines. Theoretically, sub-regional guidelines might be derived for any waterway in the state and be included in future versions of these guidelines. In some areas there will be no driving need to develop sub-regional guidelines, in which case the regional guideline values would continue to apply. However, in any areas where good quality local data has been collected, sub-regional guidelines can potentially be developed.

Sub-regional water quality guidelines (for physical and chemical indicators) have been developed for a number of waters in the South-east region, as outlined in section 3. These include waters identified as high ecological value (e.g. Fraser Island waters, eastern Moreton Bay, Great Sandy Strait) and waters identified as slightly to moderately disturbed (e.g. southern Moreton Bay, Broadwater).

A procedure for the development of sub-regional guidelines is summarised in Figure 4.4.2 and is described in more detail below. This is similar but not identical to the procedure for developing regional guidelines.

Figure 4.4.2: Procedures for deriving sub-regional guidelines
(Note: this figure should be used in conjunction with accompanying text explanations)



1. Assess need for sub-regional guidelines and define areas of application and/or water types

Areas for sub-regional guidelines will generally be identified based on priority projects relating to sub-regional water quality management. However, in waters where extensive data sets have been collected over a period of time, sub-regional guidelines can be developed even if there is no specific management driver.

In some cases, sub-regional guidelines will cover a defined water body or set of waters, with boundaries defined by natural features such as embayments and/or features such as local government or planning boundaries. This is in contrast to regional guidelines which are based on generic water types. However, this approach makes the assumption that all waters within the defined area have consistent water quality. Where a sub-regional area covers several distinct water types, then individual sets of sub-regional guidelines would need to be provided for each water type.

The definition of areas of application and water types is a crucial first step in any sub-regional guideline exercise. This will mandate the range of reference sites that are required; in other words, if there is only one area or water type being considered, then only one set of reference sites will be needed. For any additional water types, additional corresponding reference sites will be required.

The rest of this section assumes that issues related to water types have been resolved and provides a process that can be applied to a single area or water type. The process would need to be repeated for all additional areas or water types.

2. Rapid assessment of local information

Before moving into the full sub-regional guideline procedure outlined below, it is often useful to undertake a rapid first pass assessment of the available local data. Water quality for key indicators should be plotted for all monitoring sites within each proposed sub-region, using temporal and spatial data plots, to assess whether:

- typical water quality in the area is different from the regional default guideline values for some indicators;
- data is generally consistent between sites; and
- some or all sites are influenced by major water quality impacts such as localised nutrient inputs from estuaries.

If the answer to 1 and 2 is yes and sites are not unduly influenced by anthropogenic impacts, then it is very likely that useful sub-regional guidelines can be developed and it is appropriate to move into the full procedure. However, where there are no regional guidelines available, it may be useful to continue in any case. If data is inconsistent between sites, this may be natural (e.g. in ephemeral systems) and it may still be useful to continue to the detailed procedure. Where sites are significantly influenced by anthropogenic impacts, then the data will not be suitable for deriving guidelines, although it may be of use in developing interim targets.

3. Do sites meet reference site criteria?

If there is a perceived need to develop sub-regional guidelines then, ideally, sites should be assessed as to their suitability as reference sites before any data is collected (see section 4.4.2). However, for various reasons this may not have happened, in which case before proceeding further, the sites and water bodies at which data was collected should be assessed against reference criteria (see section 4.4.2). Possible outcomes from this are:

Case A Sites meet reference criteria and can therefore potentially be used to develop sub-regional guidelines.

Case B Sites fail some reference site criteria but are not heavily impacted – in this case some use may be made of the data with respect to guidelines.

Case C Sites are significantly impacted and are of no value with respect to guideline development.

Procedures for dealing with Cases A and B are outlined below. For Case C there is no further action except to seek out alternative sites that do meet or nearly meet reference criteria and restart the procedure.

Procedure where sites meet reference criteria (Case A)

4a. Is there sufficient good quality data to derive sub-regional guidelines?

Determine if there are sufficient reference sites and data points (i.e. samples) to meet the criteria for developing sub-regional guidelines (see section 4.4.3.1). Determine if the data meets the QA requirements (see section 4.4.3.2). If the answer to both these is yes, then proceed to step 5a. If no, then default to the regional guidelines. However, if there are no regional guidelines (or if regional guidelines are based on largely inappropriate national default values), and if a minimum of 12 good quality sub-regional data values are available, then proceed to 5a.

5a. Calculate 20th and 80th percentiles for each reference site and compare with regional guidelines (if available)

The 20^{th} and 80^{th} percentile values for each reference site should be calculated and then compared with each other. Ideally, there should be three or more reference sites for each water type.

If they are reasonably consistent, then calculate the average value of the 20^{th} and 80^{th} percentiles for all the sites. Next, calculate the value of one standard error around these averages. (A worked example of this process is given at the end of this sub-section.) The average values of the 20^{th} and 80^{th} percentiles should then be compared with existing regional guidelines. If these values lie within one standard error of the regional guidelines, then there is no evidence that there is any real difference between the two and the regional guidelines should be retained. Where the sub-regional values (± one standard error) lie outside the regional values, then the new values can be instated as sub-regional guidelines. In the situation where there are no regional guidelines, then the new values would be instated as sub-regional guidelines anyway.

Where the values of the 20th and 80th percentiles from the reference sites are more variable, then it is suggested that instead of calculating the average values of these numbers, the 80th percentile (of the 80th percentile values) and the 20th percentile (of the 20th percentile values) should be calculated and also the standard error around these values. Again, these should be compared with regional values. Where the new values differ from regional guidelines (by more than one standard error) then they should be instated as sub-regional guideline values or, if there are no regional guidelines, they can be accepted anyway.

Where the calculated 20thand 80th percentile values from the reference sites are highly variable, then further assessment is required. Initially, the validity of the reference status of the sites should be checked. Then, data from further reference sites should be gathered and compared with the original data. This may resolve the situation. However, the high level of variability may be natural, as is sometimes the case with ephemeral streams. In this situation, it is desirable to obtain data from as many reference sites as possible and then to calculate confidence intervals around the average 20th and 80th percentiles. In this case it is suggested that guidelines should be formulated based on ± two standard errors (+ 2xSE for 80th percentile values and – 2xSE for 20th percentile values) around the average values. This approach to dealing with highly naturally variable waters should be seen as interim and it is open to users to develop alternative approaches provided that they properly address the issue of natural variability. Ideally, new approaches should be discussed with EHP before being applied.

Procedure where sub-regional sites do not fully meet reference requirements but are in reasonable condition (Case B)

It is important to note here that good reference sites are often difficult to locate, particularly for lowland freshwater streams. It may therefore be unavoidable that guidelines for these waters have to be derived from less than perfect 'reference' sites. Defining a precise cut-off between a slightly impacted reference site and an unacceptably impacted reference site is difficult. In part the cut-off will be based on pragmatism (i.e. what quality of reference sites are actually available in a particular catchment or comparable nearby catchments) and in part it should be based on some level of expert opinion.

Assuming the decision has been made that suitable reference sites are available that are only moderately impacted, then the sub-sections below outline a suggested process for deriving guidelines from the data from these sites.

4b. Assess quantity and quality of data

Determine if there are sufficient sites and data points to meet the criteria for developing sub-regional guidelines (see section 4.4.3.1). Determine if the data meets the QA requirements (see section 4.4.3.2). If yes, proceed to 5b.

5b. Calculate 20th and 80th percentiles for each reference site and compare with regional guidelines (if available)

The 20th and 80th values for each reference site (ideally there should be 3 or more reference sites for each water type) should be calculated and then compared with each other. Considerations detailed in 5a above relating to variability between sites should be similarly assessed.

If the 20th and 80th percentiles from all the reference sites are reasonably consistent, then calculate the average value and standard error for each percentile as described in 5a. A decision needs to be made on what level of use can be made of the data. Four scenarios are considered below:

1. **Regional guidelines are not available or are based on largely inappropriate national default values.** In this situation the 20th and 80th values from the sub-regional sites (even though they are slightly impacted) are likely to be the best available option for deriving guidelines and will in any case be an improvement on the existing situation. It is therefore recommended that the sub-regional values be adopted as guidelines. If better data becomes available at some future time, then the guideline values can be amended.
2. **Regional guidelines are available but the 20th and 80th values from local sites are not significantly different from the regional guidelines.** Retain the regional guidelines.
3. **Regional guidelines are available but the 20th and /80th values from local sites indicate a quality better than the regional guidelines, for at least some indicators.** In this situation, for indicators where the sub-regional guideline values are better than regional values, then potentially these values can be accepted as sub-regional guidelines. However, care must be taken with this approach and some expert input is required to ensure that the 'better' quality is natural and not due to some anthropogenic cause (e.g. increased flow due to some form of discharge or dam release can greatly increase macroinvertebrate diversity).
4. **Regional guidelines are available and calculated sub-regional values are poorer than the regional**

values. In this situation the sub-regional values would normally be rejected in favour of the existing regional guidelines. However if, based on consolidated expert opinion, the sub-regional values genuinely reflect local reference conditions better than the regional guidelines, then some or all of the sub-regional values may be adopted as guidelines. It must be emphasised that this would only be done on the basis of a high level of agreed expert opinion.

A worked example for comparing draft sub-regional guidelines with existing regional guidelines to determine if there is a significant difference

Consider a hypothetical sub-catchment in south-east Queensland containing two lowland sites monitored over 12 months. A total of 36 samples for total phosphorous were obtained from among the indicators measured.

Site 1	Site 2
Total P (μg/L)	Total P (μg/L)
20	15.8
20	17.7
22	22.2
22	22.4
24	24
25	26.8
26	28
27	28.8
30	34
30	37.5
30	37.6
30	45
33	46.1
40	55
40	64
46	
47	
100	
100	
110	
120	
127	
137	
150	

(a) Calculate the 20th and/or 80th percentiles for each indicator at each site (for high ecological value waters 50th percentile is also established)

For each indicator at each site calculate the 20th, 50th and 80th percentiles using the following Microsoft Excel formulas:

- for the 20th percentile use '=PERCENTILE(A1:A24, 0.2)'
- for the 50th percentile use '=PERCENTILE(A1:A24, 0.5)'
- for the 80th percentile use '=PERCENTILE(A1:A24, 0.8)'

The percentiles of Total P for sites 1 and 2 are calculated as:

Site 1	20th percentile	50th percentile	80th percentile
	24.6	31.5	104
Site 2	20th percentile	50th percentile	80th percentile
	22.36	28.8	45.22

(b) Calculate the average values of the percentiles for sites 1 and 2 with a range of plus/minus one standard error.

For example, average of the 20th percentiles is: $\frac{24.6 + 22.36}{2} = 23.48$

For each indicator calculate the average value of the 20th, 50th and 80th percentiles using the following Microsoft Excel formula '=AVERAGE(A1:A2)'

The averaged percentiles of total P are:

20th percentile	50th percentile	80th percentile
23.48	30.15	74.61

For each indicator calculate standard error for each averaged percentile using the following Microsoft Excel formula: '=(STDEV(A1:A2))/(SQRT(COUNT(A1:A2)))'

The standard error for each averaged percentile of Total P are:

20th percentile	50th percentile	80th percentile
1.12	1.35	29.39

(c) Adopt local guideline values that are within the calculated ranges of the 20th and/or 80th percentiles (plus/minus one standard error)

Expert opinion may be required for final determination of local guideline values.

4.3.6 Deriving sub-regional water quality guidelines (HEV waters)

The generic guideline for high ecological value (HEV) waters is that there should be 'no change' to existing quality. Essentially this means that there should be no change in the natural range of values. This is difficult to test for and it is therefore recommended that it should be deemed that 'no change' has occurred if there are no detectable changes to the 20th, 50th and 80th percentiles of the natural distribution of values. The testing regime for this is discussed in more detail in Appendix D.2.1. The implication of this approach is that guidelines for HEV waters need to include all three of these percentiles rather than just the 80th and/or the 20th as is the case for SMD waters.

In order to determine the 20th, 50th and 80th percentiles of the natural range of values it is necessary to collect data from the HEV water body in question or from one that is very similar. Data needs to meet quantity and quality requirements set out in sections 4.4.3.1 and 4.4.3.2. Once the required number of data values has been collected, the three percentiles can be calculated and these are then set as guideline values. There are examples of HEV waters and HEV guidelines in Table 3.1.2.

5 Procedures for application of guidelines for aquatic ecosystem protection

The ANZECC 2000 Guidelines provide guidance on the application of guidelines – see particularly volume 1, sections 2.2.3.1 and 7.4.4. The Queensland guidelines fully endorse the guidance provided in the ANZECC 2000 Guidelines. However, in the same way that the Queensland guidelines aim to develop more detailed and locally tailored guideline numbers than the ANZECC 2000 Guidelines, so it is seen as a role of the Queensland guidelines to also develop guidance on the application of guidelines. Like the guideline numbers themselves, guidance on application will be developed over time.

The application issues considered in version 3 of the QWQG are:

- assessing compliance with guidelines;
- application of the guidelines under different flow conditions;
- application of guidelines to the development of water quality objectives or targets; and
- application of guidelines to development approvals (e.g. licensing discharges).

5.1 Assessing compliance with guidelines

Compliance is assessed through comparison of environmental measurements with guideline values (or water quality objectives if they are available). In a very general sense, exceedance of a guideline value is taken to be non-compliance, although the frequency and extent of exceedance have an important bearing on this. Exceedance or non-compliance can take a number of forms and some of these are illustrated below in Figure 5.1.1 for the purposes of discussion.

Figure 5.1.1: Three types of non-compliance situations

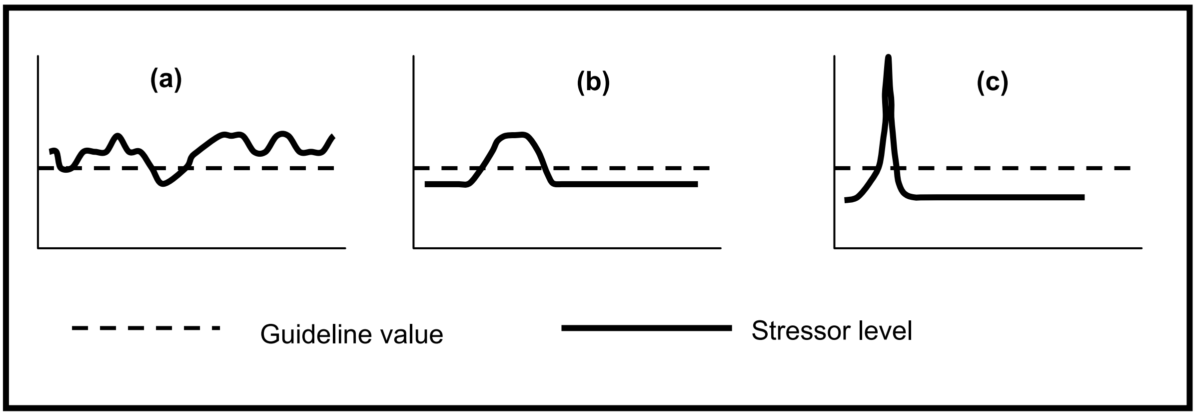


Figure 5.1.1 shows three different non-compliance situations.

1. Chronic long term non-compliance (months to years). In this case the system exhibits a small but consistent shift in the distribution of pollutant values above the guideline. This may be due to either catchment or point source pollutants.
2. Medium term (weeks to a few months) non-compliance. Here, the system exhibits intermittent periods of non-compliance. The magnitude of non-compliance may be small or large. The cause may be natural or related to activities that discharge wastes on a seasonal or cyclic basis.
3. Short-term (a few days) non-compliance. Here, the system is subjected to occasional large pulses of a pollutant that are well above the guideline. This can occur naturally due to storm inflows of pollutants but anthropogenic activities in catchments commonly cause these pulses to be much larger than they would have been under natural conditions, e.g. fine sediment runoff from urban areas is much larger than from natural bushland. Pulses occurring in dry weather are much more likely to be due to a discharge (sometimes accidental) from some form of human activity.

Any of these situations can potentially impact significantly on ecosystems, and therefore compliance mechanisms need to take into account their possible occurrence. Default ANZECC 2000 Guidelines compliance assessment approaches are well suited to assessing chronic non-compliance. Medium term non-compliance can also be picked up by ANZECC approaches provided they are tailored so that they are focussed on the likely periods of non-compliance.

Short pulses of pollutants are unlikely to be picked up by chronic compliance assessment programs. There is also the issue that short term exceedance of a guideline value that is designed to provide protection from chronic effects may not necessarily cause significant impacts on the ecosystem. There is some limited discussion of this in regard to toxicants in the ANZECC 2000 Guidelines in section 3.4.3.2, pages 3.4–16. *'At present, there is little international guidance on how to incorporate brief exposures into guidelines, and it may not yet be possible to do this. A number of chemicals can cause delayed toxic effects after brief exposures, so it has been considered unwise to develop a second set of guideline numbers based on acute toxicity to account for brief exposures. Concentrations at which acute toxicity is likely to occur may not necessarily bear any resemblance to the concentrations that should protect against transient exposure. New information about transient exposure, published in the peer-reviewed literature, may assist users to take transient exposure into account for some chemicals.'*

For naturally occurring stressors (e.g. nutrients, suspended solids, dissolved oxygen, metals), one approach is to characterise background concentrations (or loads) during storm events in reference catchments and set guidelines based on these values. This approach has been applied in the Mackay-Whitsunday region – see Table 3.2.4. However, the availability of data of this nature is generally quite limited. At a site level, this approach can sometimes be applied simply by saying that values downstream of an activity should never be worse than values upstream (or at a nearby reference site). However, where upstream conditions are poor, this approach is not necessarily appropriate. For a few indicators we can set some interim guidelines for values that should never be exceeded.

Compliance assessment schemes clearly need to be tailored to the likelihood or risk of different types of non-compliance. In particular, monitoring timing and frequency needs to be matched to the situation – low frequency long term, focussed on limited periods, event focussed or a combination of these. Assessment programs should also always include biological response indicators as well as stressor indicators. Biological indicators provide a direct measure of the health of the system and are particularly useful as measures of the significance of medium and short term stressor exceedances. For example, a short pulse of low pH levels or an overnight drop in dissolved oxygen might not be recorded, but the impacts on the biota could be very significant.

The ANZECC 2000 Guidelines stress that the aquatic ecosystem guideline values are triggers to further action. The response to non-compliance should match the magnitude and impacts of the exceedance. Initial response might include examination of data for errors, undertaking further monitoring, or determining if modifying factors exist for toxicants. The nature of further action can vary. Non-compliance in a water body may trigger action to undertake further investigation of the catchment to see what improvements can be made. Non-compliance associated with licensed activities may trigger a more regulatory type of response. However, this would still be mediated by the nature and extent of non-compliance – refer to the EHP Environment Management Enforcement Guidelines available on the department's website.

In the context of these general considerations, Appendix D discusses, in more detail, compliance associated with different types of stressors and for different levels of protection.

5.2 Application of guidelines under different flow regimes

Water quality guidelines that are derived from reference data are generally representative of waterway condition under normal baseflow regimes. It follows that guidelines should generally be applied under normal baseflow conditions. Under extreme high or low-flow conditions, guideline application requires careful consideration. Queensland inland waters are particularly subject to extreme flows. Many inland waters are ephemeral, experiencing long periods of no flow interspersed with short periods of high flow. Coastal streams are less ephemeral but still experience periods of flood flows. The following sections provide guidance on how guidelines should be applied firstly under very high flow conditions and secondly to ephemeral streams.

5.2.1 Application of guidelines to flood events

During baseflow conditions, i.e. when stream flows are being largely supplied by groundwater inflows, physico-chemical characteristics of water remain relatively consistent. During flood events, stream flows are considerably increased as a result of surface runoff. This runoff picks up large quantities of natural and man-made pollutants as it passes over land surfaces, with fine sediment being the most easily observed expression of this. This leads to short-lived but often quite large fluctuations in water quality. Such fluctuations occur naturally but, in general, the more disturbed a catchment, the greater these fluctuations are likely to be.

The issue that arises is how guideline values should be applied during flood events. The answer to this varies depending on the type of pollutant. For pollutants that have direct toxic impacts on biota, it seems reasonable that guidelines should apply equally during flood events and during baseflow events as they can still have a significant effect on the biota. However, the question that then arises is the extent to which short-lived, high-level spikes of a toxicant will impact on the biota. It seems likely that for some toxicants, short-lived increases in concentrations above guideline values may not have large consequences. However, there is very little information on this, so it is preferable to stay with the established guideline values. At a local level this issue can be approached by undertaking both toxicant and biological monitoring during and after flow events. This would help determine the actual impacts of transient spikes in toxicants and the information gained could be used to support an amended local guideline.

Where background concentrations of natural toxicants such as heavy metals exceed guidelines, a new guideline should be derived based on background data, as recommended in section 7.4.4.2 of the ANZECC 2000 Guidelines Volume 1.

For physical characteristics such as dissolved oxygen or pH, which can have lethal effects at extreme values, it is important to ensure they do not exceed such values during flood events, e.g. low pH values due to acid sulphate runoff. Therefore for these types of indicators we need to set extreme guideline values that should not be exceeded under any circumstance. These will be different from baseflow guidelines and will be designed to prevent short term lethal effects on biota. The baseflow guidelines are designed to allow biota to survive and breed successfully in the long term. Although our knowledge of lethal levels is limited, some data is available and some preliminary extreme guideline values are given in the QWQG for some of these types of indicators.

With natural pollutants such as suspended sediment or nutrients, short term increases in values during flood events may not immediately impact on biota but may have longer term impacts or downstream impacts, e.g. effects on seagrasses or coral reefs. However, simple application of baseflow concentration guidelines to these types of indicators during the short period of an event is not appropriate. The ANZECC 2000 Guidelines suggest this type of issue is best dealt with using load-based guidelines. In theory it should be possible to set load-based guidelines based on a reference approach. This would involve assessing loads in undisturbed catchments and using these to set benchmarks or guidelines for other catchments. Loads from undisturbed catchments could be assessed either through direct measurement or through the use of calibrated models. As yet, there is generally insufficient information to provide load-based guidelines and the issue will be further considered in future QWQG versions.

The difficulties in dealing with physico-chemical indicators during flood events highlight the need to include biological monitoring in all programs. Biological information integrates the various effects of short term spikes in water quality and provides the best measure of whether fluctuations during flood events are having a significant impact. For toxicants, measurement of sediment toxicant levels or use of passive samplers are similarly useful ways of integrating the impacts of short term fluctuations in water column concentrations.

5.2.2 Application of guidelines to ephemeral waters

Within Queensland, there is only one major river system that can be described as truly perennial (i.e. permanently flowing) – the Jardine River on Cape York, which is sustained by groundwater flows from a large sandstone aquifer. All other systems have stopped flowing at some time during the past 50 or more years of recorded flows. The degree of non-permanence varies greatly with climate, from streams in the Wet Tropics that almost always flow, to small creeks in western Queensland that only flow for a few days a year following intermittent rainfall. The degree of non-permanence also varies with the size of the catchment. Thus flows in the main stems of rivers are more permanent than in smaller upstream tributaries.

Once flow ceases, streams become a series of disconnected waterholes. The extent of waterholes also varies. Larger streams tend to have more and larger permanent waterholes, while waterholes in smaller or drier climate streams may completely dry out.

As flow decreases, water quality at a location becomes progressively less dependent on upstream inflows and more dependent on local effects. This can lead to changes in water quality, although this affects some indicators much more than others, e.g. dissolved oxygen values are particularly sensitive to the effects of stagnation. The smaller the waterhole and the longer the non-flow period, the more significant these changes are likely to become.

As with flood flows, the approach for applying guideline values to non-flowing streams will depend on indicators. For toxicants (in both water and sediment) it is appropriate to apply normal guideline values, as the effects on the biota under stagnant conditions will be similar to those during flowing conditions.

Physical indicators like dissolved oxygen and pH become much more variable during stagnant conditions, with greater extremes in values. Application of normal guidelines for these indicators to small waterholes in non-flow conditions is inappropriate. In larger waterholes it would be expected that values would remain closer to guidelines, although this will vary depending on a range of factors. Also, stagnation usually leads to stratification in deep waterholes. In the anoxic water below the thermocline, water quality will be totally different from normal conditions for virtually all indicators. Thus dissolved oxygen (DO) can vary widely in non-flowing waters. Values of pH may also vary more, with particularly high values occurring during daytime as a result of photosynthesis. However, with the exception of wallum-type streams, very low values of pH (i.e. less than about five) would not be expected in most streams even in stagnant conditions.

Indicators such as nutrients may also be affected by non-flow conditions, although there is not much data on this in Queensland waters. In general, large natural waterholes would not be expected to show big increases in nutrient levels simply because flow had ceased. However, small stagnant waterholes show changes due to natural inputs of organic matter and often exhibit increased levels of organic N. Normal guidelines are therefore not applicable to small waterholes.

Non-flow periods also affect biological indicators. Small creeks, which often dry up, are likely to have poorer species diversity than larger more permanent streams. There is therefore a need to develop biological guidelines that are more attuned to small creeks. For highly ephemeral creeks in western areas, the normal biological indicators (fish, macroinvertebrates) seem to be inappropriate and there is a need to develop new indicators and associated guideline values.

The fact that water quality in waterholes in non-flowing streams is different and usually poorer than in flowing streams should not be taken to mean that water quality in these areas is not important. These waterholes are often vital refuges for local species and maintaining a quality of water that allows their survival is crucial. It is one of the longer term aims of the QWQG to gather data on these types of systems so that appropriate guidelines can be developed to protect species that depend on these refuge areas.

The application of guidelines to ephemeral waters is undoubtedly problematical. The ANZECC 2000 Guidelines mention the lack of good data on these stream types but in general offer little advice on how to approach the issue. There is some existing research being undertaken to develop better indicators and methods for ephemeral waters (e.g. Review of Methods for Water Quality Assessment of Temporary Stream and Lake Systems – see the ACMER website.

5.3 Guidelines as a technical input to the derivation of water quality objectives or targets

This is a key role for guidelines under the National Water Quality Management Strategy process and is illustrated in Figure 5.3.1, adapted from the ANZECC 2000 Guidelines. This shows water quality guidelines feeding directly into the definition of water quality objectives.

It is important point to note is that although guidelines provide technical input to the development of WQOs or targets, they are not necessarily the same values as the finally adopted WQOs. The final WQOs take into account social, economic and current condition factors. These may dictate that achieving the actual guideline value is economically or technically unacceptable and that therefore the WQO should be set at some less stringent value. Hence the WQOs ultimately adopted might be the same as, or different from, the technical guideline values, depending on community and economic considerations. EVs and WQO have been scheduled for a number of waterways throughout Queensland (e.g. South-east Queensland and the Wet Tropics). The scheduled EVs/WQOs and supporting mapping are available from the department’s websiteand should be referred to for planning/decision making under the EPP Water.

In this context the QWQG should be used as the primary technical input to (i) the development of WQOs under the EPP Water, (ii) the development of water quality targets by regional NRM bodies, and (iii) the development of any other local water quality guidelines. Where QWQG values are unavailable, users should default to the ANZECC 2000 Guidelines or develop local guidelines.

The development of EVs and WQOs and the role of guidelines in this process are detailed in the Queensland procedural guideline available on the department’s website.

5.4 Guidelines as a technical input to development approvals

For information on the process of assessing point source discharges under the Environmental Protection Act, refer to the Operational Policy, *Waste water discharge to Queensland waters*, available from the department’s website.

In summary, scheduled environmental values and water quality objectives are one of a number of criteria specified in the *Environmental Protection Act 1994* to be used in considering environmental applications. Where there are no scheduled numbers, water quality guidelines (including the QWQG) must be used as a technical input to the process. The numbers contained in a water quality objective can be the same as or different from those in an environmental approval under the Act, depending on individual circumstances. The potential for variation is because the WQOs apply to the receiving water while the environmental approval relates to the discharge quality of a particular activity. Additionally, WQOs are one of a number of criteria to be considered when assessing environmental applications. Others include best practice environmental management, the public interest and the characteristics of the receiving environment.

6 Reference data for aquatic ecosystem indicators

6.1 Introduction and purpose

Assessment of condition in a water body is most commonly undertaken through comparison of its current condition with some measure of its expected natural condition. This is the reference condition approach and it relies on the availability of data for natural condition. The reference condition concept is normally applied to data collected from sites that are deemed not to be significantly impacted by anthropogenic activities, i.e. they are in a close to completely natural state. The reference data collected from such sites is used to derive water quality guidelines which are taken to represent an ideal condition. These guideline values are used both as the technical basis for deriving management objectives (water quality objectives or targets) and as a yardstick for assessing condition at test sites.

Following on from the above, the purpose of this section of the QWQG is to act as a library of good quality reference data, making it readily available to users. This section will provide reference condition data for a range of indicators that are not included in the more formalised guideline tables. This information is intended to be broad ranging in terms of the types of indicators or issues involved. The only limitations on the scope of this information are firstly that the indicators are of some practical use in managing aquatic ecosystems and secondly that good reference data is available.

The information will mainly be of use as a benchmark for assessing the condition of test sites. Where environmental data values fall outside these reference ranges, that would be seen as a trigger to undertake further investigation. The data should not be interpreted as formal guidelines. However, in the future, guideline numbers may be developed for some of the indicators included in this section.

6.2 Metals in biota

Metal contamination of the environment can be assessed through measurements of metals concentrations in water, sediment or the biota. Guidelines for metal levels in both water and sediments are provided in the ANZECC 2000 Guidelines. However, levels of metals in biota are so species specific that it is impractical to encompass this in a national document. However, it is considered practical and useful to include available information on levels of metals in some biota in the QWQG.

There are various advantages and disadvantages in measuring metals contamination in either water, sediments or the biota but it is outside the scope of this document to discuss these. However, one advantage of measuring metals in biota is that it provides information on the biological uptake of metals, which physico-chemical measures of water or sediment do not. Biological uptake is not the same thing as toxicological impact, but it nevertheless provides some insight as to the extent to which metals are entering the biological food webs and therefore potentially affecting the biota. Some species of biota are also used simply as sentinels for metals contamination e.g. mussel watch program. Where levels increase above natural levels in sentinel organisms, this is a good indication that some degree of metal contamination is occurring in the local environment.

Over the years, the Queensland Department of Environment and Heritage Protection has acquired data on the levels of metals in various species as part of investigations into possible metals contamination. Some of this data was collected at unimpacted or reference sites and, based on this, the following sub-sections provide reference ranges of metals in several species.

6.2.1 Metals in shellfish – oysters and mussels

Data on metals levels in oysters (*Saccostrea glomerata*) and mussels (*Trichomya hirsuta*) has been collected at a number of sites in the Moreton Bay region. The data showed that sites adjacent to urban areas had significantly higher levels of some metals (principally Cu, Zn and Pb) than sites in more natural condition. Based on the data from natural or reference sites, Table 6.2.1 provides reference ranges for metals concentration in these two species. These ranges are expressed as the 20^{th} and 80^{th} percentiles of the combined reference data from several sites. However, in some cases, the average 80^{th} percentile values have had to be adjusted upwards to allow for the extent of natural variation between reference sites.

The values in these tables should be compared with the median of several samples from a test site. Conclusions should not be based on the results of comparison with a single sample. Each sample should itself be comprised of at least five individual shellfish.

Table 6.2.1: Reference concentrations of metals in mussels (*Trichomya hirsuta*) and oysters (*Saccostrea glomerata*) – 20th & 80th percentiles

Metal	Mussel		Oyster	
	20th percentile	80th percentile	20th percentile	80th percentile
	mg/kg dry weight			
Lead	0.28	1.00	0.200	0.400
Cadmium	0.73	1.60	2.8	5.1
Zinc	80	135	600	1600
Copper	6.5	10.0	80	135
Chromium	1.7	16.5	1.0	10.0
Nickel	1.7	11.5	4.1	20.5
Iron	265	685	185	313
Manganese	13	21	9.4	20.0
Selenium	4.4	6.4	4.6	6.7
Antimony	0.03	0.06	0.001	0.001
Arsenic	14	26	13	23.9
	mg/kg wet weight			
Mercury	0.002	0.004	0.003	0.006

6.3 Biochemical oxygen demand

Biochemical oxygen demand (BOD) is a measure of the rate of oxygen consumption in a sample of water. (There is an analogous measure for sediments – sediment oxygen demand – which is not considered here.) BOD is usually measured over five days and is hence termed BOD_5 and is normally expressed in units of mg/L.

There are two main types of BOD measures: total BOD and carbonaceous BOD. The latter is aimed at measuring only oxygen demand due to carbonaceous material and excludes oxygen demand due to processes such as nitrification. Measuring carbonaceous BOD is achieved through the inhibition of the nitrification process by various means. Total BOD, as its name implies, includes all oxygen demanding processes and is the only measure considered here. It is the most relevant for environmental purposes as it is the overall impact on oxygen levels that is usually of interest.

The five day BOD test is not highly sensitive or accurate, especially at the low levels found in natural waters. Nevertheless, it can be a useful measure of processes occurring in the water column and can be an important input into modelling of the impacts of specific discharges.

EHP has undertaken quite extensive BOD_5 testing of a range of Queensland waters. Most of this has been at impacted sites but there were a limited number of largely unimpacted sites. Based on data from these sites, Table 6.3.1 provides a range of percentiles for this indicator that are representative of background or natural condition for BOD_5 in several different water types.

Table 6.3.1: Background levels of BOD_5 in Queensland waters

	BOD_5 (mg/L)		
Percentile	Freshwater	Estuary	Marine
10	0.5	0.5	0.5
20	0.5	0.5	0.5
50	0.7	0.8	0.7
80	1.2	1.2	1.1
90	1.3	1.5	1.2

7 Queensland guidelines for values and uses of waters other than ecosystem protection

In general, there is no reason to develop state-specific guidelines for the human use type values of waters and, for the most part, users should source guideline information from national guideline documents – these are detailed in section 9. However, there are some instances where state-level guidelines have been developed for some of these values and the purpose of section 7 of the Queensland Water Quality Guidelines is to document these state-level guidelines. These guidelines come from a number of sources in government and are included here in their original format.

7.1 Water quality guidelines for aquaculture in Queensland (Department of Agriculture, Fisheries and Forestry)

7.1.1 Introduction

One of the most crucial requirements for successful aquaculture is the management of water quality. Water quality is a general term referring to a number of physical and chemical parameters of water that affect the growth and health of cultured animals. By managing water quality parameters within optimal ranges, culturists can achieve maximum productivity from a system. Water of sub-optimal quality can lead to the death of cultured species or reduce productivity by reduced feeding, decreased growth, suppressed gonad development, reduced spawning quality or quantity and increased susceptibility to disease. The optimal range of critical water quality parameters varies between species and also depends on the life stage of the animal. Unfortunately, the majority of information available on water quality in aquaculture deals with salmon species. These guidelines provide recommendations for water quality parameters relating to species cultured in Queensland aquaculture industries. These values represent quality for the optimal growth of these species rather than absolute limits. For information on how these parameters affect cultured animals, or ways to control water quality parameters, culturists should refer to other DAFF publications.

7.1.2 Water quality parameters – generally acceptable ranges

Water quality parameters that are known to be important in the health of aquatic animals are temperature, dissolved oxygen, pH, salinity, ammonium, nitrate, nitrite, hardness, alkalinity, turbidity and the levels of toxic agents such as heavy metals, herbicides and pesticides. Freshwater and marine animals have slightly different optimal ranges of these parameters. Table 7.1.1 provides generally acceptable ranges of the critical water quality parameters for freshwater and marine culture systems. The culturist should be aware that the values presented in the table are only a general guide and specific species will have a smaller range within these values that allows optimal health and production. Additionally, the requirements of larval stages may be different to those of juvenile or adult animals.

Table 7.1.1: The generally recommended levels of water quality parameters for tropical aquaculture

Water parameter	Recommended range		Water parameter	Recommended range
	Freshwater	Marine		General aquatic
Dissolved oxygen	>4mg/L	>4mg/L	Arsenic	<0.05mg/L
Temperature ^{0}C	21–32	24–33	Cadmium	<0.003mg/L
pH	6.8–9.5	7–9.0	Calcium/Magnesium	10–160mg/L
Ammonia (TAN, total ammonia-nitrogen)	<1.0mg/L	<1.0mg/L	Chromium	<0.1mg/L
Ammonia (NH_3, unionised form)	<0.1mg/L	<0.1mg/L	Copper	<0.006mg/L in soft water
Nitrate (NO_3)	1–100mg/L	1–100 mg/L	Cyanide	<0.005mg/L
Nitrite (NO_2)	<0.1mg/L	<1.0mg/L	Iron	<0.5mg/L
Salinity	0–5ppt	15–35 ppt	Lead	<0.03mg/L
Hardness	20–450mg/L		Manganese	<0.01mg/L
Alkalinity	20–400 mg/L	>100mg/L	Mercury	<0.00005mg/L
Turbidity	<80 NTU		Nickel	<0.01mg/L in soft water; <0.04 mg/L in hard water
Chlorine	<0.003mg/L		Tin	<0.001mg/L
Hydrogen sulphide	<0.002mg/L		Zinc	0.03–0.06 mg/L in soft water; 1–2 mg/L in hard water

7.1.3 Water quality parameters for freshwater species

The major freshwater fish species cultured in Queensland is the barramundi, *Lates calcarifer*. Other fish species cultured include eels, *Anguilla reinhardtii* and *A. australis*, silver perch, *Bidyanus bidyanus*, and jade perch, *Scortum barcoo*. The culture of freshwater crustaceans is limited mainly to redclaw crayfish, *Cherax quadricarinatus*. Table 7.1.2 below lists the recommended levels of water quality parameters for optimal growth of particular species at various life stages. In some cases no species specific information is available and culturists should refer to the general recommendations presented above. It should be noted that the larval stage of the barramundi is a marine culture and information for larval barramundi is provided in the marine species section.

Table 7.1.2: Recommended levels of water quality parameters for optimal growth of particular species in freshwater

Water parameter	Barramundi	Eel	Silver perch	Jade perch	Sleepy cod	Redclaw
Dissolved oxygen	4–9mg/L	>3mg/L	>4mg/L	>3mg/L	>4.0mg/L	>4.0mg/L
Temperature ^{0}C	26–32	23–28	23–28	23–28	22–31	23–31
pH	7.5–8.5	7.0–8.5	6.5–9	6.5–9	7.0–8.5	7.0–8.5
Ammonia (TAN, Total ammonia-nitrogen)		<1.0mg/L			<1.0mg/L	<1.0mg/L

Water parameter	Barramundi	Eel	Silver perch	Jade perch	Sleepy cod	Redclaw
Ammonia (NH_3, unionised form) (pH dependent)	<0.46mg/L	<0.1mg/L	<0.1mg/L	<0.1mg/L	<0.1mg/L	<0.1mg/L
Nitrate (NO_3)			<100mg/L			
Nitrite (NO_2)	<1.5mg/L	<1.0mg/L	<0.1mg/L		<1.0mg/L	<1.0mg/L
Salinity (extended periods)	0–35ppt		<5ppt	<5ppt		<4ppt
Salinity bath	0–35ppt		5–10ppt for 1 hour		max. 20ppt for 1 hour	
Hardness ($CaCO_3$)			>50mg/L	>50mg/L	>40mg/L	>40mg/L
Alkalinity	>20mg/L		100–400 ppm	100–400 ppm	>40mg/L	>40mg/L
Chlorine	<0.04mg/L				<0.04mg/L	
Hydrogen sulphide	0–0.3mg/L				0–0.3mg/L	
Iron	<0.1mg/L		<0.5mg/L	<0.5mg/L	<0.1mg/L	<0.1mg/L
Spawning temperature	marine		23–28	23–28	>24 for more than 3 days	

7.1.4 Water quality parameters for marine species

The predominant marine fish species cultured in Queensland is the barramundi, *Lates calcarifer*. The water quality parameters recommended for barramundi are presently applied to experimental reef-fish culture, including barramundi cod, *Cromileptes altivelis*, flowery cod, *Epinephelus fuscoguttatus* and goldspot cod, *E. coioides*. The majority of marine crustacean culture produces black tiger prawns, *Peneaus monodon*; however, other species including the brown tiger prawn, *P. esculentus*, banana prawns, *P. merguiensis* and kuruma prawns, *P. japonicus* are also cultured. There is limited information about the requirements of mud crabs and rock lobsters; however, both have been reported to grow coincidently in tiger prawn ponds. Table 7.1.3 below provides water quality information specifically for marine species of significance or interest in Queensland aquaculture. In some cases species specific recommendations are not available and culturists should refer to the general recommendations presented in Table 7.1.3.

Table 7.1.3: Recommended levels of water quality parameters for optimal growth of particular marine species

Water parameter	Barramundi		Tiger prawn		Kuruma prawn
	Hatchery	Grow out	Hatchery	Grow out	Grow out
Dissolved oxygen	Saturation	>4.0mg/L	>4.0mg/L	>3.5mg/L	>4.0mg/L
Temperature ^{0}C	28–30 optimum; 25–31 range	28–30 optimum		26–32	24
pH	~ 8	~ 8	~ 8	7.5–8.5	7.5–8.5

Water parameter	Barramundi		Tiger prawn		Kuruma prawn
Ammonia (TAN, total ammonia-nitrogen)		0.1–0.5mg/L			
Ammonia (NH_3, unionised form)	<0.1mg/L	<0.1mg/L	<0.1mg/L	<0.1mg/L	<0.1mg/L
Nitrate (NO_3)	<1.0mg/L	<1.0mg/L	<1.0mg/L	<1.0mg/L	<1.0mg/L
Nitrite (NO_2)	<0.2mg/L	<20mg/L	<0.2mg/L	<0.2mg/L	<0.2mg/L
Salinity	28–31ppt	0–35ppt		10–25ppt optimum	30–35ppt optimum
Alkalinity		105–125mg/L $CaCO_3$			
Clarity				30–40cm Secchi disk	30–40cm Secchi disk
Hydrogen sulphide		<0.3mg/L			
Iron		<0.02mg/L		<1.0mg/L	
Spawning temperature		28–32 (strain dependent)		27–32	

For further information contact the QPIF Call Centre or the DPI website www.daff.qld.gov.au.

7.2 Guidelines for management of blue-green algae in contact recreation areas

When cyanobacteria (blue-green algae) is present in large amounts it can present a significant hazard, particularly to primary contact users of waters. National guidelines for managing risks in recreational water were released in 2008 by the National Health and Medical Research Council (NH&MRC) and these cover cyanobacteria. The national guidelines for cyanobacteria have been adopted for Queensland waters and supersede previous state guidelines issued by the former Department of Natural Resources and Water. A summary of the national guideline values that replace previous state values is provided below in Table 7.2.1.

Table 7.2.1: Guidelines for cyanobacteria (blue-green algae) for primary contact recreation

Status	Guidance level	Recommended action
Green level surveillance mode	≥ 500 to < 5000 cells/mL Microcystis aeruginosa or biovolume equivalent, to > 0.04 to < 0.4 mm^3/L for the combined total of all cyanobacteria.	Routine sampling to measure cyanobacteria levels.
Amber level alert mode	≥ 5000 to < 50 000 cells/mL Microcystis aeruginosa or biovolume equivalent, to ≥ 0.4 to < 4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume[a]. or[b] ≥ 0.4 to < 10 mm^3/L for the combined total of all cyanobacteria where known toxin producers are not present.	Investigations into the causes of the elevated levels, and increased sampling, to enable the risks to recreational users to be more accurately assessed.

Status	Guidance level	Recommended action
Red level action mode	Level 1 guideline: ≥ 10 µg/L total microcystins or ≥ 50 000 cells/mL toxic Microcystis aeruginosa or biovolume equivalent of ≥ 4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume. or[b] Level 2 guideline: ≥ 10 mm3/L for total biovolume of all cyanobacteria material where known toxins are not present. or cyanobacterial scums are consistently present[c].	Local authority and health authorities to warn the public that the water body is considered to be unsuitable for primary contact recreation.

Notes:

aThe definition of 'dominant' is where the known toxin producer comprises 75% or more of the total cyanobacteria in a representative sample.

bThis applies where high cell densities or scums of 'nontoxic' cyanobacteria are present, i.e. where the cyanobacterial population has been tested and shown not to contain known toxins (microcystin, nodularin, cylindrospermopsin or saxitoxins).

cThis refers to the situation where scums occur at the recreation site each day when conditions are calm, particularly in the morning. Note that it is not likely that scums are always present and visible when there is a high population, as the cells may mix down with wind and turbulence and then reform later when conditions become stable.

Source: NH&MRC (2008) *Guidelines for Managing Risks in Recreational Water*. National Health and Medical Research Council, Australian Government.

7.3 Guidelines for drinking water supply storages (South East Queensland Water Corporation)

These guidelines are based on the water quality objectives developed by SEQ Water Corporation for drinking water supply storages. They apply specifically to storages in south-east Queensland but would be appropriate for drinking water supply storages throughout Queensland. *Note that these guidelines are expressed slightly differently to normal guidelines. F*or example, a Cryptosporidium guideline of >0 implies that action must be taken if values >0 are detected. The approach used and the significance of 'Level 1' and 'Level 2' are explained in more detail in the table footnotes.

Table 7.3.1: Guidelines for drinking water supply in the vicinity of storage off-takes or in groundwater supplies, before treatment

Indicator	Water quality guideline
Suspended solids	Level 1: 25 mg/L Level 2: 100 mg/L
Blue-green algae (cyanobacteria)	Refer to Australian Drinking Water Guidelines
Taste and odour	Level 1: 5 µg/L Geosmin or 10 µg/L MIB or 10 µg/L combined Geosmin & MIB Level 2: > 30 µg/L of both Geosmin & MIB combined
Cryptosporidium	Level 1: > 0 cyst Level 2: 10 cysts per 10 L
Giardia	Level 1: > 0 cyst Level 2: 10 cysts per 10 L
E coli	Level 1: > 60 cfu/100mL No Level 2
Total coliforms	Level 1: > 800 cfu/100mL No Level 2
Manganese (soluble)	Level 1: 50 µg/L Level 2: 200 µg/L
Iron (soluble)	Level 1: 50 µg/L Level 2: 200 µg/L
Turbidity	Level 1: 25 NTU Level 2: 100 NTU
Colour	Level 1: 50 Hazen Units No Level 2
Conductivity	Refer to Australian Drinking Water Guidelines
Dissolved oxygen	Level 1: < 5 mg/L at surface No Level 2
Pesticides	Level 1: Above detection limits specified by Queensland Health Scientific Services Level 2: Presence at detectable levels; receipt of information indicating spills or illegal dumping
Hydrocarbons	No Level 1 Level 2: Notification of spills or illegal dumping
Dissolved organic carbon	Level 1: >21 mg/L No Level 2

Source: Environmental Values and Water Quality Objectives for Wivenhoe, Somerset and North Pine Dam, SEQ Water, 2005.

Notes:

- Level 1 means Level 1 Hazard and Critical Control Point (HACCP) response rating; namely, treatment-plant process-change required to ensure water quality and quantity to customers is not compromised.
- Level 2 means Level 2 Hazard and Critical Control Point (HACCP) response rating; namely, treatment-plant process-change required but water quality and quantity to customers may still be compromised.

8 Guidelines for Urban Stormwater

This chapter has two main objectives:

1. To provide information on the quality of stormwater from typical existing urban catchments; and
2. To provide design objectives for urban stormwater for new Water Sensitive Urban Design urban areas.

8.1 Urban stormwater quality characteristics of traditionally designed urban catchments (i.e. not water sensitive)

Over the past decade or more there have been numerous studies aimed at characterising the quality of urban stormwater, i.e. water running off urban areas during or immediately following significant rainfall events. These studies have shown that quality is highly variable (although not profoundly different) depending on factors such as the exact nature of urban land use and the antecedent rainfall history. Nevertheless, it is possible to characterise urban stormwater quality, within wide confidence intervals (Engineers Australia, 2006, Australian Runoff Quality).

An extensive review of overseas and Australian data on urban stormwater (Fletcher et al 2004) looked at data from a large number of studies and produced a series of tables that provide ranges of values for a number of indicators of stormwater quality. With the permission of the authors, some of the tables from this review are reproduced in these guidelines (see tables 8.1.1 to 8.1.9).

These tables from Fletcher et al (2004) represent what can be termed ‘typical’ values for urban stormwater. These values are derived from a wide range of studies on established (i.e. not water sensitive) urban development areas in Australia. The ‘typical’ value provided for each indicator is based on the geometric mean of values from these studies. The upper and lower values represent the 95% confidence interval around the geometric mean values. The ranges are wide but they do provide some guidance on the expected quality of urban stormwater from traditional urban design. Much additional and more detailed information on urban stormwater quality can be found in the original document by Fletcher et al.

The reason for including this data on typical urban stormwater quality in the QWQG is that it provides benchmark information on typical pollutant concentrations in a traditional urban design system. Traditional systems collect urban runoff and convey it to the waterway in an untreated condition. Pollutants are sourced from roads, lawns, and bare earth areas and include sediment, nutrients, hydrocarbons, heavy metals and gross pollutants. Urban stormwater has much poorer quality than runoff from undisturbed landscapes and therefore cannot be considered as natural. However, it is useful to have some measure of typical values for reference in assessing impacts on water quality objectives in such waterways. For example, if we want to assess stormwater quality in a specific urban catchment, samples of stormwater can be compared with the values given in these guidelines. If the test data lies within the ranges given here, then it is reasonable to conclude that the catchment is behaving as for a traditional urban catchment. If the test data lies outside the normal range or is close to the outer limits of the range, then further investigation of the catchment might be in order. The data is also useful as a benchmark for runoff from industrial sites and other urban developments such as commercial precincts.

It is emphasised that the data in these tables should **NOT** be taken as representing desired targets for urban stormwater quality in Queensland. That issue is addressed in section 8.2.

Table 8.1.1: Range of values for suspended solids from different land uses. Typical value represents the geometric mean while the lower and upper values are the 95% confidence intervals

Stormwater values for total suspended solids			
Land use	**Wet weather concentration (mg/L)**		
	Lower	**Typical value**	**Upper**
Roads	90	270	800
Roofs	5	20	90
General urban	40	140	500
Residential	40	140	500

Stormwater values for total suspended solids			
Land use	Wet weather concentration (mg/L)		
	Lower	Typical value	Upper
Industrial	40	140	500
Commercial	40	140	500
Mixed urban/rural	20	100	500
Rural	20	90	500
Agricultural	40	140	500
Forest/Natural	10	40	150

Table 8.1.2: Range of values for total phosphorus from different land uses. Typical value represents the geometric mean while the lower and upper values are the 95% confidence intervals

Stormwater Values for Total Phosphorus			
Land-use	Wet Weather Concentration (mg/L)		
	Lower	Typical Value	Upper
Roads	0.15	0.5	1.5
Roofs	0.06	0.13	0.3
General urban	0.08	0.25	0.8
Residential	0.08	0.25	0.8
Industrial	0.08	0.25	0.8
Commercial	0.08	0.25	0.8
Mixed urban/rural	0.08	0.25	0.8
Rural	0.08	0.25	0.6
Agricultural	0.2	0.6	2.0
Forest/Natural	0.03	0.08	0.2

Table 8.1.3: Range of values for total nitrogen from different land uses. Typical value represents the geometric mean while the lower and upper values are the 95% confidence intervals

Stormwater Values for Total Nitrogen			
Land-use	Wet Weather Concentration (mg/L)		
	Lower	Typical Value	Upper
Roads	1	2.2	5
Roofs	0.7	2	6
General urban	0.7	2	6

Stormwater Values for Total Nitrogen			
Land-use	Wet Weather Concentration (mg/L)		
	Lower	Typical Value	Upper
Residential	0.7	2	6
Industrial	0.7	2	6
Commercial	0.7	2	6
Mixed urban/rural	0.7	2	6
Rural	0.7	2	5
Agricultural	1	3	9
Forest/Natural	0.4	0.9	2

Table 8.1.4: Range of values for faecal coliforms from different land uses. Typical value represents the geometric mean while the lower and upper values are the 95% confidence intervals

Stormwater Values for Faecal Coliforms			
Land-use	Wet Weather Concentration (cfu/100mL)		
	Lower	Typical Value	Upper
Roads	1700	7000	30000
Roofs	6	60	600
General urban	300	4000	50000
Residential	2000	20000	200000
Industrial	300	4000	50000
Commercial	300	4000	50000
Mixed urban/rural	300	4000	50000
Rural	20	600	20000
Agricultural	-	-	-
Forest/Natural	20	600	20000

Table 8.1.5: Range of values for zinc from different land uses. Typical value represents the geometric mean while the lower and upper values are the 95% confidence intervals

Stormwater Values for Zinc			
Land-use	Wet Weather Concentration (mg/L)		
	Lower	Typical Value	Upper
Roads	0.1	0.4	1.5
Roofs	0.8	4	20

Stormwater Values for Zinc			
Land-use	Wet Weather Concentration (mg/L)		
	Lower	Typical Value	Upper
General urban	0.05	0.16	0.5
Residential	0.1	0.3	1
Industrial	0.05	0.16	0.5
Commercial	0.1	0.3	1
Mixed urban/rural	0.1	0.3	1
Rural	0.07	0.22	0.7
Agricultural	-	-	-
Forest/Natural	-	-	-

Table 8.1.6: Range of values for lead from different land uses. Typical value represents the geometric mean while the lower and upper values are the 95% confidence intervals

Stormwater Values for Lead			
Land-use	Wet Weather Concentration (mg/L)		
	Lower	Typical Value	Upper
Roads	0.02	0.12	0.7
Roofs	0.005	0.022	0.1
General urban	0.04	0.15	0.6
Residential	0.04	0.15	0.6
Industrial	0.04	0.15	0.6
Commercial	0.04	0.15	0.6
Mixed urban/rural	-	-	-
Rural	0.01	0.2	0.2
Agricultural	0.01	0.2	0.2
Forest/Natural	-	-	-

Table 8.1.7: Range of values for copper from different land uses. Typical value represents the geometric mean while the lower and upper values are the 95% confidence intervals

Stormwater Values for Copper (Cu)			
Land-use	Wet Weather Concentration (mg/L)		
	Lower	Typical Value	Upper
Roads	0.03	0.095	0.3
Roofs	0.007	0.024	0.08
General urban	0.02	0.08	0.3
Residential	0.02	0.08	0.3
Industrial	0.02	0.08	0.3
Commercial	0.02	0.08	0.3
Mixed urban/rural	-	-	-
Rural	0.02	0.08	0.3
Agricultural	-	-	-
Forest/Natural	-	-	-

Table 8.1.8: Range of values for cadmium from different land uses. Typical value represents the geometric mean while the lower and upper values are the 95% confidence intervals

Stormwater Values for Cadmium (Cd)			
Land-use	Wet Weather Concentration (mg/L)		
	Lower	Typical Value	Upper
Roads	0.001	0.03	0.8
Roofs	0.0002	0.0006	0.002
General urban	0.001	0.0045	0.02
Residential	0.001	0.0045	0.02
Industrial	0.001	0.0045	0.02
Commercial	0.001	0.0045	0.02
Mixed urban/rural	0.001	0.0045	0.02
Rural	-	-	-
Agricultural	-	-	-
Forest/Natural	-	-	-

Table 8.1.9: Range of values for oil & grease from different land uses. Typical value represents the geometric mean while the lower and upper values are the 95% confidence intervals

Stormwater Values for Oil & Grease			
Land-use	Wet Weather Concentration (mg/L)		
	Lower	Typical Value	Upper
Roads	3	17	100
Roofs	-	-	-
General urban	3	9.5	30
Residential	3	9.5	30
Industrial	3	9.5	30
Commercial	3	9.5	30
Mixed urban/rural	-	-	-
Rural	-	-	-
Agricultural	-	-	-
Forest/Natural	-	-	-

8.2 Water quality design objectives for water sensitive urban catchments

The need to implement Water Sensitive Urban Design (WSUD) is now well accepted in Queensland and new urban developments that incorporate WSUD are expected to achieve much higher stormwater quality entering waterways than those development areas that are not water sensitive.

Tables 8.2.1 and 8.2.2 set out the currently used urban stormwater quality design objectives for urban development in Queensland. The Department of Environment and Heritage Protection has developed summary guidelines that reflect best practice environmental management (BPEM) for water quality and flow management. These objectives (‘Urban Stormwater – Queensland BPEM Guidelines 2009’) contain further detail on the nominated design objectives for desired stormwater quality in new urban development such as subdivisions.

The design objectives can be achieved by employing a variety of structural and non-structural treatment measures. The design objectives have been chosen on the principle of best practice environmental management and relevant environmental values, taking into account the application of contemporary stormwater treatment technologies operating at the limit of economic efficiency and their practicality for application to typical developments in the various climatic regions across Queensland. For advice on how to demonstrate compliance with the design objectives, also see Urban stormwater – Queensland best practice environmental management guidelines Technical Note: Derivation of Design Objectives” prepared by AECOM (Ecological Engineering Practice Area).

There is a body of data from laboratory and field studies on the actual quality of stormwater from subdivisions that fully incorporate WSUD. This data supports the achievement of the design objectives using existing technology. Further monitoring, technological innovation and adaptive management may result in the development of refined objectives over time.

For further information users should refer to various Water Sensitive Urban Design documents that are now available (e.g. the SEQ WSUD Technical Guidelines at www.waterbydesign.com.au).

Table 8.2.1: Summary of design objectives for management of stormwater quality and flow – construction phase of development in Queensland

CONSTRUCTION PHASE STORMWATER DESIGN OBJECTIVES	**DEVELOPMENT TYPE** **Large and medium scale construction sites1** **Defined as disturbance area greater than 1 ha (large) or 2500m2 (medium density)**
INTENT	To protect water EVs by minimising hydrologic disturbance and the loads of contaminants in runoff.
POLLUTANT/ISSUE	STORMWATER DESIGN OBJECTIVES[2]
Coarse sediment	Retain coarse sediment on site.
Fine sediment (Total suspended solids—TSS)	Take all reasonable and practicable measures to collect all runoff from disturbed areas and drain to a sediment basin—up to the design storm event.[3] Site discharge during sediment basin dewatering complies with a TSS concentration less than 50 mg/L up to the design event—flocculation as required. In storms greater than the design event take all other reasonable and practicable measures to minimize erosion and sediment export.
Turbidity	Released waters from the approved discharge point(s) have turbidity[4] (NTU) less than 10% above receiving waters turbidity—measured immediately upstream of the site.
Nutrients (N and P)	Manage through sediment control.
pH	Acceptable site discharge pH range 6.5 to 8.5[5]
Litter or other waste	Prevent litter/waste entering the site or the stormwater system or internal watercourses that discharge from the site—minimise on-site production, contain on-site and regularly clear bins.[6]
Hydrocarbons and other contaminants[7]	Prevent from entering the stormwater system or internal watercourses that discharge from the site—control storage, limit application and contain contaminants at source. Waste containing contaminants must be disposed of at authorized facilities. Store oil and fuel in accordance with Australian Standard AS1940—no visible oil or grease sheen on released waters.
Wash down water	Prevent from entering the stormwater system or internal watercourses that discharge from the site.
Cations and anions	As required under an approved Acid Sulfate Soil Management Plan, including aluminium, iron and sulfate.
Stormwater drainage/flow management	Take all reasonable and practicable measures[8] to minimize changes to the natural waterway hydraulics and hydrology from: • peak flow for the 1-year and 100-year ARI event (respectively for aquatic habitat and flood protection) • runoff frequency and volumes entering receiving waters • uncontrolled release of contaminated stormwater.

Source: Draft urban stormwater – Queensland best practice environmental management guidelines, 2009.

Notes:

1. For small scale construction sites (defined as disturbance area less than 2500 m^2) and independent of a larger common development, the implementation of best practice environmental management should be in accordance with the *Queensland Development Code*, local government planning scheme requirements (including any deemed to comply provisions) and Draft urban stormwater – Queensland BPEM guidelines Appendix 1 'Model Provisions for Best Practice Erosion and Sediment Control'.
2. Compliance release limits for rainfall events less than the design storm event—(based on the design rainfall event of 80%ile five day rainfall depth for developments involving land disturbed less than six months, and 85%ile for longer disturbance).
3. For sites with disturbance greater than 1 ha, drain such area to a sediment basin where practicable. See Table 6.3 of Urban Stormwater – Queensland BPEM guidelines and IECA 2008 for details.
4. A site-specific relationship should be developed between turbidity and suspended solids, prior to the commencement of construction on large and medium scale construction sites. Background refers to receiving waters immediately upstream of site waters release points.

5. Note the range may be further limited to prevent mobilisation of specific elements.
6. Avoid wind blown litter; remove gross pollutants.
7. See the prescribed contaminant list in the *Environmental Protection Regulation 1999.*
8. Including making best use of constructed sediment basins to attenuate the discharge of stormwater from the site.

Table 8.2.2: Summary of design objectives for stormwater quality – operational (post-construction) phase

Region **(See Figure 2.5 of Urban Stormwater—Qld BPEM Guidelines 2009)**	**Minimum* reductions in mean annual loads from unmitigated development (%)**			
	Suspended solids (TSS)	**Total phosphorus (TP)**	**Total nitrogen (TN)**	**Gross pollutants > 5 mm**
Eastern Cape York	75	60	35	90
Central and Western Cape York (north)	75	60	40	90
Central and Western Cape York (south)	80	65	40	90
Wet Tropics	80	65	40	90
Dry Tropics	80	65	40	90
Central Coast (north)	75	60	35	90
Central Coast (south)	85	70	45	90
South-east Queensland	80	60	45	90
Western districts	85	70	45	90

* It is expected that application of best practice designed stormwater treatment technologies configured in an appropriately sequenced 'treatment train' will exceed the design objectives presented in Table 8.2.2.

Note: If a site is adjacent to a regional boundary (see Figure 2.5 of Urban Stormwater—Queensland BPEM Guidelines) or if in doubt about which regional design objectives apply, the most stringent regional design objectives should be adopted unless it can be shown that the sizing would not conform with the principle of best practice. In any case, local rainfall data should be used where available. Note that these regional boundaries are different from the water quality regional boundaries.

Note: The MUSIC model sets the lower particle size as 0.002 mm (i.e. excludes clay); however, the upper limit recommended by Brodie and Roswell[1] of 0.125 mm (fine sand) is significantly finer than the 0.5 mm adopted as the upper TSS limit in the MUSIC v.3 computer model.[2]

1. Brodie & Roswell, 'Using soil loss models to estimate suspended solids concentrations in stormwater runoff from pre-urban areas', *Australian Journal of Water Resources*, vol. 12, no. 1, Institute of Engineers Australia, 2008.
2. Geoff Hunter, 'Predicting the waterway impacts of urbanization: modeling considerations pre, during & post urban development', proceedings of Urbanisation and Waterway Health: A forum for Policymakers & Managers, Kawana, 2008.

9 Other applicable guidelines for Queensland waters in the absence of state-level guidelines

In the absence of state-level or locally derived guidelines, the following national guidelines for aquatic ecosystems and human-use environmental values (EVs) are recommended as defaults.

Table 9.1: Recommended default guidelines for use if no Queensland guidelines values are available

Environmental value	Water quality guidelines for particular water types
Aquatic ecosystems	Toxicants in water, sediment and biota as per ANZECC 2000 (http://www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality) Release of sewage from vessels to be controlled in accordance with requirements of the Transport Operations (Marine Pollution) Act and Regulations, 1995 (http://www.msq.qld.gov.au/Home/Environment/Sewage/) Comply with Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance, ANZECC (http://www.environment.gov.au/coasts/pollution/antifouling/code/index.html)
Protection of the human consumer	Guidelines as per ANZECC 2000 and Food Standards Code, Australia New Zealand Food Authority, 1996, and updates (http://www.foodstandards.gov.au/thecode/foodstandardscode/index.cfm#_three)
Primary contact recreation Secondary contact recreation Visual recreation	Guidelines for managing risk in recreational waters, NH&MRC, 2008 (http://www.nhmrc.gov.au/publications/synopses/_files/eh38.pdf)
Cultural & spiritual values	Protect or restore Indigenous and non-Indigenous cultural heritage consistent with relevant policies and plans.
Industrial use	No guidelines are provided in ANZECC 2000. Some were given in AWQG 1992 but guidelines vary according to the industry and this value is usually protected by other values, such as aquatic ecosystem.
Aquaculture	Guidelines such as: • Queensland Department of Primary Industries – Water Quality in Aquaculture – DPI Notes April 2004; and • ANZECC 2000 and Food Standards Code, Australia New Zealand Food Authority, 1996, and updates.
Irrigation	Guidelines as per ANZECC 2000 (http://www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality)
Stock watering	Guidelines as per ANZECC 2000
Farm use	Guidelines as per ANZECC 2000
Drinking water supply	See Table 5.3.1 for local guidelines. See also Australian Drinking Water Guidelines (2004).
Drinking water	Guidelines as for Australian Drinking Water Guidelines (2004). Can be accessed on http://www.nhmrc.gov.au/publications/synopses/eh19syn.htm

10 References

(Note: additional technical guideline documents and web links are provided in section 3.1.4 [riparian], section 3.1.5 [fisheries habitat] and appendices of the QWQG.)

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Appendixes

Appendix A: Methodology applied for deriving water types and guideline values for Queensland Water Quality Guidelines

A.1 Deriving regional water quality guidelines

Regional guidelines were derived for physical and chemical indicators in fresh, estuarine and marine waters in the Wet Tropics, Central Coast and South-east regions, where sufficient data was available.

The process for setting guidelines for physical and chemical indicators comprised:

1. selecting **reference sites**;
2. defining **water types** for which guidelines were to be set (also refer Appendix B for water types); and
3. calculating **guideline values** based on reference data sets for each water type.

A.1.1 Selecting reference sites

A **reference site** is a site whose condition is considered to be a suitable baseline or benchmark for assessing and managing sites in other waterways. Most commonly, reference sites are subject to relatively little disturbance. Sites of this type were used to derive the default guidelines in the ANZECC 2000 Guidelines, and also for the QWQG.

Reference sites for these guidelines were selected from water quality monitoring sites in past and present EHP monitoring programs. An initial list of reference sites was selected based on known degree of impact. Those reference sites had to meet all of the following criteria:

(a) minimal disturbance to local environment and upstream catchment (for example, from dense urban and industrial areas, or intensive livestock or cropping areas);

(b) no significant point source discharges nearby (e.g. sewage treatment plant discharges, industrial discharges, major agricultural or stormwater drains, localised agricultural discharges such as those from dairies); and

(c) sufficient data available (sites without 12 or more measurements for particular indicators were excluded).

A.1.2 Defining water types

Every waterway is unique, so guidelines should ideally be derived for every single waterway. However, given the impracticality of deriving individual sets of guidelines for every waterway, it is useful to group broadly similar waters together into water types, and to develop guidelines for those types.

Queensland has a wide variety of general water types, such as permanent-flowing freshwater streams, intermittent or temporary freshwater streams, lakes, wetlands, estuaries and coastal waters. In turn, those general types can be broken down further; for example, dividing freshwater streams into upland and lowland streams based on altitude and/or slope, as was done for the ANZECC 2000 guidelines.

Ideally, each water type for which guidelines is derived should:

(a) have reasonably homogenous water quality across all sites or waterways included in that type; and

(b) be readily describable in terms of its physical attributes, such as flow, depth or flushing.

The following process was used to identify and characterise water types within each region for these guidelines:

(i) Assigning reference sites to general water types
Reference sites (identified in step 1 above) were assigned to general water types, which were based on clearly defined physical and chemical characteristics, and on well established differences in expected water quality and ecological conditions. For these guidelines, general types included permanently flowing freshwater streams, estuaries (from the mouth of a waterway at the coast up to the limit of its tidally influenced length), and marine waters. These different water types are all recognised in the ANZECC 2000 guidelines.

(ii) Dividing general types into more specific sub-types based on reference site data
Reference data was assessed for homogeneity within each general water type, by inspecting data distributions of key indicators for all reference sites within each type. For some general water types there was notable variation between sites, so the general types were divided into more specific sub-types, and sites assigned to those new sub-types based on their data distributions.

(iii) Defining new water types by physical characteristics
Definable physical attributes were identified that were common to all or most sites within each of the new water types derived in step (ii). These attributes became the physical descriptions of the final, specific water types that are used in these guidelines. The initial zones based on water quality did not immediately fall out as clear-cut physical water types. However, with iterative adjustment of the water quality zones, water types were determined that had reasonably discrete physical characteristics as well as reasonably homogenous water quality.
Through steps (ii) and (iii) marine waters were divided into open coastal waters and enclosed coastal waters; estuaries were divided into upper, middle and enclosed coastal/lower estuary zones; and the ANZECC 2000 Guidelines divisions of upland and lowland freshwaters were retained. (Also refer Appendix B for water types.)

(iv) Removing or reclassifying sites with outlying distributions
After the final set of water types were defined, reference sites were assigned to those types based on the known physical attributes of the sites, and data distributions were again inspected within each water type. Sites with outlying distributions were identified and reclassified into another water type more consistent with its data distribution, if supported by more detailed scrutiny of its physical attributes.

Through this process, a number of separate water types were identified and defined for which reference site data was available: upland and lowland freshwater streams; some dune lakes; upper and middle estuaries; and enclosed coastal (including the mouth of the estuary) and open coastal waters. These water types are described in detail in Appendix B, along with criteria that can be applied to assign sites to one type or another, in different areas within each region.

A number of other water types are not included in these guidelines, as there was insufficient reference data available. These include temporary or intermittent streams and palustrine wetlands. For these water types the ANZECC 2000 Guidelines should be adopted if available for that water type, or local guidelines should be derived.

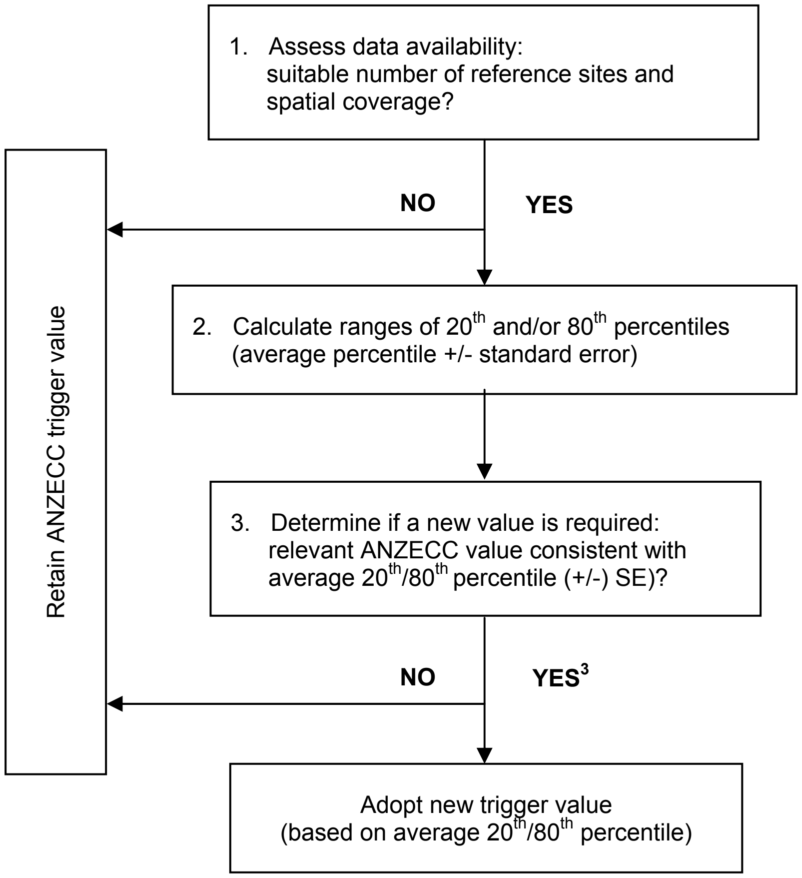
A.1.3 Calculating guideline values

The ANZECC 2000 Guidelines recommend that guidelines be developed on the basis of biological-effects data. However, such data is not commonly available, particularly for sub-lethal effects. The alternative approach recommended is to base guidelines on the 80^{th} and/or 20^{th} percentiles of data from reference sites. The 80^{th} and 20^{th} percentiles were used in this document as the basis for deriving new guideline values for slightly to moderately disturbed (level 2) waters; for high ecological value waters the 20^{th}, 50^{th} and 80^{th} percentiles were used.

All sites with fewer than 12 data points were excluded from further consideration (ANZECC 2000 Guidelines recommends 24 data points but there were a significant number of reference sites available for most water types, so 12 data points was considered sufficient to merit inclusion).

The general procedure followed to derive guidelines for each indicator in each region and water type is outlined below, in Figure A.1, and the resulting guideline values are shown in section 3 of the QWQG. Notes attached to Figure A.1 Table B1, and relevant tables in the QWQG provide further details on the source of guideline numbers.

Figure A.1: Procedure for deriving numerical guideline values from reference data for each water type within each region (slightly to moderately disturbed waters)



Notes:

Where insufficient data was available for some water types in the Central region, corresponding trigger values from the South-east region were adopted in preference to the ANZECC 2000 Guidelines defaults, because of the consistency of data between the regions for water types where data was available for both regions, and because of the generally similar climatic conditions in both regions.

The above percentiles are for slightly to moderately disturbed waters. For high ecological value waters, the guidelines have also used 50th percentiles.

Yes – i.e. new value required because there is inconsistency between average 20th/80th percentiles and ANZECC values.

Sufficient data was available for freshwater, estuarine and marine water types within the Wet Tropics, Central (east) and South-east regions. ANZECC 2000 Guidelines default trigger values apply to all other regions and water types.

Appendix B: Water types for guidelines

This Appendix:

- explains why it is necessary to divide waterways into water types;
- summarises the water types used by the QWQG relative to ANZECC 2000 water types;
- summarises the decision rules/principles used in mapping water types for the QWQG (and EVs under the EPP (Water));
- lists the main mapping sources used to spatially identify the waterways in each water type. These can ultimately be included in mapping under the EPP Water (mapping sources are subject to refinement and update as new/improved sources become available); and
- explains the linkages between QWQG water types and the wetlands mapping under the Queensland Wetlands Program.

B.1 Introduction

The aim of subdividing regions into water types is to create groupings within which water quality (or biological condition) is sufficiently homogeneous that a single guideline value can be applied to all waters within each group or water type.

The ANZECC 2000 Guidelines define a base set of water types for physical and chemical indicators (see first column of Table B.1). These types were defined *a priori*, based on physical characteristics, and may or may not represent zones of homogeneous water quality.

One aim of the QWQG is to allow further regionalisation of guidelines, including further subdivision of the ANZECC 2000 Guidelines water types where appropriate. The QWQG takes the ANZECC 2000 Guidelines base water types as a starting point and includes additional subdivisions of those types. The additional types have only been created where there was sufficient data to show that they represent a category within which water quality is (a) relatively homogeneous and (b) different from water quality in other water types. Subsequent versions of the QWQG may include further water types.

There is also a need for the QWQG to be consistent with other initiatives or programs that create water type classifications, to the extent that is practicable. Since the previous version of the QWQG there has been considerable development of wetlands mapping under the Queensland Wetlands Program. The process of defining and mapping the respective wetland/water types has, to the greatest extent possible, been kept consistent/common between both the QWQG and the Queensland Wetlands Program, i.e. the base layers used and wetland types defined by these two outputs (and in EVs/WQOs scheduled under the EPP Water) are, where possible, consistent. Some variations in terms and boundaries, and additional sub-categorisation of water/wetland types, may occur where differences in mapping approach, level of mapping detail or use of updated base layers are required for the respective purposes of each of these processes. Under these situations some variations may remain. Further details on the terms used by these respective processes and the links between them are provided in the comparison table below.

For this version of the QWQG, waters have been divided into three main categories: fresh, estuarine and marine. The following sections provide definitions of these major categories and the more detailed water sub-types within each category. In many parts of Queensland there is insufficient information to justify creating additional or different water types. Therefore the ANZECC 2000 Guidelines default water types have been retained in many cases. Table B.1 summarises the water types adopted for this version of the Queensland guidelines.

Table B.1: Water types adopted for QWQG regions

	Queensland region water types						
ANZECC base water types[1]	**SE Qld**	**Central Qld**	**Wet Tropics**	**Eastern Cape York**	**Gulf**	**Lake Eyre**	**Murray Darling**
Upland freshwater	A/EHMP	A	A	A	X	X	A
Lowland freshwater	A/EHMP	A	A	A	X	X	A
Lakes	A	A	A	A	X	X	A
Wetlands	A	A	A	A	X	X	A
Estuaries	Upper estuary	Upper estuary	n/a	A	A	n/a	n/a
	Mid-estuary	Mid-estuary	Mid-estuary				
Inshore marine	Enclosed coastal/ lower estuary	Enclosed coastal/ lower estuary	Enclosed coastal/ lower estuary	Enclosed coastal/ lower estuary	Enclosed coastal/ lower estuary	n/a	n/a
	Open Coastal	Open Coastal[3]	Open Coastal[3]	Open Coastal[3]	Open Coastal		
Offshore marine	Note 2	Midshelf [3]	Midshelf [3]	Midshelf [3]	Note 2	n/a	n/a
	Note 2	Offshore[3]	Offshore[3]	Offshore[3]	Note 2	n/a	n/a
Note 1	A = adopt default ANZECC 2000 Guidelines water type X = no types defined n/a = not applicable						
Note 2	Offshore marine areas are outside the limit of Queensland waters (three nautical miles). Refer to ANZECC 2000 Guidelines.						
Note 3	Refer to GBRMP Guidelines for guideline values but see also tables 3.2.1b (Central Coast) and 3.3.1b (Wet Tropics). See section B.2.4.2 for detailed definition of water types within the GBR Marine Park.						

B.2 Definitions of water types in the QWQG

B.2.1 How to apply these definitions

The following definitions are provided to describe the water types adopted in these guidelines and to provide guidance for determining which water types apply to particular sites or waterway sections for practical applications of the guidelines. Note that not all water types are found in each waterway, catchment or region.

The definitions include qualitative descriptions of each type, as well as default objective criteria to decide where the cut-offs are between different types. The objective criteria allow waters to be categorised according to the physical, chemical or biological attributes listed. However, those defaults may be overridden where local studies or assessments are conducted.

It is intended to undertake further spatial analysis work to define water types throughout Queensland. This will assist in reviewing the surrogates currently used to identify water types and, where necessary, in refining them based on spatial analysis output.

B.2.2 Freshwaters

This category includes all freshwaters except those that experience regular tidal influence. The tidally influenced waters are included in the upper estuary category, where present.

B.2.2.1 Upland freshwaters

Definition

In the ANZECC 2000 Guidelines upland freshwater streams are defined as all (freshwater) streams or stream sections above 150m. This arbitrary altitude-based definition may not be appropriate for many areas. For example, some small streams below 150m may be more appropriately identified as upland streams even though they fall outside this category. Similarly some waters above 150m may exhibit characteristics more reflective of lowland freshwaters. A more broadly applicable definition is:

> *'Small (first, second and third order) upland streams. Moderate to fast flowing due to steep gradients. Substrate usually cobbles, gravel or sand – rarely mud.'* (DIBM 2001)
>
> Providing better definitions of stream types will be an ongoing task.
>
> **Mapping source for this water type**
>
> Mapping uses a stream network derived from Geoscience Australia, with base stream layer varying according to region under consideration. In the absence of other information, a 150m contour surrogate is used to differentiate upland freshwaters from lowland freshwaters (i.e. waters above 150m are identified as upland freshwater). Mapping uses a 'zonal' approach to show all areas above 150m as upland freshwater. This allows for the capture of streams independently of the scale and quality of waterway/wetland mapping available, and the intent is that a water type 'zone' is to be interpreted as inclusive of all riverine waters within it. The 150m cut-off is a fairly arbitrary boundary and alternative criteria (e.g. height, other) can be used if there is justification for doing so.

B.2.2.2 Lowland freshwaters

Definition

In the ANZECC 2000 Guidelines, lowland freshwater streams are defined as all freshwater streams or stream sections below 150m. As outlined above, there are potential limitations with this surrogate, and a more broadly applicable definition is:

> *'Larger (third, fourth and fifth order or greater), slow-flowing and meandering streams and rivers. Gradient very slight. Substrates rarely cobble and gravel, more often sand, silt or mud.'* (DIBM 2001)
>
> It is intended to undertake further spatial analysis work to define streams in the stream order definition and compare them with streams under the altitude definition to assess consistency. In SEQ region, several lowland sub-types (lowland freshwater, coastal freshwater, wallum/tannin) were identified for the Ecosystem Health Monitoring Program (EHMP) and mapping of these using a 'zonal' approach is provided in maps included under the EPP Water schedule 1.
>
> **Mapping source for this water type**
>
> Mapping uses a stream network derived from Geoscience Australia, with base stream layer varying according to the region under consideration. In the absence of other information, a 150m contour surrogate is used to differentiate lowland freshwaters from upland freshwaters (i.e. waters below 150m are identified as lowland freshwater). Mapping uses a 'zonal' approach to show all areas below 150m as lowland freshwater. This allows for the capture of streams independently of the scale and quality of waterway/wetland mapping available, and the intent is that a water type 'zone' is to be interpreted as inclusive of all riverine waters within it.

B.2.2.3 Lakes

There is no formal definition of lakes in the ANZECC 2000 Guidelines. The EHP and Queensland Wetlands Program definition is:

Lacustrine: Found in, or pertaining to, lakes or ponds, or growing in them; as, lacustrine flowers. *(WordNet ® 2.0, © 2003 Princeton University). For the purposes of this method the lacustrine system includes wetlands and deepwater habitats with all of the following characteristics:*

- *situated in a topographic depression or dammed river channel;*
- *lacking trees, shrubs, persistent emergents, emergent mosses, or lichens with greater than 30 percent areal coverage; and*
- *total area exceeds 8ha (20 acres).*

Mapping source for this water type

Mapping is based on lacustrine systems identified in Queensland Wetlands Program, as updated by most recent EHP dams and weirs layer.

B.2.2.4 Wetlands (palustrine)

There is no formal definition of wetlands in the ANZECC 2000 Guidelines. However, the ANZECC Guidelines 'wetlands' essentially refers to palustrine wetlands. The definition of palustrine wetland adopted by EHP and the Queensland Wetlands Program is:

The palustrine system includes all non-tidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5‰. It also includes wetlands lacking such vegetation which have the following three characteristics: (a) where active waves are formed or bedrock features are lacking; (b) where the water depth in the deepest part of the basin is less than 2m at low water; and (c) the salinity due to ocean-derived salts is still less than 0.5‰.

Mapping source for this water type

Mapping of palustrine systems is not undertaken in waterway mapping under the QWQG/EPP Water; however, considerable detail on these systems is provided in mapping by the Queensland Wetlands Program based on interpretation of satellite imagery, regional ecosystems and other data sources. Refer to WetlandInfo website for access to mapping data sets and products.

B.2.3 Estuaries

B.2.3.1 General definitions

The following definition has been adopted for estuaries:

An estuary is:

(a) the mouth of a river where tidal effects are evident and where freshwater and seawater mix; and/or

(b) the part of a tidal river that widens out as it approaches the coastline; and/or

(c) a body of water semi-enclosed by land with sporadic access to water from the open ocean, and where ocean water is at least occasionally diluted by freshwater runoff from land; and/or

(d) a body of water where salinity is periodically increased by evaporation to a level above that of the open ocean (such a water body is termed a reverse estuary).

This definition is open to some degree of interpretation and therefore some more precise delineation of the upper and lower boundaries is provided below. For estuaries, there is sufficient local water quality data in some regions to distinguish multiple water types within the ANZECC 2000 Guidelines base estuary type (see Table B.1). These include upper estuary, middle estuary and enclosed coastal/lower estuary. These types and their respective boundaries within the overall estuary are discussed below.

B.2.3.2 Limits of estuaries

Upstream limit of estuary

For the purposes of this document, the upstream boundary of the estuary is taken as the upstream limit of tidal influence at mean high water spring (MHWS). This is the primary definition. The MHWS is the theoretical upstream limit for the mixing of salt water (see (a) above). However, in some large estuaries, slow rates of mixing and the constant inflow of freshwater means there is a permanent body of freshwater in the upper tidal reaches. This creates an anomaly if estuaries are taken to be where salt and freshwater mix. However, for water quality purposes, the tidal upper reaches are much more akin to an estuarine environment than a riverine environment.

If the MHWS mark is not defined for an estuary, the following surrogates can be used:

- the inland extent of the estuary as shown in Queensland Wetlands Program mapping;
- the declared downstream limit (DDL) or coastal management district (CMD) lines (officially determined estuary/freshwater cut-offs);
- a barrier or barrage that prevents movement of any saline waters upstream;
- the upstream extent of the saline vegetation distribution along a stream;
- the limit of saltwater influence as determined by water quality (salinity or conductivity) measurements; and
- local hydrological studies to estimate the MHWS mark.

Downstream limit of estuary

The lower limit of the estuary is its boundary with fully saline, marine waters at the coast. The boundary divides enclosed coastal waters at or out from the mouth of an estuarine channel (where there is typically some residual mixing between fresh and marine waters) from marine waters where there is typically no residual freshwater influence except under extreme conditions such as major flood events, i.e. the boundary is drawn under typical/ambient conditions rather than under flood event conditions.

Mapping source for estuarine water type (including sub-types)

Mapping uses a stream network derived from Geoscience Australia, with base stream layer varying according to the region under consideration. Cut-offs between estuarine sub-types (upper – mid – lower) are based on the processes outlined in this Appendix.

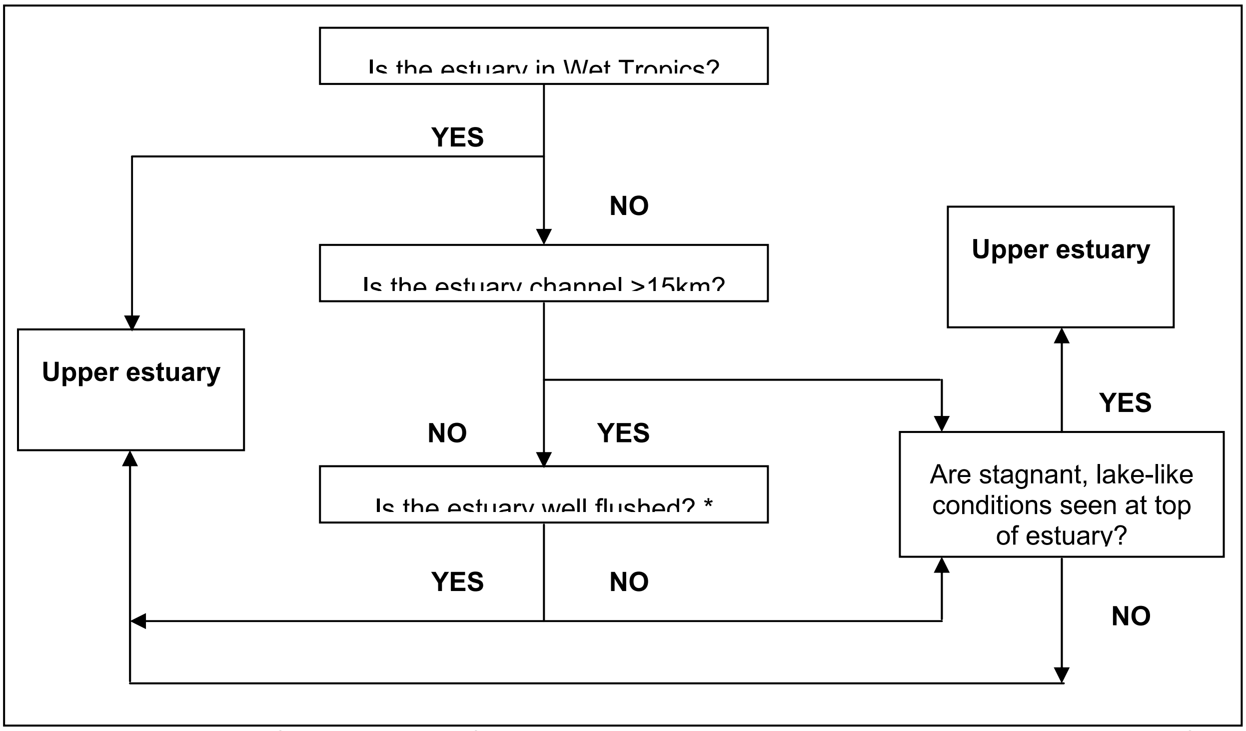
B.2.3.3 Upper estuary

This is the most upstream of all estuarine waters. In the uppermost reaches of some estuaries, there is a stagnant, lake-like zone that has limited flushing from either freshwater inflows or tidal exchange. Water in this zone typically has a long residence time, moving backwards and forwards in much the same place with successive tides. Water quality in this zone is naturally poorer, as a result of poor flushing, than in the better-flushed downstream areas, and would often fail guideline values appropriate to the main body of the estuary.

To address this issue an upper estuary water type has been created. This allows the derivation of guidelines that are more appropriate to the natural water quality of this type of zone.

Upper estuary zones are only applicable to some estuaries. For example, they are not applicable to Wet Tropics streams, where there are generally substantial freshwater flows resulting in rapid flushing of the uppermost estuarine areas. In other regions the presence or absence of an upper estuarine zone should be determined on a case-by-case basis. An upper estuary is typically present only in long estuaries, or in shorter estuaries with low freshwater inputs and weak tidal flushing. The decision tree below (Figure B.1) can be used to determine whether an upper estuarine zone is present in any particular stream.

Figure B.1: Decision tree to determine presence/absence of an upper estuarine zone



*For these guidelines, a well flushed estuary is defined as an estuary with a channel length less than 15km, that has a typical freshwater inflow of 0.2 cumecs and/or a typical tidal range of >2.5m.

Guidelines for upper estuaries allow for poorer water quality than guidelines for the other estuarine zones because water quality is naturally poorer in upper estuaries. Therefore, if there is a lack of information or doubt about whether an estuary has an upper estuarine zone after following the decision tree in Figure B.1, the default approach should be that there is no upper estuarine zone. This conservative approach will ensure that middle estuarine sites, which should have better water quality, are not compared to upper estuarine guidelines, which would allow poorer water quality in the middle estuary than is appropriate.

Upstream limit of upper estuary

The upper limit of the upper estuary is the upper limit of the whole estuary, as defined in section B.2.3.2 above.

Lower limit of upper estuary

For a stream where an upper estuary is present, the length of the upper estuary should be determined by observation and/or local hydrological studies. The aim of such studies should be to identify a cut-off at a certain distance downstream from the top of the estuary, above which there is a noticeable increase in stagnant, lake-like conditions, or water-residence time. That cut-off would mark the boundary between the upper and middle estuarine water types.

In the absence of any local studies to define the cut-off, in estuaries where an upper estuary zone is deemed to be present (see Figure B.1 above), the default length of the upper estuary zones for these guidelines is the upper 15 percent of the channel length of long estuaries (>15 km), or the upper 10 percent of the channel length of short estuaries (<15 km). For long estuaries, the default proportion of the overall channel length comprising the upper estuary is higher, because there is greater dissipation of tidal energy away from the coast. Therefore, there is generally a larger zone at the top of long estuaries where tidal water movement is restricted.

Tributaries entering the upper estuary

For these guidelines any estuarine sections of tributaries that drain into an upper estuarine zone of the main estuary channel are themselves defined as upper estuarine.

B.2.3.4 Middle estuary

The middle-estuary water type covers the majority of the length of most estuaries. The middle estuary begins below the upper estuary, if present, or from below the freshwater/estuarine cut-off if there is no upper estuarine zone. The mid-estuarine zone extends downstream to near the mouth of the estuary at the coast. It excludes the small section just upstream from and including the mouth that is well flushed each tide with incoming marine waters. The middle estuary has a moderate amount of water movement and salt and fresh water mixing.

Upstream limit of middle estuary

For long or poorly flushed estuaries with an upper estuarine zone, the top of the middle estuary is the lower limit of that upper estuarine zone (as outlined in section B.2.3.3).

For short or well flushed estuaries, with no upper estuarine zone, the upper limit of the middle estuary is the upper limit of the whole estuary (as defined in section B.2.3.2).

Lower limit of middle estuary

Selection of the various estuarine water types is primarily based on observed differences in water quality rather than specific physical attributes of estuaries. The advantage of this is that the water types reflect real (rather than presumed) differences in water quality. The disadvantage is that in the absence of a specific physical attribute, definition of the boundaries between water types is more complex.

The lower limit of the middle estuary is essentially a boundary between estuarine waters that have a significant residence time within the estuary and those waters near the mouth of the estuary that are rapidly exchanged with adjacent coastal waters. It is the degree and rapidity of exchange between the estuary and the marine dominated coastal waters that is the principal driver of differences in water quality. The influence of freshwater inflows on the estuary is also a factor in that these have more impact in the main body of the estuary than in the well flushed areas near the mouth of the estuary.

The most direct and appropriate way to define such a boundary would be on the basis of hydrodynamic modelling of the exchange between coastal and estuary waters. However, in most situations, such models are not available and therefore surrogate approaches are required. One such approach is the use of a salinity boundary. This is based on the premise that estuarine waters are influenced more by freshwater inflows than coastal waters. Thus a boundary between the middle estuary and enclosed coastal/lower estuarine waters can be based on the frequency with which salinity falls below normal seawater values. A review of EHP data indicates that for estuaries that discharge directly to open coastal waters, a reasonable boundary can be based on the following salinity rules:

- Mid estuarine waters – salinity equivalent to full marine salinity (approximately 34–36 parts per thousand, or an electrical conductivity of approximately 52–54 mS/cm) for <20% of the time; and
- Enclosed coastal/lower estuarine waters – salinity equivalent to full marine salinity (approximately 34–36 parts per thousand, or an electrical conductivity of approximately 52–54 mS/cm) for >20% of the time.

Where estuaries flow into coastal water bodies that do not have fully marine salinities (for example, narrow straits or enclosed bays) the salinity cut-off may actually occur below the mouth of the main estuary channel, out in the coastal water zone.

However, although the salinity-based boundary is a useful guide, it should not completely override common sense assessments of the extent of mixing and flushing. For example, in some estuaries, where there is limited freshwater inflow, the salinity boundary may be located some way up the main estuary channel where mixing would obviously be quite limited. Another situation is where an estuary flows into a series of narrow enclosed channels which may have high levels of salinity but which are still themselves poorly flushed and are more estuarine than coastal in nature. In these situations, some amendment of the water type boundary (see next paragraph) is acceptable.

As rules of thumb, in most estuaries, the enclosed coastal/lower estuarine zone would not extend further than 10 per cent of the total length of the main estuary channel regardless of the salinity. In small estuaries or those with significant natural barriers near the mouth (e.g. a well developed bar), the boundary would be closer to the estuary mouth. In estuaries flowing into very enclosed coastal waters, the boundary may be set beyond the mouth of the main estuary channel.

Tributaries entering the middle estuary

For these guidelines, any estuarine sections of tributaries that drain into a mid-estuarine zone of the main estuary channel are themselves defined as mid-estuarine. The criteria for deciding the estuarine/freshwater cut-off in these tributaries are the same as those outlined in section B.2.3.2 above.

Some tributaries of the main estuary channel may also have an upper estuarine zone. The criteria for deciding whether there is an estuary, and where the mid-estuarine/upper estuarine cut-off lies, are the same as those outlined in section B.2.3.3 above. The length of the estuarine section of such tributaries is the distance from the mouth at the main estuary channel to the estuarine/freshwater cut-off.

Tidal canals, constructed estuaries, marinas and boat harbours

For these guidelines tidal canals, constructed estuaries, marinas and boat harbours have water quality characteristics in common with the corresponding mid-estuary waters.

B.2.3.5 Enclosed coastal/lower estuary

Enclosed coastal/lower estuarine waters lie at or near the mouth of an estuary channel, and are frequently subject to some degree of residual mixing with inflowing fresh water. As such, they fall within the broad definition of an estuary. They include shallow coastal waters in straits or enclosed bays adjacent to the mouth of inflowing streams or estuaries. They also include the most downstream reach of the main channel of the estuary, which exchanges with coastal waters on every tide.

Upstream limit of enclosed coastal/lower estuary

The upper limit of the enclosed coastal water type is the lower limit of the middle estuary, as defined in section B.2.3.4 above. This is typically a short distance upstream of the mouth of the main estuary channel.

Lower (seaward) limit of enclosed coastal/lower estuary

The lower limit of the enclosed coastal water type is the cut-off between shallow, enclosed waters near the estuary mouth and deeper, more oceanic waters further out. For estuaries that flow directly into open oceanic waters or for passages (e.g. Pumicestone Passage), the lower limit for these guidelines is defined as the mouth of the estuary or passage, enclosed by adapting the semicircle bay rule (6.1, Article 7, *Maritime Limits and Baselines*, 1978). The semicircle rule adapted to close a passage or estuary is:

'*A passage or estuary is closed by a semicircle, with its diameter at the natural entrance(s) to the passage or estuary, drawn to extend beyond the entrance(s).*'

Generally, the entrance is defined by the downstream limits of the drainage catchment of the passage or estuary (the heads). Where the heads are undefined, the catchment limits will need to be estimated using other landscape elements.

Within an enclosed bay or strait, the lower limit may be much further out from the mouth, depending on local hydrological and topographic conditions.

For estuaries flowing into an enclosed bay or strait, the lower limit of the enclosed coastal water type should ideally be determined by site-specific studies. The most important factor to consider here is residence time. In well flushed coastal embayments the enclosed coastal zone will be limited, while in poorly flushed embayments it will be correspondingly larger. This is simply a reflection of the fact that in poorly flushed enclosed coastal areas, estuary water and general land influences will impact on water quality more than in well flushed waters which are dominated by cleaner coastal marine water quality. Unfortunately, it is not possible at this stage to provide some simple physical rules that precisely define the extent of the enclosed coastal zone. The best way to define it is to actually do some water quality measurements (assuming there are no existing human impacts) and infer the extent of the zone by comparing the data with guideline values.

If absolutely no additional information is available, the default lower limit may be based on the more landward boundary of:

- the seaward extent of the estuary shown in Queensland Wetlands Program mapping, or
- the 6m depth contour below lowest astronomical tide (LAT). This marks the outward extent of coastal wetlands according to the Ramsar wetland definition which was amended in 2003 to include*: 'may incorporate riparian and coastal zones adjacent to wetlands, and islands or bodies or marine water deeper than six metres at low tide lying within the wetlands*.'

However, it is recommended that this default be employed only if there is no possibility of collecting local data.

Tributaries entering the lower estuary

For these guidelines, any estuarine sections of tributaries that drain into a lower estuarine zone of the main estuary channel are defined as lower estuary. The criteria for deciding the estuarine/freshwater cut-off in these tributaries are the same as those outlined in section B.2.3.2 above.

Some tributaries of the main estuary channel may also have an upper estuarine zone. The criteria for deciding whether there is an estuary, and where the mid-estuarine/upper estuarine cut-off lies, are the same as those outlined in mid and upper estuary sections above. The length of the estuarine section of such tributaries is the distance from the mouth at the main estuary channel to the estuarine/freshwater cut-off.

B.2.4 Marine waters

Marine waters are part of the ocean, which covers almost three-quarters of the earth's surface. They extend out from, or near, the coastline. They have a uniform salinity of about 34–36 parts per thousand (52–54 mS/cm conductivity), and are not influenced by terrestrial freshwater inputs, except during large flood events.

B.2.4.1 Open coastal waters

Open coastal waters include all coastal waters except those with some residual influence from inflowing streams (enclosed coastal waters). Therefore, open coastal waters extend outwards from the outer limit of enclosed coastal waters, or directly out from the coastline if there are no enclosed coastal waters nearby, to the three nautical mile limit of the state.

The Great Barrier Reef Marine Park Guidelines define four water types for waters offshore from the enclosed coastal zone – see next section for detail.

Mapping source for open coastal water type (including sub-types)

The source of mapping for open coastal waters is either a depth contour or other defined spatial identifier based on the decision rules outlined above (e.g. salinity, other water quality parameters), or in the absence of these, expert judgement. Depth contour information does not appear to be available for all regions, and then only for particular depths. In SEQ, for example, the basis of the Moreton Bay cut-off was a depth contour. The basis for cut-offs may therefore vary according to local information.

B.2.4.2 Great Barrier Reef Marine Park water types

The whole of this section is an extract from the GBRMPA Guidelines that describes the water types or bodies that have been defined for the GBR Marine Park. It includes further description of the demarcation between the QWQG and the GBRMPA guidelines.

Five distinct water bodies have been defined for these (GBRMPA) guidelines:

- enclosed coastal
- open coastal
- midshelf
- offshore
- the Coral Sea.

The approximate distances of the water body delineations for each of the natural resource management regions are discussed in the following paragraphs and are presented in Table B.2.

The enclosed coastal water body is adopted from the Queensland Water Quality Guidelines 2006 (EPA 2006). This adoption facilitates complementarity between Queensland and Australian Government water quality guidelines in the Great Barrier Reef Marine Park.

The seaward limit of the enclosed coastal water body is the cut-off between shallow, enclosed waters near the estuary mouth and deeper, more oceanic waters further out. For estuaries that flow directly into open oceanic waters, the seaward limit is defined as the mouth of the estuary enclosed by adapting the semicircle bay rule (6.1, Article 7, Maritime Limits and Baselines 1978).

The semicircle rule adapted is:

'A passage or estuary is closed by a semi-circle, with its diameter at the natural entrance(s) to the passage or estuary, drawn to extend beyond the entrance(s)'.

Generally, the entrance is defined by the downstream limits of the drainage catchment of the estuary (the heads). Where the heads are undefined, the catchment limits will need to be estimated using other landscape elements.

Within an enclosed bay or strait, the seaward limit may be much further out from the mouth, depending on local hydrological and topographic conditions. For estuaries flowing into an enclosed bay or strait, the seaward limit of the enclosed coastal water body should ideally be determined by site-specific studies.

The open coastal, midshelf and offshore water body delineations adopt a slightly modified version of the De'ath and Fabricius (2008) relative distance across the shelf boundaries, to recognise the enclosed coastal water body described in B.2.3.5 of the QWQG. The De'ath and Fabricius (2008) relative distance delineation assumes the shoreline has a value of zero, and the edge of the continental shelf has a value of one.

The De'ath and Fabricius (2008) coastal water body delineation extends from 0 to 0.1; inshore water body from 0.1 to 0.4; and offshore water body from 0.4 to 1.0. (Further details are provided in Table 1 and Figure 3 of the GBRMPA guidelines. Also see QWQG Table B.2 below which indicates the widths of each water type in different sections of the GBRMP.) The modification adopted in these (GBRMPA) guidelines is that the landward edge of the coastal water body delineation commences at the seaward boundary of the enclosed coastal water body rather than the shoreline. In addition, the coastal water body is renamed open coastal and the inshore water body is renamed midshelf.

Table B2: Approximate water body delineations of the open coastal, midshelf and offshore marine water bodies in the six NRM regions (Source GBRMP Guidelines 2009)

NRM region	Open coastal (km)	Midshelf (km)	Offshore (km)
Burnett-Mary	EC* - 7	7 - 28	28 - 270
Fitzroy	EC* - 20	20 -80	80 – 340
Mackay-Whitsunday	EC* - 15	15 – 60	60 – 280
Burdekin	EC* - 12	12 – 48	48 – 180
Wet Tropics	EC* - 6	6 – 24	24 – 170
Cape York	EC* - 6	6 - 24	24 - 250

EC* The seaward edge of the enclosed water body as described above.

Note: The GBRMPA guidelines can be downloaded from:
http://www.gbrmpa.gov.au/corp_site/key_issues/water_quality/draft_water_quality_guidelines

In the enclosed coastal and open coastal water bodies, re-suspension of sediments and associated contaminants occurs in the prevailing south-east wind regime at wind speeds greater than 25 knots (Orpin et al 1999). This area is also regularly subjected to freshwater plumes from major Great Barrier Reef catchment rivers (Devlin et al 2001). In some areas tidal re-suspension also contributes strongly to the enclosed coastal turbid zone (Kleypas 1996). Turbidity is generated by winds along the coast. These effects are not evident in the offshore water body, although in more extreme flood events can affect the midshelf water body.

Coral Sea waters are contained within the Marine Park, seaward of the edge of the continental shelf. At this time trigger values have not been determined for this water body and no further reference will be made to it in these (GBRMPA) guidelines.

The delineation into enclosed coastal, open coastal, midshelf and offshore water bodies is particularly relevant for comparison of the current status of identified water bodies against guideline trigger values.

Appendix C: Quality criteria for reference data to contribute to deriving local guidelines

The following table provides information on the desired quality of data to be used to derive guidelines. These are the standards to which EHP water quality data is collected. They should not be regarded as absolute standards and small variations on these may be acceptable. However, these quality levels are attainable with modern instrumentation and analysis techniques and users should strive to come close to these values.

Reference data quality criteria are shown in Table C.1. This is in addition to the following general criteria:

Table C.1: Reference data quality criteria

General criteria	**There must be a written record of instrument calibration and/or laboratory quality assurance (whichever is appropriate) for all data. The QA system should allow a reasonable estimate of potential errors in the data.**
	Individuals collecting the data must have had some form of training in sample collection.
Indicator	Maximum error allowable for indicators 1
Temperature oC	± 0.5
pH	± 0.2
Conductivity	
10–1000μS/cm	± 5
1–10 mS/cm	± 0.1
10–50 mS/cm	± 1
Turbidity NTU	
1–5	± 1
5–10	± 2
10–50	± 5
>50	± 10
Dissolved oxygen mg/l	± 0.3
Total N μg/l (N)	± 50
Oxidised N μg/l (N)	
1–10	± 2
10–50	± 4
>50	± 10
Ammonia N μg/l (N)	
1–10	± 2
10–50	± 4

General criteria	**There must be a written record of instrument calibration and/or laboratory quality assurance (whichever is appropriate) for all data. The QA system should allow a reasonable estimate of potential errors in the data.**
	Individuals collecting the data must have had some form of training in sample collection.
>50	± 10
Total P µg/l (P)	
1–10	± 2
10–50	± 4
>50	± 10
FRP µg/l (P)	
1–10	± 2
10–50	± 4
>50	± 10
Chl-a µg/l	
0.5–5.0	± 0.5
5–10	± 0.1
10–20	± 2.0
>20	± 10%

Note: 1 Error range is in same units as the corresponding indicator, except where otherwise stated.

Appendix D: Compliance assessment protocols

D.1 ANZECC 2000 default compliance protocols

The default ANZECC 2000 Guidelines approaches to assessing compliance at different levels of protection are summarised in Table D.1. These ANZECC 2000 Guidelines default approaches are focussed on assessing long term compliance with guidelines that are designed to protect against chronic effects. The ANZECC 2000 Guidelines state that (section 3.1.7, volume 1) 'for the non-biological indicators, the guideline trigger values represent the best currently available estimates of what are thought to be ecologically low-risk levels of these indicators for *chronic (sustained) exposures*'.

Table D.1: ANZECC 2000 Guidelines default approaches to assessing compliance

Stressor type	Level of protection		
	HEV	**SMD**	**HD**
Physico-chemical stressors	No change to existing condition	'A trigger for further investigation will be deemed to have occurred when the median concentration of n independent samples taken at a test site exceeds the 80th percentile of the same indicator at a suitably chosen reference site. Where suitable reference site data do not exist, the comparison should be with the relevant guideline value published in this document.' (ANZECC – section 7.4.4.1)	Similar to SMD but compare with less stringent percentile (e.g. 90th percentile) or other locally derived value
Toxicants – water	No change to existing condition	Default guideline values: 'It is recommended that action is triggered if the 95th percentile of the test distribution exceeds the default value (or stated differently, no action is triggered if 95% of the values fall below the guideline value).' Locally derived guideline values: 'For those months, seasons or flow periods that constitute logical time intervals or events to consider and derive background data, the 80th percentile of background data (from a minimum of 10 observations) should be compared with the default guideline value. This 80th percentile value is used as the new trigger value for this period if it exceeds the default guideline value provided in Section 3.4.3 of this document. Test data is compared with the new trigger values using the same principles as outlined above for physical and chemical stressors. ' (ANZECC – section 7.4.4.2)	Similar to SMD but compare with less stringent guideline value, e.g. 90% or 80% level of protection
Toxicants – sediment	No change to existing condition	'Where sediment samples within a test site clearly exceed trigger values, or are reasonably inferred to be ecologically hazardous, these guidelines recommend additional sampling to more precisely delineate contaminated zones within the site.' (ANZECC section 7.4.4.4)	No default provided – see SMD approach
Biota	No change to existing condition	Default approach similar to physico-chemical stressors.	As for physico-chemical stressors

However, the ANZECC 2000 Guidelines also state: ‘users should also be aware that short term intermittent (or pulse) exposures to very high contaminant or stressor values may also need to be managed in certain situations’, although the guidelines provide no detailed guidance on how this is to be achieved.

Thus ecosystems need to be protected against not only long term chronic effects caused by low levels of pollutants but also against acute effects caused by exposure to short pulses of high levels of pollutants, e.g. a pulse of some toxicant. In addition, there are a range of intermediate situations whereby ecosystems may be impacted through exposure to moderately high levels of pollutants for short-to-medium time periods, e.g. several weeks exposure to high nutrient levels. From an environmental management perspective, it is important that compliance issues relating to all these different scenarios are addressed. It is also important that compliance is placed in a context of the natural variability that occurs in the environment.

The following sections address compliance issues for each of the pollutant categories in Table D.1. In some cases, the Queensland guidelines default to the ANZECC 2000 Guidelines approach while for others, additional direction is provided that addresses issues including:

- long term compliance (several months/years);
- short-to-medium term compliance (weeks);
- large pulsed exceedances of guidelines (days); and
- monitoring for compliance.

D.2 Assessing compliance for physico-chemical indicators

D.2.1 High ecological value (HEV) waters

For high ecological value waters, the generic ANZECC 2000 guideline is that there should be **no change** to existing condition. This should be seen as an overriding principle. The criterion of no change beyond natural variability is prescribed not only for physical and chemical stressors in both waters and sediments but also for biological response indicators. Thus assessment needs to take into account the character of the environment and the way that the activity may adversely affect the environment, e.g. change salinity, depress dissolved oxygen, promote epiphyte growth on seagrass, increase turbidity or rate of sediment deposition. Ideally, this will include quantitative relationships between stressors and ecological indicators that respond to those stressors. These relationships can be used in predicting potential impacts and evaluating environmental management scenarios.

The no change criterion implies that not only the median but also the entire distribution of indicator values should remain unchanged. In order to fully assess this, it would be necessary to first establish the true distribution of values of all relevant indicators in the high ecological value water body. Testing for subsequent change would then involve collecting further samples and comparing their distribution with the established true distribution using established statistical protocols, e.g. Kolmogorov-Smirnov tests (Conover 1999).

This is demanding in terms of data and an alternative testing approach that involves testing compliance against 20th, 50th and 80th percentiles is given in section D.2.1.1. This approach is deemed sufficient to deal with long term compliance but, under a regime of monthly sampling, this approach is unlikely to detect medium term or pulsed events.

As a general principle, deviations from natural 20th, 50th and 80th percentiles should not occur even over periods of several weeks, except where this is due to natural fluctuations. In the situation where a discharge occurs for only part of a year or reaches a peak at certain times of the year, compliance with 20th, 50th and 80th percentiles would need to be achieved over that period. Where there is a likely time lag between the occurrence of the activity and the potential adverse ecological response, then compliance with the ecological response indicators should be assessed over that longer period. In general, any proposals for activities in HEV waters would need to demonstrate that compliance would occur even during worst-case scenario (with respect to the impacts of the activity) periods, e.g. during neap tides or low flows.

In addition to complying with 20th, 50th and 80th percentiles, activities would need to demonstrate that they would not cause short pulses of high levels of pollutants.

Significant pulses of pollutants do occur naturally, usually as a result of significant rainfall events. However, as a general principle, anthropogenic activities should not of themselves cause high level pulses of pollutants nor should they lead to increases in the magnitude or frequency of occurrence of natural pulses. Where such activities do lead to unnatural pulses, even for a few days, this would be viewed as non-compliance with the principle of no change in HEV systems. However, in practice, setting actual guideline numbers for short term extreme values is problematical. This is partly because we have limited information on the range of extreme natural values and partly because we have limited knowledge on the effects of short term pulses of many pollutants. As a general rule, the occurrence of values clearly in excess of natural 90th percentiles (or below natural 10th percentiles) during normal baseflow conditions should be viewed as likely non-compliance and be further investigated to determine if they are due to natural causes.

If values clearly in excess of natural 90th percentiles (or below natural 10th percentiles) occur during flood events, there is a greater likelihood these are due to natural conditions. However, there is a possibility that an anthropogenic activity in the HEV may materially increase the magnitude of the natural pulse. This requires an assessment of whether the magnitude of the pulse is materially different from natural conditions.

Monitoring for compliance in HEV waters

For high ecological value waters, the criterion of no change beyond natural variability is prescribed for biological indicators, physical and chemical stressors and sediments, habitat and flow. To ensure this is achieved, a comprehensive water quality assessment program is required. The ANZECC 2000 Guidelines provide a procedural framework for monitoring water quality (see section 7.1 of ANZECC). Key aspects of this framework are emphasised below.

For high ecological value sites, a water quality assessment program should include four to six of the following aspects (see ANZECC 2000 (7.2.1.1)):

- if there are contaminants other than nutrients, whole effluent toxicity testing;
- water and sediment physico-chemistry;
- an ‘early detection’ indicator for water or sediment (whichever harbours greatest risk to the aquatic ecosystem from the waste substances);
- a quantitative biological indicator;
- a community metabolism indicator; and
- a rapid biological assessment indicator.

Where baseline data is not sufficient, additional monitoring is recommended (see ANZECC 2000 (7.2.1.2)).

To answer questions about the causes of pulsed effects, study designs are available that can infer whether measured changes observed in indicator values may be best attributed to the anthropogenic activity or natural variation. For activities potentially affecting HEV areas, preference is given for multiple before-after control-impact (MBACI) designs as these give greatest confidence that any observed differences between control and impact sites are not simply a result of natural variation (See ANZECC 2000 (7.2.2)). It would be expected that any activity intending to establish in or potentially affect an HEV area would, for short term pulse events, design to meet the conservative 90th/10th percentile guide mentioned above and carry out an effective MBACI monitoring program once established to demonstrate that if any excursion was measured above these values, it was due to natural factors.

In the long term EHP will characterise the natural range of extreme values and set additional guidelines. Such guidelines would assist in managing diffuse inputs to waters, e.g. if suspended solids levels (or loads) for natural flood event were identified in pristine catchments this information would provide a yardstick to assess concentrations or loads in waters that were being significantly impacted by catchment activities. Assessment thus relies on comparing effects of activities with relevant background conditions. The MBACI monitoring programs mentioned above can be used to develop inferences for specific activities encompassing these periods.

It is important in monitoring program design to ensure that sampling is intensive enough to detect effects larger than the acceptable natural changes in the chosen indicators and avoid type II errors. Type II errors occur when a study concludes that an impact is not occurring when one in fact is. An effective study must have a good chance of detecting an impact if one occurs. EHP has frequently set this at a minimum 80% chance. ANZECC 2000 Guidelines (7.2.3.3) provides a discussion of error rates and statistical power. This is a useful yardstick to persons carrying out or designing monitoring programs to enhance the effectiveness of their programs.

D.2.1.1 A statistical protocol for assessing medium to long term compliance in HEV waters

For the purposes of the QWQG, the testing procedure for high ecological value waters has been simplified so it is limited to testing of the 20^{th}, 50^{th} and 80^{th} percentiles for change rather than the entire distribution. It is considered that for most purposes, assessing change at all three percentiles is sufficient to address the no-change criterion. A change detected at any of these percentiles would be considered a rejection of the no-change hypothesis.

It is a requirement for monitored variables to be sensitive to changes induced by the potential discharge/activity. These variables may include additional indicators to those defined in the Queensland guidelines, depending upon the specific circumstances of activity. As an example, for a sea cage aquaculture it might be desirable to monitor organic carbon levels, redox potential of benthic sediments and seagrass health in addition to common water quality indicators.

The detailed methods for assessing change are:

1. Method to be employed for waters in which the 'true' (i.e. population) 20th, 50th and 80th percentiles have already been defined in the Queensland guidelines:
   a. Collect a minimum of 24 test values over the relevant period (12 months if a continuous activity or alternatively a shorter period for activities where discharge occurs for only part of the year).
   b. Calculate the 20th, 50th and 80th percentiles[1] of the test values.
   c. Calculate the 75 percent confidence[2] intervals around each percentile.
   d. Compare the sample percentiles with the defined population percentiles.
   e. If the defined population percentiles lie within the confidence interval around each sample percentile this is taken as compliance. If any of the defined population percentiles fall outside the sample percentiles the no-change hypothesis is rejected[3].

Note 1. There are several methods for calculating the confidence interval around percentiles. One method is that of Conover (1999).

Note 2. For these HEV waters, 75% confidence intervals rather than 95% intervals are proposed. While this increases the chance of Type 1 errors it reduces the chance of Type 2 errors, which is considered particularly important in these high value waters.

Note 3. Given the use of 75th rather than 95th percentile confidence intervals, a minor breach of the guideline would initially be viewed as a matter for further investigation and possibly increased sampling rather than an immediate trigger for a major remediation effort.

<u>Calculation of confidence intervals for percentiles</u>

This is an interval that covers a proportion *p* of the population with a stated level of confidence (1-α) and can be calculated using the following steps:

(a) Arrange the *n* observations in ascending order.

(b) Calculate the rank of the lower value of the confidence interval by determining the $\frac{\alpha}{2}$ quartile of a binomial distribution (of size *n* and probability equal to the percentile of choice).

(c) Select the number from the sorted list of observations that relates to this rank as the lower value of the tolerance interval.

(d) Calculate the rank of the upper value of the confidence interval by determining the $\left(1-\frac{\alpha}{2}\right)$ quartile of a binomial distribution (again of size *n* and probability equal to the percentile of choice).

(e) Select the number from the sorted list of observations that relate to this rank as the upper value of the confidence interval.

Example:

Consider a hypothetical location where 24 samples for chlorophyll-a have been obtained. The 20th, 50th and 80th 20/50/80 guideline percentile guideline values for this location are defined as 1.3646, 2.4596 and 4.4333 respectively.

Arrange the 24 observations in ascending order as follows.

Rank	Chlorophyll-a
1	0.47
2	0.6358
3	1.0666
4	1.249
5	1.2737
6	1.3216
7	1.3426
8	1.6141
9	1.7267
10	1.7929
11	2.031
12	2.1156
13	2.783
14	2.8781
15	2.9027
16	2.9979
17	3.2511
18	3.5862
19	3.639
20	4.327
21	4.5102
22	6.7137
23	7.8133
24	10.6659

Calculate the 20th, 50th and 80th percentiles from this data (one method of doing this is by using the PERCENTILE ( ) function in Microsoft Excel). These are calculated as 1.34024, 2.4493 and 4.9142 respectively.

Now calculate the upper and lower confidence intervals for the 20th, 50th and 80th percentiles (one method of doing this is by using the CRITBINOM ( ) function in Microsoft Excel). For a 75 percent confidence interval α is 25 percent (or 0.25). The sample size (n) is 24, so the rank of the lower value of the tolerance interval for the 20th percentile is given by the $\frac{0.25}{2}$ quartile of a binomial distribution of size 24 with probability 0.2.

The upper value of the interval is given by the $\left(1-\frac{0.25}{2}\right)$ quartile of a binomial distribution of size 24 with probability 0.2.

Proceeding with this, the lower and upper ranks for the confidence intervals for the 20th, 50th and 80th percentiles are (3, 7), (9, 15) and (17, 21). This means that the 75 percent confidence intervals for the 20th, 50th and 80th percentiles are (1.0666, 1.4426), (1.7267, 2.9027) and (3.2511, 4.5102), i.e. the values that correspond to these ranks in the sorted sample.

Each of the intervals includes the guideline values for the 20th, 50th and 80th percentiles so this hypothetical location is compliant with them.

2. **Method to be employed for waters in which the 'true' 20th, 50th and 80th percentiles have not been defined for a high ecological value water:**
    a. The first task is to estimate the true population percentiles for the HEV waters in question (ideally 24 samples over two years).
    b. Once true population percentiles have been estimated, apply the procedures as defined in (1) above.
    c. If the activity and the period of potential impact are to be confined for part of a year, e.g. only occur in summer, population percentiles may be calculated from samples taken over the relevant period. If the activity were to take place in other periods, e.g. seasons, additional samples for the additional periods would need to be obtained to provide an equivalent estimate.

Reference

Conover, W.J. (1999), *Practical nonparametric statistics*, third edn, John Wiley & Sons, New York.

D.2.2 Slightly to moderately disturbed waters

For SMD waters, the ANZECC 2000 Guidelines default approach to assessing compliance is defined as:

'A trigger for further investigation will be deemed to have occurred when the median concentration of *n* independent samples taken at a test site exceeds the eightieth percentile of the same indicator at a suitably chosen reference site.'

The question of what is an appropriate number for 'n' is discussed in the ANZECC 2000 Guidelines (vol 1, section 7.4.4.1, part 4). ' The choice of sample size at the test site is arbitrary, although there are implications for the rate of false triggering. For example, a minimum resource allocation would set n=1 for the number of samples to be collected each month from the test site. It is clear that the chance of a *single* observation from the test site exceeding the 80th percentile of a reference distribution which is *identical* to the test distribution is precisely 20%. Thus the Type I error in this case is 20%. This figure can be reduced by increasing n. For example, when n=5 the Type I error rate is approximately 0.05. The concomitant advantage of larger sample sizes is the reduction in Type II error (the probability of a false no-trigger).'

This suggests that ideally n *should be 5 or greater. However, setting* n *at 3 would still give a fairly low probability of getting a false trigger or no-trigger.*

Another issue that arises is the minimum period over which this approach may be applied. The ANZECC 2000 Guidelines provide little guidance on this. Physico-chemical guidelines are mostly based on 20th/80th percentiles of reference data. This implies that for 20% of the time even reference sites will exceed the guideline. Thus, even if five or more samples are collected on one day and the median exceeds the guideline, this does not necessarily mean the site is out of compliance; the system may simply be naturally cycling through one of its >80%ile periods. Exactly what is an appropriate minimum period is a grey area. However, it is suggested that exceedance of the guideline based on a minimum of several weeks monitoring would provide greater certainty that a site was out of compliance. Some biological indicators tend to cycle over longer periods and therefore the minimum time periods for assessing compliance with these may need to be longer.

The magnitude of exceedances by individual values is also obviously important. Where a single test sample shows that a site is well outside the guideline this might trigger an immediate response whereas a small exceedance might simply be flagged for review in light of the results of subsequent samples as discussed above. The use of control charts as recommended in the ANZECC 2000 Guidelines (vol. 1, section 7.4.4.1) is strongly supported.

Section D.2.1 (HEV waters) discussed the need for compliance to be achieved both over the long term and in the *medium term when all the same general considerations apply to SMD waters. Thus the approach of comparing medians with guidelines might be focussed on long time periods or it might be focussed on medium periods of high risk.*

Similarly, the issue of pollutant pulses needs to be addressed in SMD waters. Clearly, large pulses may occur occasionally without much affecting long or even medium term medians and therefore fail to trigger non-compliance. However, large short term exceedances, e.g. a single day of very low dissolved oxygen or pH values, can obviously cause significant impacts and are clearly undesirable. Therefore a different approach to compliance is required. As with HEV waters, as a general principle, activities in or adjacent to SMD waters should not give rise to large pulses of pollutants during dry weather periods nor should such activities significantly increase natural wet weather pulses. In the longer term it may be possible to set guidelines for high flow conditions based on pollutant levels in reference waters under similar conditions. However, at present the data available for this is limited. For a few indicators, dissolved oxygen and pH, some recommended minimum values are provided in the guidelines tables. However, for other indicators, e.g. nutrients, no values can be set at this stage. At a local level, the effects of activities on pollutant pulses can be assessed by comparing test sites with upstream conditions (provided these are not also impacted) or with nearby reference sites.

Under dry weather baseflow conditions, pulses of pollutants would not normally occur. It is therefore proposed that as an interim approach, individual values that are recorded under normal baseflow conditions and that are clearly in excess of the natural 95th percentile (or below the 5th percentile) should be viewed as non-compliance and should trigger further investigation to determine if this is due to natural causes.

Monitoring for compliance in SMD waters

Much of the discussion in the HEV waters section (D.2.1) is relevant here. Monitoring should include both stressor indicators and biological response indicators and should be focussed on the risks present at the sites under investigation. Monitoring designs are available to assess pollutant pulses. The main difference with SMD waters is that the guidelines against which monitoring data is compared are slightly less stringent.

D.2.3 Highly disturbed waters

For highly disturbed waters ('HD') the approaches would be similar to those for SMD waters but comparisons would be with less stringent guideline values. Use of reference site 10th percentile and 90th percentile results for guideline values instead of the 20th/80th used for SMD waters is suggested by the ANZECC 2000 Guidelines. Alternatively, guideline values can be derived from reference sites that are disturbed but still have good ecosystem values. Where actions are being taken to restore highly disturbed waters, improvements in the degree of non-compliance with SMD guidelines values would also be useful in evaluating compliance. For evaluating pulse events, the same approach recommended for SMD waters applies, i.e. 5th/95th rule. It is recognised that the degree and likelihood of potential non-compliance with guideline values will be greater in HD waters, but this is inherent in the state of these waters.

D.3 Assessing compliance for toxicants in water and sediments – all levels of protection

Toxicants in waters

For long or medium-term assessment, users should adopt the methods outlined in the ANZECC 2000 Guidelines (vol. 1 sections 7.4.4.2 and 7.4.4.4). Issues relating to managing pulsed events are discussed in volume 1, section 3.4.3.2 and volume 2, section 8.3.5.6.

Toxicants in sediments

Application of the sediment quality guidelines is discussed in the ANZECC 2000 Guidelines (vol. 1, section 3.5.5 and section 7.4.4.4). A decision tree for application of the sediment quality guidelines is outlined in Figure 3.5.1 in section 3.5.5. An initial step in this decision tree is an assessment of whether test site values are above or below the sediment guideline trigger values. It is recommended that this assessment should be undertaken using the protocol given in the National Ocean Disposal Guidelines for Dredged Material – sections 3.10.2 and 3.10.5. This protocol states that 'A guideline value is exceeded if the upper 95% confidence limit of the mean (of a set of test site samples) exceeds the specified (guideline) value'.

D.4 Assessing compliance for biological indicators – all levels of protection

The derivation of biological guidelines or triggers is discussed at length in the ANZECC 2000 Guidelines (see particularly vol. 1, section 3.2). This includes discussion of what effect-sizes are appropriate in setting guideline values.

Commonly, however, biological guidelines are derived using the reference approach and guideline values are set in terms of percentiles of the reference distribution, i.e. using the same approach as is used for physico-chemical indicators. This was the approach taken in development of biological guidelines for the South-east Queensland region.

For high ecological value waters the permitted effect-size will be no change. Where 20th, 50th and 80th percentiles have been defined for a particular biological indicator, then the ‘no change’ test outlined in section D.2.1.1 could be applied.

For slightly to moderately disturbed (SMD) waters, methods appropriate to different situations are discussed in the ANZECC 2000 Guidelines. Where guidelines are based on 20th/80th percentiles, the compliance assessment processes outlined for physico-chemical indicators can be applied. The only caveat is that because (for reasons of cost) biological indicators tend to be assessed less frequently than physico-chemical indicators, a more precautionary approach needs to be taken. Thus, if two consecutive samples exceed the guideline then this should trigger some response.

As with physico-chemical indicators, short term pulses in biological indicators (e.g. very high chlorophyll-a value indicating a strong algal bloom) are clearly undesirable. As a general principle, anthropogenic activities should not increase the frequency or magnitude of naturally occurring pulses in biological indicators. A similar approach to that used for physico-chemical indicators can be applied as a default. Thus, pulse values should not exceed the reference 90th percentile or fall below the 10th percentile (whichever is appropriate) in HEV waters or exceed the 95th percentile or fall below the 5th percentile in SMD waters during normal baseflow conditions. Where exceedances occur these should be evaluated with reference to prior conditions and if no natural cause is apparent this should be viewed as potential non-compliance.

Appendix E: Definition of water quality indicators used in QWQG

Table E.1 summarises some commonly used physico-chemical water quality indicators. The QWQG establishes guideline values (numbers) for the majority of these indicators (refer section 3). Details of ecological indicators (of which a number are used in the Ecosystem Health Monitoring Program – EHMP) are included in tables E.2 and E.3. The QWQG contains guideline values for a number of these ecological indicators for waters from Noosa south to the NSW border (refer section 3).

Table E.1: Physico-chemical water quality indicators

Indicator category	Indicator (and hotlink on how indicator is monitored/analysed)	Explanation of indicator
Nutrients		The nutrients nitrogen and phosphorus are essential for plant growth. High concentrations indicate potential for excessive weed and algal growth. Nutrients in the water column are made up of an inorganic component which is in the dissolved form (e.g. nitrate plus nitrite, ammonia and filterable reactive phosphorus) and an organic component, which is bound to carbon (e.g. organic nitrogen). The organic component can be either dissolved or particulate. Different forms of nutrients are measured for different purposes. The most commonly measured forms of N and P are defined below.
– Nitrogen	Total N (TN)	Includes all forms of N in a sample
	Oxidised N	Sum of nitrate N (NO3) and nitrite N (NO2)
	Ammonia N (NH3)	Includes both ionised and unionised forms of ammonia
	Dissolved inorganic N (DIN)	Sum of oxidised N and ammonia N
	Organic N	Calculated by subtracting ammonia N from total N
	Particulate N (PN)	Includes all forms of N that **do not** pass through a 0.45µm filter
	Total dissolved N (TDN)	Includes all forms of N that **do** pass through a 0.45µm filter
	Dissolved organic N (DON)	Calculated by subtracting DIN from TDN
– Phosphorus	Total P (TP)	Includes all forms of P in a sample
	Filterable reactive P (FRP)	Includes all forms of P that pass through a 0.45µm filter **and** react with molybdenum blue reagent – this fraction is usually very largely comprised of orthophosphate (PO4)
	Particulate P (PP)	Includes all forms of P that **do not** pass through a 0.45µm filter
Microalgal growth	Chlorophyll-a	An indicator of algal biomass in the water. An increase in chlorophyll-a indicates potential eutrophication of the system. Consistently high or variable chlorophyll-a concentrations indicate the occurrence of algal blooms, which can be harmful to aquatic ecosystems.

Indicator category	Indicator (and hotlink on how indicator is monitored/analysed)	Explanation of indicator
Water clarity	Suspended solids	Small particles (soil, plankton, organic debris) suspended in water. High concentrations of suspended solids limit light penetration through water, and cause silting of the benthic (bottom) environment.
	Turbidity	A measure of light scattering by suspended particles in the water column. It can provide an indirect indication of both light penetration and suspended solids but the relationships between turbidity and these other indicators vary in different waters.
	Secchi depth	The depth to which the black and white markings on a Secchi disc can be clearly seen from the surface of the water provides an indication of light penetration.
Oxygen	Dissolved oxygen	Essential for life processes of most aquatic organisms. Low concentrations of dissolved oxygen can indicate the presence of excessive organic loads in the system but may occur naturally in stagnant pools. High values can indicate excessive plant production (i.e. eutrophication). Most aquatic organisms require a certain minimum amount of dissolved oxygen in the water in order to survive.
pH	pH	A measure of the acidity or alkalinity of the water. Changes to pH can be caused by a range of potential water quality problems (e.g. low values due to acid sulphate runoff). Extremes of pH (less than 5 or greater than 9) can be toxic to aquatic organisms, although some waterways (e.g. wallum streams) have naturally acid waters (as low as pH 3.6) and ecosystems adapted to these conditions.
Salinity	Conductivity	A measure of the amount of dissolved salts in the water, and therefore an indicator of salinity. In fresh water, low conductivity indicates suitability for agricultural use. In salt waters low conductivity indicates freshwater inflows such as stormwater runoff. Under natural conditions, conductivity is highly dependent on local geology and soil types. Appendix G provides information on conductivity values in a set of 18 defined salinity zones throughout Queensland. For each zone, the guidelines provide a range of percentile values based on data from all the sites within that zone. This provides a useful first estimate of background conductivity within a zone. However, even within zones there is a degree of variation between streams and therefore the values for the zone would still need to be ground truthed against local values.
Toxicants in sediments	Trace elements in sediments	Trace elements (primarily metals and metalloids) are present in the environment naturally and derive principally from weathering of rocks and soils. Many elements are essential for aquatic organisms. However, high concentrations of some elements in sediments can be toxic to aquatic organisms and may indicate contamination from domestic or industrial sources.
	Pesticides in sediments	Commonly used pesticides accumulate in the sediments of aquatic environments and may reach concentrations toxic to aquatic organisms.

Table E.2: Ecological Indicators – freshwater

Ecological indicator	Explanation
Fish	
Percent of native species expected (PONSE)	The number of native species observed compared to the number of native species predicted by regression tree model.
Percent exotic individuals	The proportion of fish individuals in a river reach that are exotic species (species introduced from other countries).
Fish assemblage O/E50	The ratio of the observed number of species (O) to the expected number of species (E) at a given probability of occurrence level (e.g. 50%) can be used as a summary of ecosystem health on the basis of species composition.
Macroinvertebrate	
PET richness	It is generally accepted that three orders of aquatic insects, the Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies) – the PET taxa – are highly sensitive to human disturbance. PET richness is the total number of families in these three orders that are present in a sample.
Family richness	Family richness is the total number of different aquatic macroinvertebrate families that are present in a sample.
SIGNAL index	The SIGNAL index (stream invertebrate grade number average level) allocates a sensitivity grade number based to macroinvertebrate families based on their sensitivity to various water quality changes (Chessman, 1995). SIGNAL values range from 1 (most tolerant) to 10 (most sensitive). The SIGNAL index value is calculated by averaging the sensitivity grade numbers of the taxa present in a sample.
Ecological processes	
Gross primary production (GPP)	Gross primary production measures the total amount of carbon that is fixed by photosynthesis (conversion of CO2 to organic C) of benthic aquatic plants over 24 hours.
Respiration (R24)	Respiration is the conversion of organic carbon to CO_2 gas and involves the consumption of oxygen (O_2). It can result from the metabolic activity of plants, animals or bacterial decomposition. The night rate of benthic O_2 consumption is measured and it is assumed that the daytime respiration rate is similar.
Stable isotope delta ^{13}C	*Delta ^{13}C* is a measure of the ratio of two stable isotopes of carbon (12C and 13C). This is not a direct measurement of river health; however, river processes such as GPP/R24 and methanogenesis alter the ä13C ratio allowing this measure to be used as a relatively cheap surrogate for estimating overall rates of carbon cycling in a stream.
Nutrient cycling	
Algal bioassays	This indicator provides a standard substrate at all sites to measure the rate of algal biomass accumulation over four weeks under ambient and nutrient enriched conditions.
Stable isotope delta ^{15}N	*Delta ^{15}N* is a ratio in ‰, of the stable isotopes of nitrogen (15N relative to 14N). Changes in this ratio can be used to detect changes in the natural cycling of N in the environment. Any increase in the rate that nitrogen is processed by the microbial loop and/or a decrease in the efficiency of denitrification will result in an increase in the ä15N values of aquatic plants and/or sediment. For this reason the use of stable isotope analysis of aquatic plants is recommended as an inexpensive way of identify sites where the nitrogen cycle has been disturbed.

Table E.3: Ecological indicators – estuaries and marine

Ecological indicator	Explanation
Maximum depth limit of seagrass	The depth to which the seagrass *Zostera muelleri* grows, provides an indication of the water clarity at a site, as the depth to which seagrass can grow is directly dependent on the penetration of light through the water. Water clarity in south-east Queensland is usually affected by the amount of suspended sediment in the water, either from terrestrial inputs or sediment resuspension.

Appendix F: Currently identified reference sites in Queensland

The following is a list of sites that have been used as reference sites by the department. These are provided as a resource for users wishing to identify reference sites for a particular purpose. However, before using these sites for reference purposes it is recommended that users check their current condition as this may have changed in recent times.

Freshwater reference sites		LATITUDE	LONGITUDE
REGION	SITE NAME		
East Cape York	Harmer River at Middle Peak	-11.9786	142.8481
East Cape York	Olive River at Jon’s Swamp	-12.2581	142.7869
East Cape York	Lockhart River at Nundah	-13.1061	143.3972
East Cape York	Pascoe River at Fall Creek	-12.8814	142.9818
East Cape York	Pascoe River at Garraway	-12.6608	143.0477
East Cape York	Stewart River at Telegraph Line	-14.174	143.3968
Wet Tropics	McIvor River at Parkers Hut	-15.1208	145.0739
Wet Tropics	Stewart River at main road bridge	-16.2936	145.3181
Wet Tropics	Little Falls Creek at Whyanbeel Creek junction	-16.3936	145.3378
Wet Tropics	Daintree River at Creb Crossing	-16.1997	145.2908
Wet Tropics	Emmagen Creek at Cape Tribulation	-16.0411	145.4578
Wet Tropics	Hutchinson Creek at Cape Tribulation	-16.2164	145.4228
Wet Tropics	Clohesy River at Reids Pocket	-16.9242	145.5878
Wet Tropics	Stoney Creek at picnic area	-16.8756	145.6672
Wet Tropics	Freshwater Creek downstream of Crystal Cascades	-16.9572	145.6861
Wet Tropics	Freshwater Creek at Lower Freshwater Rd Crossing	-16.8769	145.6997
Wet Tropics	Mulgrave River at Goldsborough	-17.2514	145.7733
Wet Tropics	Fishery Falls Creek at Bruce Hwy	-17.1853	145.8839
Wet Tropics	Tributary at Goldsborough	-17.2461	145.7753
Wet Tropics	Behana Creek at Flick’s Bridge	-17.1533	145.8211
Wet Tropics	Henrieta Creek at Palmerston Hwy	-17.5994	145.7569
Wet Tropics	Nth Johnstone River at Malanda Falls	-17.3561	145.5853
Wet Tropics	Nth Johnstone River at Nerada	-17.5322	145.845
Wet Tropics	Thiaki Creek at Meragallan Rd	-17.4208	145.5369

Freshwater reference sites		LATITUDE	LONGITUDE
REGION	**SITE NAME**		
Wet Tropics	Ithaca Creek at Clarks Track	-17.3942	145.6208
Wet Tropics	Sth Johnstone River at Corsi's	-17.6	145.8997
Wet Tropics	Sth Johnstone River at Forestry Camp	-17.6533	145.7169
Wet Tropics	Bombeeta Creek at Trambridge	-17.7069	145.9419
Wet Tropics	Kaarru Creek at causeway	-17.6475	145.7306
Wet Tropics	Boulder Creek at Tully Intake	-17.8722	145.9108
Wet Tropics	Jarrah Creek at Army	-17.8219	145.7911
Wet Tropics	Tully River at Old Culpa	-17.9256	145.6281
Wet Tropics	Bulgun Creek at Alligators Nest Park	-17.8878	145.9292
Wet Tropics	Five Mile Creek at swimming hole	-18.3294	146.0422
Wet Tropics	Nth Murray River at Aladoon Rd	-18.0939	145.7761
Wet Tropics	Sunday Creek at rail crossing	-18.4939	146.1744
Wet Tropics	Herbert River at Cashmere crossing	-18.1375	145.3372
Wet Tropics	Vine Creek at Mt Ronald	-17.6703	145.4358
Wet Tropics	Millstream Creek at Diversion Weir	-17.6736	145.4122
Wet Tropics	Millstream Creek upstream of Vine Creek	-17.6736	145.4114
Wet Tropics	Herbert River below gorge	-18.4028	145.7578
Wet Tropics	Herbert River at Gunnawarra	-17.9222	145.21
Wet Tropics	Elphinstone Creek at Elphinstone Rd	-18.4919	146.0178
Wet Tropics	Broadwater Creek at Broadwater Park	-18.4228	145.9453
Wet Tropics	Herbert River at Mandalee Crossing	-17.7267	145.2525
Wet Tropics	Waterview Creek at forestry plot	-18.8467	146.1239
Wet Tropics	Ripple Creek at Genas Rd.	-18.5822	146.1314
Wet Tropics	Dalrymple Creek at Hawkins Creek Rd	-18.5492	146.0375
Wet Tropics	Hann_R Kalinga Homestead	-15.2026	143.8564
Wet Tropics	Jungle_Ck Kalinga	-15.3492	143.7736
Wet Tropics	Normanby River at Battlecamp	-15.2822	144.8377
Wet Tropics	Laura River at Coalseam Creek	-15.6173	144.4842
Wet Tropics	Kennedy R. at Fairlight	-15.5654	144.019

Freshwater reference sites		LATITUDE	LONGITUDE
REGION	SITE NAME		
Wet Tropics	Deighton	-15.4922	144.5281
Wet Tropics	E. Normanby River at D'ment Rd.	-15.7727	145.0136
Wet Tropics	West Normanby River at Mt Selheim	-15.7592	144.9746
Wet Tropics	Jeannie R. Warooka Rd	-14.7601	144.8551
Wet Tropics	Starcke River at Causeway	-14.8175	144.9697
Wet Tropics	Endeavour River	-15.4249	145.0729
Wet Tropics	Endeavour River at Flaggy	-15.4253	145.0636
Wet Tropics	Annan River at Mt. Simon	-15.6455	145.1921
Wet Tropics	Annan River at Beesbike	-15.6894	145.2075
Wet Tropics	Daintree River at Bairds	-16.1817	145.2808
Wet Tropics	Bloomfield River at China Gap	-15.99	145.2861
Wet Tropics	Saltwater Creek at O'Donoghue Rd	16.4297	145.3478
Wet Tropics	Whyanbeel Creek at upstream of Little Falls Creek	-16.3914	145.3369
Wet Tropics	Hartleys Creek upstream of Vievers Creek	-16.6531	145.5513
Wet Tropics	Flaggy Creek at recorder	-16.7808	145.5297
Wet Tropics	Clohesy1	-16.9117	145.5633
Wet Tropics	Kauri Creek at main road	-17.1356	145.5975
Wet Tropics	Hills Creek at Hamilton Rd	-16.9456	145.8289
Wet Tropics	Taylors Creek at Warraker	-17.5181	145.9128
Wet Tropics	Nitchaga Creek at Upper Tully	-17.8275	145.5628
Wet Tropics	Cochable Creek at powerline	-17.745	145.6281
Wet Tropics	Koolmoon Creek at Ebony Rd	-17.7361	145.555
Wet Tropics	Herbert1	-18.1383	145.3383
Wet Tropics	Blencoe River at Blencoe Falls	-18.205	145.5372
Wet Tropics	Millstr1	-17.6036	145.4769
Wet Tropics	Cameron_	-18.0681	145.3408
Wet Tropics	Millstream River downstream of Archer Creek	-17.6522	145.3408
Wet Tropics	Blunder Creek at Wooroora	-17.7375	145.4364
Wet Tropics	Rudd Creek at Gunnawarra	-17.9161	145.1497

Freshwater reference sites		LATITUDE	LONGITUDE
REGION	SITE NAME		
Central	Little Crystal Creek at Paluma Rd	-19.0164	146.2658
Central	Little Crystal Creek at Moodys	-18.9819	146.2856
Central	Bluewater Creek at foothills	-19.2397	146.4894
Central	Alligator Creek at Bowling Green Bay NP	-19.4367	146.9458
Central	St Margaret Creek at Bruce Hwy	-19.4777	147.0386
Central	Burdekin River at Reedy Brook	-18.6992	145.0556
Central	Burdekin River at Valley of Lagoons	-18.6447	145.1186
Central	Star River at Hervey Range Road	-19.4342	145.9889
Central	Fletcher Creek at main road	-19.8158	146.0539
Central	Reedy Brook at Reedy Brook	-18.6867	145.0469
Central	Burdekin River at Big Bend	-19.8469	146.1422
Central	Burdekin River at Hervey Range Rd	-19.4392	145.8594
Central	Lolworth Creek at Lochwall	-19.8719	145.8472
Central	Urannah Creek upstream of station	-20.9117	148.3797
Central	Sandy Creek at Cathu Plateau	-20.7539	148.45
Central	Lizzy Creek at pipeline	-21.1814	148.3492
Central	Small Creek at Mt William	-21.0353	148.5972
Central	Menildon	-20.1692	148.1608
Central	Don River at Pretty Bend Crossing	-20.353	148.1202
Central	Dryander Creek near quarry	-20.2781	148.5806
Central	Impulse Creek at state forest	-20.3531	148.7264
Central	Repulse Creek upstream of Impulse Creek junction	-20.3642	148.7353
Central	Boulder Creek near Mt Charlton	-21.0106	148.7181
Central	O’Connell River at Cathu	-20.8322	148.6123
Central	Pandanus Creek at Cathu Forest Stn	-20.7992	148.5417
Central	Macquarie Creek at McKays Rd	-21.0197	148.8356
Central	Murray Creek below Mt Charlton	-21.0142	148.7378
Central	Boundary Creek at Mt Bullock	-20.6975	148.5281

Freshwater reference sites		LATITUDE	LONGITUDE
REGION	SITE NAME		
Central	Cattle Creek at North Branch	-21.1233	148.575
Central	Finch Hatton Creek at picnic grounds	-21.0747	148.6364
Central	Finch Hatton Creek at swimming hole	-21.09	148.6317
Central	Blackwaterhole Creek at Junction	-21.3172	148.8533
Central	Middle Creek upstream of Teemburra Dam	-21.1822	148.6422
Central	Rocky Dam Creek near deer farm	-21.7042	149.2686
Central	Carmila Creek at Carmila West	-21.8969	149.3078
Central	Stony Creek at Blackdown	-23.7842	149.0072
Central	Nogoa River at Spyglass Peak	-24.8258	147.1914
Central	Mimosa Creek at Eastbrook	-23.9014	149.2325
Central	Mimosa Creek at Blackdown Tableland	-23.7869	149.0772
Central	Denison Creek at Retreat	-21.4814	148.8114
Central	Funnel Creek at Bolingbroke	-21.6022	149.0753
Central	Carnarvon Creek at gorge	-25.0633	148.2311
Central	Calliope River at Mt Alma	-24.0764	150.8361
Central	Colosseum Creek at Bruce Highway	-24.4444	151.5597
Central	Granite Creek at Korenan	-24.4653	151.6642
Central	Baffle Creek at Westwood Range	-24.3089	151.6494
Central	Eurimbula Creek at Eurimbula NP	-24.2	151.7889
Central	Possum Creek at Mungy Rd	-25.2561	151.5086
Central	Holsworthy Creek upstream of Campoven Creek	-24.8211	150.6689
Central	St. Johns Creek at AMTD 7.1km	-25.5897	151.1475
Central	W. Burnett River at Goondicum	-24.8869	151.4331
Central	Burnett River upstream of Upper Burnett Dam site	-25.0586	151.3264
Central	Auburn River at AMTD 4.64km weir site	-25.66	151.175
Central	Auburn River at Auburn Homestead	-25.9567	150.6142
Central	Sandy Creek at environmental park	-25.1394	152.1681
Central	Bluewater Creek at Bluewater	-19.1825	146.5483
Central	Mt Picca	-19.775	146.9569

Freshwater reference sites		LATITUDE	LONGITUDE
REGION	SITE NAME		
Central	Major_Creek	-19.6719	147.0247
Central	Burdekin River at Sellheim	-20.0003	146.4372
Central	Burdekin5	-20.6425	147.1401
Central	Bogie River	-20.1547	147.5417
Central	Keelbottom Creek at Keelbottom	-19.3719	146.3589
Central	Basalt River at Bluff Downs	-19.6825	145.5394
Central	Burdeki2	-19.1683	145.4194
Central	Burdekin River at Blue Range	-19.1719	145.4269
Central	Fletcher	-19.8172	146.0519
Central	Burdekin River at Mt Fullstop	-19.2073	145.495
Central	Burdekin River at Lucky Downs	-18.8789	144.9733
Central	Star_R L	-19.3795	146.0458
Central	Clarke River	-19.5861	144.8222
Central	Kangaroo	-18.9333	145.6658
Central	Gray Creek	-19.0233	144.9786
Central	Maryvale	-19.5883	145.2186
Central	Wyandotte Creek at Wyandotte	-18.7472	144.8322
Central	Burdeki7	-18.5022	145.2447
Central	Fanning_	-19.7164	146.4381
Central	Running River at Mt Bradley	-19.132	145.9085
Central	Burdekin River at Lake Lucy dam site	-18.5154	145.1843
Central	Bowen River	-20.9867	148.1353
Central	Emu Creek T	-20.8008	148.1636
Central	Grant_Ck	-20.82	148.3089
Central	Broken River at old racecourse (GS)	-21.1958	148.4458
Central	Belyando River at Gregory Developmental Rd	-21.5353	146.8589
Central	Cape River at Inland Hwy	-21.0003	146.4227
Central	Suttor_1	-21.229	146.9134
Central	Suttor River at St Anns	-21.2289	146.9153

Freshwater reference sites		LATITUDE	LONGITUDE
REGION	SITE NAME		
Central	Cape_R P	-20.4769	145.4736
Central	Pallaman	-20.6075	146.6425
Central	Mistake Creek at Twin Hills	-21.9565	146.9422
Central	Don_R Id	-20.2917	148.1158
Central	Elliot River	-19.935	147.8389
Central	Don River at Reeves	-20.1508	148.1539
Central	Jolimont Creek at Mt Roy	-21.0358	148.8589
Central	Connors River at Mt Bridget	-22.0383	149.1286
Central	Connors	-22.3408	148.9508
Central	Funnel Creek at Main Rd	-21.7783	148.9267
Central	Lotus Creek	-22.35	149.1047
Central	Calliope River at Castlehope	-23.9861	151.0992
Central	Calliop1	-24.0719	150.8272
Central	Baffle Creek at Roadview	-24.5156	151.7356
Central	Baffle Creek at Mimdale	-24.515	151.7356
Central	Kolan River at Springfield	-24.7544	151.5858
Central	Gin Gin Creek at dam site	-24.9692	151.8894
Central	Three Moon Creek at Meldale	-24.6858	150.9619
Central	Three Moon Creek at Cania Gorge	-24.7253	151.0069
Central	Monal Creek at Upper Monal	-24.6147	151.1122
Central	Baywulla Creek at The Gorge	-25.0845	151.3788
Central	Splinter Creek at Dakiel	-24.7472	151.2586
Central	Burnett River at Yarrol	-24.9939	151.3464
Central	Eastern Creek at Lands End	-25.2142	151.2728
Central	Barambah Creek at West Barambah	-26.3194	152.0642
Central	Auburn River at Glenwood	-25.6836	151.015
Central	Cadarga Creek at Brovinia Station	-25.9394	151.0189
Central	Sandy Creek at Eureka	-25.3389	152.1425

Freshwater reference sites		LATITUDE	LONGITUDE
REGION	SITE NAME		
South-east	Widgee Creek at Upper Widgee	-26.2053	152.4383
Southeast	Widgee Creek at Kilkivan Road	-26.0947	152.5086
Southeast	Coonoon Gibber Creek at Brooloo	-26.4956	152.7111
Southeast	Peters Creek at pump site	-26.6822	152.6064
Southeast	Bundaroo Creek at Peters Creek Road	-26.6967	152.615
Southeast	Little Yabba Creek at Sunday Creek Road	-26.6044	152.6128
Southeast	Amamoor Creek at Amamoor Range West	-26.3744	152.5033
Southeast	Eli Creek at The Mouth	-25.2981	153.2214
Southeast	Rocky Creek at Ungowa Rd	-25.4742	153.0086
Southeast	Searys Creek at Bracken Log	-25.9747	153.0719
Southeast	Petrie Creek at Hunchy	-26.6656	152.9233
Southeast	Mooloolah River at Diamond Valley Sawmill	-26.7536	152.9256
Southeast	Caboolture River at Rocksberg	-27.0017	152.8375
Southeast	Rush Creek at Pioneer Concrete weir	-27.1931	152.8617
Southeast	Enoggera Creek at Brisbane Forest Park	-27.4292	152.8394
Southeast	Brisbane River WBr at Crossing 26	-26.5894	152.1642
Southeast	Capembah Creek at Myora Springs	-27.4692	153.4258
Southeast	Cravens Creek at Moreton Island	-27.115	153.3683
Southeast	Eagers Creek at Moreton Island	-27.1475	153.4297
Southeast	Spitfire Creek at Moreton Island	-27.0722	153.4503
Southeast	Running Creek at Drynans	-28.3283	153.0172
Southeast	Burnett Creek at Pete's Place	-28.2611	152.5714
Southeast	Mt Barney Creek at Mt Maroon	-28.2386	152.7294
Southeast	Albert River at Lost World	-28.2617	153.0886
Southeast	Currumbin Creek at Mt Cougal NP	-28.2367	153.3567
Southeast	Coomera River at Tuckers Lane	-28.0581	153.1764
Southeast	Glastonbury Creek at Glastonbury 1	-26.2053	152.5267
Southeast	Munna Creek at Marodian	-25.9028	152.3492
Southeast	Munna Creek at Marodian	-25.905	152.3481

Freshwater reference sites		LATITUDE	LONGITUDE
REGION	SITE NAME		
Southeast	Teewah Creek near Coops Corner	-26.0589	153.0417
Southeast	Fifteen	-27.4586	152.0994
Southeast	Logan River at Forest Home	-28.2011	152.7747
Murray Darling	Weir River (Retreat) at Moonie Gundi Rd	-27.9017	150.3472
Murray Darling	MacIntyre Brook at Barongarook	-28.4228	151.4719
Murray Darling	Moonie River at Cambridge Crossing	-27.4139	150.4856
Murray Darling	Balonne River at Morroco	-27.4883	148.7597
Murray Darling	Sth Spring Creek at Browns Falls	-28.3397	152.3814
Murray Darling	Upper Condamine at Cowboy Crossing	-28.2947	152.3847
Murray Darling	Swan Creek downstream of gauging station	-28.1783	152.2469
Murray Darling	Amby Creek at railway	-26.5522	148.1897
Murray Darling	Nebine Creek at Balonne Hwy	-27.9983	146.8114
Murray Darling	Ward River at Byrganna	-25.5953	146.0878
Murray Darling	Ward River at Quilpie Rd	-26.5108	146.0858
Murray Darling	Nive River at four-tonne bridge	-25.6103	146.5011
Murray Darling	Paroo River at Mt Alfred	-27.1906	145.3572
Murray Darling	Paroo River at Eulo	-28.1636	145.0356
Murray Darling	Bulloo River at Thargomindah	-27.9956	143.8319
Murray Darling	Weir River at Talwood	-28.5189	149.5061
Murray Darling	Pike Creek at Pikedale	-28.65	151.6186
Murray Darling	Dumaresq River at Farnbro	-28.9186	151.5836
Murray Darling	Broadwater Creek at dam site	-28.5983	151.8883
Murray Darling	Moonie River at Nindigully	-28.4292	148.8153
Murray Darling	Yuleba Creek at forestry	-26.8497	149.4728
Murray Darling	Long Xin	-28.325	152.3411
Murray Darling	Elbow Va	-28.3736	152.1611
Murray Darling	Emu_Ck E	-28.2275	152.2483
Murray Darling	Spring_Ck	-28.3539	152.3353

Freshwater reference sites		LATITUDE	LONGITUDE
REGION	SITE NAME		
Murray Darling	Canal_Ck	-28.0321	151.5856
Murray Darling	Granite	-28.2804	151.8392
Murray Darling	Sheep Ya	-28.2822	151.844
Murray Darling	Maranoa River at Old Cashmere	-27.7331	148.4719
Lake Eyre	Eyre Creek at Bedourie	-24.3658	139.4578
Lake Eyre	King Creek at Bedourie	-24.5344	139.5636
Lake Eyre	Hamilton River at Westwood Ho	-23.0408	140.33
Lake Eyre	Georgina River at Glenormiston Crossing	-22.8981	138.8628
Lake Eyre	Hamilton River near Toolebuc	-22.1633	140.8525
Lake Eyre	Burke_R	-22.9125	139.9128
Lake Eyre	Roxborou	-22.5133	138.8417
Lake Eyre	Cooper Creek at Currareva	-25.3267	142.7311
Lake Eyre	Barcoo River at Avington Road	-24.3064	145.3147
Lake Eyre	Barcoo River at Retreat	-25.1831	143.2533
Gulf	Hann River at Cape York Road	-15.1931	143.8719
Gulf	Morehead River at Kennedy Highway	-15.0243	143.6625
Gulf	North Kennedy River at Hann Crossing	-14.7678	144.0789
Gulf	Normanby River at Kalpower Crossing	-14.9131	144.2106
Gulf	Normanby River at 12 Mile Hole	-15.1975	144.4256
Gulf	St George River at Pat. Call'n Bdge	-15.6133	144.0206
Gulf	O'Shannassy River at Riversleigh Crossing	-19.0239	138.7612
Gulf	Woolgar River at Soap Spa	-19.7272	143.3883
Gulf	Flinders River at Reedy Springs	-19.9647	144.6889
Gulf	Fountain Springs at Wee McGregor Mine	-20.9683	139.9317
Gulf	Gilbert River at Stirling	-17.1717	141.7656
Gulf	Fossilbrook Creek at Vince Ray Causeway	-17.8164	144.3886
Gulf	Luster Creek at road crossing	-16.6603	145.2483

Freshwater reference sites		LATITUDE	LONGITUDE
REGION	SITE NAME		
Gulf	Lynd River at Mitchell Junction	-16.4653	143.31
Gulf	Mitchell River at Mt Mulgrave	-16.3764	143.9747
Gulf	Alice River at Pormpuraaw Road Crossing	-15.3794	142.02
Gulf	Glenroy Creek at Palmerville Rd	-15.9222	144.0869
Gulf	Holroyd River upstream of Honeysuckle Junction	-14.3122	142.89
Gulf	Archer River at Shady Lagoon	-13.4286	142.5969
Gulf	Lankelly Creek at Coen water supply	-13.9417	143.2047
Gulf	Coen River downstream Emu Creek	-13.7808	142.8114
Gulf	Jardine River at Pedro’s swamp	-11.4606	142.6931
Gulf	Gregory River at Gregory Downs	-18.6436	139.2525
Gulf	Gregory River at Riversleigh No. 2	-18.9717	138.8022
Gulf	Connolly	-17.885	138.2642
Gulf	O Shanna	-19.1147	138.7547
Gulf	Seymour_	-19.3414	139.0125
Gulf	Mining C	-18.2201	138.3633
Gulf	Leichhardt River at Kajabbi	-20.0742	139.9394
Gulf	Paroo Creek	-20.3414	139.5175
Gulf	Floravil	-18.2567	139.8825
Gulf	Leichhardt River at Floraville	-18.2567	139.8825
Gulf	16 Mile	-18.8778	139.3586
Gulf	Flinders River at Walkers Bend	-18.1654	140.8572
Gulf	Porcupine Creek at Mt Emu Plains	-20.1625	144.5183
Gulf	Flinders River at Glendower	-20.7133	144.5247
Gulf	Cloncur1	-21.0761	140.4167
Gulf	Dugald River at railway crossing	-20.2017	140.2236
Gulf	Williams River at Landsborough Hwy	-20.8728	140.8322
Gulf	Norman River	-19.5436	143.2625
Gulf	Alehvale	-18.2775	142.3397
Gulf	Robin Ho	-18.7867	143.6031

Freshwater reference sites		LATITUDE	LONGITUDE
REGION	SITE NAME		
Gulf	Gilbert_River	-19.2708	143.6933
Gulf	Agate Creek	-18.9339	143.4678
Gulf	Percy River	-19.1619	143.4997
Gulf	Little River at Inournie	-18.2703	142.675
Gulf	Gilbert1	-17.335	141.9378
Gulf	Robertson River	-18.7764	143.3581
Gulf	Possum P	-18.8931	144.4189
Gulf	Einasle1	-17.9819	143.9044
Gulf	Minnies	-17.6361	142.7103
Gulf	Elizabeth	-18.025	144.02
Gulf	Etheridge	-18.0839	143.2706
Gulf	Spanner	-19.0872	144.1672
Gulf	Mentana Creek at Mentana Yards	-16.3764	142.0983
Gulf	Staaten River at Dorunda	-16.5347	142.0608
Gulf	Mary Creek	-16.5847	145.1845
Gulf	Mary River at Mary Farms	-16.5686	145.1922
Gulf	Lynd_R L	-17.8261	144.4422
Gulf	Rifle Creek at Font Hills	-16.6809	145.2262
Gulf	Lynd River at Torwood	-17.4347	143.8194
Gulf	Hodgkins	-16.7122	144.8129
Gulf	Tate_R T	-17.3264	143.8497
Gulf	Mitchell River at Koolatah	-15.9483	142.3767
Gulf	Mcleod River at Mulligan Highway	-16.499	145.0012
Gulf	Mitchell River at Cooktown Crossing	-16.5661	144.8892
Gulf	Palmer_3	-15.91	143.3603
Gulf	Palmer River at Drumduff Crossing	-16.0433	143.0353
Gulf	North Palmer River at Maytown	-16.0142	144.2883
Gulf	Walsh River at Trimbles Crossing	-16.5469	143.7836
Gulf	Walsh River at Rookwood	-16.9822	144.2864

Freshwater reference sites		LATITUDE	LONGITUDE
REGION	SITE NAME		
Gulf	Elizabeth Creek at Greenmantle	-16.6614	144.105
Gulf	Coleman River_	-15.1383	141.8075
Gulf	Holroyd River at Strathgordon	-14.4814	142.1877
Gulf	Archer River at telegraph line	-13.4191	142.9196
Gulf	Coen_R C	-13.9455	143.1955
Gulf	Coen River at Racecourse	-13.9553	143.1781
Gulf	Watson River at Jackin Creek	-13.1223	142.0531
Gulf	Embley River	-12.8175	142.1748
Gulf	Wenlock River at Moreton	-12.4562	142.6377
Gulf	Wenlock River at Wenlock	-13.0999	142.9411
Gulf	Wenlock1	-12.4106	142.3036
Gulf	Ducie River at Bertiehaugh	-12.1286	142.3744
Gulf	Dulhunty River at Doug's Pad	-11.834	142.4196
Gulf	Swordgra	-11.8272	142.5064
Gulf	Jardine_	-11.1536	142.3535
Gulf	Jardine River at Monument	-11.1503	142.3517

Estuary & marine reference sites			LATITUDE GDA94	LONGITUDE GDA94
REGION	WATER TYPE	SITE NAME		
Wet Tropics	Enclosed Coastal	Coopers Creek 0.1km from mouth	-16.2017	145.4453
Wet Tropics	Enclosed Coastal	Daintree River Grid Reference 346996 (AMTD 0.0)	-16.2883	145.4522
Wet Tropics	Enclosed Coastal	Hinchinbrook Channel Grid Reference 018801 (Northern - Site 1)	-18.2675	146.0611
Wet Tropics	Enclosed Coastal	Hinchinbrook Channel Grid Reference 151667 (Mid-Channel - Site 2)	-18.3856	146.1969
Wet Tropics	Enclosed Coastal	Hinchinbrook Channel Grid Reference 245551 (Southern - Site 3)	-18.4942	146.2889
Wet Tropics	Estuary	Daintree River (Ferry Crossing) 8.7km from mouth (287015)	-16.2592	145.3981
Wet Tropics	Estuary	Daintree River 12.6km from mouth (249018)	-16.2583	145.3672
Wet Tropics	Estuary	Daintree River 16.4km from mouth (235025)	-16.2517	145.3481

Estuary & marine reference sites			LATITUDE GDA94	LONGITUDE GDA94
REGION	WATER TYPE	SITE NAME		
Wet Tropics	Estuary	Daintree River 21.3km from mouth (200024)	-16.2492	145.3167
Central	Open Coastal	Cleveland Bay Grid Reference 915785 (Mid Bay)	-19.1839	146.9211
Central	Enclosed Coastal	Baffle Creek 4.1km from mouth	-24.5253	152.0358
Central	Enclosed Coastal	Boyne River at mouth	-23.9336	151.3567
Central	Enclosed Coastal	Boyne River 2.7km from mouth	-23.9578	151.3592
Central	Enclosed Coastal	Burrum River at mouth at junction with Gregory River	-25.1778	152.5564
Central	Enclosed Coastal	Elliot River 2.0km from mouth	-24.9306	152.4733
Central	Estuary	Baffle Creek 8.5km from mouth	-24.5153	151.9975
Central	Estuary	Baffle Creek 9.0km from mouth	-24.515	151.9917
Central	Estuary	Baffle Creek 10.0km from mouth	-24.5158	151.9814
Central	Estuary	Baffle Creek 11.0km from mouth	-24.5136	151.9719
Central	Estuary	Baffle Creek 16.0km from mouth	-24.5081	151.9272
Central	Estuary	Baffle Creek 23.5km from mouth	-24.5422	151.9039
Central	Estuary	Boyne River 5.1km from mouth at junction with South Trees Inlet	-23.9722	151.3447
Central	Estuary	Boyne River 8.6km from mouth	-23.9836	151.3178
Central	Estuary	Boyne River 12.0km from mouth	-24.0047	151.3419
Central	Estuary	Burrum River 5.5km upstream of junction with Gregory River	-25.2206	152.5422
Central	Estuary	Burrum River 12.7km upstream of junction with Gregory River	-25.2658	152.5689
Central	Estuary	Elliot River 5.5km from mouth	-24.9519	152.4589
Central	Estuary	Kolan River 5.3km from mouth	-24.6936	152.1639
Central	Estuary	Kolan River 8.1km from mouth	-24.6994	152.1839
Central	Estuary	Kolan River 12.0km from mouth	-24.7178	152.1744
Central	Upper Estuary	Baffle Creek 35.8km from mouth	-24.6017	151.8439
Central	Upper Estuary	Burrum River 19.2km upstream of junction with Gregory River	-25.3153	152.5889
South-east	Open Coastal	Great Sandy Straits grid reference 000003 Woody Island / Little Woody Island	-25.3236	153.0061

Estuary & marine reference sites			LATITUDE GDA94	LONGITUDE GDA94
REGION	WATER TYPE	SITE NAME		
Southeast	Open Coastal	Moreton Bay Grid Reference 336670 (EHMP) Site 506	-27.4183	153.3411
Southeast	Open Coastal	Moreton Bay Grid Reference 388712 (EHMP) Site 507	-27.3808	153.3928
Southeast	Open Coastal	Moreton Bay Grid Reference 287811 (EHMP) Site 510	-27.2883	153.2911
Southeast	Open Coastal	Moreton Bay Grid Reference 330960 (EHMP) Site 512	-27.17	153.3278
Southeast	Open Coastal	Moreton Bay Grid Reference 377783 (EHMP) Site 522	-27.3064	153.3831
Southeast	Open Coastal	Moreton Bay Grid Reference 346043 (EHMP) Site 524	-27.0778	153.3611
Southeast	Open Coastal	Moreton Bay Grid Reference 275995 (EHMP) Site 525	-27.1225	153.2761
Southeast	Open Coastal	Moreton Bay Grid Reference 230904 (EHMP) Site 527	-27.21	153.2331
Southeast	Open Coastal	Moreton Bay Grid Reference 357955 (EHMP) Site 528	-27.1625	153.3644
Southeast	Open Coastal	Southern Broadwater (430070) B (EHMP) Site 4000	-27.9511	153.4386
Southeast	Open Coastal	Southern Broadwater (450100) D (EHMP) Site 4001	-27.9264	153.4675
Southeast	Open Coastal	Southern Broadwater (420130) A (EHMP) Site 4002	-27.9056	153.4364
Southeast	Enclosed Coastal	Great Sandy Strait Grid Reference 924585 Boonooroo / Poona	-25.6894	152.9208
Southeast	Enclosed Coastal	Great Sandy Strait Grid Reference 929721 Boonlye Point	-25.5642	152.9275
Southeast	Enclosed Coastal	Great Sandy Strait Grid Reference 951657 Stewart Island	-25.625	152.9517
Southeast	Enclosed Coastal	Great Sandy Strait Grid Reference 972882 Yellow X Beacon mouth Mary River	-25.4214	152.9733
Southeast	Enclosed Coastal	Great Sandy Strait Grid Reference 979534 Tinnanba	-25.7358	152.9803
Southeast	Enclosed Coastal	Great Sandy Strait Grid Reference 984797 opposite Ungowa Jetty	-25.4994	152.9839
Southeast	Enclosed Coastal	Waterloo Bay Grid Reference 231612 (220610) (EHMP) Site 404	-27.4717	153.235
Southeast	Enclosed Coastal	Waterloo Bay Grid Reference 217636 (EHMP) Site 405	-27.45	153.2203
Southeast	Enclosed Coastal	Waterloo Bay Grid Reference 229642 (EHMP) Site 406	-27.4442	153.2328

Estuary & marine reference sites			LATITUDE GDA94	LONGITUDE GDA94
REGION	WATER TYPE	SITE NAME		
Southeast	Enclosed Coastal	Moreton Bay Grid Reference 310507 (EHMP) Site 500	-27.5667	153.315
Southeast	Enclosed Coastal	Moreton Bay Grid Reference 330542 (EHMP) Site 501	-27.5344	153.3353
Southeast	Enclosed Coastal	Moreton Bay Grid Reference 263642 (EHMP) Site 518	-27.445	153.2678
Southeast	Enclosed Coastal	Deception Bay Grid Reference 165015 (EHMP) Site 1117	-27.11	153.1694
Southeast	Enclosed Coastal	Raby Bay Grid Reference 277568 (EHMP) Site 1200	-27.5083	153.2811
Southeast	Enclosed Coastal	Toondah Harbour Grid Reference 289543 Site 2 (EHMP) Site 1201	-27.5333	153.2942
Southeast	Enclosed Coastal	Noosa River 0.3km from mouth near North Head (EHMP) Site 1601	-26.3819	153.0792
Southeast	Enclosed Coastal	Noosa River 3.9km from mouth opposite Cloudsley Street, Noosaville (EHMP) Site 1603	-26.3958	153.0586
Southeast	Enclosed Coastal	Northern Broadwater Grid Reference 400220 (previously Station 17) (EHMP) Site 105	-27.8244	153.4069
Southeast	Enclosed Coastal	Northern Broadwater Grid Reference 381266 (EHMP) Site 106	-27.7828	153.3875
Southeast	Enclosed Coastal	Northern Broadwater grid reference 413086 (EHMP) Site 118	-27.9464	153.42
Southeast	Enclosed Coastal	Northern Broadwater (411108) (EHMP) Site 119	-27.9275	153.4186
Southeast	Enclosed Coastal	Northern Broadwater (EHMP) Site 120	-27.9094	153.4167
Southeast	Enclosed Coastal	Northern Broadwater (EHMP) Site 121	-27.8911	153.4158
Southeast	Enclosed Coastal	Northern Broadwater (EHMP) Site 122	-27.8486	153.3994
Southeast	Enclosed Coastal	Northern Broadwater (EHMP) Site 123	-27.7978	153.4119
Southeast	Enclosed Coastal	Northern Broadwater (409270) (EHMP) Site 124	-27.7819	153.4144
Southeast	Enclosed Coastal	Northern Broadwater (EHMP) Site 125	-27.7667	153.4311
Southeast	Enclosed Coastal	Northern Broadwater Grid Reference 430312 (previously Station 14) (EHMP) Site 301	-27.7411	153.4372
Southeast	Enclosed Coastal	Northern Broadwater Grid Reference 317446 (previously Station 5) (EHMP) Site 308	-27.6206	153.3222

Estuary & marine reference sites			LATITUDE GDA94	LONGITUDE GDA94
REGION	WATER TYPE	SITE NAME		
Southeast	Enclosed Coastal	Northern Broadwater Grid Reference 333492 (previously Station 6) (EHMP) Site 309	-27.5789	153.3383
Southeast	Enclosed Coastal	Northern Broadwater Grid Reference 357508 (EHMP) Site 310	-27.5644	153.3625
Southeast	Enclosed Coastal	Northern Broadwater Grid Reference 402466 (EHMP) Site 313	-27.6022	153.4083
Southeast	Enclosed Coastal	Northern Broadwater Grid Reference 397441 (previously Station 10) (EHMP) Site 314	-27.6247	153.4033
Southeast	Enclosed Coastal	Northern Broadwater Grid Reference 389393 (previously Station 11) (EHMP) Site 315	-27.6683	153.3953
Southeast	Enclosed Coastal	Pumicestone Passage Grid Reference 130070 (EHMP) Site 1301	-27.0536	153.1339
Southeast	Enclosed Coastal	Pumicestone Passage Grid Reference 100090 (EHMP) Site 1302	-27.0281	153.1011
Southeast	Enclosed Coastal	Pumicestone Passage Grid Reference 110300 (EHMP) Site 1311	-26.8436	153.1175
Southeast	Enclosed Coastal	Pumicestone Passage Grid Reference 120320 (EHMP) Site 1312	-26.8061	153.1289
Southeast	Enclosed Coastal	Pumicestone Passage (EHMP) Site 1313	-27.0756	153.1506
Southeast	Enclosed Coastal	Tin Can Inlet Grid Reference 043376 (AMTD 6.4)	-25.8786	153.045
Southeast	Enclosed Coastal	Tin Can Inlet Grid Reference 028353 (AMTD 9.1)	-25.8986	153.0297
Southeast	Enclosed Coastal	Tin Can Inlet Grid Reference 017339 (AMTD 11.2)	-25.9117	153.0181
Southeast	Enclosed Coastal	Tin Can Inlet Grid Reference 035320 (AMTD 14.9)	-25.9286	153.0378
Southeast	Enclosed Coastal	Tin Can Inlet Grid Reference 021296 (AMTD 17.6)	-25.95	153.0225
Southeast	Enclosed Coastal	Tin Can Inlet Grid Reference 011269 (AMTD 20.5)	-25.9747	153.0131
Southeast	Estuary	Coomera River 0.0km at mouth (EHMP) Site 100	-27.8717	153.3969
Southeast	Estuary	Coomera River 2.8km from mouth 500m upstream of Coombabah Creek (EHMP) Site 101	-27.8722	153.3819
Southeast	Estuary	Coomera River (EHMP) Site 126	-27.8564	153.3789
Southeast	Estuary	Coomera River (EHMP) Site 127	-27.8467	153.3575
Southeast	Estuary	Noosa River 5.3km from mouth near western end of Goat Island (EHMP) Site 1604	-26.3933	153.0425

Estuary & marine reference sites			LATITUDE GDA94	LONGITUDE GDA94
REGION	**WATER TYPE**	**SITE NAME**		
Southeast	Estuary	Pumicestone Passage Grid Reference 070150 (EHMP) Site 1304	-26.9797	153.075
Southeast	Estuary	Pumicestone Passage Grid Reference 050180 (EHMP) Site 1306	-26.9483	153.0564
Southeast	Estuary	Pumicestone Passage Grid Reference 070220 (EHMP) Site 1308	-26.9142	153.0739
Southeast	Estuary	Pumicestone Passage Grid Reference 090240 (EHMP) Site 1309	-26.8939	153.0997
Southeast	Estuary	Pumicestone Passage Grid Reference 110280 (EHMP) Site 1310	-26.8708	153.1167
Southeast	Estuary	Lake Weyba on Weyba Creek Bridge Noosa Parade (EHMP) Site 1616	-26.3942	153.0786
Southeast	Upper Estuary	Coomera River 13.1km from mouth at Pacific Highway Bridge (EHMP) Site 104	-27.8767	153.3144
Southeast	Upper Estuary	Noosa River 16.0km from mouth (EHMP) Site 1608	-26.3217	153.0203
Southeast	Upper Estuary	Noosa River 18.6km from mouth at Tronson's Drain (EHMP) Site 1615	-26.3178	152.9942
Southeast	Upper Estuary	Noosa River 21.5km from mouth on Lake Cootharaba (EHMP) Site 1609	-26.3044	152.9894
Southeast	Upper Estuary	Noosa River 26.0km from mouth on Lake Cootharaba (EHMP) Site 1610	-26.2669	153.0161

Appendix G: Salinity guidelines (expressed in conductivity units) for Queensland freshwaters

Deriving salinity guidelines

Salinity values in Queensland freshwaters show significant regional variation around the state. This variation is related principally to regional variations in soils/geology and rainfall. Human activities have undoubtedly affected natural salinity levels in a few areas but this is thought to be significant only at local or, at most, sub-regional scales.

To derive guidelines it is necessary to take into account this high degree of natural regional variation. The approach used is outlined in detail in the attached report. Briefly, on the basis of many years of salinity data collected by EHP, Queensland has been divided into a total of 18 zones. Each zone represents an area within which salinity is reasonably consistent. The selected zones are described and mapped in the attached report. Table G.1 in the attached report shows calculated salinity percentiles for each zone.

It is proposed that the 75th percentile value for each zone be used as a preliminary guideline value. This value would be compared with the median value at test sites within a zone. The use of the 75th rather than the 80th percentile is proposed because with this indicator the 80th percentile is usually significantly higher than the median and allows for too much change when compared to the median (refer to Figures G.5–G.7 in the attached report). As with all indicators, further investigation at a local level could be used to modify these proposed guideline values.

NOTE: Salinity is expressed in terms of conductivity units throughout this appendix. All conductivity values are corrected to 25^{0}C.

Attachment: Report on salinity zones defined for Queensland streams

Authors: Vivienne McNeil and Roger Clarke – Dept of Natural Resources and Mines

May 2004

Executive summary

This report presents an overview of salinity ranges in streams throughout Queensland. Eighteen salinity zones have been mapped on the basis of observed salinity characteristics while maintaining an awareness of regional management divisions (Figure G.1). Percentiles of EC recorded within each zone are presented as Table G.1. These zones are sufficient to identify sites or sub-catchments where the EC is unusually high or low when compared to the regional norm.

Table G.1: EC percentiles for Queensland salinity zones

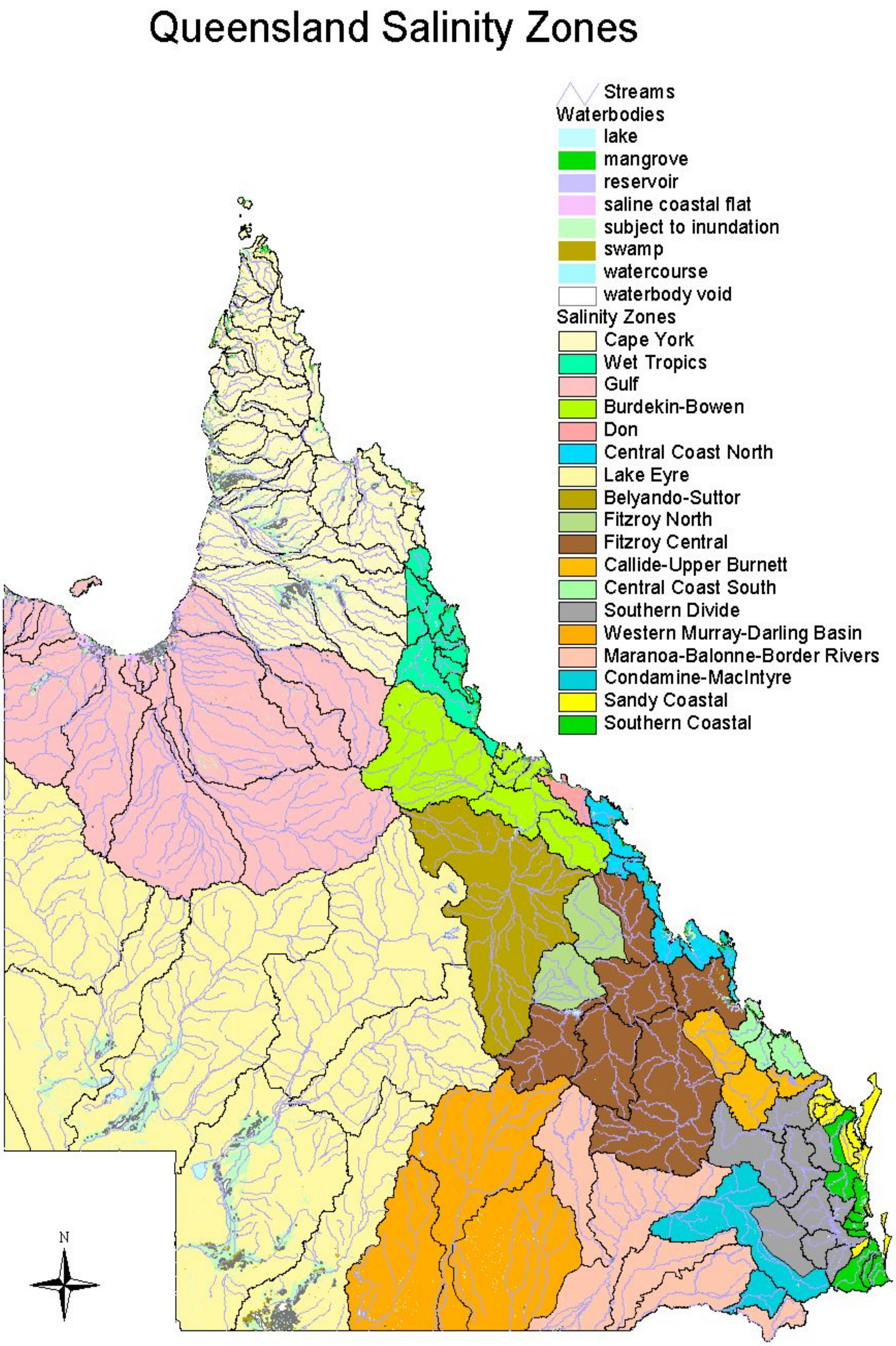
Zone	Site used	Data used		Percentiles of EC µS/cm							Relative salinity
		Sites	ECs	90	80	75	50	25	20	10	
Cape York	All	92	3166	198	140	125	82	57	52	42	Mainly low, quite variable
Wet Tropics	Rateable	49	6199	130	100	92	71	50	46	36	Generally very low
Burdekin–Bowen	Rateable	18	1944	470	310	271	176	129	120	98	Moderately low but some high outliers
Belyando–Suttor	Rateable	5	271	225	180	168	135	109	100	80	Low
Don	All	10	372	1058	814	680	346	214	200	170	High
Central Coast North	Rateable	17	1916	560	440	375	200	120	110	88	Low to moderate, variable
Fitzroy North	Rateable	11	755	1250	840	720	355	209	187	130	Moderately high and variable

Zone	Site used	Data used		Percentiles of EC µS/cm							Relative salinity
		Sites	ECs	90	80	75	50	25	20	10	
Fitzroy Central	Rateable	42	4376	510	380	340	242	175	161	130	Low to moderate
Central Coast South	Rateable	6	653	1500	1100	970	640	444	390	230	High and variable
Southern Divide	Rateable	59	5935	1570	1244	1120	760	481	425	289	Generally very high
Callide Upper Burnett	Rateable	28	2501	1450	890	760	500	339	310	240	High, very variable
Southern Coastal	Rateable	45	6717	732	578	520	340	212	182	121	Moderate but variable
Sandy Coastal	Rateable	11	1195	1310	730	626	368	216	188	90	Moderate to high, very variable
Condamine–Macintyre	Rateable	33	4003	755	555	500	355	255	235	189	Moderate to high
Maranoa–Balonne–Border rivers	Rateable	28	2872	471	356	325	234	165	152	123	Moderately low
Western Murray–Darling basin	All	36	253	312	195	169	118	88	82	70	Appears to be low
Lake Eyre	Rateable	4	383	410	230	200	128	90	82	71	Low
Gulf	Rateable	12	565	630	550	500	245	157	134	100	Moderate

The assessment is based on about 63,000 EC measurements from streams throughout Queensland collected by Queensland Government agencies and a number of other organisations.

The zones vary in size and complexity, with greater definition in the south-east, where most of the data has been collected. However, it is reasonable to assume that the eastern part of the state is also the region where most natural variation would occur, owing to the more complex geology and climate, and relatively recent geomorphological changes. The zones mainly follow catchment boundaries but some are related to the properties of a watershed. Each zone still contains regional variability and it is possible that further refinement could take place for strategic monitoring.

Figure G.1:


Queensland Salinity Zones
Streams
Waterbodies
lake
mangrove
reservoir
saline coastal flat
subject to inundation
swamp
watercourse
waterbody void
Salinity Zones
Cape York
Wet Tropics
Gulf
Burdekin-Bowen
Don
Central Coast North
Lake Eyre
Belyando-Suttor
Fitzroy North
Fitzroy Central
Callide-Upper Burnett
Central Coast South
Southern Divide
Western Murray-Darling Basin
Maranoa-Balonne-Border Rivers
Condamine-MacIntyre
Sandy Coastal
Southern Coastal
N

The saline zones are found towards the east of southern and central Queensland, but contain mainly low-discharge streams with limited impact on big river systems. By contrast, the far north and south-west of the state have characteristically low-salinity streams. Some zones have been defined for the convenience of catchment management, although they are virtually identical in terms of salinity and water chemistry. These particularly include parts of the Murray Darling basin and adjoining sections of the Fitzroy basin that were kept separate to be consistent with NAP regionalisation. Other zones may be combined, subdivided or redefined, but this would best be done on the basis of local input or in a joint review, including biological boundaries or other water quality parameters.

The question that cannot be fully answered is whether ranges of EC that are truly natural can be estimated when virtually all of Queensland has been disturbed to some extent, particularly in the lower catchments of major streams. Accordingly, the ranges calculated refer to the salinity that has existed over the period of collection, beginning in the 1960s and 1970s, and not necessarily to the natural or desirable salinity. Despite this there is sufficient consistency in magnitude, variability and chemical composition to infer that the percentiles obtained are close to normal. In addition, trend analyses previously carried out by NRM&E and CSIRO indicate that longer term stream EC trends have been slight in comparison with observed variability since at least about 1970 and tend to be cyclical in nature.

There has, of necessity, been a high degree of subjectivity in the outlining of zones, so supporting information is provided in the appendices of the main report to allow for review of boundaries if required. No attempt has been made to discuss the processes behind the variability in this broad-scale review, and trends and cycles are also beyond the scope of this work.

Issues raised include the need for strategic monitoring of certain areas to clearly define ambient salinity ranges, regardless of other monitoring needs such as compliance or trends analysis. These particularly include low-lying coastal areas and islands between the mouth of the Fitzroy and the NSW border; and the western part of the state, including the Gulf catchments, the Lake Eyre catchment, and the portion of the Murray Darling basin west of the Balonne. More input is needed on the effect of stream regulation and other forms of development on stream salinity, and related impacts on biota.

In summary, the percentiles as presented do not constitute salinity targets, but provide a tool to assist in the development of such targets by providing baseline information about ambient ranges. These can be used to identify anomalously high or low sites that have been sufficiently monitored, but local investigation will be required to disclose whether their salinity state is natural, or contributed to by human factors.

Introduction

Many factors contribute to variability in stream salinity. They can be both environmental and anthropogenic in nature. Broad-scale natural determinants are climate, geology, palaeoclimate, recent geological history including sea-level fluctuations, and the physiography of the landscape including maturity of stream reaches and depth of the alluvium. Smaller scale natural anomalies result from, for instance, tidal influences in low-lying coastal areas, or rain shadowed sub-catchments containing saline sediments and soils. Some recognised anthropogenic impacts on stream salinity are clearing, irrigation, effluent discharges, and upstream storages.

This report presents an overview of salinity ranges in streams throughout Queensland. The analysis was based on salinity measurements stored in the NRM&E HYDSYS surface water database, supplemented by collections of salinity data in terms of electrical conductivity (EC) from several other organisations recognised as having a high degree of data quality control. The combined data supplied some coverage over virtually all parts of the state. The definition of zones was based around observed spatial similarity in the magnitude and variability of salinity as displayed through individual sites. Only sites with a specified degree of data adequacy were used for zone definition, but all other data was used to support the conclusions. Water chemistry in terms of major ion content was also considered, and because much of the process has been necessarily subjective, supporting material has been included in the appendices.

Eighteen salinity zones have been mapped on the basis of existing salinity characteristics, while maintaining an awareness of regional management divisions. The zones identified vary in size and complexity, with greater definition in the south-east, where most of the data has been collected. It is possible that further refinement could take place as more comprehensive data becomes available. The salinity ranges for each zone are presented in terms of percentiles, which were calculated from the amalgamated records of reliable sites where possible. In some zones with very few or poorly distributed reliable sites, all riverine data was used for percentile calculation, although it is recognised that bias may occur in these cases. Strategic monitoring is recommended for these zones.

Although the zones identified indicate the ambient magnitude and range of stream EC, these may not be the only significant factors in terms of ecosystem salinity requirements. Temporal trends, seasonality and flow relationships may be important also; however, the percentile ranges are sufficiently precise to provide a tool to assist in the development of salinity targets by providing baseline information.

Data

Quality controlled freshwater data sets, containing salinity as EC, have been collected through ambient monitoring by the EPA and NRM&E and by various organisations for specific projects. These were amalgamated, amounting to around 63,000 independent EC readings. Missing flows or GIS coordinates were affixed where possible. The project specific data sets are from Condamine Balonne Water Committee, described in CBWC (1999); Western streams water quality monitoring project (Humphery, 1996); Border rivers, Border River Catchment Management Association (McGloin, 2001); NRM&E and Australian Centre for Tropical Freshwater Research (Congdon, 1991; McNeil et al., 2000); and the Fitzroy National Landcare Program (Noble et al., 1997).

Assessment methods

The procedure used to subdivide Queensland into salinity zones was carried out in stages:

1. Establishing site reliability;
2. Categorising reliable sites in terms of percentiles of EC and defining salinity zones; and
3. Inspecting results to refine boundaries and determine data adequacy to calculate percentiles.

Site reliability

Site reliability in terms of adequacy of data is calculated by the same method used for the Queensland State of the Environment Report (EPA, 2004) and other recent reports. The reliability of data sets was rated in terms of excellent, good, moderate and poor, while sites lacking sufficient or comprehensive data were labelled as unrateable (Table G.2).

Figure G.2: Factors considered in assessing the reliability of data sets at each site

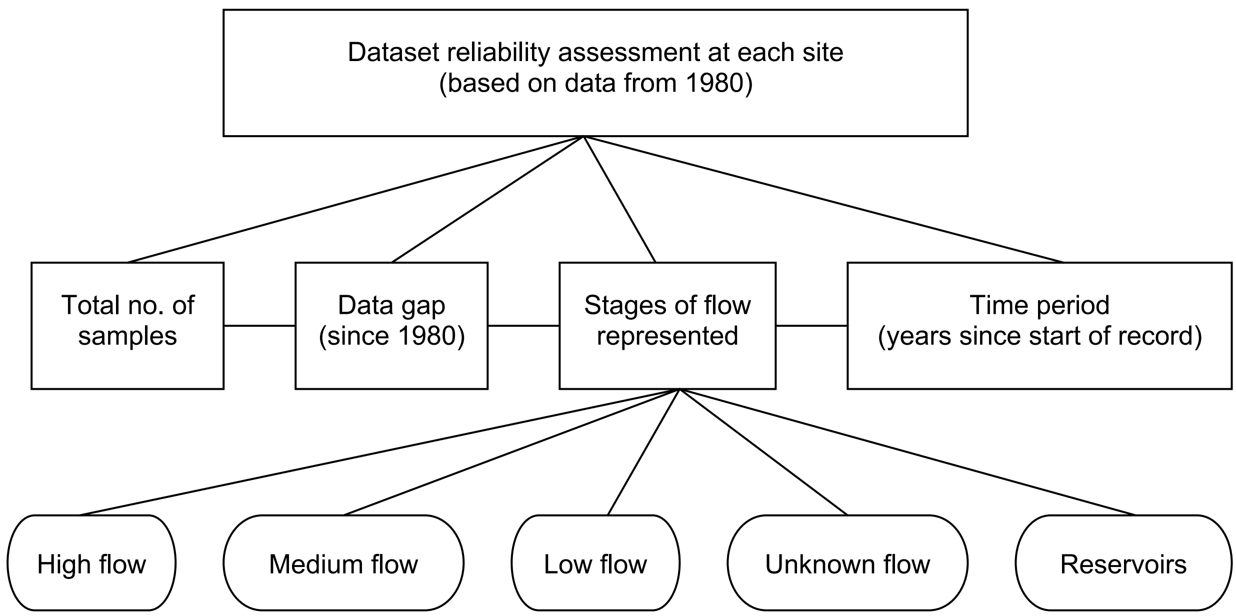


Table G.2: Criteria used to assess the reliability of data sets at each site

Time period (years)	Data gap (years)	Total no. of samples	Stages of flow represented (number of samples)					Reliability rating
			Low	Medium	High	Unknown	Reservoir	
>20	<5	>70	>7	>20	>18	–	–	Excellent
>15	<3	>60	>6	>18	>15	–	–	Good
>15	<3	>60	–	–	–	–	>60	Good
>10	–	>40	>4	>10	>10	–	–	Moderate
>10	<3	>60	–	–	–	–	>50	Moderate
>10	<3	>120	–	–	–	>120	–	Moderate
>10	<3	>50	–	–	–	–	–	Moderate
>5	–	>20	>2	>6	>5	–	–	Poor
>5	–	>20	–	–	–	–	>30	Poor
>5	–	>20	–	–	–	>60	–	Poor
>5	–	>30	–	–	–	–	–	Poor

Defining salinity zones

Lists of percentiles were produced for each reliable site and the resulting table was examined to find a method that would classify the site salinity in terms of both absolute levels and variability. A scheme that satisfied both criteria, and when plotted on GIS produced a good geographical coherence, is based on the 50th and 80th percentiles, and is summarised in Table G.3. Briefly, there is a strong regional pattern that differentiates tropical, central, southern and inland characteristics, as well as providing some local definition.

Table G.3: Salinity categories (EC in uS/cm)

Type	50 percentile EC	80 percentile EC	Salinity description
1	<100	<=100	Very low
2	50–200	100–200	Low
3	50–200	200–500	Generally low but variable
4	200–500	200–500	Moderate
5	200–500	500–1000	Generally moderate but variable
6	500–1000	>500	High
7	>1000	>1000	Very high

The salinity categories were colour coded, and the sites plotted on two working maps of the state:

1. showing all classifiable sites with sizes based on annual flow volume. This was useful for separating headwater and minor tributary ranges from those applicable to lower catchments; and
2. showing all sites with sizes based on data adequacy. There were few excellent sites, and some large catchments with no suitable representative sites; but there was a wide scatter of unrateable locations where data has been collected, and it was possible to amalgamate these to produce provisional percentile ranges for

some areas.

From these maps, with reference also to the chemistry of the local salts, regional or sub-basin salinity zones were drawn which are reasonably homogeneous and have relevance where possible to NAP and NHT 2 boundaries.

These zones were then defined as shapes within ArcGIS. The starting point was the shapefile for the basin sub-area polygons available from the GIS server. Where necessary new sub-areas were created by splitting an existing polygon. The zones were then created as aggregates of sub-areas. All the sites within a particular zone could then be selected and labelled as belonging to that zone. When all the sites were so labelled, the data could then be exported from ArcGIS and statistically summarised for each zone.

The final salinity zones with the categorised sites used to define them, as well as the locations of the unrateable sites, are shown in Figure G.3. A summary of the salt chemistry from McNeil (2002) is shown in Figure G.4.

Determining percentiles and data adequacy

As Figure 3 indicates, many zones, particularly those outside the east coast, have either an inadequate number of, or distribution of, classifiable sites. Therefore a box and whisker plot for EC was produced for each site within each zone, colour-coded as to site reliability, and visually inspected for outliers or inconsistencies. This led to some redefining of the zones. The box and whisker plots are contained in Appendix 1 (not included in the QWQG), with the 10^{th} and 90^{th} zone percentiles marked on the plots for comparison.

It was considered desirable to base zone percentiles exclusively on rateable sites where possible, because unrateable sites may be biased in a number of ways, and may not always represent normal stream data. But it was clear that for some zones, ranges would have to be based on, or at least supported by, the unrateable sites. Accordingly, percentiles were initially calculated within each zone for all riverine data, and also for the subset of reliable sites. The results were compared as plots in Appendix 2 (not included in the QWQG) and a subjective decision made as to which set to select as the final percentiles for each zone. In most cases the results were very similar, even when there were few classifiable sites in apparently unrepresentative locations. It should be noted that no attempt was made to identify and exclude sites on the basis of human interference. This was not possible within the timeframe of this project, nor considered necessary, as the volume of available data was sufficient to exclude outliers through the percentile selection. Appendix 1 (not included in the QWQG) demonstrates that the selected percentile ranges will identify anomalous sites.

Results

The final salinity zone map is illustrated in Figures G.3 and G.4. The percentiles for each zone, summarised on Table G.1, are listed with more supporting information on Table G.4. The 18 salinity zones on the maps vary in size and complexity, with greater definition in the south-east where most of the data has been collected. It is anticipated that further refinement would be possible through comments from people with local knowledge as well as through future data collection. However, it is reasonable to assume the eastern part of the state is also the region where most natural variation would occur, because of the more varied geology and climate, and the relatively recent geomorphological development. The zones mainly follow catchment boundaries, but some such as the Southern Divide are related to headwater environments and watersheds.

Figure G.3:

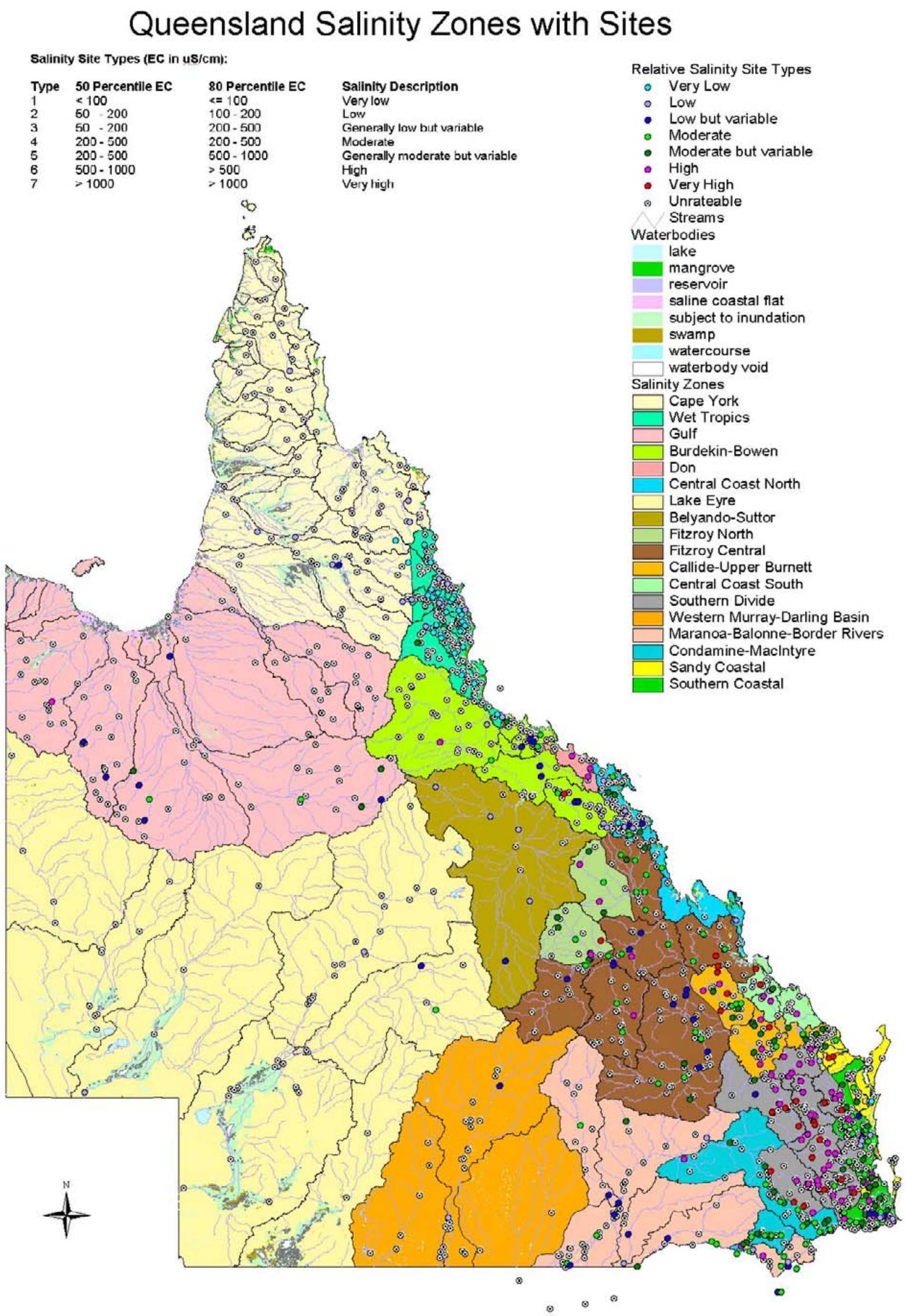

Queensland Salinity Zones with Sites
Salinity Site Types (EC in uS/cm):
Type | 50 Percentile EC | 80 Percentile EC | Salinity Description
1 | < 100 | <= 100 | Very low
2 | 50 - 200 | 100 - 200 | Low
3 | 50 - 200 | 200 - 500 | Generally low but variable
4 | 200 - 500 | 200 - 500 | Moderate
5 | 200 - 500 | 500 - 1000 | Generally moderate but variable
6 | 500 - 1000 | > 500 | High
7 | > 1000 | > 1000 | Very high
Relative Salinity Site Types
Very Low
Low
Low but variable
Moderate
Moderate but variable
High
Very High
Unrateable
Streams
Waterbodies
lake
mangrove
reservoir
saline coastal flat
subject to inundation
swamp
watercourse
waterbody void
Salinity Zones
Cape York
Wet Tropics
Gulf
Burdekin-Bowen
Don
Central Coast North
Lake Eyre
Belyando-Suttor
Fitzroy North
Fitzroy Central
Callide-Upper Burnett
Central Coast South
Southern Divide
Western Murray-Darling Basin
Maranoa-Balonne-Border Rivers
Condamine-MacIntyre
Sandy Coastal
Southern Coastal
N

Figure G.4: Distribution of water types for drainage systems in Queensland

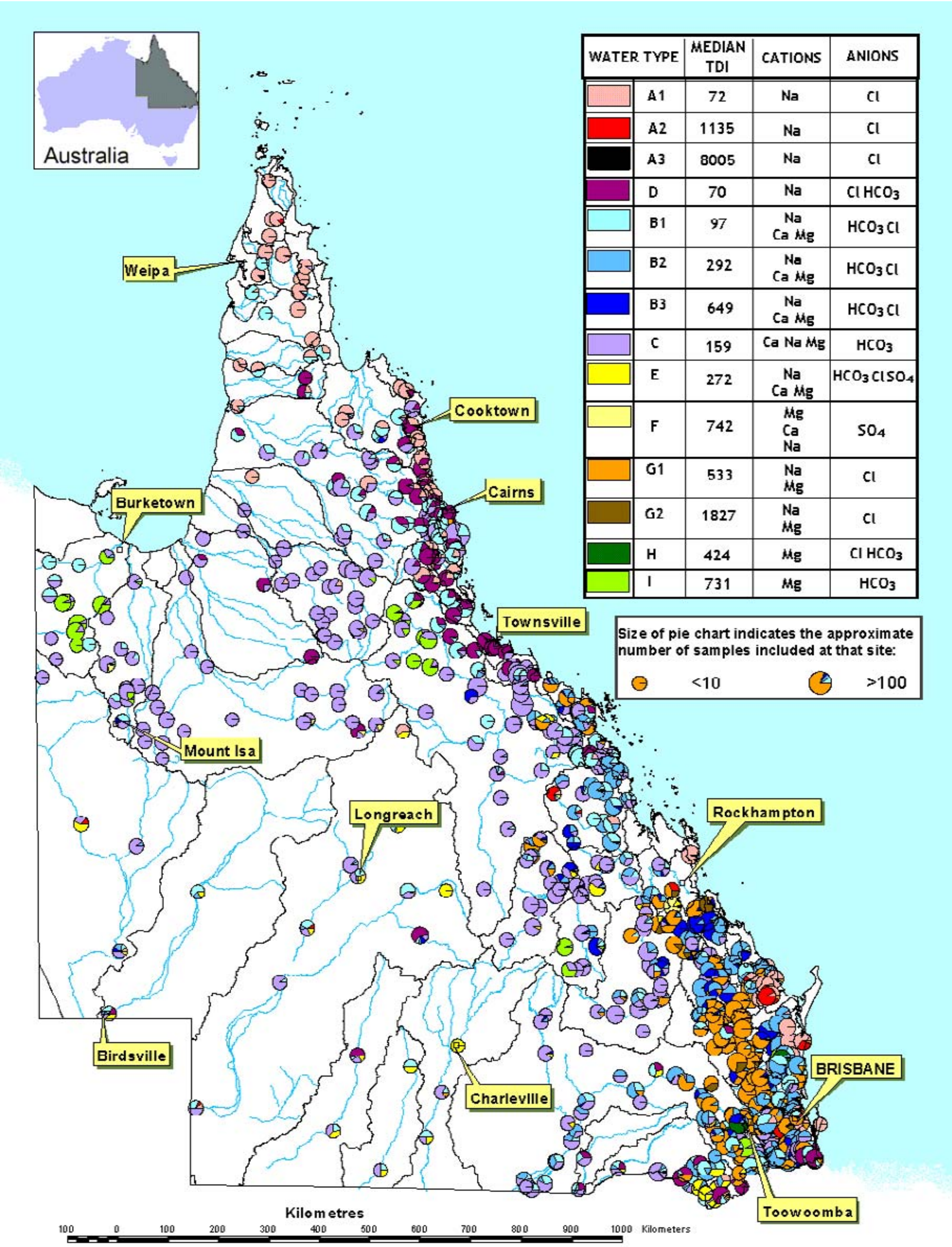


Figure 7. Distribution of water types for drainage systems in Queensland.
Pie diagrams show what proportion of the stream water samples from a gauging station were of each water type.
Similar types are shown in similar colours.
The table includes the median Total Dissolved Ions in mg L^{-1}

Table G.4: EC percentiles for salinity zones for all riverine data as well as for rateable sites only

Zone	Site type	Data used		Percentiles of EC							Area	Sufficiency of data	Relative salinity	General chemistry		Comments
		Sites	ECs	90	80	75	50	25	20	10				Cations	Anions	
Cape York	All	92	3166	198	140	125	82	57	52	42	Cape York north of Gilbert and Einasleigh rivers, and west of Wet Tropics and Atherton Tablelands	Few rateable sites not sufficiently representative, so all data used	Mainly low but quite variable	sodium	chloride	Similar to Wet Tropics but difference in chemistry affects EC:salt ratio.
	Rateable	11	1222	152	125	118	81	57	54	46						
Wet Tropics	All	252	8912	135	105	95	71	49	45	36	Endeavour to Black rivers and Atherton Tablelands	Sufficient rateable	Generally very low	sodium	chloride bicarbonate	Generally lowest salinity in Queensland
	Rateable	49	6199	130	100	92	71	50	46	36						
Burdekin Bowen	All	111	3678	560	378	325	186	125	115	91	Burdekin basin excluding Suttor – Belyando, with Bowen, Ross, Haughton and Barratta	Sufficient rateable	Moderately low, but variable	all	bicarbonate	Some high outliers which may have estuarine influence
	Rateable	18	1944	470	310	271	176	129	120	98						
Belyando Suttor	All	11	415	235	190	170	135	109	102	81	Suttor and Belyando river systems in south-west Burdekin basin	Sufficient rateable	Low	all	bicarbonate	Significantly less saline than rest of Burdekin basin
	Rateable	5	271	225	180	168	135	109	100	80						
Don	All	10	372	1058	814	680	346	214	200	170	Don catchment on coast south of Townsville	Rateable data unevenly distributed so all data used	High	sodium magnesium	chloride bicarbonate	Small high salinity catchment, needs strategic monitoring
	Rateable	3	206	1153	980	920	562	360	319	200						
Central Coast north	All	95	2537	560	431	373	202	124	110	89	Proserpine to Waterpark, just north of Rockhampton	Rateable sufficient, although higher in midrange	Low to moderate, variable	sodium others	bicarbonate chloride	Some high outlier sites
	Rateable	17	1916	560	440	375	200	120	110	88						
Fitzroy north	All	21	843	1250	811	690	330	195	175	125	Nogoa basin north of	Rateable	Moderately high and	sodium	bicarbonat	Higher salinity zone in north-west

Zone	Site type	Data used		Percentiles of EC							Area	Sufficiency of data	Relative salinity	General chemistry		Comments
		Sites	ECs	90	80	75	50	25	20	10				Cations	Anions	
	Rateable	11	755	1250	840	720	355	209	187	130	Emerald, and upper Isaac River to junction with Funnel Creek	sufficient	variable	others	e chloride	quadrant of Fitzroy
Fitzroy central	All	141	5891	604	405	360	250	178	165	134	Dawson apart from the Callide, Don and Dee, Comet and southern Nogoa basins	Rateable reasonably representative	Low to moderate	all	bicarbonat e	Basically a continuation of Lower Murray–Darling basin
	Rateable	42	4376	510	380	340	242	175	161	130						
Central Coast South	All	22	764	1440	1050	950	690	470	413	250	Coast south of Rockhampton, i.e. Calliope, Boyne and Baffle catchments, Curtis Is.	Rateable sufficient	High and variable	sodium others	bicarbonat e chloride	Similar to Southern Divide, but different chemically and slightly less saline
	Rateable	6	653	1500	1100	970	640	444	390	230						
Southern Divide	All	228	8406	1550	1200	1075	697	438	376	276	Brisbane catchment, Burnett apart from Three Moon Ck in north, and adjoining tributaries of Mary and Condamine	Rateable sufficient	Generally very high	sodium magnesium	chloride	Most generally saline zone in Queensland
	Rateable	59	5935	1570	1244	1120	760	481	425	289						
Callide Upper Burnett	All	70	3314	1277	890	772	490	324	293	233	Three Moon Creek, Kolan and the Callide, Don and Dee systems	Rateable sufficient	High, very variable	sodium others	all	Callide, Don and Dee systems resemble adjoining upper Burnett rather than Dawson
	Rateable	28	2501	1450	890	760	500	339	310	240						
Southern	All	211	8281	754	580	520	340	202	170	120	Maroochy	Rateable	Moderate	sodium	bicarbonat	Small to medium

Zone	Site type	Data used		Percentiles of EC							Area	Sufficiency of data	Relative salinity	General chemistry		Comments
		Sites	ECs	90	80	75	50	25	20	10				Cations	Anions	
Coastal	Rateable	45	6717	732	578	520	340	212	182	121	Caboolture and Pine rivers, upper and central Mary Valley, and south coast including Logan and Albert rivers	sufficient	but variable	others	e chloride	catchments around mouth of Brisbane River
Sandy Coastal	All	48	1563	1126	650	580	318	187	160	95	Elliot, Gregory, Isis, Burrum and Noosa rivers and larger sand islands around Morton Bay	Rateable sufficient, although unevenly distributed	Moderate to high very variable	sodium	chloride	Low-lying coast and islands, high in NaCl with some tidal influence, needs monitoring
	Rateable	11	1195	1310	730	626	368	216	188	90						
Condamine MacIntyre	All	89	4989	720	550	492	346	250	230	180	Condamine River, excluding eastern tributaries between Warwick and Dalby, and Macintyre Brook	Rateable sufficient	Moderate to high	sodium magnesium	chloride bicarbonat e	Higher salinity and different chemically from downstream Queensland MDB
	Rateable	33	4003	755	555	500	355	255	235	189						
Maranoa–Balonne–Border rivers	All	92	3660	450	345	310	230	165	154	124	Balonne–Maranoa–Culgoa to border, and border rivers excluding Macintyre Brook	Rateable sufficient	Moderately low	all	bicarbonat e	Most of MDB discharges into NSW. Basically identical to Central Fitzroy
	Rateable	28	2872	471	356	325	234	165	152	123						
Western	All	36	253	312	195	169	118	88	82	70	MDB west of	Only one	Appears to	sodium	bicarbonat	Similar and

Zone	Site type	Data used		Percentiles of EC							Area	Sufficiency of data	Relative salinity	General chemistry		Comments
		Sites	ECs	90	80	75	50	25	20	10				Cations	Anions	
Murray–Darling basin	Rateable	2	82	282	195	173	127	96	85	76	the Balonne–Culgoa, including the Mungallala Creek system, Warrego and Paroo	rateable site, all riverine data used	be low	others	e chloride sulphate	geographically connected to Belyando Suttor. More monitoring needed
Lake Eyre	All	58	767	377	231	205	134	94	86	71	Catchments draining to Lake Eyre and other inland salt lakes, including the Bulloo, Barcoo, Thompson, Coopers Ck, Diamantina and Georgina	Few rateable but reasonably representative	Low	sodium others	bicarbonat e chloride sulphate	Very large area with variable chemistry. May be subdivided after more monitoring
	Rateable	4	383	410	230	200	128	90	82	71						
Gulf	All	109	1980	603	500	435	195	105	92	69	Catchments south of Cape York draining into the Gulf of Carpentaria, from the Gilbert River in the east to the NT border	Few rateable but reasonably representative . Slightly higher but more reliable	Moderate	all	bicarbonat e	Salinity slightly higher than in Lake Eyre region. May subdivide after more monitoring
	Rateable	12	565	630	550	500	245	157	134	100						

The spatial distribution of site salinity types on Figure G.3 reveals that EC characteristics vary significantly in a regional manner, and that the zones can be differentiated into salinity categories. The plots of percentiles in low, moderate and high categories are shown in Figures G.5, G.6 and G.7, with the two most saline zones in the lower categories being duplicated in the category above for comparison. This creates fuzzy divisions that reflect real spatial salinity relationships better than sharp division. The saline zones are found towards the east of southern and central Queensland, but contain mainly low-discharge streams with limited impact on big river systems. By contrast, the far north and south-west of the state have characteristically low salinity streams. The Central Fitzroy and Balonne–Maranoa zones are very similar both chemically and in terms of salinity, as are the western Murray Darling basin and Belyando–Suttor, but these zones were kept separate to be consistent with NAP regionalisation.

Discussion

This technical report presents an overview of salinity ranges in streams throughout Queensland in terms of 18 zones, which are reasonably homogeneous in terms of natural salinity and chemical characteristics. Each zone still contains regional variation, and the exact boundaries or subdivisions of zones may be further refined by expert local knowledge. No attempt has been made to discuss the processes behind the variability in this broad-scale review, or the relationship between salinity variation and biological provinces, as these are the focus of studies both within NRM&E and other organisations. Temporal salinity in terms of trends and cycles are also beyond the scope of this work.

Because there has, of necessity, been a high degree of subjectivity in the outlining of zones, supporting information is provided in the appendices to allow for review of the boundaries if required.

The question that cannot be fully answered is whether ranges of EC that are truly natural can be estimated when virtually all of Queensland has been disturbed to some extent, particularly in the lower catchments of major streams. Accordingly, the ranges calculated refer to the salinity that has existed over the period of collection, beginning in the 1960s and 1970s, and not necessarily to the natural or desirable salinity. Despite this, there is sufficient consistency in magnitude, variability and chemical composition to imply that the percentiles obtained are close to normal. Previous trend analyses, i.e. DPI (1994), Jolly et al. (2000) McNeil and Cox (2002), support this by indicating that EC trends in Queensland streams since at least 1970 have been slight in comparison with natural variability (usually of the order of less than 1 μS/cm/year), and tend to be cyclical rather than monotonic.

These arguments add confidence that the ranges presented here are sufficient to identify sites or sub-catchments where the EC is unusually high or low compared with the regional norm. However, the assumption of near natural EC would be violated using this methodology, if a very large proportion of a zone were to be in an unnatural condition. One possible case is the Macintyre Brook catchment. This strongly regulated system resembles the adjoining Condamine catchment, also subject to regulation, rather than the remainder of the border rivers, which are consistent with the lower Balonne.

In summary, the percentiles as presented provide a tool to assist in the development of guidelines by providing baseline information about ambient ranges. These can be used to identify anomalously high or low sites that have been sufficiently monitored. Local investigation is desirable to disclose whether their salinity state is natural or contributed to by human factors.

Figure 5: EC Percentiles for Low Salinity Zones, (overlapping with moderate category)

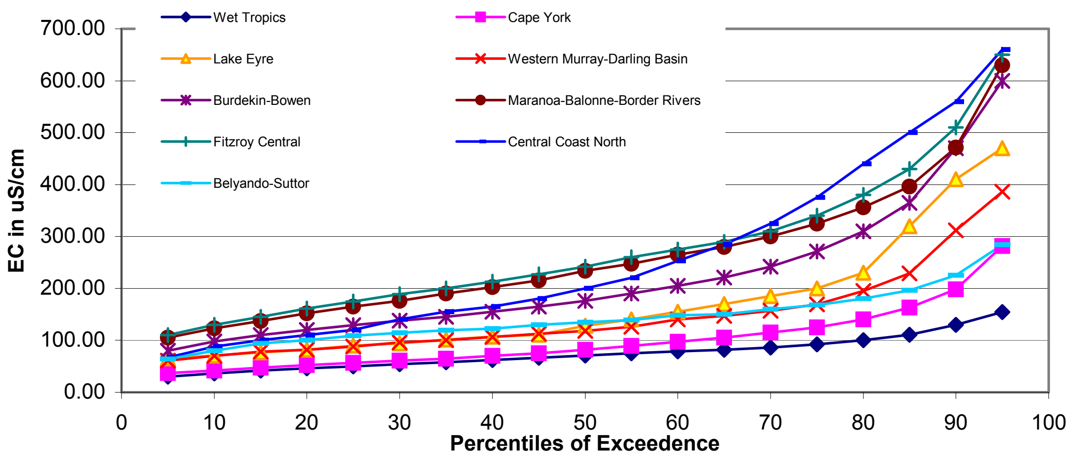


Figure 6: EC Percentiles for Moderate Salinity Zones, (overlapping with low and high)

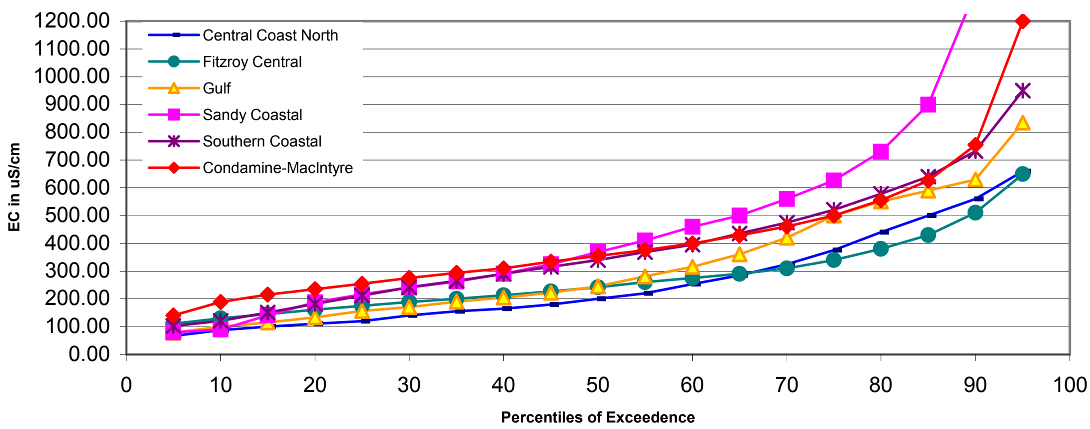
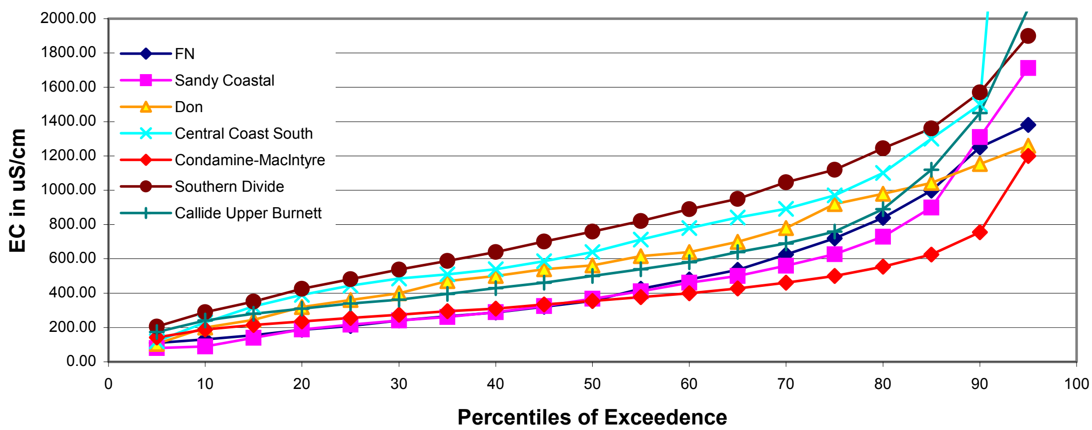


Figure 7: EC Percentiles for High Salinity Zones, (overlapping with moderate category)



Conclusions

In most zones there is a high degree of similarity between percentiles calculated for all riverine data and those using only data from sites with a reliability rating. This suggests that established sites with a reasonable history are sufficiently representative. However, it is clear that some areas of Queensland would benefit from strategic monitoring to clearly define ambient salinity ranges, regardless of other monitoring needs such as compliance or trends analysis. These particularly include low-lying coastal areas and islands between the mouth of the Fitzroy and the NSW border; and the western part of the state, including the Gulf catchments, the Lake Eyre catchment, and the portion of the Murray Darling basin west of the Balonne.

Some zones have been defined for the convenience of catchment management, although they are virtually identical in terms of salinity and water chemistry. These particularly include parts of the Murray Darling basin and adjoining sections of the Fitzroy basin.

Other zones may be combined, subdivided or redefined, but this would best be done on the basis of local input or in a joint review, including biological boundaries or other water quality parameters.

More input is needed on the effect of stream regulation and other forms of development on stream salinity, and related impacts on biota.

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Appendix H: Suite of environmental values that can be chosen for protection

Environmental Values	ICON	Definitions
Aquatic Ecosystems	❒	The intrinsic value of aquatic ecosystems, habitat and wildlife in waterways and riparian areas – for example, biodiversity, ecological interactions, plants, animals, key species (such as turtles, platypus, seagrass and dugongs) and their habitat, food and drinking water. Waterways include perennial and intermittent surface waters, ground waters, tidal and non-tidal waters, lakes, storages, reservoirs, dams, wetlands, swamps, marshes, lagoons, canals, natural and artificial channels and the bed and banks of waterways. See below for details of three possible "levels of protection" contained in the Australian water quality guidelines (AWQG).
		Level 1: High ecological/conservation value (HEV) ecosystems *"effectively unmodified or other highly valued systems, typically (but not always) occurring in national parks, conservation reserves or in remote and/or inaccessible locations. While there are no aquatic ecosystems in Australia and New Zealand that are entirely without some human influence, the ecological integrity of high conservation/ecological value systems is regarded as intact." (AWQG 2000; 3.1-10)*
		Level 2: Slightly–moderately disturbed (SMD) ecosystems *"Ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained. Typically, freshwater systems would have slightly to moderately cleared catchments and/or reasonably intact riparian vegetation; marine systems would have largely intact habitats and associated biological communities. Slightly–moderately disturbed systems could include rural streams receiving runoff from land disturbed to varying degrees by grazing or pastoralism, or marine ecosystems lying immediately adjacent to metropolitan areas."* (AWQG 2000; 3.1-10) (Note: EPP Water 2009 recognises the potential to distinguish slightly from moderately disturbed systems and establish different management intents – see EPP Water)
		Level 3: Highly disturbed (HD) ecosystems *"These are measurably degraded ecosystems of lower ecological value. Examples of highly disturbed systems would be some shipping ports and sections of harbours serving coastal cities, urban streams receiving road and stormwater runoff, or rural streams receiving runoff from intensive horticulture. The third ecosystem condition recognises that degraded aquatic ecosystems still retain, or after rehabilitation may have, ecological or conservation values, but for practical reasons it may not be feasible to return them to slightly–moderately disturbed condition." (AWQG 2000; 3.1-10)*
Primary industries	⑥	**Irrigation:** Suitability of water supply for irrigation - for example, irrigation of crops, pastures, parks, gardens and recreational areas.
	⑩	**Farm Water Supply:** Suitability of domestic farm water supply, other than drinking water. For example, water used for laundry and produce preparation.

Environmental Values	ICON	Definitions
	⑧	**Stock Watering:** Suitability of water supply for production of healthy livestock.
	②	**Aquaculture:** Health of aquaculture species and humans consuming aquatic foods (such as fish, molluscs and crustaceans) from commercial ventures.
	♦	**Human Consumers of Aquatic Foods:** Health of humans consuming aquatic foods - such as fish, crustaceans and shellfish (other than oysters) from natural waterways.
Recreation and aesthetics	❖	**Primary Recreation:** Health of humans during recreation which involves direct contact and a high probability of water being swallowed - for example, swimming, surfing, windsurfing, diving and water-skiing
	☒	**Secondary Recreation:** Health of humans during recreation which involves indirect contact and a low probability of water being swallowed – for example, wading, boating, rowing and fishing.
	⌘	**Visual Recreation:** Amenity of waterways for recreation which does not involve any contact with water - for example, walking and picnicking adjacent to a waterway.
Drinking Water	④	Suitability of raw drinking water supply. This assumes minimal treatment of water is required – for example, coarse screening and/or disinfection.
Industrial uses	⓪	Suitability of water supply for industrial use - for example, food, beverage, paper, petroleum and power industries. Industries usually treat water supplies to meet their needs.
Cultural and spiritual values	❁	Indigenous and non-indigenous cultural heritage - for example: • custodial, spiritual, cultural and traditional heritage, hunting, gathering and ritual responsibilities; • symbols, landmarks and icons (such as waterways, turtles and frogs); and • lifestyles (such as agriculture and fishing).