Environmental Protection (Water) Policy 2009

# Curtis Island, Calliope River and Boyne River Basins

# Environmental Values and Water Quality Objectives

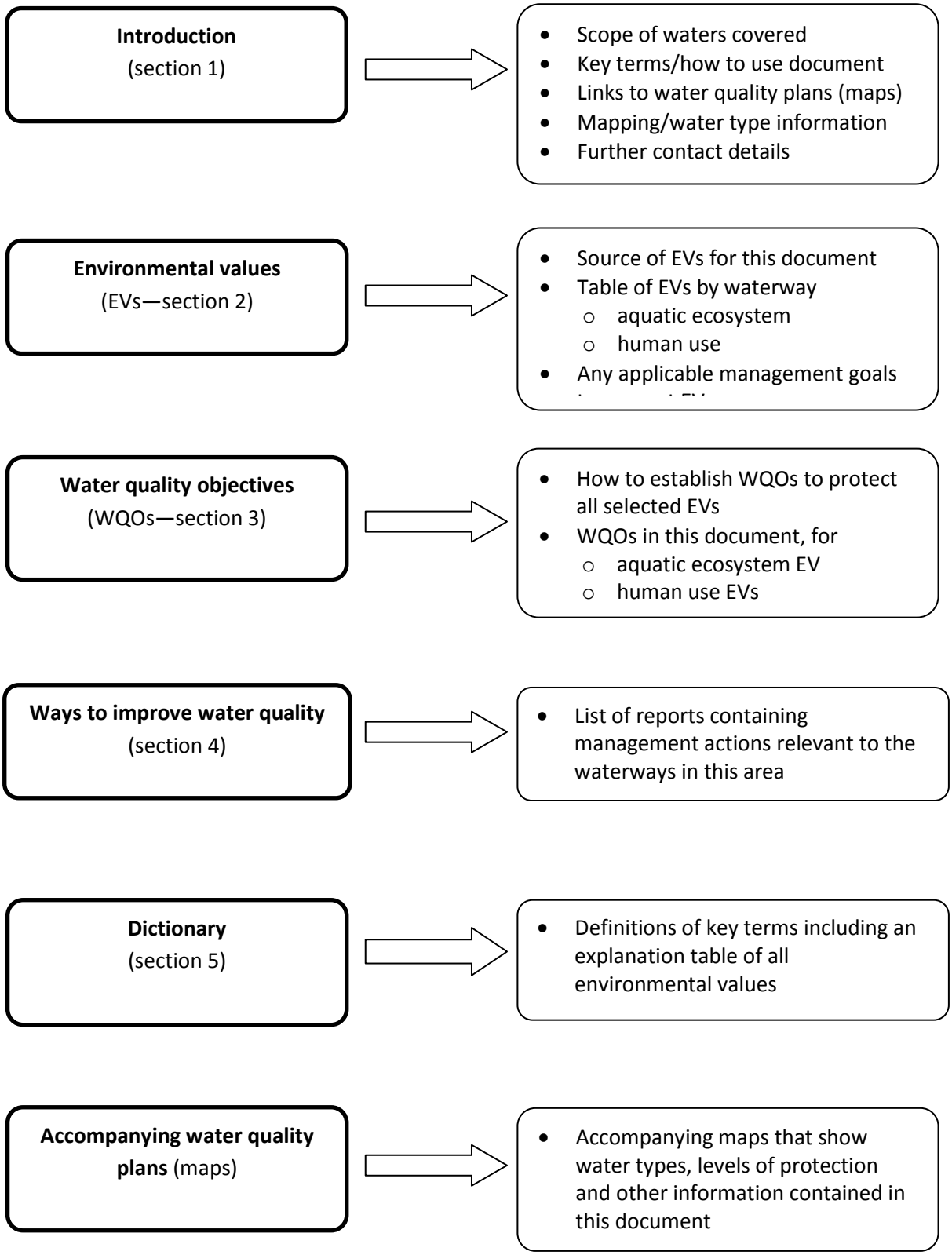
Basins 131, 132 and 133, including all waters of Gladstone Harbour, the Narrows, Curtis Island, Calliope and Boyne River basins, and adjacent coastal waters

Prepared by: Environmental Policy and Planning Division, Department of Environment and Heritage Protection



November 2014

# Main parts of this document and what they contain



# Contents



# List of tables

# 1 Introduction

This document is made pursuant to the provisions of the Environmental Protection (Water) Policy 2009 (EPP (Water)), which is subordinate legislation under the *Environmental Protection Act 1994*. The EPP (Water) provides a framework for:

- identifying environmental values (EVs) for Queensland waters, and deciding the water quality objectives (WQOs) to protect or enhance those EVs (WQOs are long-term goals for receiving waters, not individual point source emission objectives).
- including the identified EVs and WQOs under Schedule 1 of the EPP (Water).

This document contains EVs and WQOs for waters in the Curtis Island, Calliope River and Boyne River basins, Gladstone Harbour, the Narrows and adjacent coastal waters, and is listed under schedule 1 of the EPP (Water).

## 1.1 Purpose

The purpose of this document is to identify locally relevant environmental values and water quality objectives for the region, based on local historical data and in close consultation with the local community. These water quality objectives are used to help set development conditions, influence local government planning schemes and underpin report card grades for ecosystem health monitoring programs like the Gladstone Healthy Harbour Partnership and other similar programs. These water quality objectives have been refined from national and state water quality guidelines and present a truer picture of the values and water quality of local waterways. This ensures the values the community holds for its waterways can be maintained and improved into the future, without imposing unrealistic standards from national guidelines that may be inappropriate for local conditions.

## 1.2 Waters to which this document applies

This document applies to fresh and estuarine surface waters and groundwaters draining the basins of the Curtis Island, Calliope River and Boyne River basins (basins 131, 132 and 133[1]), and coastal waters, including Gladstone Harbour and the Narrows, as indicated in the accompanying plans (WQ1311—Curtis Island and Calliope River, WQ1312—Gladstone Harbour and the Narrows, WQ1331— Boyne River, WQ1272—coastal waters, WQ1273—groundwaters)[2].

Waters covered by this document include:

- all Curtis Island Basin fresh and estuarine waters, including Graham and Middle creeks
- all Calliope River Basin fresh and estuarine waters, including Calliope River, Auckland, Larcom and Boat creeks
- all Boyne River Basin fresh and estuarine waters, including Boyne River, Diglum Creek and South Trees Inlet

[1] Australia's River Basins 1997—Product User Guide. Published by Geoscience Australia. Canberra, ACT (3rd edition, 2004).

[2] This document and the accompanying plans are available from the department's website at www.ehp.qld.gov.au. The boundaries in the accompanying plans WQ1311, WQ1312, WQ1331, WQ1272, and WQ1273 are indicative only. EVs, water types and aquatic ecosystem management intent (level of protection) depicted in the accompanying plans are stored in electronic form as part of the Central Queensland Environmental Values Schedule 1 Geodatabase November 2014, and held at the department's offices at 400 George Street Brisbane. Geodatabase regions are based on the regions established in the Queensland Water Quality Guidelines. Spatial (GIS) datasets can be downloaded free of charge from the Queensland Spatial Catalogue (QSpatial) at http://qldspatial.information.qld.gov.au/catalogue/custom/index.page. For further information, email the department at epa.ev@ehp.qld.gov.au.

- wetlands, lakes and reservoirs (including Awoonga Reservoir)
- groundwaters
- enclosed coastal and open coastal waters, including Gladstone Harbour, South Trees Inlet, the Narrows, the lower Fitzroy delta estuary/inner Keppel Bay, Balaclava Island, and open coastal waters east of Curtis and Facing islands.

The geographical extent of waters addressed by this document is shown in the accompanying plans and is broadly:

- north to the Fitzroy River delta lower estuary/inner Keppel Bay
- west and south to the boundary with the Fitzroy, Burnett, Kolan and Baffle river basins
- east to the limit of Queensland Coastal Waters

Note: Additional water quality information is provided for Rodds Bay to assist in report card processes for Gladstone Harbour. EVs and WQOs for Rodds Bay will be included in EPP Water schedule documentation for the Baffle Basin.

# 1.3 Guidance on using this document

## 1.3.1 **Key terms (refer to dictionary for additional terms)**

**ADWG** means the Australian Drinking Water Guidelines (2011, updated December 2013), prepared by the National Health and Medical Research Council (NHMRC) in collaboration with the Natural Resource Management Ministerial Council (NRMMC)[3].

**AWQG** means the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (October 2000), prepared by the Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ)[4].

**Environmental values (EVs) for water** means the EVs specified in Table 1 of this document for the corresponding water. EVs for water are the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses. These EVs need to be protected from the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use. Particular waters may have different EVs. The range of EVs and the waters they can potentially apply to are listed below, and further details are provided in the dictionary (refer section 5).

**List of EVs and applicable waters**

| Environmental value (EV) | Potentially applicable to: | |
|---|---|---|
| | Tidal waters | Fresh (non-tidal) waters |
| **Protection of aquatic ecosystems (aquatic ecosystem EV)** | | |
| Protection or enhancement of aquatic ecosystem values, under four possible levels of ecosystem conditions:<br>• high ecological value (effectively unmodified) waters<br>• slightly disturbed waters<br>• moderately disturbed waters<br>• highly disturbed waters.<br>(Suitability for seagrass and wildlife habitat have also been specifically identified for some Queensland waters as a component of this EV). | ✓ | ✓ |
| **EVs other than aquatic ecosystem EV (called human use EVs)** | | |
| Suitability for drinking water supplies | | ✓ |
| Suitability for primary contact recreation (e.g. swimming) | ✓ | ✓ |
| Suitability for secondary contact recreation (e.g. boating) | ✓ | ✓ |
| Suitability for visual (no contact) recreation | ✓ | ✓ |
| Suitability for human consumers of wild or stocked fish, shellfish or crustaceans (suitability for oystering has also been specifically identified for some Queensland waters) | ✓ | ✓ |
| Protection of cultural and spiritual values, including traditional owner values of water | ✓ | ✓ |
| Suitability for industrial use (including mining, minerals refining/processing) | ✓ | ✓ |
| Suitability for aquaculture (e.g. red claw, barramundi) | ✓ | ✓ |

[3] The ADWG are available on the National Health and Medical Research Council website at www.nhmrc.gov.au.

[4] The AWQG are available on the Australian Government's National Water Quality Management Strategy website.

| | | |
|---|---|---|
| Suitability for crop irrigation | | ✓ |
| Suitability for stock watering | | ✓ |
| Suitability for farm supply/use | | ✓ |

**GBRMPA WQG means the** Water Quality Guidelines for the Great Barrier Reef Marine Park, Great Barrier Reef Marine Park Authority 2010, published at the GBRMPA website.

**Level of protection for a water (aquatic ecosystem EV)** means the level of aquatic ecosystem condition specified in Table 2 of this document that the corresponding WQOs for that water are intended to achieve (refer to management intent definition below for further information).

**Management goal** means the goals (if any) stated in section 2 of this document to support the EVs for waters identified in Table 1.

**Management intent for a water (aquatic ecosystem EV)** is defined in s. 14 of the EPP (Water). It is the management intent for the waters that the decision to release waste water or contaminant to the waters must ensure the following:

- for high ecological value (HEV) waters—the measures for the indicators are maintained
- for slightly disturbed (SD) waters—the measures for the slightly modified physical or chemical indicators are progressively improved to achieve the water quality objectives for high ecological value water
- for moderately disturbed (MD) waters:
  - if the measures for indicators of the EVs achieve the water quality objectives for the water—the measures for the indicators are maintained at levels that achieve the water quality objectives for the water, or
  - if the measures for indicators of the EVs do not achieve the water quality objectives for the water—the measures for indicators of the EVs are improved to achieve the water quality objectives for the water
- for highly disturbed (HD) waters—the measures for the indicators of all environmental values are progressively improved to achieve the water quality objectives for the water.

**QWQG** means the Queensland Water Quality Guidelines[5].

**Water quality guidelines** (defined in the EPP (Water)) are numerical concentration levels or statements for indicators that protect a stated environmental value. Under the EVs setting process contained in the EPP (Water), water quality guidelines are used as an input to the development of WQOs.

**Water quality indicator (for an EV)** means a property that is able to be measured or decided in a quantitative way. Examples of water quality indicators include physical indicators (e.g. temperature), chemical indicators (e.g. nitrogen, phosphorus, metals), and biological indicators (e.g. macroinvertebrates, seagrass, fish).

**Water quality objectives (WQOs)** means the WQOs specified in tables 2–12 and 14 of this document to support the EVs for waters identified in Table 1.

WQOs are long-term goals for water quality management. They are numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect the designated EVs for those waters. Water quality objectives are not individual point source emission objectives, but the receiving water quality objectives.

They are based on scientific criteria or water quality guidelines but may be modified by other inputs (e.g. social, cultural, economic).

Examples of WQOs include:

- total phosphorus concentration less than 20 micrograms per litre (µg/L)

[5] The QWQG are available on the department's website.

- chlorophyll a concentration less than 1 µg/L
- dissolved oxygen between 95 per cent and 105 per cent saturation
- family richness of macroinvertebrates greater than 12 families
- exotic individuals of fish less than five per cent.

**Water type** means groupings of waters with similar characteristics, as shown in the accompanying plans. Water types can include fresh waters (lowland, upland, lakes/reservoirs), wetlands and groundwaters, estuarine waters (lower, middle and upper estuaries), tidal canals, constructed estuaries, marinas and boat harbours, and coastal marine waters (open coastal, enclosed coastal). WQOs applying to different water types are outlined in this document. More detail on water types is provided in section 1.5.

Refer to dictionary for additional terms.

### 1.3.2 Main components of this document

The main components of this document are summarised in the introductory chart (prior to contents) and include the accompanying plans (showing the spatial extent of water types covered by this document) and the following main sections:

- Section 1—introduction and guidance on how to use the document
- Section 2 (Table 1)—EVs applying to waters covered by this document
- Section 3 (tables 2–12 and 14)—WQOs applying to different EVs:
  - tables 2 and 14 provide WQOs to protect the aquatic ecosystem EV, and closely link to the water types shown on the accompanying plans
  - tables 3 to 12 provide WQOs to protect human use EVs
- Section 4—ways to improve water quality: containing a list of relevant documents, provided for information purposes only
- Section 5—a dictionary of other terms relevant to EVs and WQOs.

### 1.3.3 Use of this document

Section 2 (Table 1) lists the identified EVs for protection for particular waters. The aquatic ecosystem EV is a default applying to all Queensland waters. Reference to section 3 (tables 2 and 14) provides the corresponding WQOs to protect the aquatic ecosystem EV. For the human use EVs specified in Table 1, tables 3 to 12 provide the corresponding WQOs to support these EVs.

Where Table 1 indicates more than one EV applies to a given water, the adoption of the most stringent WQO for the identified EVs applies to each water quality indicator in order to protect all identified EVs. Further detail on selection of most stringent WQOs is provided in section 3.

This document also refers to a number of guidelines, codes and other reference sources on water quality. In particular, the QWQG prepared by the department provide a technical basis for the majority of the WQOs contained in this document. The QWQG also provide more detailed information on water types, water quality indicators, derivation of local water quality guidelines, application during flood events, monitoring, and predicting and assessing compliance.

## 1.4 Information about mapped areas and boundaries

The boundaries in the accompanying plans WQ1311, WQ1312, WQ1331, WQ1272, and WQ1273 are indicative only. EVs, water types and aquatic ecosystem management intent (level of protection) depicted in the accompanying plans are stored in electronic form as part of the Central Queensland Environmental Values Schedule 1 Geodatabase November 2014, and held at the department's offices at

400 George Street Brisbane. Geodatabase regions are based on the regions established in the QWQG. Spatial (GIS) datasets can be downloaded free of charge from the Queensland Spatial Catalogue (QSpatial) at http://qldspatial.information.qld.gov.au/catalogue/custom/index.page. For further information, email the department at epa.ev@ehp.qld.gov.au.

## 1.5 Water types and basis for boundaries

### 1.5.1 **Water types**

Waters in this document have been classified into different water types, including the following (not all water types are present in all areas):

- upland freshwaters—small upstream streams, moderate - fast flowing with steeper gradients than lowland freshwaters. Shown on the accompanying plan as freshwaters above 150 metres altitude
- lowland freshwaters—larger slow moving freshwater streams and rivers, shown on the accompanying plan as freshwaters under 150 metres altitude
- freshwater lakes/reservoirs
- groundwaters
- mid estuary—waters extending the majority of the length of estuaries with a moderate amount of water movement from either freshwater inflow or tidal exchange
- lower estuary/enclosed coastal (LE/EC)—waters occurring at the downstream end of estuaries and including shallow coastal waters in adjacent enclosed bays
- marinas, boat harbours, tidal canals, and constructed estuaries
- wetlands
- open coastal (OC) and other marine waters—extending to the seaward limits of Queensland waters.

The water types are based on local water quality studies (refer to the source documents listed after Table 2), the AWQG and mapping and definitional rules contained in the QWQG. Further detail on water types is contained in these sources. Water types identified in this document are shown in Table 2 and the accompanying plans.

### 1.5.2 **Water type boundaries**

The boundaries of different water types have been mapped using a variety of attributes, including:

- geographic coordinates
- catchment or subcatchment boundaries
- highest/lowest astronomical tide
- tidal limiting structure (weirs)
- maritime mapping conventions
- coastline
- surveyed terrestrial boundaries
- altitude
- boundaries based on technical investigations.

Boundaries are shown on the plans. The boundaries of water types may be confirmed or revised by site investigations. Refer to section 1.3 above.

## 1.6 Matters for amendment

Amendments of the following type may be made to this schedule 1 document for the purposes of replacement under section 12(2)(b) of the EPP (Water):

- changes to EVs
- changes to management goals
- changes to WQOs
- changes to management intent (level of protection) categories
- changes to waterway or water type boundaries/descriptions
- updates to information/data sources, websites and email contact details, agency/departmental names, other institutional names, references.

# ENVIRONMENTAL VALUES

# 2 Environmental values

## 2.1 Environmental values

EVs for waters covered by this document are shown in the accompanying plans (WQ1311, WQ1312, WQ1331, WQ1272 and WQ1273) and the following tables:

- Table 1A: Gladstone Harbour and adjacent coastal waters, mainland estuaries, the Narrows and Fitzroy delta estuary
- Table 1B: Boyne River Basin
- Table 1C: Calliope River Basin
- Table 1D: Curtis Island Basin and adjacent coastal waters

Details of stakeholder consultation activities carried out by the department and Fitzroy Basin Association (FBA) as input to EVs are reported in:

- Fitzroy Basin Association, 2014*,* Establishing environmental values and water quality objectives for Capricorn and Curtis Coast basins and coastal waters: draft community consultation report, February 2014.

The dictionary to this document provides further explanation of EVs (refer section 5).

## 2.2 Management goals to support environmental values

### 2.2.1 **Management intent for waters**

It is the management intent for Queensland waters that the decision to release waste water or contaminant to waters must ensure the following:

- for high ecological value (HEV) waters—the measures for the indicators are maintained
- for slightly disturbed (SD) waters—the measures for the slightly modified physical or chemical indicators are progressively improved to achieve the water quality objectives for high ecological value water
- for moderately disturbed (MD) waters:
  - if the measures for indicators of the EVs achieve the water quality objectives for the water—the measures for the indicators are maintained at levels that achieve the water quality objectives for the water, or
  - if the measures for indicators of the EVs do not achieve the water quality objectives for the water—the measures for indicators of the EVs are improved to achieve the water quality objectives for the water
- for highly disturbed (HD) waters—the measures for the indicators of all environmental values are progressively improved to achieve the water quality objectives for the water.

*Note 1* — refer to accompanying plans for locations of waters and level of protection/management intent applying to waters

*Note 2* — see the Environmental Protection Regulation 2008, section 51

*Note 3* — see the Environmental Protection (Water) Policy 2009, section 14.

### 2.2.2 Raw water for drinking water consumption

The management goal is to:

- minimise the risk that the quality of raw water taken for treatment for human consumption results in adverse human health effects
- maintain the palatability rating of water taken for treatment for human consumption at the level of good as set out in the ADWG
- minimise the risk that the quality of raw water taken for treatment for human consumption results in the odour of drinking water being offensive to consumers.

### 2.2.3 Irrigation water quality

The management goal for irrigation water is that the quality of water, when used in accordance with the best irrigation and crop management practices and principles of ecologically sustainable development, does not result in crop yield loss or soil degradation.

### 2.2.4 Recreational water quality

The management goal for recreational water quality is to achieve a low risk to human health from water quality threats posed by exposure through ingestion, inhalation or contact during recreational use of water resources.

# ENVIRONMENTAL VALUES FOR

- **GLADSTONE HARBOUR, ADJACENT COASTAL WATERS**
- **MAINLAND ESTUARIES**
- **THE NARROWS**

**Table 1A Environmental values for Gladstone Harbour and adjacent coastal waters, mainland estuaries, the Narrows and Fitzroy Delta**

| **GLADSTONE HARBOUR, ADJACENT COASTAL WATERS, MAINLAND ESTUARIES**<br><br>**THE NARROWS**<br><br>**FITZROY DELTA** | **Environmental values**[1–7] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Aquatic ecosystems** | **Irrigation** | **Farm supply/use** | **Stock water** | **Aquaculture** | **Human consumer** | **Primary recreation**[5] | **Secondary recreation**[5] | **Visual recreation** | **Drinking water** | **Industrial use** | **Cultural and spiritual values** |
| **Water** |  |  |  |  |  |  |  |  |  |  |  |  |
| **GLADSTONE HARBOUR (listed west to east)** [7] **AND ADJACENT COASTAL WATERS** | | | | | | | | | | | | |
| Western Basin | ✓ | | | | | ✓ | | ✓[5] | ✓ | | ✓ | ✓ |
| Inner Harbour (including waters adjacent to Spinnaker Park beach, Barney Point) | ✓ | | | | | ✓ | ✓[5] | ✓[5] | ✓ | ✓[6] | ✓ | ✓ |
| Mid Harbour | ✓ | | | | | ✓ | ✓[5] | ✓[5] | ✓ | ✓[6] | ✓ | ✓ |
| Outer Harbour | ✓ | | | | | ✓ | ✓[5] | ✓[5] | ✓ | ✓[6] | ✓ | ✓ |
| Coastal waters outside Gladstone Harbour east and south of Facing Island (to southern limits of Port) | ✓ | | | | | ✓ | ✓[5] | ✓[5] | ✓ | ✓[6] | ✓ | ✓ |
| Coastal waters east of Curtis Island | ✓ | | | | | ✓ | ✓[5] | ✓[5] | ✓ | | | ✓ |
| Coastal waters around Heron Island Group (Capricorn Group) | ✓ | | | | | ✓ | ✓[5] | ✓[5] | ✓ | ✓[6] | | ✓ |

| **GLADSTONE HARBOUR, ADJACENT COASTAL WATERS, MAINLAND ESTUARIES**<br><br>**THE NARROWS**<br><br>**FITZROY DELTA** | **Environmental values**[1–7] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Aquatic ecosystems** | **Irrigation** | **Farm supply/use** | **Stock water** | **Aquaculture** | **Human consumer** | **Primary recreation**[5] | **Secondary recreation**[5] | **Visual recreation** | **Drinking water** | **Industrial use** | **Cultural and spiritual values** |
| **Water** |  |  |  |  |  |  |  |  |  |  |  |  |
| **MAINLAND ESTUARIES ENTERING GLADSTONE HARBOUR (listed north to south)** [7] | | | | | | | | | | | | |
| Calliope River estuary, Boat Creek | ✓ | | | | | ✓ | | ✓[5] | ✓ | | ✓ | ✓ |
| Auckland Inlet and Gladstone Marina | ✓ | | | | ✓ | ✓ | | ✓[5] | ✓ | | ✓ | ✓ |
| South Trees Inlet | ✓ | | | | ✓ | ✓ | | ✓[5] | ✓ | | ✓ | ✓ |
| Boyne River estuary | ✓ | | | | | ✓ | ✓[5] | ✓[5] | ✓ | | | ✓ |
| **NARROWS and FITZROY DELTA LOWER ESTUARY** [7] | | | | | | | | | | | | |
| The Narrows (north of Graham Creek), Deception Creek, East Balaclava Island, Connor Creek and Kamiesh Passage (estuarine reaches) | ✓ | | | | | ✓ | | ✓[5] | ✓ | | | ✓ |
| Lower Fitzroy River (estuarine waters) | ✓ | | | | | ✓ | | ✓[5] | ✓ | | ✓ | ✓ |
| **GLADSTONE HARBOUR - ISLAND FRESH WATERS** [7] | | | | | | | | | | | | |
| Facing Island fresh waters | ✓ | | | | | ✓ | ✓ | | ✓ | | | ✓ |
| Island fresh waters (Quoin and other harbour islands, excluding Curtis and Facing islands) | ✓ | | | | | | | | | | | ✓ |

**Notes:**

1. Refer to the accompanying plans WQ1311, WQ1312, WQ1331, and WQ1273 for locations of EVs. For fresh water and estuarine rows, the EVs shown relate to waters within each subcatchment (for example 'Boyne River estuarine reaches') as shown on the plans.

2. ✓ means the EV is selected for protection. Blank indicates that the EV is not chosen for protection.

3. Refer to the dictionary for further explanation of EVs.

4. Refer to section 3 for WQOs applying to the EVs in this table.

5. The selection of recreational EVs for waters does not mean that these waters are free of dangerous aquatic organisms, for example venomous organisms (e.g. marine stingers including box jellyfish, irukandji jellyfish), crocodiles, and sharks. Direct contact with dangerous aquatic organisms should be avoided. Refer to EHP CrocWatch, council, www.health.qld.gov.au, www.beachsafe.org.au, www.marinestingers.com.au and other information sources for further details on swimming safety and information on specific waters.

6. Waters in which desalination for drinking water may apply.

7. For more specific information on activity restrictions in waterways including Gladstone Port refer to Gladstone Ports Corporation (GPC) website ('security'), and Maritime Services Queensland ('restricted areas'). Within Gladstone Port, landside and waterside restricted zones limit activities when activated. Further details on landuse planning for strategic port lands are provided in the GPC's landuse plan (available from the GPC website).

# ENVIRONMENTAL VALUES FOR

# BOYNE RIVER BASIN

## Table 1B Environmental values for Boyne River Basin

| BOYNE River Basin | Environmental values[1–6] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aquatic ecosystems | Irrigation | Farm supply/use | Stock water | Aquaculture | Human consumer | Primary recreation[5] | Secondary recreation[5] | Visual recreation | Drinking water | Industrial use | Cultural and spiritual values |
| Water |  |  |  |  |  |  |  |  |  |  |  |  |
| **SURFACE FRESH WATERS (rivers, creeks, streams) in developed areas (e.g. urban, industrial, rural residential, agriculture, farmlands)** | | | | | | | | | | | | |
| **Upstream of Lake Awoonga (listed Boyne River main channel, then in anti-clockwise direction)** | | | | | | | | | | | | |
| Upper Boyne River main channel | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Mid Boyne River main channel | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Northern Boyne tributaries around Lake Awoonga | ✓ | | | ✓ | | | ✓ | | ✓ | | ✓ | ✓ |
| Upper northern creeks (including Futter and Diglum creeks) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Mid Boyne western tributaries (including Marble and other creeks) | ✓ | | ✓ | ✓ | | | | | ✓ | | | ✓ |
| Upper Boyne western tributaries (including Degalgil and Ridler creeks) | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| Upper Boyne eastern tributaries (including Blackmans and Oaky creeks) | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |



16

| BOYNE River Basin | Environmental values[1–6] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aquatic ecosystems | Irrigation | Farm supply/use | Stock water | Aquaculture | Human consumer | Primary recreation[5] | Secondary recreation[5] | Visual recreation | Drinking water | Industrial use | Cultural and spiritual values |
| **Water** |  |  |  |  |  |  |  |  |  |  |  |  |
| Mid Boyne eastern tributaries (including Eastern Boyne River and other creeks) | ✓ | | ✓ | ✓ | | | | | ✓ | | | ✓ |
| Southern/eastern Boyne tributaries around Lake Awoonga (including Iveragh Creek) | ✓ | | ✓ | ✓ | | | | | ✓ | | ✓ | ✓ |
| **Lake Awoonga** | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Downstream of Lake Awoonga (listed Boyne River main channel, then all western sub catchment tributaries, then eastern tributaries)** | | | | | | | | | | | | |
| Lower Boyne River main channel (downstream to Manns Weir) | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ | | | ✓ |
| Lower Boyne western tributaries (downstream of Awoonga Dam) | ✓ | ✓ | ✓ | ✓ | | | | | ✓ | | | ✓ |
| Fresh waters in Gladstone urban area and Boyne Island (excluding South Trees Inlet) | ✓ | | | | | ✓ | | ✓ | ✓ | | | ✓ |
| Lower Boyne eastern tributaries (downstream of Awoonga Dam—including Station Creek) | ✓ | | ✓ | ✓ | | | | | ✓ | | ✓ | ✓ |
| Fresh waters in Tannum Sands | ✓ | | | ✓ | | | | | ✓ | | ✓ | ✓ |
| **OTHER FRESH WATERS** | | | | | | | | | | | | |
| SURFACE FRESH WATERS in undeveloped areas through basin (e.g. in national parks) | ✓ | | | | | | | | ✓ | | | ✓ |
| **GROUNDWATERS (bores, etc)** | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ | ✓ | ✓ |

| **BOYNE River Basin** | **Environmental values**[1–6] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Aquatic ecosystems** | **Irrigation** | **Farm supply/use** | **Stock water** | **Aquaculture** | **Human consumer** | **Primary recreation**[5] | **Secondary recreation**[5] | **Visual recreation** | **Drinking water** | **Industrial use** | **Cultural and spiritual values** |
| **Water** |  |  |  |  |  |  |  |  |  |  |  |  |
| **ESTUARIES** [6] | | | | | | | | | | | | |
| Boyne River estuary | ✓ | | | | | ✓ | ✓[5] | ✓[5] | ✓ | | | ✓ |
| South Trees Inlet | ✓ | | | | ✓ | ✓ | | ✓[5] | ✓ | | ✓ | ✓ |
| Gladstone Harbour | Refer to Table 1A[6] | | | | | | | | | | | |

**Notes:**

1. Refer to the accompanying plans WQ1331 and WQ1273 for locations of EVs. For fresh water and estuarine rows, the EVs shown relate to waters within each subcatchment (for example 'mid Boyne River main channel') as shown on the plans.

2. ✓ means the EV is selected for protection. Blank indicates that the EV is not chosen for protection.

3. Refer to the dictionary for further explanation of EVs.

4. Refer to section 3 for WQOs applying to the EVs in this table.

5. The selection of recreational EVs for waters does not mean that these waters are free of dangerous aquatic organisms, for example venomous organisms (e.g. marine stingers including box jellyfish, irukandji jellyfish), crocodiles, and sharks. Direct contact with dangerous aquatic organisms should be avoided. Refer to EHP CrocWatch, council, www.health.qld.gov.au, www.beachsafe.org.au, www.marinestingers.com.au and other information sources for further details on swimming safety and information on specific waters.

6. For more specific information on activity restrictions in waterways including Gladstone Port refer to Gladstone Ports Corporation (GPC) website ('security'), and Maritime Services Queensland ('restricted areas'). Within Gladstone Port, landside and waterside restricted zones limit activities when activated. Further details on landuse planning for strategic port lands are provided in the GPC's landuse plan (available from the GPC website).

# ENVIRONMENTAL VALUES FOR

# CALLIOPE RIVER BASIN



19

## Table 1C Environmental values for Calliope River Basin

| CALLIOPE River Basin | Environmental values[1–6] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aquatic ecosystems | Irrigation | Farm supply/use | Stock water | Aquaculture | Human consumer | Primary recreation[5] | Secondary recreation[5] | Visual recreation | Drinking water | Industrial use | Cultural and spiritual values |
| **Water** |  |  |  |  |  |  |  |  |  |  |  |  |
| **GLADSTONE STATE DEVELOPMENT AREA (SDA) WATERS** (mainland)[6] | | | | | | | | | | | | |
| Gladstone SDA waters (mainland) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | | ✓ | ✓ |
| **SURFACE FRESH WATERS OUTSIDE STATE DEVELOPMENT AREA (rivers, creeks, in developed areas, e.g. urban, industrial, rural residential, agriculture, farmlands)** | | | | | | | | | | | | |
| **Upper Calliope River (including tributaries)** | | | | | | | | | | | | |
| Upper Calliope River main channel | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Upper Calliope northern tributaries (including Larcom, Alma and Harper creeks) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Upper Calliope southern tributaries (including Maxwelton, Toms and Sheep Station creeks) | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |



20

| CALLIOPE River Basin | Environmental values[1–6] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aquatic ecosystems | Irrigation | Farm supply/use | Stock water | Aquaculture | Human consumer | Primary recreation[5] | Secondary recreation[5] | Visual recreation | Drinking water | Industrial use | Cultural and spiritual values |
| **Water** |  |  |  |  |  |  |  |  |  |  |  |  |
| **Mid Calliope River (including tributaries)** | | | | | | | | | | | | |
| Mid Calliope River main channel (above tidal limit), including Gladstone Weir | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Mid Calliope northern tributaries (including Gravel and other creeks) | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Mid Calliope southern tributaries (including Neill and Double creeks) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Lower Calliope River (including tributaries)** | | | | | | | | | | | | |
| Lower Calliope River main channel | Refer to Calliope estuarine waters below | | | | | | | | | | | |
| Lower Calliope northern tributaries (including Oaky and other creeks) | ✓ | ✓ | ✓ | ✓ | | ✓ | | | ✓ | ✓ | ✓ | ✓ |
| Lower Calliope southern tributaries (including Clyde and other creeks) | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| South of Calliope River – Gladstone area fresh waters (including Auckland and other creeks) | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ |
| Munduran Creek and other fresh waters (draining to the Narrows/Deception Creek) | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| **OTHER FRESH WATERS** | | | | | | | | | | | | |
| SURFACE FRESH WATERS in undeveloped areas through basin (e.g. in National Parks) | ✓ | | | | | | | | ✓ | | | ✓ |
| **GROUNDWATERS (bores, etc)** | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | ✓ | ✓ | ✓ |

| CALLIOPE River Basin | Environmental values[1–6] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aquatic ecosystems | Irrigation | Farm supply/use | Stock water | Aquaculture | Human consumer | Primary recreation[5] | Secondary recreation[5] | Visual recreation | Drinking water | Industrial use | Cultural and spiritual values |
| **Water** |  |  |  |  |  |  |  |  |  |  |  |  |
| **ESTUARIES (listed alphabetically)[6]** | | | | | | | | | | | | |
| Auckland Inlet and Gladstone Marina | ✓ | | | | ✓ | ✓ | | ✓[5] | ✓ | | ✓ | ✓ |
| Calliope River estuary, Boat Creek | ✓ | | | | | ✓ | | ✓[5] | ✓ | | ✓ | ✓ |
| The Narrows, Deception Creek | Refer to Table 1A[6] | | | | | | | | | | | |
| Gladstone Harbour | Refer to Table 1A[6] | | | | | | | | | | | |

**Notes:**

1. Refer to the accompanying plans WQ1311, WQ1312, and WQ1273 for locations of EVs. For fresh water and estuarine rows, the EVs shown relate to waters within each subcatchment (for example 'upper Calliope northern tributaries') as shown on the plans.

2. ✓ means the EV is selected for protection. Blank indicates that the EV is not chosen for protection.

3. Refer to the dictionary for further explanation of EVs.

4. Refer to section 3 for WQOs applying to the EVs in this table.

5. The selection of recreational EVs for waters does not mean that these waters are free of dangerous aquatic organisms, for example venomous organisms (e.g. marine stingers including box jellyfish, irukandji jellyfish), crocodiles, and sharks. Direct contact with dangerous aquatic organisms should be avoided. Refer to EHP CrocWatch, council, www.health.qld.gov.au, www.beachsafe.org.au, www.marinestingers.com.au and other information sources for further details on swimming safety and information on specific waters.

6. Some EVs within Gladstone State Development Area (SDA) are only applicable to fresh waters. For more specific information on land use designations and corresponding uses within Gladstone SDA, refer to Gladstone State Development Area Development Scheme and mapping, available from DSDIP website. For more specific information on activity restrictions in waterways including Gladstone Port refer to Gladstone Ports Corporation (GPC) website ('security'), and Maritime Services Queensland ('restricted areas'). Within Gladstone Port, landside and waterside restricted zones limit activities when activated. Further details on landuse planning for strategic port lands are provided in the GPC's landuse plan (available from the GPC website).



22

# ENVIRONMENTAL VALUES FOR

# CURTIS ISLAND BASIN

## Table 1D Environmental values for Curtis Island Basin

| CURTIS ISLAND Basin | Environmental values[1–6] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aquatic ecosystems | Irrigation | Farm supply/use | Stock water | Aquaculture | Human consumer | Primary recreation [5] | Secondary recreation[5] | Visual recreation | Drinking water | Industrial use | Cultural and spiritual values |
| **Water** |  |  |  |  |  |  |  |  |  |  |  |  |
| **GLADSTONE STATE DEVELOPMENT AREA (SDA) WATERS** (Curtis Island) [6] | | | | | | | | | | | | |
| Curtis Island SDA Industry/corridor precinct fresh waters | ✓ | | | | | | | | | | ✓ | ✓ |
| Curtis Island SDA environmental management precinct fresh waters | ✓ | | | | | | | | ✓ | | | ✓ |
| **SURFACE FRESH WATERS OUTSIDE STATE DEVELOPMENT AREA (listed anti-clockwise from southern end)** | | | | | | | | | | | | |
| Curtis Island—eastern and southern draining fresh waters | ✓ | | | | | | | | ✓ | | | ✓ |
| Curtis Island—northern draining fresh waters | ✓ | | ✓ | ✓ | | ✓ | | ✓ | ✓ | | | ✓ |
| Curtis Island—western draining fresh waters north of Graham Creek (including Middle, Boat and Badger creeks) | ✓ | | | | | ✓ | | ✓ | ✓ | ✓ | | ✓ |
| Graham Creek catchment western draining fresh waters (outside SDA) | ✓ | | | | | | | ✓ | ✓ | | | ✓ |
| **GROUNDWATERS (bores, etc.)** | ✓ | | | | | | | | | ✓ | | ✓ |



24

| CURTIS ISLAND Basin | Environmental values[1–6] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aquatic ecosystems | Irrigation | Farm supply/use | Stock water | Aquaculture | Human consumer | Primary recreation[5] | Secondary recreation[5] | Visual recreation | Drinking water | Industrial use | Cultural and spiritual values |
| Water |  |  |  |  |  |  |  |  |  |  |  |  |
| **ESTUARIES / BAYS** | | | | | | | | | | | | |
| Curtis Island northern/eastern draining estuaries (to ocean - including tributaries) | ✓ | | | | | ✓ | | ✓[5] | ✓ | | | ✓ |
| Curtis Island southern draining estuaries | Refer to Table 1A | | | | | | | | | | | |
| Graham Creek (estuarine reaches) | ✓ | | | | | ✓ | | ✓[5] | ✓ | | | ✓ |
| The Narrows | Refer to Table 1A | | | | | | | | | | | |
| **COASTAL AND MARINE WATERS – east of Curtis Island, and around Heron Island Group** | | | | | | | | | | | | |
| Coastal waters north and east of Curtis Island | ✓ | | | | | ✓ | ✓[5] | ✓[5] | ✓ | | | ✓ |
| Coastal waters around Heron Island Group (Capricorn Group) | ✓ | | | | | ✓ | ✓[5] | ✓[5] | ✓ | ✓[6] | | ✓ |
| **GLADSTONE HARBOUR, THE NARROWS – refer to Table 1A** [6] | | | | | | | | | | | | |

**Notes:**

1. Refer to the accompanying plans WQ1311, WQ1312, WQ1272, and WQ1273 for locations of EVs. For fresh water and estuarine rows, the EVs shown relate to waters within each subcatchment (for example 'Curtis island – northern draining fresh waters') as shown on the plans.

2. ✓ means the EV is selected for protection. Blank indicates that the EV is not chosen for protection.

3. Refer to the dictionary for further explanation of EVs.

4. Refer to section 3 for WQOs applying to the EVs in this table.

5. The selection of recreational EVs for waters does not mean that these waters are free of dangerous aquatic organisms, for example venomous organisms (e.g. marine stingers including box jellyfish, irukandji jellyfish), crocodiles, and sharks. Direct contact with dangerous aquatic organisms should be avoided. Refer to EHP CrocWatch, council, www.health.qld.gov.au, www.beachsafe.org.au, www.marinestingers.com.au and other information sources for further details on swimming safety and information on specific waters.

6. For more specific information on land use designations and corresponding uses within Gladstone SDA, refer to Gladstone State Development Area Development Scheme and mapping, available from DSDIP website. For more specific information on activity restrictions in waterways including Gladstone Port refer to Gladstone Ports Corporation (GPC) website ('security'), and Maritime Services Queensland ('restricted areas'). Within Gladstone Port, landside and waterside restricted zones limit activities when activated. Further details on landuse planning for strategic port lands are provided in the GPC's landuse plan (available from the GPC website).

# WATER QUALITY OBJECTIVES TO PROTECT ENVIRONMENTAL VALUES

# 3 Water quality objectives to protect environmental values

This section provides WQOs to support and protect different EVs identified for waters in Table 1. WQOs are long-term goals for water quality management. They are numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect the designated EVs for those waters. Water quality objectives are not individual point source emission objectives, but the receiving water quality objectives.

This section is in two main parts.

**Aquatic ecosystem WQOs**

Following stakeholder consultation and analysis of water quality data, WQOs have been derived for both baseflow and event WQOs in Gladstone Harbour and other waterways where data was available. Section 3.1 (tables 2 and 14) outlines WQOs to protect the aquatic ecosystem EV. Key WQOs tables in this section are:

- table 2A: Gladstone Harbour, the Narrows, adjacent coastal waters and estuaries – baseflow WQOs
- table 2B: Gladstone Harbour and the Narrows: time/flow thresholds for applying baseflow WQOs
- table 2C: Gladstone Harbour, the Narrows and adjacent estuaries – toxicants WQOs
- table 2D: Gladstone Harbour and Boat Creek: event WQOs
- table 2E: Boyne River Basin: baseflow WQOs
- table 2F: Calliope River Basin: baseflow WQOs
- table 2G: Curtis Island, Facing Island and coastal waters WQOs
- table 14: surface water and groundwater WQOs (ionic indicators).

The aquatic ecosystem EV is a default applying to all Queensland waters, and therefore the WQOs for aquatic ecosystems form the minimum WQOs for all waters. Where no human use EVs are identified, the WQOs identified for aquatic ecosystem protection remain applicable.

**Human use EVs**

Section 3.2 (tables 3 to 12) provides WQOs for EVs other than aquatic ecosystem (‘human use EVs’) such as recreational water use, irrigating crops, and aquaculture.

Sources used in deriving WQOs are provided in and after the tables.

Where reference to table 1 indicates more than one EV applies to a given water (for example aquatic ecosystem and recreational use), the most stringent WQO for each water quality indicator applies, which will then protect all identified EVs. Refer to the following example on selection of most stringent WQOs. Note that this is an example only and should not be directly adopted for use.

**Example**

For lowland freshwater streams with aquatic ecosystem and drinking water EVs, the respective turbidity WQOs are:

- aquatic ecosystem lowland freshwater stream: less than 10 nephelometric turbidity units (NTU)
- drinking water: less than 25 NTU.

In this case the aquatic ecosystem WQO for turbidity (less than 10 NTU) is the more stringent, and its adoption therefore supports both the aquatic ecosystem and drinking water EVs.

# 3.1 Water quality objectives to protect aquatic ecosystems

This section provides physico-chemical, biological (section 3.1.1) and riparian (section 3.1.2) WQOs to support the aquatic ecosystem EV. Sources used in deriving locally relevant WQOs are provided in and after the tables in each of these sections. Section 3.1.3 provides information about the State Planning Policy (SPP) (state interest – water quality).

## 3.1.1 **Physico–chemical and biological water quality objectives**

Each table includes the following information:

- water area or water type (column 1) (for boundaries of specified areas, refer to the accompanying plans)
- the corresponding management intent (level of protection) for the identified waters (column 2)
- the corresponding physico-chemical and biological WQOs to achieve the management intent (level of protection) for the identified waters (column 3).

Waters for which all physico-chemical WQOs (e.g. nutrients, toxicants) have been set corresponding to HEV management intent are identified in columns 1 and 2 of table 2. Each of these waters is given a specific label in the table (e.g. 'HEV1234') which links to the accompanying plans. Slightly disturbed (SD) waters are similarly identified.

The management intent (level of protection) for most waters other than HEV or SD is to achieve a 'moderately disturbed' (MD) condition, for which corresponding WQOs have been derived. Where local WQOs are derived for MD areas these are also identified with specific labels (e.g. ‘MD1234’). For some indicators and water types, WQOs correspond with a 'slightly to moderately disturbed' (SMD) level of protection, based on management intent categories specified in source technical guidelines, in particular the Australian water quality guidelines (ANZECC, 2000). For ease of interpretation, this document and accompanying mapping include these within the MD level of protection. For some MD waters a higher level of protection may be provided for toxicants (e.g. pesticides).

WQOs for metals and other toxicants, where not stated in this document, are referred to the ANZECC guidelines. In the case of aluminium, reference is made to a recent peer reviewed study of toxicity of aluminium in marine waters by Golding et al. (2014). This study used ANZECC protocols to derive a marine guideline value of 24 µg/L of aluminium (that applies to the measured concentration in seawater that passes through a 0.45 µm filter) to protect 95% of species (with a 99% species protection value of 2.1 µg/L). This supersedes the existing low reliability guideline of 0.5 µg/L which was derived using conservative safety margins from limited data.

Source: Golding, L.A., Angel, B.M., Batley, G.E., Apte, S.C., Krassoi, R. and Doyle, C.J. 2014. Derivation of a water quality guideline for aluminium in marine waters. *Environmental Toxicology and Chemistry* (Accepted) (DOI: 10.1002/etc.2771).

### Application

The QWQG (section 5, Appendix D) address procedures for the application of guidelines for aquatic ecosystem protection, and compliance assessment protocols. For the comparison of test site monitoring data against WQOs, the median water quality value (e.g. concentration) of a number (preferably five or more) of independent samples at a particular monitoring ('test') site should be compared against the water quality objective of the same indicator, water type and level of aquatic ecosystem protection, as listed in table 2 below.

For WQOs based on GBRMPA data, where single value WQOs are given for specified indicators (e.g. Secchi depth, particulate N), these should be compared to annual mean (rather than median) values. Relevant seasonal adjustments can be referenced in GBRMPA (2010) Water quality guidelines for the Great Barrier Reef Marine Park 2010. Also refer to notes after the tables.

# AQUATIC ECOSYSTEM EV

# WATER QUALITY OBJECTIVES FOR GLADSTONE HARBOUR, AND ADJACENT WATERS

**Table 2A Gladstone Harbour, the Narrows, adjacent coastal waters and estuaries: Water quality objectives to protect aquatic ecosystem environmental value under baseflow conditions (peak discharge < 100 $m^3$/sec)**

| Water area/type<br><br>Refer plans WQ1311, 1312, 1331, 1272<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | GLADSTONE HARBOUR, THE NARROWS, COASTAL WATERS, ESTUARIES: Baseflow water quality objectives (WQOs) [1–7]<br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th %iles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **DO** (% sat) | **Turb** (NTU) | | **pH** | |
| | | | | | | | | | **Dry** (May–Oct) | **Wet** (Nov–Apr) | **<40mS/cm** | **>40mS/cm** |
| **GLADSTONE HARBOUR, THE NARROWS, ADJACENT COASTAL WATERS** | | | | | | | | | | | | |
| **MD2421 Western Basin (s1)** | **MD** | 3–3–8 | 1–4–16 | 145–170–210 | 1–3–7 | 14–18–29 | 0.5–1.0–2.0 | 91–96–100 | 4–8–17 | 7–13–29 | 7.2–8.2 | 7.4–8.3 |
| **MD2422 Inner Harbour (s1)** | **MD** | 3–3–10 | 2–5–12 | 130–160–220 | 1–3–6 | 15–21–33 | 0.5–1.0–2.0 | 93–96–98 | 4–8–17 | 7–13–29 | 7.2–8.2 | 7.4–8.3 |
| **MD2423 Mid Harbour (s1)** | **MD** | 3–3–12 | 1–3–9 | 110–135–200 | 1–2–3 | 9–14–23 | 0.5–1.0–2.0 | 94–97–101 | 2–4–7 | 4–9–16 | 7.2–8.2 | 7.4–8.3 |
| **MD2424 Outer Harbour (EC waters) (s1)** | **MD** | 3–4–5 | 1–3–6 | 115–130–170 | 1–1–3 | 9–13–21 | 0.5–1.0–2.0 | 94–97–100 | 1–3–6 | 2–7–13 | 8.0–8.1–8.2 | |
| **SD2428 Colosseum Inlet (s1)** | **HEV** | 3–3–15 | 1–3–5 | 105–130–180 | 1–1–3 | 8–10–15 | 0.5–0.8–1.4 | 86–91–97 | 1–3–4 | 3–7–14 | 7.2–8.2 | 7.4–8.3 |
| **SD2441, 2442 The Narrows, Deception Creek, East Balaclava Is (s1)** | **HEV** | 3–3–10 | 2–3–9 | 140–170–220 | 3–3–7 | 15–20–29 | 0.5–1.0–2.0 | 87–92–95 | 4–7–12 | 8–15–30 | 7.2–8.2 | 7.4–8.3 |
| Rodds Bay – the following water quality guidelines have been derived for Rodds Bay and are provided to assist in the derivation of the Gladstone Healthy Harbour report card. EVs and WQOs for Rodds Bay will be included in the Baffle Basin EVs and WQOs document. | | | | | | | | | | | | |
| **Rodds Bay (s4, s3, s2)** | **all** | 3–3–4 | 1–1–3 | 140–160–200 | 1–1–3 | 11–13–21 | 0.5–1.0–2.2 | 93–96–98 | 3–4–7 | 2–5–12 | 7.2–8.2 | 7.4–8.3 |

## Table 2A continued

| Water area/type<br><br>Refer plans WQ1311, 1272<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | COASTAL AND MARINE WATERS OUTSIDE GLADSTONE HARBOUR: Water quality objectives (WQOs) [1–7] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th %iles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | | | | | | | |
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Partic N** (µg/L) | **Total Diss N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Partic P** (µg/L) | **Total Diss P** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **Silicate** (µg/L) | **DO** (% sat) | **Turb** (NTU) | **Secchi** (m) | **SS** (mg/L) | **pH** |
| **Open coastal waters adjacent to Gladstone Harbour (east of Facing Island) (landward of GBR plume line) (s4, s1, s3, s2)** | **SMD** | <3 | <1 | ≤20 (ann. mean) | <70 | <100 | <1 | ≤2.8 (ann. mean) | <6 | <8 | ≤0.45 (ann. mean) | >60 | 95–105 | Dry:<1 (May-Oct)<br>Wet:<2 (Nov-Apr) | ≥10 (ann. mean) | ≤2 (ann. mean) | 8.1–8.4 |
| **Open coastal designated spoil grounds (s1, s2, s3)** | **MD** | <3 | <1 | ≤20 (ann. mean) | - | <100 | <1 | ≤2.8 (ann. mean) | - | <8 | ≤0.45 (ann. mean) | - | 95–105 | Dry:<1 (May-Oct)<br>Wet:<2 (Nov-Apr) | ≥10 (ann. mean) | ≤2 (ann. mean) | 8.1–8.4 |
| **Other coastal/marine waters** | Refer to Table 2G | | | | | | | | | | | | | | | | |
| **Coastal and marine waters (s3)** | **all** | Temperature: increases of no more than 1°C above long-term (20 year) average maximum. (GBRMPA, 2010) | | | | | | | | | | | | | | | |
| **All waters: toxicants, metals** | **all** | Refer to Table 2C | | | | | | | | | | | | | | | |
| **All waters: biological** | **all** | Seagrass: Minimum light requirement is a photosynthetic active radiation (PAR) two week moving average of greater than 6 mol $m^{-2}$ $day^{-1}$. This is minimum requirement only and is generally below the current average conditions of the harbour. It does not include potential impacts on benthic microalgae and phytoplankton at this light level. Objective based on Chartrand et al. *(2012) Development of a Light-Based Seagrass Management Approach for the Gladstone Western Basin Dredging Program.*<br><br>Mangroves: No loss of mangrove area. EHP/ Queensland Herbarium conducts biennial mapping of mangrove cover and this could be used as an assessment tool. Mapping is available from EHP. | | | | | | | | | | | | | | | |

## Table 2A continued

| Water area/type<br><br>Refer plans WQ1311, 1312, 1331, 1272<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | GLADSTONE HARBOUR, THE NARROWS, ADJACENT ESTUARIES: Baseflow water quality objectives (WQOs) [1–7]<br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **DO** (% sat) | **Turb** (NTU) | | **pH** | |
| | | | | | | | | | **Dry** (May–Oct) | **Wet** (Nov–Apr) | **<40mS/cm** | **>40mS/cm** |
| **ESTUARIES adjoining GLADSTONE HARBOUR and THE NARROWS (by river basin)** | | | | | | | | | | | | |
| **All estuaries: toxicants, metals** | **all** | Refer to Table 2C | | | | | | | | | | |
| **All estuaries: biological** | **all** | Seagrass: Minimum light requirement is a photosynthetic active radiation (PAR) two week moving average of greater than 6 mol $m^{-2}$ $day^{-1}$. This is minimum requirement only and is generally below the current average conditions of the harbour. It does not include potential impacts on benthic microalgae and phytoplankton at this light level. Objective based on Chartrand et al. *(2012) Development of a Light-Based Seagrass Management Approach for the Gladstone Western Basin Dredging Program.*<br><br>Mangroves: No loss of mangrove area. EHP/ Queensland Herbarium conducts biennial mapping of mangrove cover and this could be used as an assessment tool. Mapping is available from EHP. | | | | | | | | | | |
| **Boyne River Basin** | | | | | | | | | | | | |
| **MD2464 Boyne middle estuary (s1)** | **MD** | 2–5–12 | 2–3–13 | 145–220–320 | 2–2–6 | 9–14–23 | 0.7–1.6–3.5 | 82–89–96 | 2–4–5 | 3–6–11 | 7.0–8.4 | |
| **MD2463 Boyne lower estuary (s1)** | **MD** | 3–3–7 | 1–1–4 | 110–120–180 | 1–1–3 | 8–11–17 | 0.5–0.8–1.5 | 90–97–102 | 1–3–6 | 2–5–10 | 7.2–8.2 | 7.4–8.3 |
| **MD2462 Upper South Trees Inlet (s1)** | **MD** | 3–3–7 | 1–2–8 | 140–175–265 | 1–1–8 | 15–20–34 | 1.0–1.6–4.9 | 67–76–83 | 4–6–9 | 10–14–29 | 7.0–8.4 | |
| **MD2461 South Trees Inlet (s1)** | **MD** | 3–3–11 | 1–3–8 | 140–170–250 | 1–4–8 | 15–20–31 | 0.5–1.1–2.5 | 86–93–99 | 4–11–24 | 7–13–32 | 7.2–8.2 | 7.4–8.3 |

| Water area/type<br><br>Refer plans WQ1311, 1312, 1331, 1272<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | **GLADSTONE HARBOUR, THE NARROWS, ADJACENT ESTUARIES: Baseflow water quality objectives (WQOs) [1–7]**<br><br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **DO** (% sat) | **Turb** (NTU) | | **pH** | |
| | | | | | | | | | **Dry** (May–Oct) | **Wet** (Nov–Apr) | **<40mS/cm** | **>40mS/cm** |
| **Toxicants, metals** | **all** | Refer to Table 2C | | | | | | | | | | |
| **Calliope River Basin** | | | | | | | | | | | | |
| **SD2449, MD2445 Calliope middle estuary (s1)** | **SD/MD** | 2–8–23 | 2–8–27 | 150–200–275 | 3–7–14 | 16–22–33 | 1.7–3.0–5.3 | 87–93–99 | 5–9–17 | 5–12–25 | 7.0–8.4 | |
| **MD2444 Calliope lower estuary (s1)** | **MD** | 3–6–10 | 3–3–10 | 140–175–210 | 2–4–6 | 17–22–25 | 1.0–1.7–2.7 | 91–95–100 | 5–11–21 | 6–11–24 | 7.2–8.2 | 7.4–8.3 |
| **MD2443 Boat Creek estuary (s1)** | **MD** | 3–4–11 | 1–3–8 | 160–190–220 | 1–3–6 | 15–22–32 | 1.0–2.0–4.0 | 85–92–98 | 9–14–22 | 13–25–32 | 7.2–8.2 | 7.4–8.3 |
| **MD2446 Auckland Inlet (s1)** | **MD** | 3–6–13 | 3–6–13 | 140–160–200 | 2–3–5 | 12–16–23 | 1.1–1.9–2.9 | 93–98–100 | 3–6–13 | 5–8–12 | 7.2–8.2 | 7.4–8.3 |
| **Toxicants, metals** | **all** | Refer to Table 2C | | | | | | | | | | |

| Water area/type<br><br>Refer plans WQ1311, 1312, 1331, 1272<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | **GLADSTONE HARBOUR, THE NARROWS, ADJACENT ESTUARIES: Baseflow water quality objectives (WQOs) [1–7]**<br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **DO** (% sat) | **Turb** (NTU) | | **pH** | |
| | | | | | | | | | **Dry** (May–Oct) | **Wet** (Nov–Apr) | **<40mS/cm** | **>40mS/cm** |
| **Curtis Island Basin** | | | | | | | | | | | | |
| **MD2441, 2442 Graham Creek estuary (Curtis Island) (s1)** | **MD** | 3–3–8 | 1–3–7 | 140–170–220 | 2–4–7 | 15–20–29 | 0.5–1.0–2.3 | 83–88–94 | 3–8–14 | 10–13–28 | 7.2–8.2 | 7.4–8.3 |
| **Toxicants, metals** | **all** | Refer to Table 2C | | | | | | | | | | |
| OTHER CURTIS ISLAND ESTUARINE WATERS – refer to Table 2G | | | | | | | | | | | | |
| **Fitzroy lower estuary** | | | | | | | | | | | | |
| **Fitzroy delta middle estuarine waters (s2 )** | **MD** | <10 | <10 | <300 | <8 | <25 | <4.0 | 85–100 | id | id | 7.0–8.4 | |
| **Fitzroy delta LE/EC waters (s1, s2)** | **MD** | <8 | <3 | <200 | <6 | <20 | <2.0 | 90–100 | Dry<br>ATMD 0 – 9km: <114<br>Other EC: <101<br>(near bottom turbidity) | | 8.0–8.4 | |
| **Toxicants, metals** | **all** | Refer to Table 2C | | | | | | | | | | |

**Sources:**

S1: Local datasets (e.g. DSITIA, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Reef Rescue Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG

Notes 1–7: Refer notes after Table 2G.

## Table 2B Gladstone Harbour and the Narrows: time thresholds for use of baseflow WQOs (relative to flows – also see Table 2D: Event flow WQOs)

| Water area/type<br><br>Refer plans WQ1311, 1312, 1331, 1272 | Discharge threshold ($m^3/s$)<br><br>(Castlehope gauging station, Calliope River) | TIME THRESHOLDS for WQO indicators [1-4]<br>(aquatic ecosystem EV) | | | |
|---|---|---|---|---|---|
| | | Nutrients (N, P) | Chl-a | DO<br>(% sat) | Turb (NTU) |
| MD2421<br>Western Basin | 100–500 | No withholding period | No withholding period | No withholding period | No withholding period |
| | 500–1000 | 3 weeks | 3 weeks | 3 days | 3 days |
| | >1000 | 3 weeks | 3 weeks | 7 days | 7 days |
| MD2422<br>Inner Harbour | 100–500 | No withholding period | No withholding period | No withholding period | No withholding period |
| | 500–1000 | 3 weeks | 3 weeks | 3 days | 3 days |
| | >1000 | 3 weeks | 3 weeks | 7 days | 7 days |
| MD2423<br>Mid Harbour | 100–500 | No withholding period | No withholding period | No withholding period | No withholding period |
| | 500–1000 | 3 weeks | 3 weeks | No withholding period | No withholding period |
| | >1000 | 3 weeks | 3 weeks | 7 days | 7 days |
| SD2442<br>The Narrows | 100–500 | 2 weeks | 2 weeks | 3 days | 3 days |
| | 500–1000 | 3 weeks | 3 weeks | 3 days | 3 days |
| | >1000 | 3 weeks | 3 weeks | 7 days | 7 days |

**Notes:**

1. Interpretation: The table shows the time periods after which baseflow WQOs are to be applied to waters, relative to different sized peak flow events at the Castlehope gauging station. For example, when peak discharge at the Castlehope gauging station is in the range of 100-500 $m^3$/sec, baseflow turbidity and DO WQOs for the Narrows are not applicable until three days after the flows have returned to <100 $m^3$/sec. During the withholding period, event flow WQOs are applicable. After the withholding period has concluded, baseflow WQOs apply.
2. Castlehope gauging station (132001A) is located at lat -23.984983/long 151.097564. Details are available from the DNRM website.
3. Within the event and withholding periods refer to Table 2D below.
4. No withholding period means the baseflow WQOs can be applied at any stage.

## Table 2C Gladstone Harbour, the Narrows and adjacent estuaries: Water quality objectives for toxicants

| Metal / toxicant | Water quality objective for marine waters, slightly-moderately disturbed systems (95% species protection unless specified) (µg/L) | Interim sediment quality guideline (ISQG) – low (mg/kg dry weight) |
|---|---|---|
| **Aluminium** | 24 (MD waters – 95%)<br>2.1 (HEV/SD waters – 99%)<br>Source: Golding et al, 2014 | id |
| **Arsenic (AsIII)** | id [1] | 20 |
| **Arsenic (AsV)** | id | |
| **Cadmium** | 0.7 (99%) | 1.5 |
| **Chromium (CrIII)** | 27.4 | 80 |
| **Chromium (CrVI)** | 4.4 | |
| **Copper (Cu)** | 1.3 | 65 |
| **Cyanide** | 4 | id |
| **Gallium** | id | id |
| **Lead (Pb)** | 4.4 | 50 |
| **Molybdenum** | id | id |
| **Nickel (Ni)** | 7 (99%) | 21 |
| **Zinc (Zn)** | 15 | 200 |
| **Other toxicants** | • Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8, including s 8.3.4.4 on application in estuarine waters). AWQG values for the MD level of protection typically correspond to protection of 95% species (in a small number of cases where bioaccumulation may occur, the AWQG recommends 99% species protection level).<br>• Toxicants in sediments: refer to AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)<br>• Pesticides: As per GBRMPA and AWQG water quality guidelines, to protect marine species at the HEV level of protection (except where noted). Pesticides/biocides specified in GBR water quality guidelines include: Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L; Tributyltin: <0.006 µg/L (95% species protection)<br>Sewage: Release of sewage from vessels to be controlled in accordance with requirements of the Transport Operations (Marine Pollution) Act 1995 and Regulations. (Refer to Maritime Services Queensland website for further information.)<br>Anti-fouling: Comply with *Anti-fouling and in-water cleaning guidelines* (June 2013) | |

**Notes:**

1. id: insufficient data. Values to be updated when available.

**Sources:**

ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (AWQG).

Golding, LA, Angel, BM, Batley, GE, Apte, SC, Krassoi, R and Doyle, CJ (2014) Derivation of a water quality guideline for aluminium in marine waters, *Environ Toxicol Chem.*, Accepted Article • DOI: 10.1002/etc.2771, accepted 3 October 2014

Great Barrier Reef Marine Park Authority (2010) Water quality guidelines for the Great Barrier Reef Marine Park 2010, Great Barrier Reef Marine Park Authority, Townsville, available on the Great Barrier Reef Marine Park Authority's website.

## Table 2D Gladstone Harbour and Boat Creek: Event flow water quality objectives to protect aquatic ecosystem environmental value

| Water area/type<br><br>Refer plans WQ1311, 1312, 1331, 1272<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | Discharge threshold ($m^3/s$)<br><br>(Castlehope gauging station, Calliope River) | GLADSTONE HARBOUR: Event flow [1, 2] water quality objectives (WQOs)<br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Total P** (µg/L) | **DO** (% sat) | **Turb** (NTU) | SS (mg/L) | **pH** |
| **FRESH WATERS** | | | | | | | | | | | |
| **Boat Creek (s1)** | **MD** | **Above local baseflow** | 12–50–95 | 7–65–390 | 50–600–1540 | 5–10–30 | id | 85–90–95 | 5–28–48 | 8–59–85 | - |
| **GLADSTONE HARBOUR, THE NARROWS** | | | | | | | | | | | |
| **MD2421 Western Basin (s1)** | **MD** | 100–500 | - | - | - | - | - | 80–110 | Apply baseflow WQO | - | - |
| | | 500–1000 | | | | | | 65–115 | 300 | | |
| | | >1000 | | | | | | 50–170 | 1000 | | |
| **MD2422 Inner Harbour (s1)** | **MD** | 100–500 | - | - | - | - | - | 80–110 | Apply baseflow WQO | - | - |
| | | 500–1000 | | | | | | 70–115 | 110 | | |
| | | >1000 | | | | | | 60–140 | 650 | | |
| **MD2423 Mid Harbour (s1)** | **MD** | 100–500 | - | - | - | - | - | 90–135 | Apply baseflow WQO | - | - |
| | | 500–1000 | | | | | | 85–130 | Apply baseflow WQO | | |
| | | >1000 | | | | | | 80–160 | 150 | | |
| **SD2442 The Narrows (s1)** | **HEV** | 100–500 | - | - | - | - | - | 80–140 | 120 | - | - |
| | | 500–1000 | | | | | | 50–135 | 130 | | |
| | | >1000 | | | | | | 70–160 | 850 | | |

**Notes:**

1. Interpretation: The table shows the values applying during event flow and withholding period, relative to peak flow events at the Castlehope gauging station. Withholding periods are specified in Table 2B. For baseflow WQOs refer to separate tables in this document.

2. Castlehope gauging station (132001A) is located at lat -23.984983/long 151.097564. Details are available from the DNRM website.

**Sources:** S1: Local datasets (e.g. DSITIA, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Reef Rescue Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG

# WATER QUALITY OBJECTIVES

# for BOYNE RIVER BASIN FRESH WATERS

## Table 2E Boyne River Basin: Water quality objectives to protect aquatic ecosystem environmental value under baseflow conditions

| Water area/type<br><br>Refer plans WQ 1331, 1273<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | **BOYNE: Baseflow water quality objectives (WQOs) [1–7]**<br><br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **DO** (% sat) | **Turb** (NTU) | **SS** (mg/L) | **pH** |
| **BOYNE FRESH WATERS** | | | | | | | | | | | |
| **HEV2461, 2462, 2463, 2464, 2465 (protected estate)** | **HEV** | Insufficient data. Refer to QWQG for details on how to establish local WQOs | | | | | | | | | |
| **Upland fresh >150m (s2)** | **MD** | <10 | <15 | <250 | <15 | <30 | na | 90–110 | <25 | - | 6.5–7.5 |
| **MD2465 Diglum Creek lowland fresh (s1, s2)** | **MD** | <20 | <60 | <580 | <20 | <100 | <5 | 85–110 | <5 | <10 | 6.5–8.0 |
| **MD2466 Boyne Valley lowland fresh (s1, s2)** | **MD** | <20 | <60 | <260 | <20 | <50 | <5 | 85–110 | <4 | <10 | 6.5–8.0 |
| **Lowland fresh <150m (other waters) (s2)** | **MD** | <20 | <60 | <500 | <20 | <50 | <5 | 85–110 | <50 | <10 | 6.5–8.0 |
| **Lake Awoonga (s1)** | **MD** | - | - | <700 | - | <40 | - | 85–105 | <4.7 | - | 7.75–8.4 |
| **Lakes / reservoirs (other) (s2)** | **MD** | <10 | <10 | <350 | <5 | <10 | <5 | 90–110 | 1–20 | id | 6.5–8.0 |

| Water area/type<br><br>Refer plans WQ 1331, 1273<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | **BOYNE: Baseflow water quality objectives (WQOs) [1–7]** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | |
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **DO** (% sat) | **Turb** (NTU) | **SS** (mg/L) | **pH** |
| **HEV fresh waters: toxicants (s5)** | **HEV** | Toxicants in water and sediment as per AWQG:<br>• Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the HEV level of protection correspond to protection of 99% species<br>• Toxicants in sediments: refer to AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)<br>Anti-fouling: Comply with *Anti-fouling and in-water cleaning guidelines* (June 2013) | | | | | | | | | |
| **Fresh waters: toxicants (all other fresh waters) (s5)** | **MD** | Toxicants in water and sediment as per AWQG:<br>• Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the MD level of protection typically correspond to protection of 95% species (in a small number of cases where bioaccumulation may occur, the AWQG recommends 99% species protection level).<br>• Toxicants in sediments: refer to AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)<br>Anti-fouling: Comply with *Anti-fouling and in-water cleaning guidelines* (June 2013) | | | | | | | | | |
| **Fresh waters: ionic indicators** | **all** | Refer to additional ionic indicators in Table 14 (from DSITIA analyses) | | | | | | | | | |
| **WETLANDS (s5)** | **all** | id | id | id | id | id | id | id | id | id | id |
| | | Refer to section 3.1.2 | | | | | | | | | |
| **RIPARIAN** | **all** | Refer section 3.1.2 | | | | | | | | | |
| **GROUND WATERS (s1)** | **HEV** | WQOs are provided according to their chemistry zone and depth category in Table 14 (refer plan WQ1273). Where groundwaters interact with surface waters, groundwater quality should not compromise identified EVs and WQOs for those waters.<br>Note: the AWQG recommends that the highest level of protection should be provided to underground aquatic ecosystems, given their high conservation value. Where groundwaters are in good condition the intent is to maintain existing water quality (20th, 50th and 80th percentiles). | | | | | | | | | |

Notes 1–7: Refer notes after Table 2G.

**Sources:** S1: Local datasets (e.g. DSITIA, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Reef Rescue Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG

# WATER QUALITY OBJECTIVES

# for

# CALLIOPE RIVER BASIN FRESH WATERS

## Table 2F Calliope River Basin: Water quality objectives to protect aquatic ecosystem environmental value under baseflow conditions

| Water area/type<br><br>Refer plans WQ1311, 1312, 1273<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | CALLIOPE: Baseflow and event water quality objectives (WQOs) [1–7]<br><br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **DO** (% sat) | **Turb** (NTU) | **SS** (mg/L) | **pH** |
| **CALLIOPE FRESH WATERS INSIDE STATE DEVELOPMENT AREA** | | | | | | | | | | | |
| **Upland fresh >150m (s2)** | **MD** | <10 | <15 | <250 | <15 | <30 | na | 90–110 | <25 | id | 6.5–7.5 |
| **Lowland fresh <150m (s2)** | **MD** | <20 | <60 | <500 | <20 | <50 | <5 | 85–110 | <50 | <10 | 6.5–8.0 |
| **Toxicants** | **MD** | Toxicants in water and sediment as per AWQG:<br>• Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the MD level of protection typically correspond to protection of 95% species (in a small number of cases where bioaccumulation may occur, the AWQG recommends 99% species protection level).<br>• Toxicants in sediments: refer to AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)<br>Anti-fouling: Comply with *Anti-fouling and in-water cleaning guidelines* (June 2013) | | | | | | | | | |
| **LOCAL EVENT WQOs** | | | | | | | | | | | |
| **MD2447 Teningie, Scrubby creeks (event) (s1)** | **MD** | <30 | <50 | <500 | <10 | id | - | 81–96 | - | 102 | 7.3–8.1 |
| **MD2448 Humpy Creek (event) (s1)** | **MD** | <48 | <65 | <600 | <10 | id | - | 85–96 | - | 59 | 7.2–7.9 |
| **MD2449 Targinie and other creeks (event) (s1)** | **MD** | <36 | <10 | <530 | <5 | id | - | 67–96 | - | 10 | 6.8–7.4 |

| Water area/type<br><br>Refer plans WQ1311, 1312, 1273<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | **CALLIOPE: Baseflow and event water quality objectives (WQOs) [1–7]**<br><br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **DO** (% sat) | **Turb** (NTU) | **SS** (mg/L) | **pH** |
| **CALLIOPE FRESH WATERS OUTSIDE STATE DEVELOPMENT AREA** | | | | | | | | | | | |
| **HEV2442, 2443, 2444 SD2443, 2448** | **HEV** | Insufficient data. Refer to QWQG for details on how to establish local WQOs | | | | | | | | | |
| **HEV and SD fresh waters: toxicants (s5)** | **HEV** | Toxicants in water and sediment as per AWQG:<br>• Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the HEV level of protection correspond to protection of 99% species<br>• Toxicants in sediments: refer to AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)<br>Anti-fouling: Comply with *Anti-fouling and in-water cleaning guidelines* (June 2013) | | | | | | | | | |
| **Upland fresh >150m (s2)** | **MD** | <10 | <15 | <250 | <15 | <30 | na | 90–110 | <25 | id | 6.5–7.5 |
| **Lowland fresh <150m (s1, s2)** | **MD** | <20 | <60 | <500 | <20 | <50 | <5 | 85–110 | <4.2 | <10 | 6.5–8.0 |
| **Lakes / reservoirs (s2)** | **MD** | <10 | <10 | <350 | <5 | <10 | <5 | 90–110 | 1–20 | id | 6.5–8.0 |
| **Fresh waters: toxicants (all other fresh waters) (s5)** | **MD** | Toxicants in water and sediment as per AWQG:<br>• Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the MD level of protection typically correspond to protection of 95% species (in a small number of cases where bioaccumulation may occur, the AWQG recommends 99% species protection level).<br>• Toxicants in sediments: refer to AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)<br>Anti-fouling: Comply with *Anti-fouling and in-water cleaning guidelines* (June 2013) | | | | | | | | | |
| **Fresh waters: ionic indicators** | **all** | Refer to additional ionic indicators in Table 14 (from DSITIA analyses) | | | | | | | | | |

| Water area/type<br><br>Refer plans WQ1311, 1312, 1273<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | **CALLIOPE: Baseflow and event water quality objectives (WQOs) [1–7]**<br><br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **DO** (% sat) | **Turb** (NTU) | **SS** (mg/L) | **pH** |
| | | id | id | id | id | id | id | id | id | id | id |
| **WETLANDS (s5)** | **all** | Refer to section 3.1.2 | | | | | | | | | |
| **RIPARIAN** | **all** | Refer to section 3.1.2 | | | | | | | | | |
| **GROUND WATERS (s1)** | **HEV** | WQOs are provided according to their chemistry zone and depth category in Table 14 (refer plan WQ1273). Where groundwaters interact with surface waters, groundwater quality should not compromise identified EVs and WQOs for those waters.<br>Note: the AWQG recommends that the highest level of protection should be provided to underground aquatic ecosystems, given their high conservation value. Where groundwaters are in good condition the intent is to maintain existing water quality (20th, 50th and 80th percentiles). | | | | | | | | | |

Notes 1–7: Refer notes after Table 2G

**Sources:** S1: Local datasets (e.g. DSITIA, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Reef Rescue Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG

# WATER QUALITY OBJECTIVES

# for

# CURTIS ISLAND BASIN AND ADJACENT COASTAL WATERS

**Table 2G Curtis Island Basin, Facing Island and coastal waters (outside Gladstone Harbour): Water quality objectives to protect aquatic ecosystem environmental value under baseflow conditions**

| Water area/type<br><br>Refer plans WQ1311, 1312, 1272, and 1273<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | CURTIS ISLAND: Baseflow water quality objectives (WQOs) [1–7]<br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **DO** (% sat) | **Turb** (NTU) | **SS** (mg/L) | **EC** (µS/cm) | **pH** |
| **CURTIS ISLAND FRESH WATERS** | | | | | | | | | | | | |
| **HEV2441, SD2427, 2444, 2445, 2446, 2447 (protected estate)** | **HEV** | Insufficient data. Refer to QWQG for details on how to establish local WQOs. The following, derived from Shoalwater Bay Defence Practice Area fresh water WQOs are provided. | | | | | | | | | | |
| **Lowland freshwater (s1)** | **HEV** | <20 (DO>80%)<br><30 (DO 40–80%)<br><60 (DO<40%) | 2–2–5 | 180–350–620 | 2–2–3 | 14–20–28 | 0.5–1–4 | Refer Amm N | 6–17–30 | - | 155–190–245 | 5.5–7 |
| **Sand aquifer creeks (emanating from sand dunes) (s1)** | **HEV** | 6–12–17 | 40–58–76 | 260–360–400 | 2–2–2 | 3–9–10 | <0.5–<0.5–<0.5 | 85–90–95 | 2–3–4 | - | 130–130–145 | 4–5 |
| **Lowland fresh <150m (SDA and other waters) (s1)** | **MD** | <20 (DO>80%)<br><30 (DO 40–80%)<br><60 (DO<40%) | <5 | <620 | <3 | <28 | <4 | Refer Amm N | <30 | - | 130–145 | 5.5–7 |

## CURTIS ISLAND: Baseflow water quality objectives (WQOs) [1–7]

**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).

HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed

| Water area/type<br>Refer plans WQ1311, 1312, 1272, and 1273<br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | Amm N (µg/L) | Oxid N (µg/L) | Total N (µg/L) | FRP (µg/L) | Total P (µg/L) | Chl-a (µg/L) | DO (% sat) | Turb (NTU) | SS (mg/L) | EC (µS/cm) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **HEV and SD fresh waters: toxicants (s5)** | **HEV** | Toxicants in water and sediment as per AWQG:<br>• Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the HEV level of protection correspond to protection of 99% species<br>• Toxicants in sediments: refer to AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)<br>Anti-fouling: Comply with *Anti-fouling and in-water cleaning guidelines* (June 2013) | | | | | | | | | | |
| **Fresh waters: toxicants (all other fresh waters) (s5)** | **MD** | Toxicants in water and sediment as per AWQG:<br>• Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the MD level of protection typically correspond to protection of 95% species (in a small number of cases where bioaccumulation may occur, the AWQG recommends 99% species protection level).<br>• Toxicants in sediments: refer to AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)<br>Anti-fouling: Comply with *Anti-fouling and in-water cleaning guidelines* (June 2013) | | | | | | | | | | |
| **WETLANDS (s5)** | **all** | id | id | id | id | id | id | id | id | id | id | id |
| | | Refer to section 3.1.2 | | | | | | | | | | |
| **RIPARIAN** | **all** | Refer to section 3.1.2 | | | | | | | | | | |
| **GROUND WATERS (s1)** | **HEV** | WQOs are provided according to their chemistry zone and depth category in Table 14 (refer plan WQ1273). Where groundwaters interact with surface waters, groundwater quality should not compromise identified EVs and WQOs for those waters.<br>Note: the AWQG recommends that the highest level of protection should be provided to underground aquatic ecosystems, given their high conservation value. Where groundwaters are in good condition the intent is to maintain existing water quality (20th, 50th and 80th percentiles). | | | | | | | | | | |

**Table 2G continued**

| Water area/type<br><br>Refer plans WQ1311, 1312, 1272, and 1273<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | **CURTIS ISLAND: Baseflow water quality objectives (WQOs) [1–7]**<br>**(aquatic ecosystem EV)**<br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **DO** (% sat) | **Turb** (NTU) | **SS** (mg/L) | **Secchi** (m) | **pH** |
| **CURTIS ISLAND ESTUARINE WATERS DRAINING TO NARROWS, GLADSTONE HARBOUR– refer to Table 2A** | | | | | | | | | | | | |
| **CURTIS ISLAND OTHER ESTUARINE WATERS** | | | | | | | | | | | | |
| **HEV2441, SD2427, SD2446 Northern/eastern draining middle-estuary waters (s2)** | **HEV** | 3–6–10 | 2–3–10 | 130–200–300 | 3–5–8 | 12–16–25 | 1.5–2.5–4.0 | 85–90–100 | 3–5–8 | 8–15–20 | 1.0–1.4–2.0 | 7.0–8.4 |
| **SD2427 Northern/eastern draining lower estuary/enclosed coastal waters (s2)** | **HEV** | 2–3–8 | 2–2–3 | 100–130–200 | 2–2–6 | 6–9–20 | 0.5–1.0–2.0 | 90–95–100 | 1–3–6 | 6–12–15 | 1.5–2.3–3.1 | 8.0–8.4 |
| **Northern draining middle estuary (all others) (s2)** | **MD** | <10 | <10 | <300 | <8 | <25 | <4.0 | 85–100 | <8 | <20 | >1 | 7.0–8.4 |
| **Estuaries draining to coast: toxicants (s5)** | **all** | Toxicants in water and sediment as per AWQG:<br>• Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8, including section 8.3.4.4 on application in estuarine waters)<br>• Toxicants in sediments: refer to AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)<br>Sewage: Release of sewage from vessels to be controlled in accordance with requirements of the Transport Operations (Marine Pollution) Act 1995 and Regulations. (Refer to Maritime Services Queensland website for further information.)<br>Anti-fouling: Comply with *Anti-fouling and in-water cleaning guidelines* (June 2013) | | | | | | | | | | |

| Water area/type<br><br>Refer plans WQ1311, 1312, 1272, and 1273<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | **CURTIS ISLAND: Baseflow water quality objectives (WQOs) [1–7]**<br>**(aquatic ecosystem EV)**<br><br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **DO** (% sat) | **Turb** (NTU) | **SS** (mg/L) | **Secchi** (m) | **pH** |
| **All estuaries: biological** | **all** | Seagrass: Minimum light requirement is a photosynthetic active radiation (PAR) two week moving average of greater than 6 mol $m^{-2}$ $day^{-1}$. This is minimum requirement only and is generally below the current average conditions of the harbour. It does not include potential impacts on benthic microalgae and phytoplankton at this light level. Objective based on Chartrand et al. *(2012) Development of a Light-Based Seagrass Management Approach for the Gladstone Western Basin Dredging Program.*<br><br>Mangroves: No loss of mangrove area. EHP/ Queensland Herbarium conducts biennial mapping of mangrove cover and this could be used as an assessment tool. Mapping is available from EHP. | | | | | | | | | |

## Table 2G continued

| Water area/type<br><br>Refer plans WQ1311, 1272<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | COASTAL AND MARINE WATERS OUTSIDE GLADSTONE HARBOUR: Water quality objectives (WQOs) [1–7]<br><br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Partic N** (µg/L) | **Total Diss N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Partic P** (µg/L) | **Total Diss P** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **Silicate** (µg/L) | **DO** (% sat) | **Turb** (NTU) | **Secchi** (m) | **SS** (mg/L) | **pH** |
| **COASTAL and MARINE WATERS (OUTSIDE GLADSTONE HARBOUR)** | | | | | | | | | | | | | | | | | |
| **HEV2427 Open coastal waters east of Curtis Island (seaward of GBR plume line) (s4, s3, s2)** | **HEV** | 0–1–3 | 0–0–1 | 12–15–20 | 60–70–100 | 75–85–120 | 1–2–3 | 1.5–2.5–3.0 | 5–6–10 | 6–10–15 | ≤0.45 (ann. mean) | 40–60–125 | 95–105 | 0.3–0.5–1.5 | 7–10–11 | 0.4–1.0–1.9 | 8.1–8.3–8.4 |
| **HEV2430 Capricorn Group offshore marine (seaward of GBR plume line) (s4, s3, s2)** | **HEV** | 0–1–3 | 0–0–1 | 10–13–16 | 50–65–80 | 80–90–110 | 0–1–3 | 1.1–1.7–2.2 | 3–6–10 | 5–8–15 | 0.23–0.34–0.57 | 15–35–125 | 95–105 | ≤1 | 9–11–14 | 0.2–0.4–0.9 | 8.1–8.3–8.4 |
| **SD2429 Open coastal waters east of Curtis Island (landward of GBR plume line) (s4, s3, s2)** | **HEV** | 0–1–3 | 0–0–1 | 12–15–20 | 60–70–100 | 75–85–120 | 1–2–3 | 1.5–2.5–3.0 | 5–6–10 | 6–10–15 | ≤0.45 (ann. mean) | 40–60–125 | 95–105 | 0.3–0.5–1.5 | 7–10–11 | 0.4–1.0–1.9 | 8.1–8.3–8.4 |

| Water area/type<br><br>Refer plans WQ1311, 1272<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | **COASTAL AND MARINE WATERS OUTSIDE GLADSTONE HARBOUR: Water quality objectives (WQOs) [1–7]**<br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Partic N** (µg/L) | **Total Diss N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Partic P** (µg/L) | **Total Diss P** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **Silicate** (µg/L) | **DO** (% sat) | **Turb** (NTU) | **Secchi** (m) | **SS** (mg/L) | **pH** |
| **Open coastal waters north of Curtis Island (landward of GBR plume line )<br><br>(those that are not identified as SD or HEV) (s4, s3, s2)** | **SMD** | <1 | <0.5 | ≤20 (ann. mean) | <70 | <85 | <2 | ≤2.8 (ann. mean) | <6 | <10 | ≤0.45 (ann. mean) | >60 | 95–105 | ≤1.5 (ann. mean) | ≥10 | ≤2.0 (ann. mean) | 8.1–8.4 |
| **Open coastal waters from Cape Capricorn east of Curtis/Facing Islands (including waters adjacent to Gladstone Harbour (landward of GBR plume line) (s4, s1, s3, s2)** | **SMD** | <3 | <1 | ≤20 (ann. mean) | <70 | <100 | <1 | ≤2.8 (ann. mean) | <6 | <8 | ≤0.45 (ann. mean) | >60 | 95–105 | Dry:<1 (May-Oct)<br>Wet:<2 (Nov-Apr) | ≥10 (ann. mean) | ≤2 (ann. mean) | 8.1–8.4 |
| **Coastal and marine waters (s3)** | **all** | Temperature: increases of no more than 1°C above long-term (20 year) average maximum. (GBRMPA, 2010) | | | | | | | | | | | | | | | |

| Water area/type<br><br>Refer plans WQ1311, 1272<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | **COASTAL AND MARINE WATERS OUTSIDE GLADSTONE HARBOUR: Water quality objectives (WQOs) [1–7]**<br><br>**Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed |
|---|---|---|

| Amm N (µg/L) | Oxid N (µg/L) | Partic N (µg/L) | Total Diss N (µg/L) | Total N (µg/L) | FRP (µg/L) | Partic P (µg/L) | Total Diss P (µg/L) | Total P (µg/L) | Chl-a (µg/L) | Silicate (µg/L) | DO (% sat) | Turb (NTU) | Secchi (m) | SS (mg/L) | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | |
|---|---|---|
| **Coastal waters outside ports, marinas, spoil grounds: toxicants (s3, s5)** | **all** | WQOs for all toxicants in these waters as per GBRMPA and AWQG water quality guidelines (except Aluminium, specified below), to protect marine species at the HEV level of protection.<br>Pesticides/biocides specified in GBR water quality guidelines include:<br>• Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L; Tributyltin: <0.0004 µg/L<br>For other toxicants not listed in GBRMPA guidelines, refer to AWQG and sources below:<br>• Toxicants in water: refer to AWQG section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). Values correspond to protection of 99% species<br>• Aluminium: <2.1 µg/L (Source: Golding, LA, Angel, BM, Batley, GE, Apte, SC, Krassoi, R and Doyle, CJ (2014) Derivation of a water quality guideline for aluminium in marine waters, *Environ Toxicol Chem.*, Accepted Article DOI: 10.1002/etc.2771, accepted 3 October 2014<br>• Toxicants in sediments: refer to AWQG section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)<br>Sewage: Release of sewage from vessels to be controlled in accordance with requirements of the Transport Operations (Marine Pollution) Act 1995 and Regulations. (Refer to Maritime Services Queensland website for further information.)<br>Anti-fouling: Comply with *Anti-fouling and in-water cleaning guidelines* (June 2013) |
| **Coastal waters in ports, marinas, spoil grounds: toxicants (s3, s5)** | **all** | Pesticides:<br>WQOs for all pesticides in these waters as per GBRMPA and AWQG water quality guidelines, to protect marine species at the HEV level of protection (except where noted). Pesticides/biocides specified in GBR water quality guidelines include:<br>• Ametryn: <0.5 µg/L; Atrazine: <0.6 µg/L; Diuron: <0.9 µg/L; Hexazinone: <1.2 µg/L; Simazine: <0.2 µg/L; Tebuthiuron: <0.02 µg/L; 2,4-D: <0.8 µg/L; Tributyltin: <0.006 µg/L (95% species protection)<br>For other toxicants not listed in GBRMPA guidelines, refer to AWQG and sources below:<br>• Toxicants in water: refer to AWQG volume 1 section 3.4—'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the MD level of protection typically correspond to protection of 95% species (in a small number of cases where bioaccumulation may occur, the AWQG recommends 99% species protection level).<br>• Aluminium: <24 µg/L (Source: Golding, LA, Angel, BM, Batley, GE, Apte, SC, Krassoi, R and Doyle, CJ (2014) Derivation of a water quality guideline for aluminium in marine waters, *Environ Toxicol Chem.*, Accepted Article • DOI: 10.1002/etc.2771, accepted 3 October 2014<br>• Toxicants in sediments: refer to AWQG volume 1 section 3.5—'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)<br>Sewage: Release of sewage from vessels to be controlled in accordance with requirements of the Transport Operations (Marine Pollution) Act 1995 and Regulations. (Refer to Maritime Services Queensland website for further information.)<br>Anti-fouling: Comply with *Anti-fouling and in-water cleaning guidelines* (June 2013) |
| **Coastal waters: biological** | **all** | Seagrass: Minimum light requirement is a photosynthetic active radiation (PAR) two week moving average of greater than 6 mol $m^{-2}$ $day^{-1}$. This is minimum requirement only and is generally below the current average conditions of the harbour. It does not include potential impacts on benthic microalgae and phytoplankton at this light level. Objective based on Chartrand et al. *(2012) Development of a Light-Based Seagrass Management Approach for the Gladstone Western Basin Dredging Program.* |

| Water area/type<br><br>Refer plans WQ1311, 1272<br><br>(s1–s5: source for WQOs, listed after table) | Management intent /level of protection | **COASTAL AND MARINE WATERS OUTSIDE GLADSTONE HARBOUR: Water quality objectives (WQOs)** [1–7] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Note:** WQOs for indicators are shown as 20th, 50th and 80th percentiles (e.g. 3–4–5), lower and upper limits (20th/80th percentiles, e.g. pH: 7.2-8.2), or as a single values (median or 80th percentile) (e.g. <15).<br><br>HEV: high ecological value; SD: slightly disturbed; MD: moderately disturbed | | | | | | | | | | | | | | | |
| | | **Amm N** (µg/L) | **Oxid N** (µg/L) | **Partic N** (µg/L) | **Total Diss N** (µg/L) | **Total N** (µg/L) | **FRP** (µg/L) | **Partic P** (µg/L) | **Total Diss P** (µg/L) | **Total P** (µg/L) | **Chl-a** (µg/L) | **Silicate** (µg/L) | **DO** (% sat) | **Turb** (NTU) | **Secchi** (m) | **SS** (mg/L) | **pH** |
| | | Mangroves: No loss of mangrove area. EHP/ Queensland Herbarium conducts biennial mapping of mangrove cover and this could be used as an assessment tool. Mapping is available from EHP. | | | | | | | | | | | | | | | |

**Sources:** S1: Local datasets (e.g. DSITIA, key stakeholder); S2: QWQG guidelines and /or data; S3: GBRMPA (2010) WQG; S4: GBRMPA analysis of Reef Rescue Marine Monitoring Program and/or Long Term Monitoring Program datasets; S5: ANZECC (2000) AWQG

**Notes to Table 2 (where applicable):**

Abbreviations: id: insufficient information; na: not applicable; -: WQO for indicator not available. Will be updated if guidelines become available

1. Nutrients: Except where specified for event conditions, nutrient objectives do not apply during high flow events in fresh and estuarine waters. 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 WQOs. 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 WQOs, provided this is due to natural causes. See QWQG (section 5 and Appendix D) for more information on applying guidelines under high flow conditions.

2. Suspended solids: Suspended solids (and hence turbidity and Secchi depth) levels in coastal waters are naturally highly variable depending on wind speed/wave height and in some cases on tidal cycles. The values in this table provide guidance on what the long term values of turbidity, Secchi depth or TSS should comply with. However, these values will often be naturally exceeded in the short term during windy weather or spring tides. They therefore should not be used for comparison with short term data sets. Where assessable coastal developments are proposed, proponents should carry out site specific intensive monitoring of these indicators (or equivalent light penetration indicators) and use these as a baseline for deriving local guidelines and for comparison with post development conditions.

3. Oxidised N = $NO_2$ + $NO_3$

4. Dissolved oxygen (DO): Dissolved Oxygen (DO) objectives apply to daytime conditions. Lower values will occur at night in most waters. In estuaries, reductions should only be in the region of 10–15 per cent saturation below daytime values. In freshwaters, night-time reductions are more variable. Following significant rainfall events, reduced DO values may occur due to the influx of organic material. In estuaries post-event values as low as 40 per cent saturation may occur naturally for short periods but values well below this would indicate some anthropogenic effect. In freshwaters, post-event DO reductions are again more variable. In general, DO values consistently less than 50 per cent are likely to impact on the ongoing ability of fish to persist in a water body while short term DO values less than 30 per cent saturation are toxic to some fish species. Very high DO (supersaturation) values can be toxic to some fish as they cause gas bubble disease. DO values for fresh waters should only be applied to flowing waters. Stagnant pools in intermittent streams naturally experience values of DO below 50 per cent saturation.

5. Wallum habitat: Wallum/tannin-stained waters contain naturally high levels of humic acids (and have a characteristic brown tea-tree stain). In these types of waters, natural pH values may range from 3.6 to 6. During flood events or nil flow periods, pH values should not fall below 5.5 (except in wallum/tannin waters) or exceed 9.

6. Temperature: Temperature varies both daily and seasonally, it is depth dependent and is also highly site specific. It is therefore not possible to provide simple generic WQOs for this indicator for fresh or estuarine waters. (In open coastal/marine waters a WQO based on GBRMPA WQGs is provided.) The recommended approach is that local WQOs be developed. Thus, WQOs 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 WQOs should be expressed in terms of these indicators. 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.

7. Open coastal/marine waters – GBR plume line: The GBR plume discharge area is derived from a smoothed version of the ‘high’ and ‘very high’ risk classes of modelled outputs from the risk assessment element of the Reef Plan Scientific Consensus Statement 2013 (Waterhouse et al 2013).

**References:**

ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (AWQG).

Australian Government (2013) *Anti-fouling and in-water cleaning guidelines* (June 2013), Department of Agriculture, Fisheries and Forestry, Canberra.

Chartrand et al (2012) Development of a Light-Based Seagrass Management Approach for the Gladstone Western Basin Dredging Program.

De'ath G, Fabricius KE (2008) Water quality of the Great Barrier Reef: distributions, effects on reef biota and trigger values for the protection of ecosystem health. Final Report to the Great Barrier Reef Marine Park Authority. Australian Institute of Marine Science, Townsville. (104 pp.).

Department of Science, Information Technology, Innovation and the Arts, Queensland (2014) Report on draft aquatic ecosystem water quality guidelines for the Capricorn Curtis Coast (draft).

Golding, LA, Angel, BM, Batley, GE, Apte, SC, Krassoi, R and Doyle, CJ (2014) Derivation of a water quality guideline for aluminium in marine waters, *Environ Toxicol Chem.*, Accepted Article • DOI: 10.1002/etc.2771, accepted 3 October 2014.

Great Barrier Reef Marine Park Authority (2010) Water quality guidelines for the Great Barrier Reef Marine Park 2010*,* Great Barrier Reef Marine Park Authority, Townsville, available on the Great Barrier Reef Marine Park Authority's website.

Queensland Government (2009, as amended) Queensland Water Quality Guidelines. (Refer to section 5 and Appendix D of the QWQG for more detail on compliance assessment protocols.)

Schaffelke B, Carleton J, Doyle J, Furnas M, Gunn K, Skuza M, Wright M, Zagorskis I (2011) Reef Rescue Marine Monitoring Program. Final Report of AIMS Activities 2010/11– Inshore Water Quality Monitoring. Report for the Great Barrier Reef Marine Park Authority. Australian Institute of Marine Science, Townsville. (83 p.). Additional years also published accessible for download from GBRMPA.

*Transport Operations (Marine Pollution) Act 1995* and Regulations 2008, available on the Office of Queensland Parliamentary Counsel website.

Waterhouse, J., Maynard, J., Brodie, J., Randall, L., Zeh, D., Devlin, M., Lewis, S., Furnas, M., Schaffelke, B., Fabricius, K., Collier, C., Brando, V., McKenzie, L., Warne, M.St.J., Smith, R., Negri, A., Henry, N., Petus, C., da Silva, E., Waters, D., Yorkston, H., Tracey, D., 2013. *Section 2: Assessment of the risk of pollutants to ecosystems of the Great Barrier Reef including differential risk between sediments, nutrients and pesticides, and among NRM regions.* In: Brodie *et al.*, *Assessment of the relative risk of water quality to ecosystems of the Great Barrier Reef. A report to the Department of the Environment and Heritage Protection, Queensland Government, Brisbane.* TropWATER Report 13/28, Townsville, Australia.

### 3.1.2 Vegetation (riparian, wetland) objectives

The clearing of native vegetation in Queensland is regulated by the *Vegetation Management Act 1999*, the *Sustainable Planning Act 2009* and associated policies and codes. This includes the regulation of clearing in water and drainage lines.

For vegetation management relating to waterways, reference should be made to:

- State Development Assessment Provisions (SDAP) Module 8: Native vegetation clearing. This module includes performance requirements relating to clearing of native vegetation and a table relating to watercourse buffer areas and stream order. To review the SDAP Modules, contact the Department of State Development, Infrastructure and Planning website
- SDAP Module 11: Wetland protection area
- relevant self-assessable codes under the *Vegetation Management Act 1999*. These codes are activity based, some applying to different regions, and include performance requirements relating to watercourses and wetlands, aimed at maintaining water quality, bank stability, aquatic and terrestrial habitat. Codes include vegetation clearing controls that vary according to stream order. To review the latest applicable self-assessable code (and other explanatory information), contact the Department of Natural Resources and Mines website.

To review the current vegetation management laws refer to the Queensland Government website or Department of Natural Resources and Mines website.

To review the SDAP Modules, refer to the Department of State Development, Infrastructure and Planning website.

Local Government Planning schemes under the *Sustainable Planning Act 2009* may also specify riparian buffers (for example under catchment protection or waterway codes). Refer to the Department of State Development, Infrastructure and Planning website and local government websites for further information about planning schemes.

**Wetlands**

The Environmental Protection Regulation section 81A defines environmental values for wetlands.

The State assesses impacts from earth works that may have impacts on freshwater wetlands of High Ecological Significance in Great Barrier Reef Catchments against State Development Assessment Provisions (SDAP) Module 11: Wetland protection area.

This module includes performance requirements to ensure:

- adverse effects on hydrology, water quality and ecological processes of a wetland are avoided or minimised
- any significant adverse impacts on matters of state environmental significance and on riparian areas or wildlife corridors in strategic environmental areas are avoided.

### 3.1.3 State planning policy – (state interest – water quality)

The State Planning Policy (SPP) defines the Queensland Government's policies about matters of state interest in land use planning and development (a state interest is defined under the *Sustainable Planning Act 2009*).

Water quality is a state interest. The SPP (state interest – water quality) seeks to ensure that 'the environmental values and quality of Queensland waters are protected and enhanced'. It includes provisions relating to planning schemes, acid sulfate soils and water supply buffer areas.

The provisions of the SPP are operationalised through the SPP code – water quality (Appendix 3 of the SPP). The purpose of the code is to 'ensure development is planned, designed, constructed and

operated to manage stormwater and wastewater in ways that support the protection of environmental values identified in the Environmental Protection (Water) Policy 2009'. The code contains detailed performance objectives for planning schemes, development and land use activities to implement the code's purpose. These include stormwater management design objectives by climatic region (construction and post-construction phases).

The SPP (state interest – water quality) is supported by the State Planning Policy—state interest guideline – water quality. The SPP (including SPP code) and supporting guideline are available from the DSDIP website.

# WATER QUALITY OBJECTIVES

# for

# HUMAN USE ENVIRONMENTAL VALUES

## 3.2 Water quality objectives for human use environmental values

This section outlines WQOs to protect human use EVs, which comprise those EVs other than the aquatic ecosystem EV (e.g. recreation, stock watering, aquaculture and crop irrigation). Table 1 of this document outlines the EVs that have been identified for different waters in the catchment. Where a human use EV has been identified, the following tables can be used to identify the WQOs to support that EV. Where Table 1 indicates more than one EV applies to a given water (for example aquatic ecosystem and recreational use), the adoption of the most stringent WQO for each water quality indicator will then protect all identified EVs.

WQOs in this section are, unless otherwise specified, based on relevant national water quality guidelines including AWQG and the ADWG[6]. Table 3 outlines human use EVs, applicable water types, and a selection of more commonly used WQOs to support those EVs. Tables 4 to 12 provide further WQOs to protect particular human use EVs (based on national guidelines or other more local studies). Where national guidelines or other codes remain the primary source for WQOs, reference to those national guidelines or codes is necessary to obtain comprehensive listings of all indicators and corresponding WQOs.

**Table 3 Water quality objectives to protect human use environmental values**

| Environmental value | Water type/area (refer Table 1 and plans WQ1272, 1273, 1311, 1312, 1331) | Water quality objectives to protect EV (refer to specified codes and guidelines for full details) |
|---|---|---|
| Suitability for drinking water supply | All fresh waters including groundwaters | Local WQOs for drinking water supply are provided in Table 4.<br>Note: For water quality after treatment or at point of use refer to legislation and guidelines, including:<br>• *Public Health Act 2005* and Regulation<br>• *Water Supply (Safety and Reliability) Act 2008*, including any approved drinking water quality management plan under the Act<br>• *Water Fluoridation Act 2008* and Regulation<br>• Australian Drinking Water Guidelines (ADWG) 2011, as amended. |
| Protection of the human consumer for oystering | Estuarine and coastal waters | Objectives as per AWQG and Australia New Zealand Food Standards Code[7], Food Standards Australia New Zealand, as amended. |
| Protection of the human consumer | Fresh waters, estuarine and coastal waters | Objectives as per AWQG and Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, as amended. |
| Protection of cultural and spiritual values | Fresh waters (including groundwaters), estuarine and coastal waters | Protect or restore indigenous and non-indigenous cultural heritage consistent with relevant policies and plans. |

[6] The AWQG are available on the National Water Quality Management Strategy website.

The ADWG are available on the NHMRC website.

[7] Information on the Australia New Zealand Food Standards Code is available on the Food Standards Australia and New Zealand website.

| Environmental value | Water type/area (refer Table 1 and plans WQ1272, 1273, 1311, 1312, 1331) | Water quality objectives to protect EV (refer to specified codes and guidelines for full details) |
|---|---|---|
| Suitability for industrial use | Fresh waters, estuarine and coastal waters | No WQOs are provided in this scheduling document for industrial uses. Water quality requirements for industry vary within and between industries. The AWQG do not provide guidelines to protect industries, and indicate that industrial water quality requirements need to be considered on a case-by-case basis. This EV is usually protected by other values, such as the aquatic ecosystem EV. |
| Suitability for aquaculture | Fresh waters, estuarine and coastal waters | Objectives as per:<br>• tables 5–7<br>• AWQG and Australia New Zealand Food Standards Code, Food Standards Australia New Zealand, 2007 and updates. |
| Suitability for irrigation | All fresh waters including groundwaters | ANZECC objectives for pathogens and metals are provided in tables 8 and 9. For other indicators, such as salinity, sodicity and herbicides, see AWQG. |
| Suitability for stock watering | All fresh waters including groundwaters | Objectives as per AWQG, including median faecal coliforms <100 organisms per 100 mL.<br>WQOs for total dissolved solids and metals are provided in Tables 10 and 11, based on AWQG.<br>For other objectives, such as cyanobacteria and pathogens, see AWQG. |
| Suitability for farm supply/use | All fresh waters including groundwaters | Objectives as per AWQG. |
| Suitability for primary contact recreation | Fresh waters, estuarine and coastal waters | Objectives as per NHMRC (2008)[8], including:<br>• water free of physical (floating and submerged) hazards<br>• temperature range: 16–34°C<br>• pH range: 6.5–8.5<br>• DO: >80%<br>• faecal contamination: designated recreational waters are protected against direct contamination with fresh faecal material, particularly of human or domesticated animal origin. Two principal components are required for assessing faecal contamination:<br>− assessment of evidence for the likely influence of faecal material<br>− counts of suitable faecal indicator bacteria (usually *enterococci*)<br>These two components are combined to produce an overall microbial classification of the recreational water body<br>• intestinal enterococci: 95th percentile ≤ 40 organisms per 100mL (for healthy adults) (NHMRC, 2008; Table 5.7)<br>• direct contact with venomous or dangerous aquatic organisms should be avoided. Recreational water bodies should be reasonably free of, or protected from, venomous organisms (e.g. box jellyfish and bluebottles)<br>• waters contaminated with chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreational purposes. |
| Suitability for primary contact recreation | Fresh waters | • cyanobacteria/algae: Recreational water bodies should not contain:<br>− level 1[1]: ≥ 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<br>− level 2[1]: ≥ 10 $mm^3$/L for total biovolume of all cyanobacterial material where known toxins are not present<br>or |

[8] Guidelines for Managing Risks in Recreational Water are available on the NHMRC website.

| Environmental value | Water type/area (refer Table 1 and plans WQ1272, 1273, 1311, 1312, 1331) | Water quality objectives to protect EV (refer to specified codes and guidelines for full details) |
|---|---|---|
| | | − cyanobacterial scums consistently present. Further details are contained in NHMRC (2008) and Table 12. |
| | Estuarine, coastal waters | • cyanobacteria/algae: Recreational water bodies should not contain ≥ 10 cells/mL *Karenia brevis* and/or have *Lyngbya majuscula* and/or *Pfiesteria* present in high numbers[2]. Further details are contained in NHMRC (2008) and Table 12. |
| Suitability for secondary contact recreation | Fresh waters, estuarine and coastal waters | Objectives as per NHMRC (2008), including:<br>• intestinal enterococci: 95th percentile ≤ 40 organisms per 100mL (for healthy adults) (NHMRC, 2008; Table 5.7)<br>• cyanobacteria/algae—refer objectives for primary recreation, NHMRC (2008) and Table 12. |
| Suitability for visual recreation | Fresh waters, estuarine and coastal waters | Objectives as per NHMRC (2008), including:<br>• recreational water bodies should be aesthetically acceptable to recreational users. The water should be free from visible materials that may settle to form objectionable deposits; floating debris, oil, scum and other matter; substances producing objectionable colour, odour, taste or turbidity; and substances and conditions that produce undesirable aquatic life.<br>• cyanobacteria/algae—refer objectives for primary recreation, NHMRC (2008) and Table 12. |

**Notes:**

1. Level 1 recognises the probability of adverse health effects from ingestion of known toxins, in this case based on the toxicity of microcystins. Level 2 covers circumstances in which there are very high cell densities of cyanobacterial material, irrespective of the presence of toxicity or known toxins. Increased cyanobacterial densities increase the likelihood of non-specific adverse health outcomes, principally respiratory, irritation and allergy symptoms. (NHMRC, 2008; 8).
2. The NHMRC states that its guidelines are concerned 'only with risks that may be associated with recreational activities in or near coastal and estuarine waters. This includes exposure through dermal contact, inhalation of sea-spray aerosols and possible ingestion of water or algal scums, but does not include dietary exposure to marine algal toxins.' (NHMRC, 2008; 121).

**Sources:**

The WQOs were determined from a combination of documents, including:

Australian Drinking Water Guidelines (NHMRC, 2011 as updated 2013).

Australia New Zealand Food Standards Code (Australian Government: Food Standards Australia New Zealand).

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

Guidelines for Managing Risks in Recreational Water (NHMRC, 2008).

**Table 4 Drinking water EV: Priority water quality objectives for drinking water supply in the vicinity of off-takes, including groundwater, before treatment**

This table outlines WQOs for water **before treatment**, unless otherwise stated (e.g. ADWG). For water quality after treatment or at the point of use, refer to relevant legislation and guidelines, including *Public Health Act 2005* and Regulation, *Water Supply (Safety and Reliability) Act 2008* and Regulation, including any approved drinking water management plan under the Act, *Water Fluoridation Act 2008*, and the Australian Drinking Water Guidelines (ADWG, 2011, updated December 2013). Sources for objectives are provided in the table. For raw water (pre-treatment) the main source is Gladstone Area Water Board.

| Indicator | Water quality objective[1] |
|---|---|
| *Giardia* | 0 cysts (Queensland Water Supply Regulator)<br>No guideline set (ADWG, 2011)<br>If *Giardia* is detected in drinking water then the health authorities should be notified immediately and an investigation of the likely source of contamination undertaken (ADWG). |
| *Cryptosporidium* | 0 cysts (Queensland Water Supply Regulator)<br>No guideline value set (ADWG, 2011)<br>If *Cryptosporidium* is detected in drinking water then the health authorities should be notified immediately and an investigation of the likely source of contamination undertaken (ADWG). |
| *E. coli* | <50 cfu/100mL<br>Well designed treatment plants with effective barriers and disinfection are designed to address faecal contamination. *E. coli* or thermotolerant coliforms should not be present in any 100 mL sample of (treated) drinking water (ADWG). |
| Algal toxin | Raw water: <1 µg/L Microcystin |
| Turbidity | Raw water: <5 NTU (95$^{th}$ %ile) |
| Colour | Raw water: <70 Hazen units (95$^{th}$ %ile) |
| pH | Raw water: 5.5–8.5 |
| Total hardness | Raw water: <200 mg/L as $CaCO_3$ |
| Conductivity | Raw water: <350 µS/cm |
| Total dissolved solids (TDS) | Raw water: <600mg/L<br>The concentration of total dissolved solids in treated drinking water should not exceed 600 mg/L (ADWG 2011, based on taste considerations). |
| Sodium | Raw water: <50 mg/L<br>General[2]: The concentration of sodium in reticulated drinking water supplies should not exceed 180 mg/L (ADWG, based on threshold at which taste becomes appreciable).<br>At-risk groups (medical)[2]: The concentration of sodium in water supplies for at-risk groups should not exceed 20 mg/L (ADWG). |
| Sulfate | Raw water: <250 mg/L<br>The concentration of sulfate in drinking water should not exceed 250 mg/L (ADWG 2011, based on taste/aesthetic considerations).<br>ADWG 2011 health guideline: <500mg/L |
| Dissolved oxygen | >85% saturation (treated water; ADWG, 2011) |
| Pesticides | Raw water: Below detectable limits.<br>Treated drinking water: Refer to ADWG. |
| Other indicators (including physico-chemical indicators) | Refer to ADWG. |

**Notes**:

1. All values are based on advice/historical data provided by Gladstone Area Water Board, except where otherwise indicated.
2. The ADWG notes that 50 mg/L is a '*typical value*' in reticulated supplies. The ADWG value for sodium is 180 mg/L (based on level at which taste become appreciable) however '*sodium salts cannot be easily removed from drinking water*' and '*any steps to reduce sodium concentrations are encouraged'.* It further notes that '*medical practitioners treating people with severe hypertension or congestive heart failure should be aware if the sodium concentration in the patient's drinking water exceeds 20 mg/L*' (ADWG; sodium factsheet).

**Sources:** Gladstone Area Water Board, Queensland Water Supply Regulator, Australian Drinking Water Guidelines (NHMRC, 2011, updated December 2013)

## Table 5 Aquaculture EV: Water quality objectives for tropical aquaculture

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

**Source:** Department of Primary Industries and Fisheries: Water Quality in Aquaculture—DPI Notes April 2004.

## Table 6 Aquaculture EV: Water quality objectives for optimal growth of particular species in fresh water

| Water parameter | Barramundi | Eel | Silver perch | Jade perch | Sleepy cod | Redclaw |
|---|---|---|---|---|---|---|
| **Dissolved oxygen** | 4–9 mg/L | >3 mg/L | >4 mg/L | >3 mg/L | >4.0 mg/L | >4.0 mg/L |
| **Temperature ˚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)** | | <1.0 mg/L | | | <1.0 mg/L | <1.0 mg/L |
| **Ammonia ($NH_3$, un-ionised form)*pH dependent.** | <0.46 mg/L | <0.1 mg/L | <0.1 mg/L | <0.1 mg/L | <0.1 mg/L | <0.1 mg/L |
| **Nitrate ($NO_3$)** | | | <100 mg/L | | | |
| **Nitrite ($NO_2$)** | <1.5 mg/L | <1.0 mg/L | <0.1 mg/L | | <1.0 mg/L | <1.0 mg/L |
| **Salinity (extended periods)** | 0–35 ppt | | <5 ppt | <5 ppt | | <4 ppt |
| **Salinity bath** | 0–35 ppt | | 5–10 ppt for 1 hour | | max. 20 ppt for one hour | |
| **Hardness ($CaCO_3$)** | | | >50 mg/L | >50 mg/L | >40 mg/L | >40 mg/L |
| **Alkalinity** | >20 mg/L | | 100–400 ppm | 100–400 ppm | >40 mg/L | >40 mg/L |
| **Chlorine** | <0.04 mg/L | | | | <0.04 mg/L | |
| **Hydrogen sulphide** | 0–0.3 mg/L | | | | 0–0.3 mg/L | |
| **Iron** | <0.1 mg/L | | <0.5 mg/L | <0.5 mg/L | <0.1 mg/L | <0.1 mg/L |
| **Spawning temperature ˚C** | Marine | | 23–28 | 23–28 | >24 for more than three days | |

**Source:** Department of Primary Industries and Fisheries: Water Quality in Aquaculture—DPI Notes April 2004.

## Table 7 Aquaculture EV: Water quality objectives 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 mg/L | >4 mg/L | >3.5 mg/L | >4 mg/L |
| **Temperature ˚C** | 28–30 optimum<br>25–31 range | 28–30 optimum | | 26–32 | 24 |
| **pH** | ~8 | ~8 | ~8 | 7.5–8.5 | 7.5–8.5 |
| **Ammonia (TAN, total ammonia-nitrogen)** | | 0.1–0.5 mg/L | | | |
| **Ammonia ($NH_3$, un-ionised form)** | <0.1 mg/L | <0.1 mg/L | <0.1 mg/L | <0.1 mg/L | <0.1 mg/L |
| **Nitrate ($NO_3$)** | <1.0 mg/L | <1.0 mg/L | <1.0 mg/L | <1.0 mg/L | <1.0 mg/L |
| **Nitrite ($NO_2$)** | <0.2 mg/L | <1.0 mg/L | <0.2 mg/L | <0.2 mg/L | <0.2 mg/L |
| **Salinity** | 28–31 ppt | 0–35 ppt | | 10–25 ppt optimum | 30–35 ppt optimum |
| **Alkalinity** | | 105–125 mg/L $CaCO_3$ | | | |
| **Clarity** | | | | 30–40 cm Secchi disk | 30–40 cm Secchi disk |
| **Hydrogen sulphide** | | <0.3 mg/L | | | |
| **Iron** | | <0.02 mg/L | | <1.0 mg/L | |
| **Spawning temperature ˚C** | | 28–32 | | 27–32 | |

**Source:** Department of Primary Industries and Fisheries—Water Quality in Aquaculture—DPI Notes April 2004 (as amended).

## Table 8 Irrigation EV: Water quality objectives for thermotolerant (faecal) coliforms in irrigation waters used for food and non-food crops[1]

| Intended use | Median values of thermotolerant coliforms (colony forming units—cfu)[2] |
|---|---|
| Raw human food crops in direct contact with irrigation water (e.g. via sprays, irrigation of salad vegetables) | <10 cfu/100 mL |
| Raw human food crops not in direct contact with irrigation water (edible product separated from contact with water, e.g. by peel, use of trickle irrigation); or crops sold to consumers cooked or processed | <1000 cfu/100 mL |
| Pasture and fodder for dairy animals (without withholding period) | <100 cfu/100 mL |
| Pasture and fodder for dairy animals (with withholding period of five days) | <1000 cfu/100 mL |
| Pasture and fodder (for grazing animals except pigs and dairy animals, i.e. cattle, sheep and goats) | <1000 cfu/100 mL |
| Silviculture, turf, cotton, etc. (restricted public access) | <10 000 cfu/100 mL |

**Notes:**

1. Adapted from ARMCANZ, ANZECC and NHMRC (1999).
2. Refer to AWQG, Volume 1, Section 4.2.3.3 for advice on testing protocols.

**Source:** AWQG, Volume 1, Section 4.2.3.3, Table 4.2.2.

**Table 9 Irrigation EV: Water quality objectives for heavy metals and metalloids in agricultural irrigation water[1]—long-term trigger value (LTV), short-term trigger value (STV) and soil cumulative contamination loading limit (CCL)**

| Element | Soil cumulative contaminant loading limit (CCL)[2] (kg/ha) | Long-term trigger value (LTV) in irrigation water (up to 100 years) (mg/L) | Short-term trigger value (STV) in irrigation water (up to 20 years) (mg/L) |
|---|---|---|---|
| Aluminium | ND[2] | 5 | 20 |
| Arsenic | 20 | 0.1 | 2.0 |
| Beryllium | ND | 0.1 | 0.5 |
| Boron | ND | 0.5 | Refer to AWQG, Vol 3, Table 9.2.18 |
| Cadmium | 2 | 0.01 | 0.05 |
| Chromium | ND | 0.1 | 1 |
| Cobalt | ND | 0.05 | 0.1 |
| Copper | 140 | 0.2 | 5 |
| Fluoride | ND | 1 | 2 |
| Iron | ND | 0.2 | 10 |
| Lead | 260 | 2 | 5 |
| Lithium | ND | 2.5 (0.075 for citrus crops) | 2.5 (0.075 for citrus crops) |
| Manganese | ND | 0.2 | 10 |
| Mercury | 2 | 0.002 | 0.002 |
| Molybdenum | ND | 0.01 | 0.05 |
| Nickel | 85 | 0.2 | 2 |
| Selenium | 10 | 0.02 | 0.05 |
| Uranium | ND | 0.01 | 0.1 |
| Vanadium | ND | 0.1 | 0.5 |
| Zinc | 300 | 2 | 5 |

**Notes:**

1. Concentrations in irrigation water should be less than the trigger values. Trigger values should only be used in conjunction with information on each individual element and the potential for off-site transport of contaminants (refer AWQG, Volume 3, Section 9.2.5).

2. ND = Not determined; insufficient background data to calculate CCL.

**Source:** AWQG, Volume 1, Section 4.2.6, Table 4.2.10.

## Table 10 Stock watering EV: Water quality objectives for tolerances of livestock to total dissolved solids (salinity) in drinking water[1]

| Livestock | Total dissolved solids (TDS) (mg/L) | | |
|---|---|---|---|
| | No adverse effects on animals expected. | Animals may have initial reluctance to drink or there may be some scouring, but stock should adapt without loss of production | Loss of production and decline in animal condition and health would be expected. Stock may tolerate these levels for short periods if introduced gradually |
| Beef cattle | 0–4000 | 4000–5000 | 5000–10 000 |
| Dairy cattle | 0–2500 | 2500–4000 | 4000–7000 |
| Sheep | 0–5000 | 5000–10 000 | 10 000–13 000[2] |
| Horses | 0–4000 | 4000–6000 | 6000–7000 |
| Pigs | 0–4000 | 4000–6000 | 6000–8000 |
| Poultry | 0–2000 | 2000–3000 | 3000–4000 |

**Notes:**

1. From ANZECC (1992), adapted to incorporate more recent information.
2. Sheep on lush green feed may tolerate up to 13 000 mg/L TDS without loss of condition or production.

**Source:** AWQG, Volume 1, Section 4.3.3.5, Table 4.3.1.

## Table 11 Stock watering EV: Water quality objectives (low risk trigger values) for heavy metals and metalloids in livestock drinking water

| Metal or metalloid | Trigger value (low risk)[1,2] (mg/L) |
|---|---|
| Aluminium | 5 |
| Arsenic | 0.5 (up to 5[3]) |
| Beryllium | ND |
| Boron | 5 |
| Cadmium | 0.01 |
| Chromium | 1 |
| Cobalt | 1 |
| Copper | 0.4 (sheep), 1 (cattle), 5 (pigs), 5 (poultry) |
| Fluoride | 2 |
| Iron | not sufficiently toxic |
| Lead | 0.1 |
| Manganese | not sufficiently toxic |
| Mercury | 0.002 |
| Molybdenum | 0.15 |
| Nickel | 1 |
| Selenium | 0.02 |
| Uranium | 0.2 |
| Vanadium | ND |
| Zinc | 20 |

**Notes:**

1. Higher concentrations may be tolerated in some situations (further details provided in AWQG, Volume 3, Section 9.3.5).
2. ND = not determined, insufficient background data to calculate.
3. May be tolerated if not provided as a food additive and natural levels in the diet are low.

**Source:** AWQG, Volume 1, Section 4.3.4, Table 4.3.2.

## Table 12 Recreational waters: Alert levels and corresponding actions for management of cyanobacteria

When cyanobacteria are present in large numbers they can present a significant hazard, particularly to primary contact users of waters. Water quality objectives for cyanobacteria in recreational waters are provided in Table 3. Monitoring/action requirements relative to cyanobacteria 'alert' levels are summarised below, and are explained more fully in the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008). Further details on the process to determine suitability of waters for recreation, relative to historical cyanobacterial levels and susceptibility to cyanobacterial contamination, are contained in sections 6 and 7 of the NHMRC guidelines.

| Green level surveillance mode[1] | Amber level alert mode[1] | Red level action mode[1] |
|---|---|---|
| **Fresh waters** | | |
| ≥ 500 to <5000 cells/mL *M. aeruginosa* or biovolume equivalent of >0.04 to <0.4 $mm^3$/L for the combined total of all cyanobacteria. | ≥ 5000 to <50 000 cells/mL *M. aeruginosa* or biovolume equivalent of ≥ 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[2].<br>or[3]<br>≥ 0.4 to <10 $mm^3$/L for the combined total of all cyanobacteria where known toxin producers are not present. | Level 1 guideline[4]:<br>≥ 10 µg/L total microcystins<br>or<br>≥ 50 000 cells/mL toxic *M. 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.<br>or[3]<br>Level 2 guideline[4]:<br>≥ 10 $mm^3$/L for total biovolume of all cyanobacterial material where known toxins are not present.<br>or<br>cyanobacterial scums are consistently present[5]. |
| **Coastal and estuarine waters** | | |
| *Karenia brevis* | | |
| ≤ 1 cell/mL | > 1– < 10 cells/mL | ≥ 10 cells/mL |
| *Lyngbya majuscula, Pfiesteria* spp. | | |
| History but no current presence of organism | Present in low numbers | Present in high numbers. (For *Lyngbya majuscula* this involves the relatively widespread visible presence of dislodged algal filaments in the water and washed up onto the beach) |
| *Nodularia spumigena*: See NHMRC, Chapter 6 (Cyanobacteria and algae in fresh water) for details. | | |

**Notes:**

1. Recommended actions at different alert levels are outlined below (based on NHMRC, 2008, Table 6.6—fresh waters. Similar actions are outlined for coastal/estuarine waters in NHMRC Table 7.6):

   a. **Green**: Regular monitoring. Weekly sampling and cell counts at representative locations in the water body where known toxigenic species are present (i.e. *Microcystis aeruginosa, Anabaena circinalis, Cylindrospermopsis raciborskii, Aphanizomenon ovalisporum, Nodularia spumigena*); or fortnightly for other types including regular visual inspection of water surface for scums.

   b. **Amber**: Notify agencies as appropriate. Increase sampling frequency to twice weekly at representative locations in the water body where toxigenic species (above) are dominant within the alert level definition (i.e. total biovolume) to establish population growth and spatial variability in the water body. Monitor weekly or fortnightly where other types are dominant. Make regular visual inspections of water surface for scums. Decide on requirement for toxicity assessment or toxin monitoring.

   c. **Red**: Continue monitoring as for (amber) alert mode. Immediately notify health authorities for advice on health risk. ('In action mode the local authority and health authorities warn the public of the existence of potential health risks; for example, through the media and the erection of signs by the local authority.' NHMRC, 2008; 114). Make toxicity assessment or toxin measurement of water if this has not already been done. Health authorities warn of risk to public health (i.e. the authorities make a health risk assessment considering toxin monitoring data, sample type and variability).

2. The definition of 'dominant' is where the known toxin producer comprises 75 per cent or more of the total biovolume of cyanobacteria in a representative sample.

3. This applies where high cell densities or scums of 'non toxic' cyanobacteria are present i.e. where the cyanobacterial population has been tested and shown not to contain known toxins (mycrocystins, nodularian, cylindrospermopsin or saxitoxin).
4. Health risks and levels: Level 1 is developed to protect against short-term health effects of exposure to cyanobacterial toxins ingested during recreational activity, whereas the Level 2 applies to the circumstance where there is a probability of increased likelihood of non-specific adverse health outcomes, principally respiratory, irritation and allergy symptoms, from exposure to very high cell densities of cyanobacterial material irrespective of the presence of toxicity or known toxins (NHMRC, 2008;114).
5. This 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:** Based on NHMRC (2008) Guideline for Managing Risks in Recreational Water (tables 6.2, 6.6, 7.3).

# 4 Ways to improve water quality

The following documents are relevant in considering ways to improve water quality. The document list below is additional to the plans, guidelines and other sources referred to in previous sections, **and is provided for information only**.

**Local plans, studies**

- Council planning scheme and supporting codes, policies, available DSDIP website and council websites

**Regional plans, studies**

- Central Queensland Regional Plan, available from the DSDIP website
- Central Queensland Regional Water Supply Strategy, available from the DEWS website

**State plans, policies, guidelines, agreements etc**

- Reef Water Quality Protection Plan, Australian and Queensland governments, available from the Reef Water Quality Protection Plan's website
- State Planning Policy (state interest – water quality), including SPP code – water quality, and supporting SPP guidelines, available from the DSDIP website
- Monitoring and Sampling Manual, available from the department's website

**Water quality guidelines**

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (AWQG)
- Monitoring and Sampling Manual, available from the department's website
- Queensland Water Quality Guidelines (QWQG), available from the department's website
- Water quality guidelines for the Great Barrier Reef Marine Park 2010, available on the Great Barrier Reef Marine Park Authority's website

**Other supporting technical information – riparian management**

- Healthy Waterways Incorporated – Water by Design: resources and information available on the Water by Design website, including content on the Reef Urban Stormwater Management Improvement Group (RUSMIG)
- Managing riparian widths to achieve multiple objectives, fact sheet 13, Land and Water Australia, Australian Government, 2004
- Improving water quality, fact sheet 3, Land & Water Australia, Australian Government, 2002
- Riparian Land Management Technical Guidelines—Volume 1 and 2, November 1999, Land and Water Resources Research and Development Corporation (LWRRDC)
- Guidelines for Queensland Streambank Stabilisation with Riparian Vegetation, CRC for Catchment Hydrology, September 1999
- Restoration of Fish Habitats—Fisheries Guidelines for Marine Areas, FHG002, available from the Department of Agriculture, Fisheries and Forestry
- Fisheries Guidelines for Fish Habitat Buffer Zones, FHG003, available from the Department of Agriculture, Fisheries and Forestry
- Guidelines for Riparian Filter Strips for Queensland Irrigators, CSIRO Land and Water, September 1999

# 5 Dictionary

**AMTD** means the adopted middle thread distance which is the distance in kilometres, measured along the middle of a watercourse, that a specific point in the watercourse is from the watercourse's mouth or junction with the main watercourse (definition based on Water Regulation 2002).

**ANZECC** means the Australian and New Zealand Environment and Conservation Council.

**Aquatic ecosystems** (defined in the AWQG) comprise the animals, plants and micro-organisms that live in water, and the physical and chemical environment and climatic regime in which they interact. It is predominantly the physical components (e.g. light, temperature, mixing, flow, habitat) and chemical components (e.g. organic and inorganic carbon, oxygen, nutrients) of an ecosystem that determine what lives and breeds in it, and therefore the structure of the food web. Biological interactions (e.g. grazing and predation) can also play a part in structuring many aquatic ecosystems.

**ARMCANZ** means the Agriculture and Resource Management Council of Australia and New Zealand.

**Basin** means the basin name and number provided by Geoscience Australia, Canberra (3rd edition, 2004).

**Biological integrity,** of water, means the water's ability to support and maintain a balanced, integrative, adaptive community of organisms having a species composition, diversity and functional organisation comparable to that of the natural habitat of the locality in which the water is situated.

**Biotoxin** (defined in the AWQG): means a toxin (poison) which originates from a living thing (a plant, animal, fungi, bacteria, etc.).

**Catchment** means the total area draining into a river, creek, reservoir or other body of water. The limits of a given catchment are the heights of land (such as hills or mountains) separating it from neighbouring catchments. Catchments can be made up of smaller subcatchments.

**Ecological health** (defined in the AWQG) means the 'health' or 'condition' of an ecosystem. It is the ability of an ecosystem to support and maintain key ecological processes and organisms so that their species compositions, diversity and functional organisations are as comparable as possible to those occurring in natural habitats within a region (also termed ecological integrity).

**Environmental value (EV)** means:

(a) a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or

(b) another quality of the environment identified and declared to be an environmental value under an Environmental Protection Policy or Regulation (e.g. water suitable for swimming in or drinking).

The EVs for water that can be identified for protection are outlined in Table 13.

**Highest astronomical tide (HAT)** (defined in Marine Parks (Declaration) Regulation 2006) means the highest level of the tides that can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions.

**High water mark** (defined in *Coastal Protection and Management Act 1995*) means the ordinary high water mark at spring tides.

**Mean high water spring** refer high water mark.

**Queensland waters** (as defined in *Acts Interpretation Act 1954*): means all waters that are a) within the limits of the state; or b) coastal waters of the state.

**Sub-basin** means part of a basin.

**Subcatchment** means part of a catchment.

**Toxicant** (defined in the AWQG): means a chemical capable of producing an adverse response (effect) in a biological system at concentrations that might be encountered in the environment, seriously injuring structure or function or producing death. Examples include pesticides, heavy metals and biotoxins.

## Table 13 Suite of environmental values that can be chosen for protection

| Environmental values and definitions | ICON (as shown on plans) |
|---|---|
| **Aquatic ecosystem**<br>'A community of organisms living within or adjacent to water, including riparian or foreshore area.' (EPP (Water), schedule 2 - Dictionary)<br>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.<br>Waterways include perennial and intermittent surface waters, groundwaters, 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.<br>(This EV incorporates the 'wildlife habitat' EV used in the South East Queensland Regional Water Quality Management Strategy). See below for more details on aquatic ecosystems, based on the EPP (Water). |  |
| **High ecological/conservation value waters**<br>'Waters in which the biological integrity of the water is effectively unmodified or highly valued.' (EPP (Water), schedule 2). | None |
| **Slightly disturbed waters**<br>'Waters that have the biological integrity of high ecological value waters with slightly modified physical or chemical indicators but effectively unmodified biological indicators.' (EPP (Water), schedule 2). | None |
| **Moderately disturbed waters**<br>'Waters in which the biological integrity of the water is adversely affected by human activity to a relatively small but measurable degree.' (EPP (Water), schedule 2). | None |
| **Highly disturbed waters**<br>'Waters that are significantly degraded by human activity and have lower ecological value than high ecological value waters or slightly or moderately disturbed waters.' (EPP (Water), schedule 2). | None |
| **Seagrass** (goal within the aquatic ecosystem EV)<br>Maintenance or rehabilitation of seagrass habitat. (Applies only to tidal waterways.) |  |

| Environmental values and definitions | ICON (as shown on plans) |
|---|---|
| **Irrigation**<br>Suitability of water supply for irrigation, for example, irrigation of crops, pastures, parks, gardens and recreational areas. |  |
| **Farm water supply/use**<br>Suitability of domestic farm water supply, other than drinking water. For example, water used for laundry and produce preparation. |  |
| **Stock watering**<br>Suitability of water supply for production of healthy livestock. |  |
| **Aquaculture**<br>Health of aquaculture species and humans consuming aquatic foods (such as fish, molluscs and crustaceans) from commercial ventures. |  |
| **Human consumers of aquatic foods**<br>Health of humans consuming aquatic foods, such as fish, crustaceans and shellfish from natural waterways. Note that in some areas oystering is a more specific goal identified under the human consumer EV (see below). |  |
| **Oystering** (goal within the EV of human consumers of aquatic foods)<br>Health of humans consuming oysters from natural waterways and commercial ventures. (Applies only to tidal waterways.) |  |
| **Primary recreation**<br>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.<br>Primary recreational use, of water, means full body contact with the water, including, for example, diving, swimming, surfing, waterskiing and windsurfing. (EPP (Water), s. 6). |  |
| **Secondary recreation**<br>Health of humans during recreation which involves indirect contact and a low probability of water being swallowed, for example, wading, boating, rowing and fishing.<br>Secondary recreational use, of water, means contact other than full body contact with the water, including, for example, boating and fishing. (EPP (Water), s. 6). |  |
| **Visual recreation**<br>Amenity of waterways for recreation which does not involve any contact with water—for example, walking and picnicking adjacent to a waterway.<br>Visual recreational use, of a water, means viewing the water without contact with it. (EPP (Water), s. 6). |  |

| Environmental values and definitions | ICON (as shown on plans) |
|---|---|
| **Drinking water supply**<br>Suitability of raw drinking water supply. This assumes minimal treatment of water is required, for example, coarse screening and/or disinfection. |  |
| **Industrial use**<br>Suitability of water supply for industrial use, for example, food, beverage, paper, petroleum and power industries, mining and minerals refining/processing. Industries usually treat water supplies to meet their needs. |  |
| **Cultural and spiritual values**<br>Indigenous and non-indigenous cultural heritage, for example:<br>• custodial, spiritual, cultural and traditional heritage, hunting, gathering and ritual responsibilities<br>• symbols, landmarks and icons (such as waterways, turtles and frogs)<br>• lifestyles (such as agriculture and fishing).<br>Cultural and spiritual values, of water, means its aesthetic, historical, scientific, social or other significance, to the present generation or past or future generations. (EPP (Water), s. 6). |  |

# WATER QUALITY OBJECTIVES FOR SURFACE AND GROUNDWATERS –IONIC INDICATORS

**Table 14 Capricorn–Curtis Coast region surface and groundwater ions: water quality objectives (aquatic ecosystem) according to water chemistry zone and depth**

**SURFACE WATER**

| Flow[1] | Percentile | Indicator[2] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | SAR |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | |
| **Upper Boyne Alluvium (Boyne upstream of confluence with Diglum Creek)** | | | | | | | | | | | | | | | | | | | |
| normal | 25th | 41 | - | 37 | - | 15 | - | 165 | | 62 | - | 11 | - | 498 | 151 | 136 | 22.83 | 0.12 | 1.38 |
| | 75th | 44 | - | 42 | - | 17 | - | 181 | - | 75 | - | 18 | - | 546 | 175 | 150 | 27.33 | 0.15 | 1.50 |
| **Boyne –Diglum Creek (including Boyne basin downstream of confluence with Diglum Creek) and Calliope (excluding central alluvium – main channel)** | | | | | | | | | | | | | | | | | | | |
| normal | 25th | 59 | - | 40 | - | 24 | - | 202 | - | 96 | - | 14 | - | 665 | 198 | 168.5 | 20 | 0.20 | 1.71 |
| | 75th | 84 | - | 63 | - | 32 | - | 316 | - | 135 | - | 21 | - | 920 | 286 | 264 | 35 | 0.30 | 2.19 |
| **Central Calliope** | | | | | | | | | | | | | | | | | | | |
| normal | 25th | 108 | - | 44 | - | 36 | - | 226 | - | 198 | - | 9 | - | 1039 | 272 | 186.0 | 12.08 | 0.20 | 2.80 |
| | 75th | 153 | - | 63 | - | 51 | - | 316 | | 305 | - | 20 | - | 1416 | 363 | 263 | 24.00 | 0.28 | 3.58 |

**Note**:

1. Normal flow conditions exclude the top and bottom 10% of flows.

2. Abbreviations: Na: Sodium, Ca: Calcium, Mg: Magnesium, $HCO_3$: Bicarbonate, Cl: Chloride, $SO_4$: Sulfate, EC: Electrical conductivity, $SiO_2$: Silica, F: Fluoride, SAR: Sodium adsorption ratio, '-': insufficient data to perform statistical summaries, or the parameter was not tested.

**Source:** WQOs for these indicators are based on DSITIA analysis of data collected as part of the Queensland Government Surface Water Ambient Network (SWAN) monitoring program, and stored on the 'Hydstra' database. Prepared for EHP by DSITIA.

McNeil V.H. and Raymond M.A. (2014) Regional groundwater chemistry zones of the Curtis and Capricorn Coast: Draft Technical Notes. Department of Science, Information Technology, Innovation and the Arts, Queensland

McNeil V. H and Clarke R. (2004) Salinity zones defined for Queensland streams. Report prepared for Queensland Water Quality Guidelines, Appendix G.



81

## GROUNDWATER (refer plan WQ1273)

### Groundwater Zone 1 – Banksia [1, 2, 3, 4]

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | pH | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | Fe ($mg{\cdot}L^{-1}$) | Mn ($mg{\cdot}L^{-1}$) | Zn ($mg{\cdot}L^{-1}$) | Cu ($mg{\cdot}L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | | | | | | | |
| moderate | 20th | 558 | 79 | 5 | 1 | 20 | 6 | 215 | 13 | 771 | 66 | 26 | 1 | | | 2,864 | 96 | 7.8 | 180.6 | 107 | 0.22 | | | | | 19.12 | 1.13 |
| | 50th | 570 | 91 | 12 | 2 | 24 | 7 | 220 | 14 | 840 | 83 | 30 | 2 | 1.50 | 0 | 3,050 | 127 | 8.1 | 186.0 | 109 | 0.35 | | | | | 22.00 | 1.87 |
| | 80th | 1,096 | 93 | 43 | 3 | 134 | 17 | 1,251 | 33 | 1,394 | 85 | 44 | 2 | 3.00 | 0 | 5,705 | 657 | 8.3 | 1,026.6 | 110 | 0.76 | | | | | 24.79 | 7.46 |

Note: insufficient data to derive WQOs for shallow and artesian depth profiles. Refer to all notes after zone 15.

### Groundwater Zone 2 – Coorooman [1, 2, 3, 4]

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | pH | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | Fe ($mg{\cdot}L^{-1}$) | Mn ($mg{\cdot}L^{-1}$) | Zn ($mg{\cdot}L^{-1}$) | Cu ($mg{\cdot}L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | | | | | | | |
| moderate | 20th | 295 | 41 | 69 | 14 | 57 | 20 | 185 | 8 | 634 | 79 | 34 | 2 | 0.18 | 0 | 2,581 | 396 | 7.1 | 153.5 | 37 | 0.29 | | 0.001 | 0.015 | 0.005 | 4.45 | |
| | 50th | 403 | 56 | 139 | 19 | 125 | 25 | 262 | 12 | 1,100 | 84 | 58 | 3 | 1.40 | 0 | 3,845 | 877 | 8.0 | 221.0 | 40 | 0.40 | | 0.030 | 0.030 | 0.020 | 6.50 | |
| | 80th | 673 | 62 | 224 | 26 | 166 | 32 | 368 | 17 | 1,580 | 89 | 105 | 5 | 1.77 | 0 | 5,279 | 1,197 | 8.3 | 304.5 | 50 | 0.57 | | 0.106 | 0.105 | 0.035 | 9.55 | |

Note: insufficient data to derive WQOs for shallow depth profile. Refer to all notes after zone 15.

## Groundwater Zone 3 - Styx [1, 2, 3, 4]

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | pH | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | Fe ($mg{\cdot}L^{-1}$) | Mn ($mg{\cdot}L^{-1}$) | Zn ($mg{\cdot}L^{-1}$) | Cu ($mg{\cdot}L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | | | | | | | |
| shallow | 20th | 781 | 44 | 95 | 6 | 163 | 17 | 326 | 5 | 1,727 | 70 | 164 | 4 | | | 6,445 | 867 | 7.5 | 272.5 | 23 | 0.32 | | 0.035 | 0.039 | | 7.60 | |
| | 50th | 1,296 | 71 | 222 | 11 | 209 | 18 | 583 | 11 | 2,342 | 84 | 301 | 8 | 0.00 | 0 | 7,620 | 1,346 | 7.7 | 478.5 | 30 | 0.68 | | 0.165 | 0.140 | 0.010 | 15.30 | |
| | 80th | 1,564 | 77 | 315 | 21 | 310 | 36 | 628 | 15 | 3,607 | 88 | 653 | 15 | 3.26 | 0 | 9,887 | 1,995 | 8.0 | 524.5 | 33 | 1.07 | 0.09 | 0.478 | 12.666 | 0.041 | 22.60 | |
| moderate | 20th | 763 | 61 | 35 | 2 | 137 | 18 | 52 | 1 | 1,617 | 78 | 18 | 1 | 0.65 | 0 | 5,457 | 711 | 5.1 | 42.5 | 30 | 0.47 | | 0.105 | 0.144 | 0.071 | 11.25 | |
| | 50th | 1,062 | 76 | 70 | 4 | 185 | 21 | 105 | 2 | 2,094 | 92 | 100 | 3 | 2.00 | 0 | 7,380 | 1,121 | 7.2 | 86.0 | 43 | 0.60 | | 0.330 | 0.900 | 0.080 | 13.90 | |
| | 80th | 1,650 | 78 | 235 | 18 | 211 | 22 | 793 | 20 | 3,045 | 96 | 278 | 6 | 5.50 | 0 | 9,490 | 1,302 | 7.6 | 653.5 | 79 | 1.08 | 0.34 | 1.878 | 1.035 | 0.476 | 22.60 | |

Note: insufficient data to derive WQOs for deep and very deep depth profiles. Refer to all notes after zone 15.

## Groundwater Zone 4 - Yeppoon [1, 2, 3, 4]

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | pH | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | Fe ($mg{\cdot}L^{-1}$) | Mn ($mg{\cdot}L^{-1}$) | Zn ($mg{\cdot}L^{-1}$) | Cu ($mg{\cdot}L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | | | | | | | |
| very shallow | 20th | 198 | 48 | 24 | 4 | 32 | 14 | 23 | 2 | 482 | 83 | 10 | 1 | 0.67 | 0 | 1,695 | 191 | 7.5 | 22.9 | 6 | 0.01 | 0.02 | | | | 4.10 | |
| | 50th | 265 | 77 | 24 | 8 | 56 | 15 | 49 | 4 | 630 | 93 | 10 | 1 | 2.20 | 0 | 2,100 | 290 | 7.6 | 40.0 | 10 | 0.10 | 0.02 | 0.010 | | | 8.60 | |
| | 80th | 603 | 82 | 60 | 16 | 83 | 36 | 153 | 16 | 1,098 | 97 | 20 | 2 | 4.90 | 0 | 3,450 | 492 | 9.0 | 125.5 | 17 | 0.10 | 0.02 | 0.020 | | | 15.71 | |
| moderate | 20th | 236 | 73 | 29 | 10 | 25 | 15 | 122 | 14 | 398 | 73 | 12 | 2 | 0.50 | 0 | 1,506 | 181 | 6.3 | 100.9 | 27 | 0.26 | | 0.010 | 0.006 | | 7.53 | |
| | 50th | 264 | 74 | 34 | 11 | 29 | 15 | 133 | 15 | 477 | 83 | 14 | 2 | 1.05 | 0 | 1,747 | 208 | 7.4 | 110.0 | 44 | 0.31 | 0.01 | 0.230 | 0.020 | 0.015 | 8.35 | |
| | 80th | 472 | 76 | 46 | 12 | 51 | 16 | 390 | 24 | 717 | 84 | 36 | 3 | 2.27 | 0 | 2,720 | 316 | 7.9 | 330.0 | 48 | 0.77 | 0.03 | 0.433 | 0.039 | 0.015 | 10.32 | 0.07 |
| deep | 20th | 289 | 79 | 20 | 5 | 17 | 6 | 123 | 10 | 465 | 78 | 5 | 1 | - | - | 1,725 | 127 | 7.0 | 100.5 | | 0.30 | | | | | 9.72 | |
| | 50th | 368 | 85 | 24 | 5 | 22 | 10 | 128 | 11 | 596 | 89 | 7 | 1 | 0.05 | 0 | 1,950 | 140 | 7.6 | 105.0 | | 0.45 | | | | | 13.50 | |
| | 80th | 445 | 88 | 28 | 9 | 25 | 13 | 202 | 20 | 699 | 90 | 13 | 2 | 0.10 | 0 | 2,265 | 170 | 8.1 | 168.0 | | 0.60 | | | | | 17.19 | |

Note: insufficient data to derive WQOs for shallow depth profile. Refer to all notes after zone 15.

## Groundwater Zone 5 -Pacific [1, 2, 3, 4]

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | pH | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | Fe ($mg{\cdot}L^{-1}$) | Mn ($mg{\cdot}L^{-1}$) | Zn ($mg{\cdot}L^{-1}$) | Cu ($mg{\cdot}L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | | | | | | | |
| shallow | 20th | 703 | 68 | 133 | 6 | 98 | 18 | 149 | 0 | 1,407 | 79 | 56 | 4 | | | 4,818 | 735 | 6.0 | 152.4 | 20 | 0.20 | | 0.102 | 0.026 | 0.064 | 11.32 | |
| | 50th | 8,900 | 71 | 635 | 6 | 1,475 | 21 | 265 | 1 | 16,500 | 86 | 3,100 | 11 | 7.20 | 0 | 40,000 | 8,194 | 7.3 | 230.0 | 25 | 0.43 | 0.06 | 1.900 | 0.040 | 0.210 | 41.90 | |
| | 80th | 11,072 | 76 | 785 | 10 | 1,857 | 23 | 396 | 9 | 19,705 | 89 | 5,231 | 15 | 23.20 | 0 | 49,050 | 9,295 | 7.5 | 335.9 | 33 | 0.51 | 0.96 | 5.707 | 0.236 | 0.279 | 47.80 | |

Note: insufficient data to derive WQOs for moderate depth profile. Refer to all notes after zone 15.

## Groundwater Zone 6 - Jacob [1, 2, 3, 4]

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | pH | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | Fe ($mg{\cdot}L^{-1}$) | Mn ($mg{\cdot}L^{-1}$) | Zn ($mg{\cdot}L^{-1}$) | Cu ($mg{\cdot}L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | | | | | | | |
| shallow | 20th | 1,548 | 64 | 189 | 8 | 297 | 21 | 441 | 6 | 3,470 | 92 | 4 | 0 | - | - | 12,000 | 1,650 | 7.5 | 361.1 | 21 | 0.10 | 0.95 | | | | 15.46 | |
| | 50th | 1,925 | 66 | 253 | 10 | 376 | 24 | 457 | 7 | 4,300 | 93 | 10 | 0 | 0.85 | 0 | 12,000 | 2,209 | 7.7 | 396.5 | 23 | 0.20 | 1.95 | | | | 17.95 | |
| | 80th | 2,508 | 68 | 282 | 12 | 455 | 25 | 641 | 8 | 5,117 | 94 | 85 | 1 | 2.65 | 0 | 12,000 | 2,509 | 8.4 | 525.2 | 24 | 0.30 | 2.75 | | | | 21.56 | |
| moderate | 20th | 77 | 47 | 3 | 4 | 8 | 16 | 24 | 9 | 144 | 51 | 2 | 1 | | | 654 | 40 | 5.8 | 20.0 | | 0.01 | - | | | | 5.30 | |
| | 50th | 220 | 64 | 93 | 15 | 55 | 21 | 377 | 22 | 373 | 71 | 91 | 6 | | | 1,852 | 459 | 6.3 | 311.5 | | 0.06 | 1.00 | | | | 5.30 | |
| | 80th | 364 | 81 | 182 | 27 | 103 | 25 | 730 | 36 | 603 | 90 | 180 | 11 | | | 3,050 | 878 | 6.7 | 603.0 | | 0.10 | 2.00 | | | | 5.30 | |
| deep | 20th | 906 | 65 | 91 | 5 | 103 | 14 | 551 | 5 | 1,254 | 64 | 126 | 4 | 0.40 | 0 | 4,376 | 746 | 7.0 | 451.5 | | 0.30 | 0.25 | | | | 12.11 | 2.61 |
| | 50th | 1,456 | 72 | 160 | 8 | 178 | 18 | 638 | 17 | 2,280 | 75 | 215 | 7 | 4.00 | 0 | 6,790 | 979 | 7.1 | 528.5 | | 0.70 | 0.64 | | | | 19.65 | 5.48 |
| | 80th | 4,060 | 77 | 317 | 17 | 630 | 23 | 1,245 | 32 | 7,335 | 86 | 446 | 8 | 14.71 | 0 | 18,440 | 3,180 | 7.5 | 1,021.2 | | 1.82 | 8.35 | | | | 29.89 | 8.30 |

Note: insufficient data to derive WQOs for very shallow depth profile. Refer to all notes after zone 15.

**Groundwater Zone 7 - Woodbury [1, 2, 3, 4]**

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | pH | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | Fe ($mg{\cdot}L^{-1}$) | Mn ($mg{\cdot}L^{-1}$) | Zn ($mg{\cdot}L^{-1}$) | Cu ($mg{\cdot}L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | | | | | | | |
| shallow | 20th | 16 | 63 | 1 | 4 | 1 | 11 | 2 | 3 | 16 | 38 | 5 | 10 | | | 119 | 8 | 4.8 | 6.0 | 11 | | | | 0.020 | | 1.68 | |
| | 50th | 18 | 79 | 1 | 6 | 2 | 15 | 8 | 12 | 18 | 48 | 10 | 21 | 11.50 | 10 | 120 | 10 | 6.5 | 8.0 | 12 | | 0.03 | | 0.045 | 0.005 | 2.30 | |
| | 80th | 20 | 83 | 3 | 14 | 4 | 22 | 13 | 24 | 27 | 59 | 28 | 36 | 13.42 | 21 | 170 | 23 | 6.8 | 11.8 | 13 | 0.10 | 0.05 | 0.010 | 0.070 | 0.010 | 2.87 | 0.02 |
| deep | 20th | 525 | 57 | 197 | 23 | 91 | 18 | 300 | 11 | 689 | 45 | 765 | 38 | 0.75 | 0 | 3,775 | 866 | 7.0 | 249.0 | 26 | 0.35 | 0.02 | 0.006 | | | 7.70 | |
| | 50th | 660 | 57 | 230 | 23 | 120 | 19 | 340 | 12 | 880 | 47 | 1,000 | 41 | 2.20 | 0 | 4,620 | 1,069 | 7.9 | 285.0 | 36 | 0.40 | 0.06 | 0.260 | | | 8.60 | |
| | 80th | 700 | 58 | 261 | 25 | 128 | 20 | 389 | 13 | 896 | 49 | 1,164 | 43 | 3.60 | 0 | 4,900 | 1,169 | 7.9 | 324.0 | 38 | 0.55 | 0.14 | 1.361 | | | 8.95 | |

Note: refer to all notes after zone 15.

**Groundwater Zone 8 - Welton [1, 2, 3, 4]**

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | pH | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | Fe ($mg{\cdot}L^{-1}$) | Mn ($mg{\cdot}L^{-1}$) | Zn ($mg{\cdot}L^{-1}$) | Cu ($mg{\cdot}L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | | | | | | | |
| shallow | 20th | 17 | 66 | 2 | 5 | 3 | 15 | 5 | 3 | 28 | 64 | 4 | 4 | | | 145 | 15 | 5.7 | 4.0 | 6 | | | 0.010 | 0.030 | | 1.90 | |
| | 50th | 35 | 73 | 4 | 8 | 5 | 18 | 15 | 12 | 56 | 74 | 10 | 9 | 0.50 | 0 | 261 | 29 | 6.5 | 12.0 | 15 | 0.10 | 0.02 | 0.055 | 0.060 | | 2.70 | |
| | 80th | 59 | 79 | 7 | 13 | 8 | 22 | 36 | 22 | 93 | 82 | 16 | 19 | 2.20 | 3 | 384 | 50 | 7.0 | 30.3 | 22 | 0.10 | 0.41 | 0.160 | 0.138 | 0.010 | 4.00 | |
| moderate | 20th | 50 | 72 | 3 | 4 | 3 | 6 | 65 | 24 | 50 | 40 | 4 | 2 | | | 289 | 21 | 7.0 | 53.5 | 35 | 0.21 | | | 0.010 | | 3.49 | 0.49 |
| | 50th | 74 | 80 | 7 | 8 | 6 | 11 | 117 | 41 | 70 | 54 | 8 | 4 | 0.28 | 0 | 436 | 38 | 7.4 | 97.0 | 58 | 0.42 | 0.01 | 0.010 | 0.020 | 0.005 | 5.30 | 1.16 |
| | 80th | 175 | 89 | 16 | 14 | 11 | 15 | 196 | 53 | 205 | 71 | 17 | 6 | 1.40 | 0 | 950 | 87 | 7.8 | 160.4 | 66 | 0.63 | 0.18 | 0.159 | 0.050 | 0.015 | 8.90 | 2.01 |
| deep | 20th | 25 | 66 | 3 | 7 | 3 | 12 | 30 | 22 | 38 | 49 | 3 | 2 | | | 187 | 18 | 6.7 | 24.5 | 28 | 0.14 | | | 0.030 | 0.005 | 2.21 | 0.05 |
| | 50th | 63 | 75 | 7 | 9 | 6 | 15 | 59 | 38 | 68 | 60 | 6 | 3 | 0.30 | 0 | 410 | 45 | 7.7 | 48.0 | 46 | 0.22 | | | 0.030 | 0.010 | 4.00 | 0.50 |
| | 80th | 97 | 81 | 12 | 12 | 9 | 20 | 162 | 46 | 106 | 75 | 11 | 8 | 1.10 | 0 | 592 | 66 | 8.0 | 134.3 | 62 | 0.49 | 0.00 | 0.408 | 0.100 | 0.020 | 6.36 | 1.62 |

Note: refer to all notes after zone 15.

## Groundwater Zone 9 - Leixlip [1, 2, 3, 4]

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | pH | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | Fe ($mg{\cdot}L^{-1}$) | Mn ($mg{\cdot}L^{-1}$) | Zn ($mg{\cdot}L^{-1}$) | Cu ($mg{\cdot}L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | | | | | | | |
| very shallow | 20th | 303 | 48 | 52 | 10 | 92 | 28 | 705 | 49 | 308 | 31 | 30 | 2 | | | 2,500 | 567 | 7.7 | 638.8 | 33 | 0.61 | | | | | 4.96 | 1.59 |
| | 50th | 324 | 51 | 87 | 16 | 108 | 34 | 966 | 55 | 370 | 36 | 45 | 3 | 3.60 | 0 | 2,615 | 682 | 7.8 | 792.0 | 34 | 1.10 | 0.05 | | | | 5.40 | 3.11 |
| | 80th | 343 | 57 | 104 | 20 | 124 | 35 | 1,074 | 65 | 441 | 47 | 87 | 6 | 6.60 | 0 | 2,730 | 711 | 8.6 | 880.1 | 35 | 1.47 | 0.86 | | | | 6.27 | 4.77 |
| shallow | 20th | 299 | 54 | 36 | 7 | 46 | 13 | 574 | 23 | 200 | 26 | 32 | 3 | | | 1,960 | 309 | 7.6 | 474.7 | 24 | 0.20 | | | | 0.010 | 5.85 | 1.35 |
| | 50th | 425 | 67 | 74 | 14 | 68 | 20 | 752 | 52 | 430 | 42 | 85 | 6 | 1.80 | 0 | 2,450 | 469 | 7.9 | 627.0 | 27 | 0.60 | 0.30 | 0.005 | 0.010 | 0.015 | 9.00 | 6.07 |
| | 80th | 639 | 76 | 137 | 22 | 99 | 28 | 983 | 69 | 966 | 65 | 146 | 10 | 31.00 | 2 | 3,500 | 651 | 8.3 | 843.3 | 45 | 0.90 | 1.23 | 0.020 | 0.092 | 0.110 | 12.30 | 10.99 |
| moderate | 20th | 391 | 57 | 61 | 8 | 61 | 16 | 275 | 9 | 369 | 37 | 73 | 4 | | | 2,759 | 487 | 7.2 | 228.2 | 30 | 0.20 | | | 0.002 | 0.001 | 7.30 | 0.24 |
| | 50th | 500 | 63 | 120 | 13 | 84 | 20 | 788 | 38 | 634 | 56 | 110 | 7 | 0.30 | 0 | 3,640 | 632 | 7.8 | 681.0 | 32 | 0.40 | 0.10 | 0.055 | 0.020 | 0.010 | 9.60 | 3.73 |
| | 80th | 898 | 71 | 187 | 26 | 178 | 23 | 923 | 55 | 1,319 | 80 | 217 | 9 | 15.15 | 2 | 7,839 | 909 | 8.3 | 837.9 | 44 | 0.90 | 0.46 | 0.562 | 0.047 | 0.028 | 13.18 | 7.70 |
| deep | 20th | 832 | 74 | 20 | 2 | 24 | 5 | 567 | 11 | 628 | 45 | 47 | 2 | | | 4,111 | 148 | 7.1 | 492.1 | | 0.91 | 0.10 | | | | 17.59 | 0.47 |
| | 50th | 850 | 80 | 53 | 6 | 77 | 14 | 808 | 21 | 1,150 | 73 | 105 | 5 | | | 4,300 | 449 | 8.0 | 664.0 | | 1.00 | 0.50 | | | | 22.90 | 9.85 |
| | 80th | 2,065 | 93 | 203 | 8 | 269 | 18 | 1,262 | 52 | 3,580 | 82 | 371 | 6 | | | 10,690 | 1,614 | 8.5 | 1,034.8 | | 1.99 | 21.65 | | | | 33.43 | 19.22 |

Note: refer to all notes after zone 15.

**Groundwater Zone 10 - Uplands** [1, 2, 3, 4]

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | pH | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | Fe ($mg{\cdot}L^{-1}$) | Mn ($mg{\cdot}L^{-1}$) | Zn ($mg{\cdot}L^{-1}$) | Cu ($mg{\cdot}L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | | | | | | | |
| Very shallow | 20th | 44 | 31 | 34 | 27 | 12 | 14 | 171 | 55 | 41 | 13 | 8 | 3 | 0.10 | 0 | 495 | 158 | 7.5 | 141.0 | 25 | 0.11 | | | 0.005 | | 1.40 | |
| | 50th | 60 | 37 | 55 | 39 | 17 | 24 | 266 | 64 | 64 | 29 | 22 | 6 | 1.00 | 0 | 680 | 234 | 7.8 | 220.0 | 30 | 0.20 | 0.01 | 0.010 | 0.010 | 0.010 | 1.70 | 0.40 |
| | 80th | 100 | 44 | 84 | 47 | 39 | 28 | 506 | 77 | 97 | 39 | 44 | 9 | 7.00 | 1 | 970 | 350 | 8.1 | 417.6 | 36 | 0.50 | 0.04 | 0.010 | 0.045 | 0.015 | 2.60 | 2.31 |
| moderate | 20th | 85 | 33 | 56 | 21 | 34 | 25 | 449 | 65 | 49 | 13 | 13 | 2 | 2.25 | 0 | 899 | 314 | 7.5 | 370.9 | 31 | 0.35 | | | 0.010 | 0.010 | 1.90 | 0.51 |
| | 50th | 93 | 36 | 79 | 35 | 38 | 27 | 511 | 74 | 75 | 18 | 33 | 6 | 7.70 | 1 | 1,050 | 376 | 7.8 | 422.0 | 35 | 0.58 | 0.01 | | 0.020 | 0.020 | 2.10 | 1.43 |
| | 80th | 108 | 41 | 98 | 41 | 64 | 35 | 590 | 81 | 111 | 31 | 38 | 7 | 11.27 | 2 | 1,225 | 431 | 8.0 | 486.2 | 51 | 0.60 | 0.03 | 0.010 | 0.068 | 0.030 | 2.60 | 1.84 |

Note: insufficient data to derive WQOs for very deep depth profile. Refer to all notes after zone 15.

**Groundwater Zone 11 - Cawarral** [1, 2, 3, 4]

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | pH | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | Fe ($mg{\cdot}L^{-1}$) | Mn ($mg{\cdot}L^{-1}$) | Zn ($mg{\cdot}L^{-1}$) | Cu ($mg{\cdot}L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | | | | | | | |
| shallow | 20th | 38 | 20 | 38 | 15 | 42 | 36 | 328 | 58 | 71 | 20 | 20 | 4 | 0.62 | 0 | 774 | 330 | 7.5 | 275.0 | 28 | 0.09 | | | 0.010 | 0.010 | 0.87 | |
| | 50th | 66 | 26 | 42 | 25 | 66 | 46 | 475 | 72 | 95 | 23 | 26 | 4 | 4.40 | 1 | 960 | 417 | 7.7 | 391.0 | 37 | 0.15 | | | 0.320 | 0.165 | 1.50 | |
| | 80th | 77 | 31 | 78 | 45 | 90 | 59 | 563 | 75 | 115 | 39 | 26 | 6 | 9.89 | 2 | 1,052 | 472 | 8.0 | 461.6 | 43 | 0.16 | | | 0.630 | 0.320 | 1.53 | 0.41 |
| moderate | 20th | 30 | 14 | 30 | 16 | 67 | 49 | 394 | 76 | 48 | 11 | 18 | 4 | 2.06 | 0 | 817 | 380 | 7.7 | 330.7 | 64 | 0.02 | | | 0.050 | 0.030 | 0.63 | |
| | 50th | 45 | 16 | 59 | 28 | 72 | 51 | 528 | 78 | 55 | 17 | 19 | 4 | 9.80 | 2 | 949 | 420 | 8.0 | 436.0 | 75 | 0.12 | | | 0.345 | 0.080 | 0.90 | |
| | 80th | 52 | 21 | 81 | 34 | 75 | 69 | 580 | 79 | 65 | 18 | 34 | 6 | 36.35 | 5 | 1,057 | 494 | 8.3 | 482.8 | 86 | 0.16 | | | 0.640 | 0.130 | 1.08 | 0.28 |

Note: insufficient data to derive WQOs for very deep depth profiles. Refer to all notes after zone 15.

## Groundwater Zone 12 - Emu [1, 2, 3, 4]

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg \cdot L^{-1}$) | pH | Alkalinity ($mg \cdot L^{-1}$) | $SiO_2$ ($mg \cdot L^{-1}$) | F ($mg \cdot L^{-1}$) | Fe ($mg \cdot L^{-1}$) | Mn ($mg \cdot L^{-1}$) | Zn ($mg \cdot L^{-1}$) | Cu ($mg \cdot L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg \cdot L^{-1}$ | % | $mg \cdot L^{-1}$ | % | $mg \cdot L^{-1}$ | % | $mg \cdot L^{-1}$ | % | $mg \cdot L^{-1}$ | % | $mg \cdot L^{-1}$ | % | $mg \cdot L^{-1}$ | % | $\mu S \cdot cm^{-1}$ | | | | | | | | | | | |
| Very shallow | 20th | 40 | 44 | 18 | 27 | 6 | 13 | 76 | 32 | 58 | 42 | 10 | 5 | 0.43 | 0 | 368 | 77 | 7.3 | 62.1 | 10 | | | | | | 1.83 | |
| | 50th | 42 | 49 | 29 | 36 | 7 | 15 | 105 | 40 | 64 | 51 | 12 | 7 | 0.60 | 0 | 420 | 99 | 7.5 | 87.0 | 14 | 0.10 | 0.01 | 0.010 | 0.505 | | 2.00 | |
| | 80th | 71 | 55 | 59 | 40 | 21 | 20 | 134 | 48 | 116 | 54 | 116 | 13 | 1.35 | 1 | 749 | 233 | 7.9 | 110.7 | 16 | 0.10 | 0.10 | 0.024 | 1.010 | | 2.10 | 0.08 |
| shallow | 20th | 39 | 40 | 29 | 24 | 7 | 11 | 105 | 31 | 51 | 28 | 5 | 2 | | | 448 | 119 | 7.2 | 92.2 | 11 | 0.01 | | | | | 1.60 | |
| | 50th | 75 | 47 | 47 | 36 | 12 | 15 | 185 | 45 | 114 | 46 | 15 | 5 | 0.60 | 0 | 720 | 176 | 7.9 | 157.0 | 16 | 0.10 | 0.01 | 0.010 | 0.010 | | 2.30 | |
| | 80th | 110 | 59 | 68 | 45 | 21 | 22 | 280 | 59 | 166 | 57 | 35 | 12 | 2.03 | 0 | 935 | 250 | 8.1 | 230.9 | 20 | 0.18 | 0.05 | 0.200 | 0.020 | 0.015 | 3.30 | 0.36 |
| moderate | 20th | 52 | 51 | 5 | 3 | 3 | 2 | 115 | 30 | 80 | 40 | 6 | 2 | 0.11 | 0 | 449 | 25 | 7.2 | 94.5 | 23 | 0.18 | | | 0.005 | | 2.40 | |
| | 50th | 139 | 74 | 15 | 12 | 8 | 13 | 244 | 37 | 140 | 58 | 13 | 3 | 0.50 | 0 | 820 | 65 | 8.0 | 202.5 | 28 | 0.27 | 0.01 | 0.010 | 0.010 | | 10.90 | 1.10 |
| | 80th | 287 | 95 | 44 | 26 | 26 | 22 | 282 | 54 | 355 | 67 | 41 | 5 | 1.78 | 0 | 1,564 | 224 | 8.2 | 235.0 | 55 | 0.92 | 0.06 | 0.010 | 6.360 | 0.020 | 20.47 | 3.94 |
| deep | 20th | 40 | 44 | 14 | 19 | 11 | 24 | 41 | 35 | 49 | 38 | 2 | 0 | 0.10 | 0 | 333 | 92 | 6.7 | 75.3 | | 0.17 | 0.06 | | | | 1.90 | 0.06 |
| | 50th | 58 | 49 | 25 | 23 | 16 | 29 | 116 | 52 | 74 | 47 | 5 | 1 | 2.45 | 0 | 468 | 120 | 7.5 | 114.0 | | 0.24 | 0.10 | | | | 2.40 | 0.61 |
| | 80th | 132 | 54 | 55 | 26 | 47 | 34 | 188 | 61 | 344 | 65 | 7 | 2 | 4.80 | 0 | 1,254 | 330 | 8.5 | 154.0 | | 0.34 | 0.46 | | | | 3.03 | 0.69 |

Note: refer to all notes after zone 15.

## Groundwater Zone 13 - Bracewell [1, 2, 3, 4]

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | pH | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | Fe ($mg{\cdot}L^{-1}$) | Mn ($mg{\cdot}L^{-1}$) | Zn ($mg{\cdot}L^{-1}$) | Cu ($mg{\cdot}L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | | | | | | | |
| very shallow | 20th | 179 | 45 | 48 | 15 | 32 | 11 | 425 | 45 | 155 | 22 | 36 | 6 | | | 759 | 365 | 7.8 | 353.9 | 23 | 0.20 | 0.20 | 0.010 | | | 3.27 | 1.78 |
| | 50th | 238 | 53 | 81 | 23 | 67 | 26 | 638 | 63 | 213 | 29 | 83 | 10 | 5.00 | 0 | 1,650 | 472 | 8.1 | 594.5 | 25 | 0.40 | 0.30 | 0.015 | | | 5.10 | 3.52 |
| | 80th | 301 | 59 | 121 | 33 | 90 | 31 | 853 | 74 | 328 | 43 | 128 | 12 | 5.93 | 1 | 2,065 | 598 | 8.4 | 741.0 | 27 | 0.60 | 0.89 | 0.020 | | | 6.03 | 6.03 |
| shallow | 20th | 150 | 39 | 70 | 17 | 32 | 15 | 361 | 23 | 177 | 31 | 35 | 4 | | | 1,400 | 370 | 7.4 | 305.0 | 23 | 0.10 | 0.03 | | 0.001 | 0.002 | 3.00 | |
| | 50th | 220 | 48 | 120 | 30 | 57 | 23 | 542 | 41 | 355 | 47 | 88 | 8 | 6.00 | 1 | 1,715 | 554 | 7.7 | 452.0 | 28 | 0.30 | 0.30 | 0.010 | 0.010 | 0.015 | 4.20 | 0.83 |
| | 80th | 430 | 60 | 192 | 39 | 89 | 29 | 690 | 58 | 779 | 70 | 149 | 12 | 23.00 | 2 | 2,630 | 809 | 8.1 | 582.6 | 31 | 0.40 | 2.20 | 0.010 | 0.019 | 0.020 | 7.31 | 3.25 |
| moderate | 20th | 65 | 43 | 26 | 13 | 12 | 16 | 91 | 16 | 84 | 29 | 8 | 3 | 2.65 | 0 | 489 | 120 | 6.9 | 81.0 | 20 | 0.10 | | | 0.020 | | 2.60 | |
| | 50th | 170 | 51 | 68 | 28 | 31 | 20 | 355 | 31 | 242 | 56 | 40 | 7 | 8.15 | 1 | 1,160 | 341 | 7.5 | 300.5 | 24 | 0.20 | 0.08 | 0.010 | 0.030 | 0.010 | 3.40 | 0.34 |
| | 80th | 315 | 65 | 174 | 37 | 82 | 25 | 573 | 57 | 526 | 75 | 121 | 11 | 22.00 | 6 | 2,430 | 696 | 7.9 | 476.5 | 30 | 0.30 | 1.10 | 0.020 | 0.075 | 0.055 | 6.00 | 1.84 |
| deep | 20th | 171 | 41 | 127 | 28 | 40 | 11 | 378 | 18 | 315 | 52 | 40 | 3 | 0.04 | 0 | 1,793 | 535 | 6.9 | 315.9 | 18 | 0.10 | 0.01 | | 0.020 | | 3.40 | |
| | 50th | 305 | 46 | 225 | 35 | 56 | 16 | 462 | 25 | 790 | 71 | 85 | 5 | 1.30 | 0 | 3,150 | 773 | 7.3 | 381.0 | 22 | 0.20 | 0.32 | | 0.030 | | 4.90 | 0.15 |
| | 80th | 512 | 57 | 280 | 44 | 80 | 19 | 569 | 44 | 1,213 | 76 | 126 | 9 | 10.30 | 1 | 4,327 | 1,007 | 7.7 | 481.3 | 24 | 0.30 | 4.65 | 0.026 | 0.220 | 0.080 | 7.20 | 0.55 |
| very deep | 20th | 240 | 42 | 154 | 28 | 36 | 12 | 167 | 11 | 509 | 57 | 29 | 3 | 0.05 | 0 | 2,200 | 569 | 6.8 | 136.6 | 15 | 0.05 | 0.01 | | 0.013 | | 4.10 | |
| | 50th | 302 | 46 | 221 | 40 | 53 | 15 | 404 | 20 | 721 | 75 | 70 | 4 | 0.80 | 0 | 2,953 | 765 | 7.3 | 334.0 | 26 | 0.10 | 0.12 | | 0.020 | 0.005 | 4.55 | |
| | 80th | 403 | 54 | 304 | 45 | 66 | 17 | 502 | 30 | 983 | 86 | 112 | 6 | 6.45 | 0 | 3,586 | 985 | 7.8 | 420.3 | 30 | 0.20 | 5.46 | 1.960 | 0.027 | 0.010 | 6.47 | |

Note: refer to all notes after zone 15.

**Groundwater Zone 14 - Boondoola [1, 2, 3, 4]**

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg \cdot L^{-1}$) | pH | Alkalinity ($mg \cdot L^{-1}$) | $SiO_2$ ($mg \cdot L^{-1}$) | F ($mg \cdot L^{-1}$) | Fe ($mg \cdot L^{-1}$) | Mn ($mg \cdot L^{-1}$) | Zn ($mg \cdot L^{-1}$) | Cu ($mg \cdot L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg \cdot L^{-1}$ | % | $mg \cdot L^{-1}$ | % | $mg \cdot L^{-1}$ | % | $mg \cdot L^{-1}$ | % | $mg \cdot L^{-1}$ | % | $mg \cdot L^{-1}$ | % | $mg \cdot L^{-1}$ | % | $\mu S \cdot cm^{-1}$ | | | | | | | | | | | |
| shallow | 20th | 116 | 44 | 33 | 15 | 29 | 21 | 125 | 18 | 246 | 60 | 7 | 1 | | | 1,119 | 207 | 7.2 | 102.5 | 44 | 0.19 | | | 0.013 | - | 2.65 | |
| | 50th | 144 | 50 | 40 | 18 | 41 | 30 | 186 | 27 | 270 | 68 | 22 | 4 | 0.80 | 0 | 1,307 | 269 | 7.5 | 153.0 | 62 | 0.30 | | 0.020 | 0.020 | 0.005 | 3.60 | |
| | 80th | 248 | 62 | 83 | 23 | 75 | 34 | 312 | 29 | 572 | 79 | 42 | 5 | 11.77 | 1 | 1,965 | 491 | 7.8 | 259.3 | 85 | 0.33 | 0.05 | 0.415 | 0.034 | 0.010 | 5.31 | |
| moderate | 20th | 108 | 41 | 10 | 8 | 12 | 14 | 66 | 10 | 209 | 65 | 5 | 1 | | | 863 | 74 | 6.5 | 54.5 | 31 | 0.22 | | | 0.010 | | 3.10 | |
| | 50th | 167 | 50 | 53 | 20 | 48 | 24 | 167 | 22 | 333 | 74 | 15 | 3 | 0.90 | 0 | 1,460 | 329 | 7.4 | 137.0 | 51 | 0.30 | | 0.010 | 0.020 | 0.020 | 4.00 | |
| | 80th | 258 | 78 | 100 | 31 | 66 | 32 | 326 | 31 | 599 | 87 | 23 | 3 | 2.68 | 0 | 2,164 | 519 | 7.9 | 269.0 | 66 | 0.57 | | 0.196 | 0.073 | 0.042 | 6.55 | 0.07 |
| deep | 20th | 76 | 54 | 7 | 3 | 4 | 5 | 124 | 25 | 162 | 53 | 6 | 2 | 0.03 | 0 | 695 | 40 | 7.3 | 102.0 | 50 | 0.23 | 0.00 | | | | 3.65 | 2.36 |
| | 50th | 197 | 82 | 11 | 13 | 6 | 5 | 264 | 43 | 199 | 54 | 14 | 3 | 0.10 | 0 | 1,018 | 47 | 7.8 | 223.0 | 57 | 0.48 | 0.02 | | | | 7.30 | 3.53 |
| | 80th | 221 | 92 | 45 | 22 | 30 | 24 | 286 | 43 | 217 | 74 | 23 | 4 | 0.31 | 0 | 1,119 | 234 | 8.4 | 238.5 | 85 | 0.50 | 1.35 | 0.036 | | | 14.60 | 3.70 |

Note: refer to all notes after zone 15.

## Groundwater Zone 15 - Bison [1, 2, 3, 4]

| Depth[2] | Percentile[3] | Indicator[4] and Water Quality Objective (WQO) | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Na | | Ca | | Mg | | $HCO_3$ | | Cl | | $SO_4$ | | $NO_3$ | | EC | Hardness ($mg{\cdot}L^{-1}$) | pH | Alkalinity ($mg{\cdot}L^{-1}$) | $SiO_2$ ($mg{\cdot}L^{-1}$) | F ($mg{\cdot}L^{-1}$) | Fe ($mg{\cdot}L^{-1}$) | Mn ($mg{\cdot}L^{-1}$) | Zn ($mg{\cdot}L^{-1}$) | Cu ($mg{\cdot}L^{-1}$) | SAR | RAH ($meqL^{-1}$) |
| | | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $mg{\cdot}L^{-1}$ | % | $\mu S{\cdot}cm^{-1}$ | | | | | | | | | | | |
| shallow | 20th | 137 | 33 | 45 | 20 | 31 | 20 | 332 | 26 | 180 | 45 | 29 | 5 | | | 1,060 | 240 | 6.8 | 272.0 | 30 | 0.20 | 0.02 | | | | 2.20 | 1.31 |
| | 50th | 245 | 46 | 75 | 28 | 52 | 23 | 560 | 43 | 330 | 47 | 49 | 7 | | | 1,800 | 401 | 7.6 | 465.0 | 30 | 0.30 | 0.02 | | | | 4.20 | 1.53 |
| | 80th | 289 | 57 | 402 | 47 | 106 | 25 | 605 | 49 | 995 | 66 | 153 | 9 | | | 3,675 | 1,441 | 8.0 | 500.0 | 38 | 0.50 | 0.02 | | | | 5.30 | 1.74 |
| moderate | 20th | 384 | 22 | 542 | 38 | 327 | 38 | 210 | 4 | 2,200 | 88 | 189 | 6 | 12.90 | 0 | 6,570 | 2,699 | 7.2 | 173.0 | 29 | 0.23 | | | | | 3.10 | |
| | 50th | 390 | 23 | 582 | 39 | 344 | 38 | 237 | 5 | 2,337 | 89 | 202 | 6 | 23.55 | 0 | 7,035 | 2,869 | 7.4 | 195.0 | 31 | 0.27 | | | | | 3.15 | |
| | 80th | 396 | 24 | 623 | 40 | 361 | 38 | 263 | 6 | 2,474 | 89 | 215 | 6 | 34.20 | 1 | 7,500 | 3,038 | 7.5 | 217.0 | 33 | 0.30 | | | | | 3.20 | |

Note: insufficient data to derive WQOs for shallow depth profile. Refer to all notes below.

**Notes:**

1. Refer to plan WQ1273 to locate the relevant chemistry zone.

2. Within each chemistry zone, groundwater quality values are provided for different depths (Very shallow: <5m, Shallow: 5–20m, Moderate: 20–40m, Deep: 40–60m, Very deep: >60m, Artesian: all artesian (max 240m).

3. The management intent is to maintain 20th, 50th and 80th percentile values. Values are provided for each of these percentiles.

4. Abbreviations: EC: Electrical conductivity, $CaCO_3$: Calcium carbonate, Ca: Calcium, Mg: Magnesium, Na: Sodium, Cl: Chloride, $SO_4$: Sulfate, $HCO_3$: Bicarbonate, $NO_3$: Nitrate, $SiO_2$: Silica, F: Fluoride, Fe: Iron, Mn: Manganese, Zn: Zinc, Cu: Copper, SAR: Sodium adsorption ratio, RAH: Residual alkali hazard, EH: Redox (oxidation/reduction) potential, '-': insufficient data to perform statistical summaries, or the parameter was not tested.

**Source**: McNeil V.H. and Raymond M.A. (2014). Regional groundwater chemistry zones of the Curtis and Capricorn Coast: Draft Technical Notes. Department of Science, Information Technology, Innovation and the Arts, Queensland

WQOs for these indicators are based on data collected as part of the Queensland Government Surface Water Ambient Network (SWAN) monitoring program, and stored on the 'Hydstra' database. For electrical conductivity, the 75th percentile value is used instead of the 80th percentile, based on QWQG (2009).