Wet Tropics
Report Card
Program Design

FIVE YEAR PLAN 2018 – 2022

Wet Tropics Healthy Waterways Partnership

NOVEMBER 2018

Wet Tropics
Healthy Waterways Partnership

wettropicswaterways.org.au

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EXECUTIVE SUMMARY

Report cards are an increasingly used communication tool for aquatic ecosystem health monitoring programs in Australia and around the world. They facilitate the summary and communication of complex, systematically collected scientific information from multiple sources in a way that enables understanding across broad and diverse audiences, and encourages discussion. In Queensland report cards are generally developed through partnership arrangements and collaborations between government, research, industry, and community organisations.

The Wet Tropics Healthy Waterways Partnership (the Partnership) was established to develop an annual waterway health Report Card specific to the Wet Tropics Natural Resource Management (NRM) region. This region covers the waterway environments of the Daintree Basin in the north to those of the Herbert Basin in the south, and the adjacent marine environment extending to the eastern boundary of the Great Barrier Reef Marine Park. The Report Cards will provide a regional assessment of ecosystem health and social, economic and cultural values.

There are a wide range of programs and projects collecting and reporting on data relating to waterways within the Wet Tropics and the Wet Tropics Healthy Waterways Report Card serves to collate, assess, integrate and report from these diverse information sources to provide a focused report of waterway health for the region. The Report Cards, published annually, build on the existing waterway monitoring activities, whilst applying methodologies for reporting consistent with those used across the state. The key audiences for the Report Cards are the local communities and organisations of the Wet Tropics region.

At commencement, the Partnership established a vision for the program, which was used to define and develop a program for the achievement of the Partnership's objectives, including the production of a Wet Tropics Waterways Report Card. This document outlines this vision and the design of the program.

The Program Design provides information on the condition, pressures and impacts of the region's waterways, linkages with other programs, geographical extent and reporting zones of waterway environments, and the sources of data. The identification and selection of indicators used to report on the environmental condition of freshwater basins, estuaries, inshore and offshore marine environments is provided in detail. The reporting approach for human dimensions including social, economic, stewardship and cultural values is outlined. The Program Design also presents a five year plan outlining the procedures for updating the Report Card, the scope and objectives to deliver required improvements to the Report Card, a proposed schedule to address the objectives, a prioritisation of the objectives, a schedule for data updates and Report Card releases, and a program review outline.

This Program Design aims to build upon the initial Program Design documents by consolidating the information relating to the development of the Report Card and to present a plan for progressing the Report Card over the five year period of 2018 to 2022. By providing a plan through the Program Design and setting the baselines for the five year period, stable environmental reporting and tracking of trends can be delivered.

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Acronyms and Abbreviations

DEHP	Queensland Department of Environment and Heritage Protection
DES	Queensland Department of Environment and Science (formerly DEHP and DSITI)
DIN	Dissolved Inorganic Nitrogen
DNRM	Queensland Department of Natural Resources and Mines
DPSIR framework	Drivers-Pressures-State-Impact-Responses framework
DSC	Douglas Shire Council
DSITI	Queensland Department of Science, Information Technology and Innovation (formerly DSITIA)
FRP	Filter Reactive Phosphorus
GBR	Great Barrier Reef
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
GIS	Geographic Information System
ISP	Independent Science Panel
ms-PAF	Multiple Substances Potential Affected Fraction
NERP	National Environmental Research Program
NRM	Natural Resource Management
OGBR	Office of the Great Barrier Reef (Queensland Government)
P2R	Paddock to Reef Integrated Monitoring, Modelling and Reporting Program
Reef Plan	Reef Water Quality Protection Plan 2013
Reef 2050 Plan	Reef 2050 Long-term Sustainability Plan
RIMReP	Reef Integrated Monitoring and Reporting Program
SELTMP	Social and Economic Long Term Monitoring Program
SEQ	South-East Queensland
SSIMR	Spatial and Scientific Information Management for Reef
TSS	Total Suspended Solids
TWG	Technical Working Group for Regional Report Cards
WQIP	Water Quality Improvement Plan
WT	Wet Tropics
WTWHA	Wet Tropics World Heritage Area

1. BACKGROUND

1.1. Purpose of the Program Design

The 2018–2022 Program Design for the Wet Tropics Healthy Waterways Partnership Report Card (to be referred to as the Report Card henceforth) is presented in this document. The previous versions of the Program Design have focused on the development of the Pilot Report Card released in 2016 and the Report Card released in 2017 and were reviewed and published on an annual basis. This Program Design aims to build upon the initial Program Design documents by consolidating the information relating to the development of the Report Card and to present a plan for progressing the Report Card over the five year period of 2018 to 2022. By providing a plan through the Program Design and setting the baselines for the five year period stable environmental reporting and tracking of trends can be delivered.

The Program Design provides information on the condition, pressures and impacts of the region's waterways, linkages with other programs, geographical extent and reporting zones of waterway environments and the sources of data. The identification and selection of indicators used to report on the environmental condition of freshwater basins, estuaries, inshore and offshore marine environments is provided in detail. The reporting approach for human dimensions including social, economic, stewardship and cultural values is outlined. The Program Design also presents a five year plan outlining the procedures for updating the Report Card, the scope and objectives to deliver required improvements to the report card, a proposed schedule to address the objectives, prioritisation of the objectives, a schedule for data updates and Report Card releases, and a program review outline.

Separate technical reports (available at www.wettropicswaterways.org.au) present the methods and results for the Report Card and provide further information about the Report Card development process.

1.2. Report Cards

Report cards have become an increasingly popular communication tool for aquatic ecosystem health monitoring programs in Australia and around the world. Report cards enable complex, systematically collected scientific information from multiple sources to be summarised and communicated in a way that enables broad understanding and encourages discussion. They also enable a broad understanding of the complexity and range of influences on the condition of catchments and waterway environments from a range of activities.

In Queensland, a well-established annual report card for aquatic ecosystem monitoring exists in South-East Queensland (Healthy Land and Water), the Fitzroy River Basin (Fitzroy Partnership for River Health), and, more recently, for Gladstone Harbour (Gladstone Healthy Harbour Partnership), and Mackay-Whitsunday region (Mackay-Whitsunday Healthy Rivers to Reef Partnership). These report cards are generally developed through partnership arrangements which involve collaborations between government, research, industry, and community organisations. There is also a Great Barrier Reef-wide report card program specifically designed to report on changes in Reef health as a result of efforts to reduce anthropogenic impacts, particularly those resulting from agricultural land use.

1.3. Wet Tropics Healthy Waterways Partnership

The Wet Tropics Healthy Waterways Partnership (the Partnership) was established to develop an annual waterway health Report Card specific to the Wet Tropics for the reporting of environmental, social, economic and cultural waterway values. The term "waterway" encompasses natural aquatic ecosystems and includes freshwater basins, estuaries, and inshore and offshore marine environments. The aim of the Report Card is to communicate to the community on waterway health and stewardship issues to increase knowledge and contribute to driving positive change. Currently there are a wide range of programs and projects collecting and reporting on data relating to waterways in the Wet Tropics. The Report Card builds on the existing waterway monitoring activites, whilst applying methodologies for reporting that are consistent with those used across the state. The geographical extent covered by the Partnership is defined by the Wet Tropics natural resource management (NRM) area for river basins and the marine region (Figure 1). The local government areas within the Wet Tropics NRM region are presented in Figure 2.

1.4. The Wet Tropics Region

The Wet Tropics NRM region covers a land area of 21,722 km^2 and supports a residential population of some 240,184 people (Australian Bureau of Statistics), including more than 20,000 Rainforest Aboriginal people, in a number of urban and rural centres and settings (Terrain NRM 2015). Land use in the region is dominated by nature conservation and agriculture (Table 1). As well as the agricultural sector, important regional industries include marine and land-based tourism, commercial and recreational fisheries, and aquaculture.

Table 1. Land use area in the Wet Tropics region.

Land use	Area (km^2)	Area (%)
Nature conservation	9,468	53.5
Grazing (including dairy)	7,250	33.4
Bananas	156	0.7
Dryland cropping	8	<0.05
Horticulture	88	0.4
Irrigated cropping	142	0.7
Sugarcane	1,797	8.3
Forestry	1,643	7.5
Water	714	3.3
Urban	314	1.4

Source: Hateley (2014).

The region's tropical climate is characterised by higher rainfall and temperatures during the summer wet season which is dominated by major events such as rain depressions, monsoons and cyclones (Hateley 2014). The Wet Tropics is the wettest of the Great Barrier Reef regions with annual rainfall averaging 1,580 mm (Hateley 2014). Rainfall is highly variable geographically and between years. Approximate annual rainfall ranges are between 500–4,500 mm and follow an east to west gradient with the highest at the coastal fringes (averaging 3,000 mm annually) and lowest at the region's most westerly boundary (averaging 500 mm annually) (Hateley 2014). The high relief mountains located close to the coast form a narrow coastal plain (McDonald & Weston 2004). These features when combined with high rainfall events result in large river discharges and high streamflow velocities (Hateley 2014). The Wet Tropics region consists of nine river basins and from north to south they are Daintree, Mossman, Barron, Mulgrave, Russell, Johnstone, Tully, Murray and Herbert (Figure 1). Of these, Herbert Basin covers the largest area of the region (45%) and includes the areas of the lowest rainfall in the west.

The Wet Tropics NRM region includes 91% of the Wet Tropics World Heritage Area (WTWHA) and is part of the Great Barrier Reef World Heritage Area (GBRWHA) and Great Barrier Reef Marine Park. The WTWHA is Australia's largest rainforest area and has a high biodiversity of species including over 2,800 known vascular plants, 110 mammals, 314 birds and 151 reptiles (DSITIA 2013). The area has a high diversity of aquatic habitats ranging from high altitude mountain streams and lakes to coastal rivers, streams, floodplain wetlands, mangroves, and estuaries which support 42% of Australia's freshwater fish species and Australia's most diverse frog assemblage (DSITIA 2013). There are over 30 'Australian Wetlands of National Importance' located in the Wet Tropics region (Environment Australia, 2001).

The Wet Tropics NRM marine region is within the GBRWHA and is characterised by a diversity of unique environments including coral reefs, seagrass meadows, coastal wetlands, estuaries, coral cays, and continental islands. The area also includes Hinchinbrook Island, the largest island in the Great Barrier Reef (Johnson 2014). These environments support a high diversity of species including fish, marine turtles, marine mammals and seabirds. Many species are considered rare and are of conservation importance including the humpback whale, dugong, and several species of turtles and seabirds (Johnson 2014). These marine and coastal assets have ecological, social and cultural importance, and support important industries, including tourism and fisheries, which are dependent on healthy ecosystems (Johnson 2014).

1.5. Wet Tropics Waterways Condition and Threats

The condition and threats to waterways of the Wet Tropics have been recently assessed in detail as part of the Wet Tropics Water Quality Improvement Plan (WQIP). The following summary is from the findings of the Wet Tropics WQIP (Terrain NRM 2015).

The Wet Tropics landscape has been heavily modified since European settlement, resulting in changes to hydrological connectivity and ecological functions such as material trapping, filtering and diversion. Modifications include large scale changes in land use and activities that generate greater pollutant loads, particularly in coastal areas. The WTWHA covers 35% of the region, which has provided a degree of protection to the integrity of the catchment waterways. However, a high proportion of freshwater ecosystems in the coastal areas outside of this protected estate and within developed land uses such as agriculture and urban areas have been assessed as being in a moderately or highly modified state (Burrows 1998). This is particularly evident in the central and southern basins of the region. Key threats are associated with altered hydrology, loss of connectivity, loss and disturbance of habitat, poor water quality and soil chemistry, introduction of pest species and fishing. It is not possible to determine the cumulative effects of all impacts but the interaction of multiple processes and the overarching influence of climate change also present considerable threats to the Wet Tropics waterways (Terrain NRM 2015).

Assessment of the status of key marine and coastal assets in the Wet Tropics region conducted between 2010 to 2013 have identified a number of assets at risk and that are in poor or very poor condition (Johnson 2014). These include: inshore and mid-shelf coral reefs, inshore and reef seagrass meadows, dugong populations, low-lying islands, and species of climate sensitive seabirds (Johnson 2014). Key drivers of change include poor water quality (largely driven by catchment land uses), crown-of-thorns starfish (COTS) outbreaks (which are linked to poor water quality), climate extremes (floods, cyclones,

thermal coral bleaching), coastal developments including ports and shipping, and the cumulative impacts of these pressures (Johnson 2014).

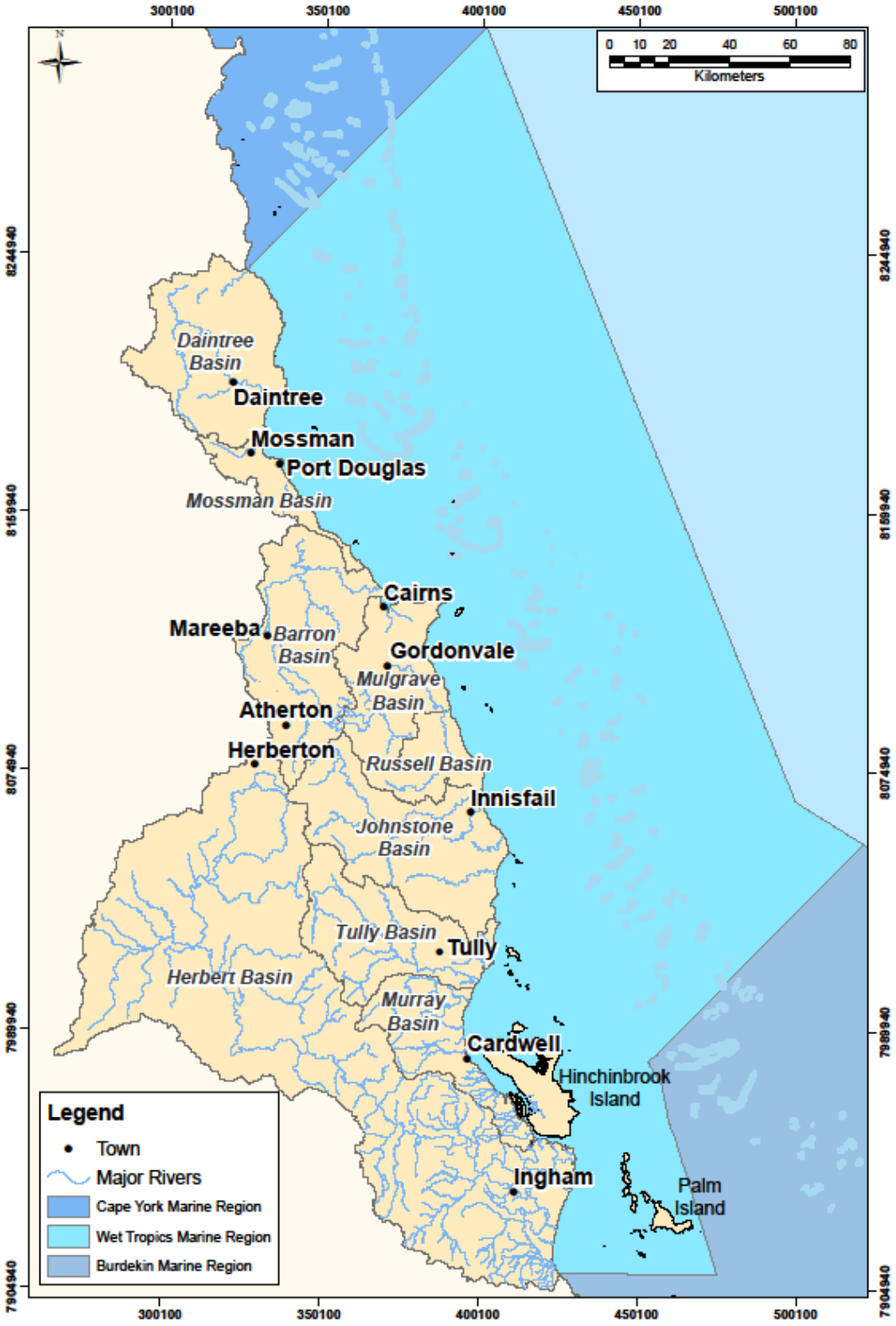


Figure 1 Geographic coverage of the Wet Tropics Healthy Waterways Partnership.

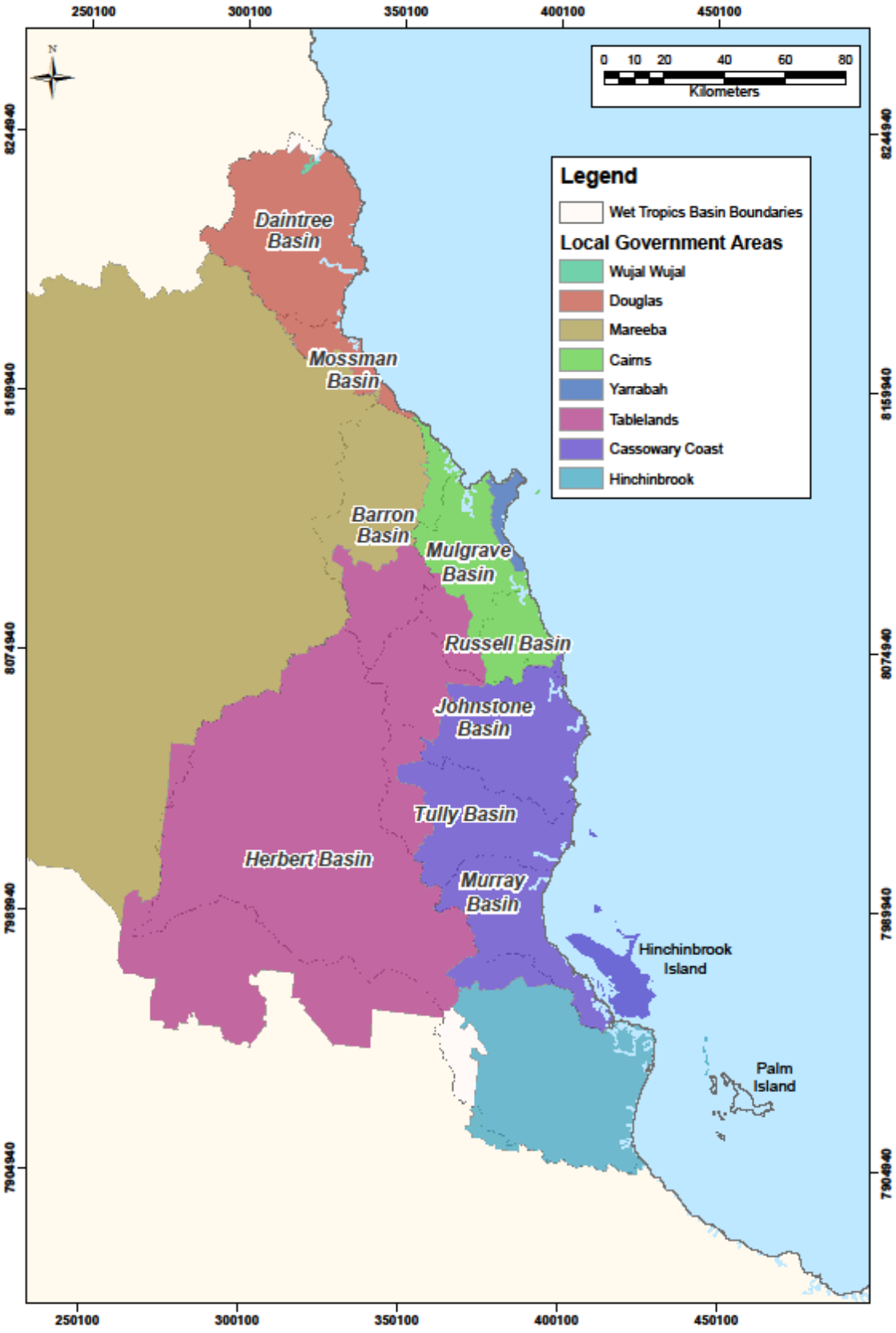


Figure 2. Local Government Areas in the Wet Tropics NRM region.

2. REPORT CARD DEVELOPMENT

2.1. Development Process

The key stages of Report Card development by the Partnership are shown in Figure 3. Details of the procedures applied to develop the Pilot Report Card are provided in previous versions of the Program Design (WTHWP 2017a). Initially the Partnership established a vision for the program from which the Partnership and Report Card objectives were defined. Guided by the Partnership objectives, report card objectives and the Drivers-Pressures-State-Impact-Response (DPSIR) framework, appropriate indicators were identified to report on the state and condition of ecosystem health for the region's waterways. The scoring and reporting is used to identify and prioritise investment into management actions that address regional issues. The Partnership intends to set associated regional targets in subsequent years such that the Report Card will transition to include progress toward long-term targets.

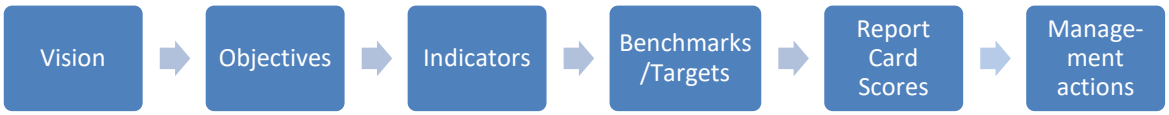


Figure 3. Process of the Partnership's development of the report card from the vision to the production of scores and management actions.

2.2. Vision and Objectives of the Partnership

The Partnership's vision is "partnering for healthy tropical waterways and vibrant communities".

For the purposes of the Partnership and the Report Card, the term 'waterways' is used to refer to the creeks, rivers, wetlands and estuarine environments of the nine nominated basins, and the inshore and offshore marine environments (Figure 1).

Healthy waterways includes the concept of a healthy ecosystem, which is defined as "an ecological system which is healthy and free from distress if it is stable and sustainable – that is, if it is active and maintains its organisation and autonomy over time and is resilient to stress" (Costanza 1992). The health of waterways can be assessed using a wide variety of metrics that relate to the structure and function of the ecosystem.

The following are the objectives of the Partnership and are also presented in the Governance Charter.

- Communicate information effectively and at a relevant scale to the broader community on waterway health issues and stewardship to increase knowledge and help drive community change.
- Develop an annual waterway health report card specific to the Wet Tropics over the longer term, including environmental, social, economic and cultural indicators, by building on existing monitoring and reporting programs, and using consistent methodologies.
- Coordinate and share data and information across a range of stakeholders to identify monitoring gaps and reduce duplication.
- Ensure scientific integrity, independence and transparency using a robust methodology to identify long-term trends, stimulate management action and drive positive change.
- Recognise and support the efforts of Partners and others to improve regional waterway health.
- Identify waterway health related knowledge gaps and address them.
- Identify priority activities and efforts for the Partnership, and advocate for them.
- Participate in the coordination of a regional management response to the Report Card findings.

2.3. Report Card Objectives

In supporting the Partnership's vision of "partnering for healthy tropical waterways and vibrant communities", the main purpose of the Report Card is to bring together the best available information for the evaluation of the condition of the region's waterways in terms of their environmental, social, cultural, and economic values and to report on progress towards agreed targets for improvement. The state and condition of the region's ecosystems, and how these impact on the region's prosperity and lifestyle was assessed using a range of key indicators representative of these values.

The Partnership objectives (section 2.2) will be achieved by the ongoing implementation of the Report Card program to regularly assess and report on the environmental health and condition, and the social, economic, and cultural values relevant to the waterways within the Wet Tropics region. This Report Card provides the region's communities with the latest available information about the current state of their waterways and improvements to on-ground management practices.

The specific Report Card objectives, listed below, are focused on assessing the current state of the region, the progress toward targets, the tracking of trends over time, and assessment of the effectiveness of management responses. Whilst the objectives focus upon reporting of pressures on waterways (e.g. E3) consideration of the drivers which influence the pressures, for example climate and rainfall, must also be acknowledged. The

reporting of economic benefits relating to healthy waterways (e.g. Econ1) should also report on how this is balanced with industry practices that have negative effect on waterway health. All objectives of the Report Card are to be linked to the natural environments associated with waterways. Further, the objectives have been chosen so that the Report Card assesses and addresses issues affecting the values of the community as they relate to the health of the waterways. The Partnership will use the detailed annual results for the Report Card from the technical reports to provide insight into the trends in water quality and ecosystem health over time, and corresponding changes in social, cultural and economic values.

Environmental objectives:

- E1 Assess and report on the quality of water in freshwater, estuarine and marine ecosystems to track changes over time.
- E2 Assess and report on freshwater, estuarine, and marine ecosystems using indicators of structure, function, connectivity, resilience and biodiversity to track changes over time.
- E3 Report on pressures in the region's waterways and progress to environmental targets.

Cultural objectives:

- C1 Report on trends in Indigenous cultural heritage sites and values.
- C2 Report on trends in non-indigenous cultural heritage sites and values.
- C3 Report on trends in Indigenous and non-indigenous connection to the region's coastal lands and waterways.

Social objectives:

- S1 Provide local communities with the latest available information about the current condition of their waterways and ecosystem health, and the link to on-ground management practices.
- S2 Gauge the stewardship of key industries and communities in the region, as they relate to the waterways.
- S3 Monitor trends in use of coastal land and adjacent waterways in the region.
- S4 Monitor trends in how the community values coastal land and adjacent waterways in the region, and the level of importance placed upon the region's waterways.
- S5 Understand how changes in key social, cultural, economic, and environmental values affect local communities' quality of life.
- S6 Assess and monitor the local communities' perception of the health of the waterways in the region.

Economic objectives:

- Econ1 Calculate and monitor the direct economic benefits of industries that depend upon the presence of healthy waterways in the region.
- Econ2 Assess the values and importance the local communities place upon the waterways in the region and the relation to their quality of life.
- Econ3 Calculate and monitor the local economy associated with healthy waterways in the region and ecologically sustainable development.

2.4. Report Card Framework

The regional report cards, including the Wet Tropics Report Card, provide reporting of values for freshwater and estuarine systems as well as their relationship and connection to the Reef and the evaluation of management actions at the local level. Regional reporting is a key component of RIMReP which aims to ensure standardisation of core monitoring indicators and cross-regional comparability. The Drivers-Pressures-State-Impact-Response (DPSIR) model (EEA 1999) which has been incorporated in the Reef 2050 Integrated Monitoring and Reporting Program Strategy (RIMReP) (Great Barrier Reef Marine Park Authority & Queensland Government 2015) provides a common framework for the alignment and coordination of regional and Reef-wide reporting. The DPSIR model (Figure 4) includes a component for driving forces (i.e. economic growth, population growth, climate) and for impacts on the environment and will guide the development of the Report Card outputs and the adaptive management response approach. Its application is particularly relevant for the indicator selection (section 5) and scoring (Wet Tropics Report Card Methods (WTHWP 2017b) and the Wet Tropics Report Card Results (WTHWP 2017c)). The Pressure-Stressor-Response model used for the Queensland Integrated Waterways Monitoring Framework (DERM 2011) is a variant of the DPSIR model and can be adapted to the DPSIR framework. The DPSIR model can be applied to conceptual diagrams which provide a visual representation of environmental and management interactions (section 2.5).

The DPSIR framework presents the relationship between drivers within the region (e.g. economic growth, climate), pressures on the environment (human activities and impacts), the state or condition of the environment (e.g. biodiversity and natural resources), the impacts of environmental change (e.g. ecological, economic and social) and the management responses to address regional drivers, pressures and environmental impacts. The management responses are actions with the intent to prevent, reduce, or mitigate impacts on the environment.

This framework guided the prioritisation and selection of indicators used to assess pressures that potentially impact upon the health of waterways in the Wet Tropics region,

and provides support to the Partnership vision of "partnering for healthy tropical waterways and vibrant communities".

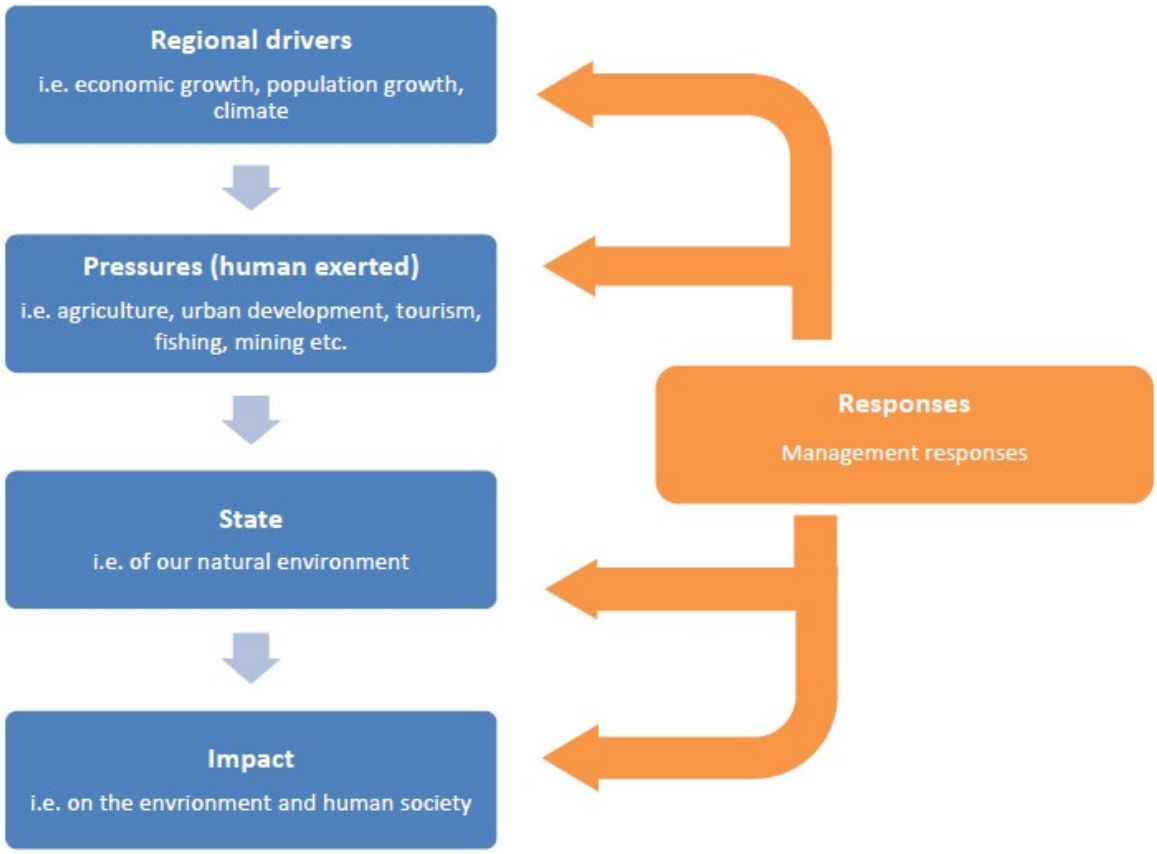


Figure 4. Drivers, Pressures, State, Impact, and Responses framework used to guide development of the Report Card including indicator selection and adaptive management for the Wet Tropics region.

2.5. Conceptual Diagram

There have been numerous conceptual diagrams produced that are relevant to aquatic ecosystem structure and function and the pressures and impacts that affect ecosystem health in the Wet Tropics. Following the development of the Partnership vision and objectives, and Report Card objectives, the Partnership used existing information and local knowledge of the region to develop a conceptual diagram to encompass the diversity of waterway environments and identify key pressures and impacts affecting the waterway health for the region. The Partnership's conceptual diagram developed for the Wet Tropics (Figure 5) incorporates the region's geography, environmental pressures, impacts and key habitat types for waterway environments. The conceptual diagram was developed at a workshop in Cairns (April 2016) which included regional stakeholders and experts, and the key pressures within the region were identified. The conceptual diagram serves to present and clarify interactions and relative importance of the regional drivers, pressures and impacts, and to guide indicator prioritisation and selection. The diagram has allowed for

the incorporation of the environmental reporting zones which provide an integrated geographical context of pressures, impacts and condition reporting for waterways (section 3).

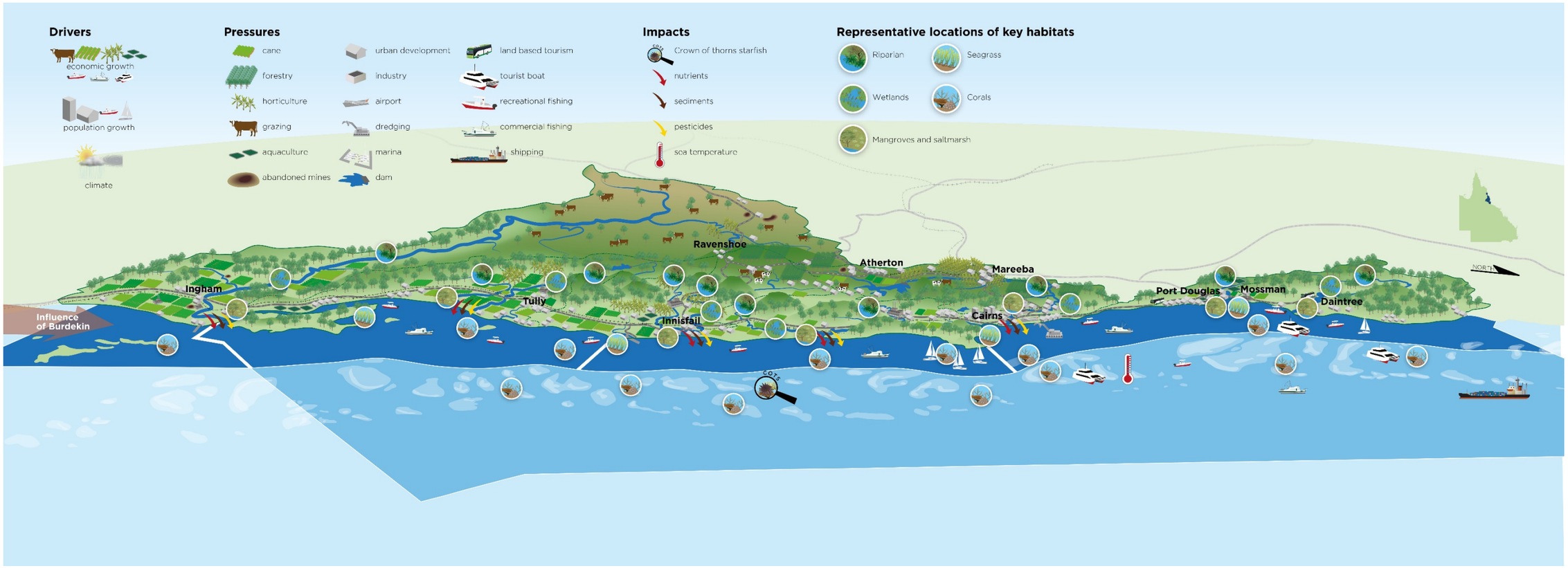


Figure 5. The conceptual diagram of the key drivers, pressures, impacts and habitats for waterways of the Wet Tropics region. The regional drivers involve human activities that exert pressures on the environment. The pressures result in a range of impacts that affect environmental state and condition including key habitats.

2.6. Linkages with other Programs

The Wet Tropics Healthy Waterways Partnership and Report Card have been developed to complement, enhance and build upon existing programs related to waterway health across the region and the State at a range of scales from local community focused activities to whole of GBR catchment programs. Programs that relate to the Report Card are listed in the Monitoring Program Inventory (Appendix A). Programs that have served as major drivers towards establishment of the Partnership and development of the Report Card, and to which the Partnership and Report Card are strongly linked include those outlined below.

Great Barrier Reef Strategic Assessment
Recommendations made by the Great Barrier Reef (GBR) Strategic Assessment included a partnership approach to reporting on Reef health at a regional scale. A strategy to achieve this is through the development of Report Cards to help coordinate, align, refine and target management actions. The Strategic Assessment Program's aim is a healthy Great Barrier Reef for future generations through continuing and enhancing the management foundation that protects biodiversity and heritage values and provides for ecologically sustainable use. Achieving this requires strengthened engagement and collaboration with others to reduce the risks to the Reef and restore its condition. This aim represents a direct link to the development of a regional Report Card for the Wet Tropics region.

Reef 2050 Long-term Sustainability Plan
The Reef 2050 Long-term Sustainability Plan has direct links to the Partnership as it stipulates that regionally-based implementation plans are important to address locally significant risks and to encourage community participation.

The Partnership is an example, to be built upon, under the Plan's Water Quality Action 8 – "Increase industry participation in regional water quality improvement initiatives and partnerships aimed at managing, monitoring and reporting of water quality."

The Partnership is also a direct action under Water Quality Action 23 – "Expand 'nested' integrated water quality monitoring and report card programs at major ports and activity centres (e.g. Gladstone), in priority catchments and Reef-wide, to guide local adaptive management frameworks and actions."

Reef Integrated Monitoring and Reporting Program (RIMReP)
The Reef Integrated Monitoring and Reporting Program (RIMReP) is being developed to support over half of the actions identified in the Reef 2050 Plan. GBRMPA is taking the lead in developing the RIMReP. The Program will facilitate the coordination, alignment and integration of existing monitoring, modelling and reporting programs to capitalise on existing program investment, provide value for money, improve efficiency and avoid duplication of effort. Its objectives are as follows:

- Enable the early detection of trends and changes in the Reef's environment, inform the assessment of key threats and future risks, and drive adaptive management.
- Inform the evaluation of management effectiveness, including efforts to maintain and enhance ecosystem health; marine biodiversity and coastal habitats; water quality; heritage values; and social and economic benefits derived from the environment.
- Ensure investments are focused on actions that will effectively deliver measurable results.
- Inform regional stakeholders and the national and international communities on whether the Reef 2050 Plan is on track to addressing key threats and delivering its vision.

The Reef Water Quality Protection Plan 2013 and the Reef 2050 Water Quality Improvement Plan 2017–2022.

The Reef Water Quality Protection Plan 2013 is a joint commitment of the Australian and Queensland Governments. The plan is a collaborative program of coordinated projects and partnerships designed to improve the quality of water in the Great Barrier Reef. It identifies actions that will help minimise the risk to the Reef from a decline in the quality of water entering the reef from adjacent catchments, including improving land management in Reef catchments to reduce non-point source pollution.

The Reef Water Quality Protection Plan 2013 sets targets for improved water quality and land management practices which are stated as being ambitious but achievable, and identifies actions to improve the quality of water entering the Reef. The plan is a significant part of the overall strategy of both governments to protect and preserve the reef. It incorporates and supports the actions of industry, community groups and government that impact on Reef health and links with a number of other legislative and planning initiatives.

The Reef 2050 Water Quality Improvement Plan 2017–2022 has expanded the scope of the Reef Water Quality Protection Plan 2013 and supports delivery of the "Reef 2050 Long-term Sustainability Plan". The plan addresses all land-based sources of water pollution including run-off from urban, industrial and public lands, whilst recognising the majority of pollution comes from agricultural activities. It also includes social, cultural and economic values for the first time. Water quality targets based on modelling and other scientific information have been set for the catchments adjacent to the Great Barrier Reef and include all freshwater basins of the Wet Tropics. The targets define the reduction in nutrients and fine sediment required by 2025. This provides a new level of specificity from the Reef 2050 targets that commit to achieving reductions of up to 80% in dissolved inorganic nitrogen and up to 50% in sediment in priority areas. Spatial priorities for water quality improvement have also been identified based on the Scientific Consensus Statement assessment of relative risk (Waterhouse *et al*. 2017).

Wet Tropics Water Quality Improvement Plan

Regional water quality improvement plans (WQIPs) aim to identify the main issues impacting waterways (freshwater, estuarine and marine environments) from land-based activities, and to identify and prioritise management actions that will halt or reverse the trend of declining water quality within an NRM region. Utilising the knowledge generated from the Wet Tropics WQIP will enable the Partnership to develop consistent management priorities, environmental values, and ecologically relevant targets underpinned by the latest science based upon the most comprehensive and relevant information available for the region.

Regional Waterway Report Card Partnerships

Within Queensland there are a number of partnerships with similar regional waterway health initiatives to the WTHWP and include the following:

- Healthy Land and Water was formed in 1999 and releases annual report cards covering basins of South East Queensland and the Moreton Bay estuary.
- Fitzroy Partnership for River Health was formed in 2012 and releases annual report cards for the sub-basins and catchments within the Fitzroy River Basin.
- The Gladstone Healthy Harbours Partnership was formed in 2013 and releases annual report cards for the waterways of Gladstone Harbour.
- The Mackay-Whitsunday Healthy Rivers to Reef Partnership was formed in 2015 and releases annual report cards for basins, estuary, inshore marine and offshore marine environments for the Mackay-Whitsunday region.

The development of the Wet Tropics report card program in 2016 was closely aligned with the Mackay-Whitsunday report card program. Both programs are guided by the same regional report card Technical Working Group which provides consistent and consolidated advice and support including an aligned approach to indicator selection. The Wet Tropics and Mackay-Whitsundays report card programs built upon the existing programs in Queensland including South-East Queensland (Healthy Land and Water) the Fitzroy River Basin (Fitzroy Partnership for River Health), and Gladstone Harbour (Gladstone Healthy Harbour Partnership).

The National Waterway Report Card Network includes membership from all the Queensland partnerships, as well as from similar initiatives across Australia. The Network meets on a regular basis either by phone or in person.

3. GEOGRAPHIC EXTENT OF THE REPORT CARD

The geographic extent of the Report Card includes the Wet Tropics natural resource management (NRM) region which spans from the Daintree Basin in the north to the Herbert Basin in the south, and the adjacent marine environment within the Wet Tropics NRM

marine region which extends to the eastern boundary of the Great Barrier Reef Marine Park (Figure 1).

The Wet Tropics NRM region covers about 2.2 million hectares of land, reaching from the Daintree forests of the north to the sugarcane land delta of the Herbert River catchment in the south, and then west to the dry rangelands of Mount Garnet. To the north, the Bloomfield River catchment forms the boundary with Cape York and to the south, the Herbert River catchment is the boundary with the Burdekin Dry Tropics region.

For the purposes of the Report Card, the freshwater, estuarine and marine environments are differentiated into reporting zones that align with related initiatives such as the Reef Water Quality Protection Plan, the Reef 2050 Water Quality Improvement Plan, Paddock to Reef and the Wet Tropics WQIP to provide consistency of data collection, analysis, reporting and presentation. It is also necessary to balance the aim of consistency with regionally important geographic distinctions based upon bio-physical and ecological relevance and pragmatism. The reasoning is provided below where reporting zones recommended by the TWG differ from established boundaries. A summary of the reporting zones is provided in Table 2.

Table 2. Reporting zones and boundary information.

<table>
<tr><th colspan="2">Freshwater</th><th colspan="2">Inshore (adjacent basins)</th></tr>
<tr><td>Daintree Basin</td><td rowspan="10">Freshwater reporting zones correspond with the river basin boundaries</td><td>North zone (from the northern NRM boundary to Cape Grafton)</td><td rowspan="10">Inshore zones include enclosed coastal, open coastal and mid-shelf waters</td></tr>
<tr><td>Mossman Basin</td><td rowspan="3">Central zone (Cape Grafton south to Double Point)</td></tr>
<tr><td>Barron Basin</td></tr>
<tr><td>Mulgrave Basin</td></tr>
<tr><td>Russell Basin</td><td rowspan="3">South zone (Double Point south to North West bank of the Seaforth Channel mouth)</td></tr>
<tr><td>Johnstone Basin</td></tr>
<tr><td>Tully Basin</td></tr>
<tr><td>Murray Basin</td><td rowspan="2">Palm Island zone (Seaforth Channel mouth south to NRM boundary)</td></tr>
<tr><td>Herbert Basin</td></tr>
<tr><th colspan="2">Estuary</th><th colspan="2">Offshore</th></tr>
<tr><td>Daintree River</td><td rowspan="8">Estuarine reporting zones provide representation of estuarine environment diversity in the region</td><td rowspan="8">Offshore zone</td><td rowspan="8">Single zone includes all offshore waters within the Wet Tropics NRM marine region</td></tr>
<tr><td>Dickson Inlet</td></tr>
<tr><td>Barron River</td></tr>
<tr><td>Trinity Inlet</td></tr>
<tr><td>Mulgrave-Russell</td></tr>
<tr><td>Johnstone River</td></tr>
<tr><td>Moresby River</td></tr>
<tr><td>Hinchinbrook Channel</td></tr>
</table>

The nine river basins, which all flow east to the Great Barrier Reef Marine Park, provide the reporting zones for the freshwater environment (Figure 6). These boundaries differ from those used in the Wet Tropics WQIP in that the TWG concluded that separate reporting for the Russell and Mulgrave basins and for the Mossman and Daintree basins was preferable for the Report Card due to different hydrology, land use and geology, and due to the feasibility of reporting environmental indicators for each basin. The environmental targets recommended by the WQIP can be applied to each basin as per the values set for the combined basins. Progress to targets and tracking of trends over time will be possible as future Report Cards are generated.

The interface between freshwater and marine ecosystems are the estuarine environments which support key ecosystem processes and habitat. In the Wet Tropics, estuarine environments vary between relatively short single sections of river channel, for example the Tully River, to extensive channel networks such as the Moresby River and Trinity Inlet. The eight reporting zones (Figure 6) for estuaries are representative of the diversity of estuarine environments in the region.

The inshore reporting zone includes enclosed coastal, open coastal and mid-shelf marine water types (Figure 6), extending east to the boundary with the offshore waters (GBRMPA 2010). Water quality in the inshore GBR generally shows minor gradients away from river mouths, with slightly elevated levels of most water quality indicators closest to the coast (Waterhouse *et al*. 2017). The gradients are represented in the water quality guideline values for the different marine water types. The gradients are influenced over short time periods by flood events and sediment resuspension, and over longer time periods by a complex interplay of physical forcing and biological transformation processes (Waterhouse *et al*. 2017). The inclusion of enclosed coastal, open coastal and mid-shelf waters for the inshore zone is consistent with the inshore zoning used by the Marine Monitoring Program (MMP) in the Wet Tropics region for their annual inshore monitoring reports for water quality (Lønborg *et al.* 2016, refer to sections 5.4.1 to 5.4.4 and see, for example Figure 5.1.7), coral (Thompson *et al.* 2016) and seagrass (McKenzie *et al.* 2016). This consistency of inshore zoning is important since the MMP provides most of the waterway health reporting for the inshore marine environment in the Report Card. The inshore marine environment is within the Wet Tropics NRM marine region with the exception of the southern boundary which the TWG endorsed to extend south beyond the NRM marine boundary to include the Palm Island group with the associated MMP monitoring sites. The key reasons for this were that the zone of influence of the Herbert River (Waterhouse *et al*. 2014) extends to the Palm Island group (Figure 7) and that the local Ingham community has an affiliation with the Palm Island group due to its proximity. The intent of the regional Report Card is to communicate areas of interest to the local community, therefore reporting on the marine health for this area is relevant to galvanise local community interest. Since part of the Palm Island zone is within the Burdekin Dry Tropics NRM region it could feature in the future report cards that cover the Dry Tropics region. The four reporting zones located in the northern, central,

southern, and Palm Island sections of the inshore environment (Figure 6) provide representation of different coastal characteristics of the region. The zones of influence of rivers (shown in Figure 7) are driven by the strong northerly currents of the inshore environment which result in extensive overlap of discharge from the rivers (Waterhouse 2014). Whilst inshore reporting zones are influenced by discharge from the adjacent rivers they are also influenced by the discharge from rivers to the south due to the currents and patterns of mixing (Figure 7). Consequently the influence on inshore condition is not limited to river basins that flow directly into the reporting zone.

The offshore environment is less directly affected by impacts from river discharge due to its distance from the coast. The movement and change of currents, the mixing of waters, and the geographic spread and number of monitoring sites were reasons for representation of the offshore environment with a single zone (Figure 6).

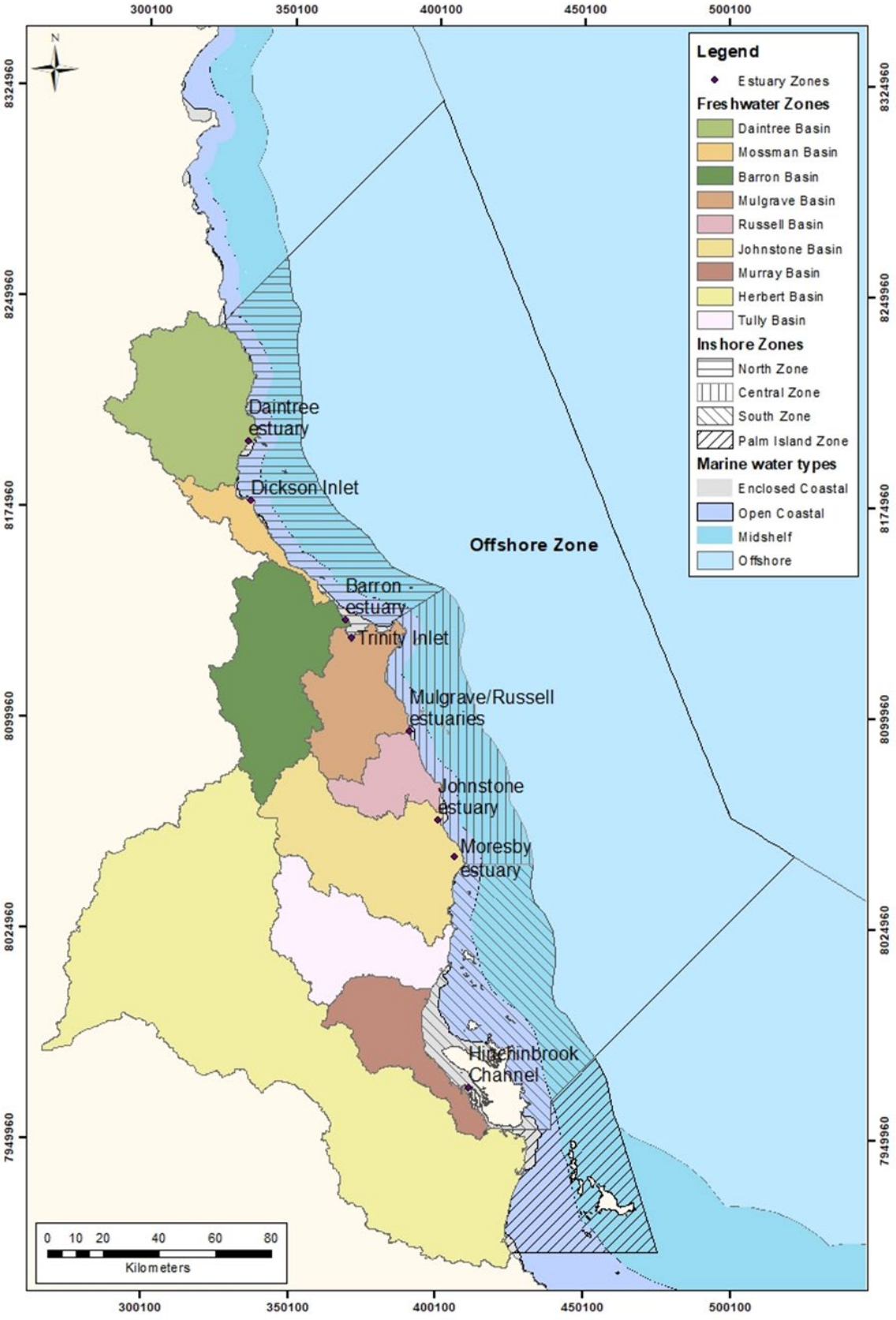


Figure 6. The Wet Tropics Report Card reporting zones for freshwater, estuarine, inshore marine and offshore marine environments. Inshore zones include enclosed coastal, open coastal and mid-shelf marine water types.

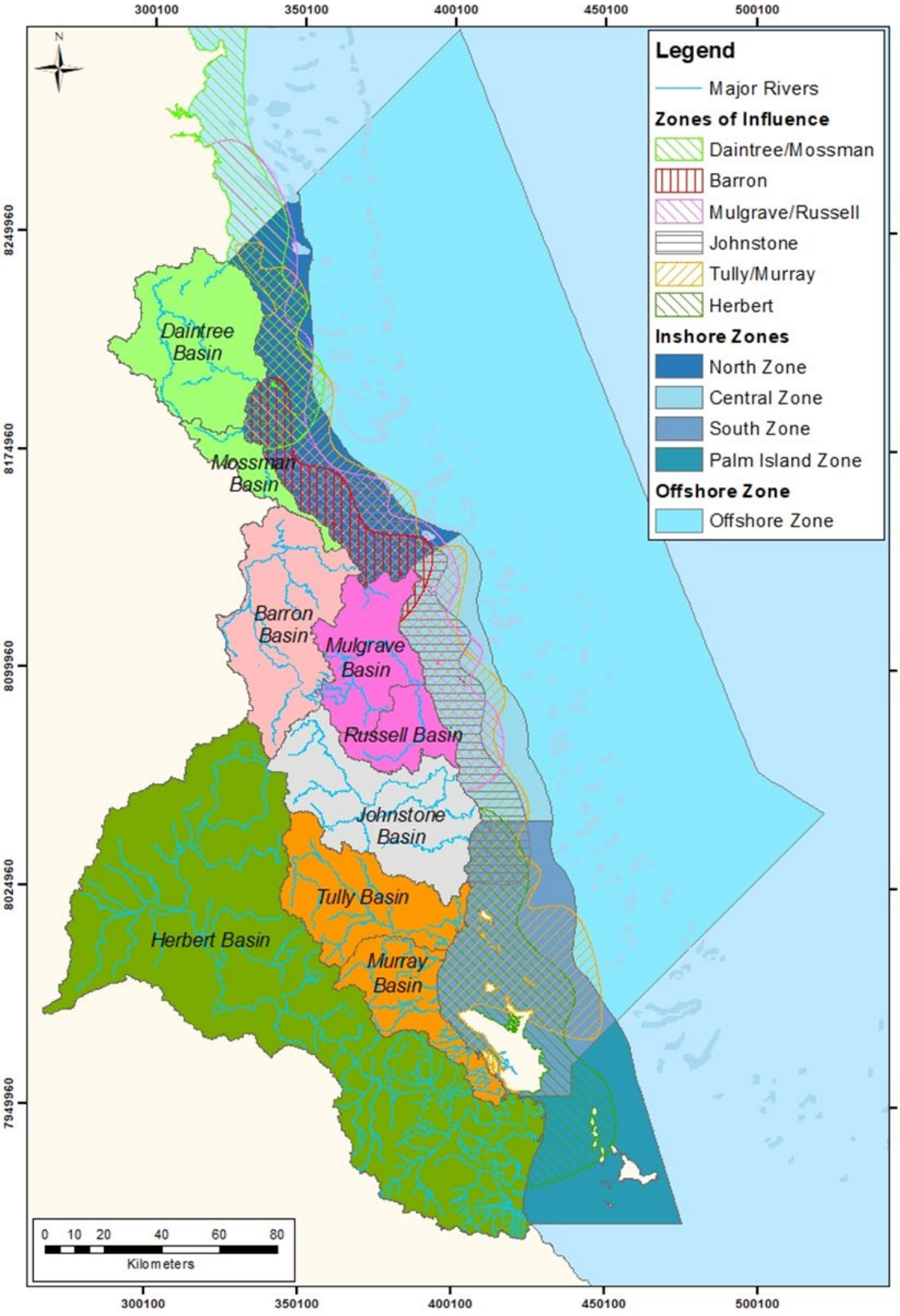


Figure 7. Zones of influence of discharge from river basins in the Wet Tropics. (Source: Waterhouse 2014)

4. DRIVERS, PRESSURES, IMPACTS AND RESPONSE

The Report Card framework uses relevant information to identify regional drivers and the human-related pressures that affect waterways in the region, and assesses the state of the environment as a result of impacts from the pressures. Assessment of progress toward targets and tracking of trends over time is possible as future Report Cards are generated. The Report Card results and outputs are available to contribute to the prioritisation of management and intervention activity responses. The Report Card can be used to assess the condition of indicators (state), and how they have been impacted by pressures, and where management practice interventions (responses) could assist to reduce such impacts.

4.1. Drivers and Pressures in the Region

The three key regional drivers identified in the Wet Tropics region are:

- Climate (including climate change and variability)
- Population growth
- Economic growth.

Numerous pressures have impacts on waterways in the Wet Tropics and these occur across a wide range of spatial and temporal scales. Pressures can vary from localised and short term impacts to global and long term impacts. Pressures on waterways in the Wet Tropics include the following:

- Urban, coastal, and industrial development
- Cyclones and episodic events (including drought and flood events)
- Port and shipping activities and development
- Agricultural activities and development
- Fishing and hunting (recreational, commercial, and traditional)
- Tourism and recreational use
- Litter
- Water quality
    - Diffuse sources (agriculture and urban)
    - Point source (urban and industrial)
- Water resource development and alteration of natural flow regimes
- Invasive species (flora and fauna) associated with waterway, wetland, and marine health.

4.2. State of Waterway Environments and Impacts from Pressures

The state of the waterway environments and impacts from pressures in the Wet Tropics has been described in detail in the WQIP and its supporting studies and reports (http://www.terrain.org.au/Projects/Water-Quality-Improvement-Plan). The Wet Tropics is characterised by high value freshwater, coastal and marine assets. Approximately 35% of land in the region is within the WTWHA which provides some protection to the integrity of catchment waterways. Despite this protection a large proportion of catchment waterways are impacted by agricultural and urban land uses including coastal and inland areas. Other pressures, including in-stream barriers, impoundments, invasive pests and weeds, fishing and water extraction, contribute to aquatic ecosystem disturbance. Land use development has reduced the extent of wetlands, floodplains and riparian and mangrove communities which provide a whole range of functions including improvement of water quality by reducing nutrients, pollutants and suspended solids.

The region's marine environments are within the GBR Marine Park which provides a degree of protection to their integrity and to the diverse habitats they support including coral reefs, seagrass meadows, estuaries, coastal islands and cays. These habitats in turn support a vast biodiversity including many species of conservation concern. Habitats that are now determined to be in poor condition include inshore coral reefs, seagrass meadows, and low lying islands. Impacts from land use include water quality, in particular nutrients, pesticides and suspended solids. Shipping and port activities and development affect the marine environment particularly through dredging and dredge soil dumping which can exert impacts for over 20 kilometres. Other human activities that directly impact the marine environments include commercial and recreational fishing, coastal development and tourism. The crown-of-thorns starfish is a highly significant threat to coral reefs and outbreaks are considered to be promoted by increased nutrient runoff. Extreme weather events, sea level rise, increased sea surface temperatures and ocean acidification present a whole range of highly significant threats and impacts to the marine ecosystem as a result of climate change.

4.3. Response to Pressures

The responses to address the pressures affecting the region's waterways include the development of plans, targets, delivery of management activities, monitoring, modelling and reporting. The following are examples of key programs.

The Reef Water Quality Protection Plan (Reef Plan) 2013 provides a GBR catchment-wide approach with the goal of achieving nil detrimental impact on the GBR due to the quality of water entering the Reef from broad-scale land use. Land and catchment management targets include: adoption of best agricultural management practices; maintenance of minimum groundcover; increase in riparian vegetation extent; no net loss of wetlands; and improved

wetland values. Water quality targets include the reduction of nutrient, suspended sediment and pesticide loads.

The Reef Plan is supported by the *Paddock to Reef (P2R) Program* which provides monitoring, evaluation and continuous improvement through adaptive management and provides reporting on the progress towards the goals and targets. The P2R program involves collaboration with a wide range of partners and stakeholders to conduct research, monitoring, evaluation and reporting outcomes

Wet Tropics WQIP (Terrain NRM 2015) has been developed to identify the main issues impacting waterways (including marine environments) from land-based activities and to identify and prioritise management actions that will halt or reverse the trend of declining water quality within the NRM region. The WQIP provides a regional focus and highlights issues, priorities and management actions that target the achievement of specific outcomes.

5. REPORT CARD INDICATORS

Indicators for assessing waterway values are required to assess the current state and condition of the region's waterways, and to assess trends over time towards long-term targets and objectives. Indicator selection for waterway environments was conducted at a workshop in Cairns (5th May 2016) with an expert panel that included regional stakeholders with local knowledge. The conceptual diagram (Figure 5) and the regional pressures (Section 1.5) provided a starting point and the approach was informed by the document "A landscape hazard assessment for wetlands in the Great Barrier Reef catchment" (DSITIA 2015) which categorises the impacts of numerous pressures on waterways.

A selection of indicators was guided by the SMART principles developed by Doran (1981) and which are commonly applied in monitoring and evaluation practices. The SMART principles for indicator selection are defined below (after Olivier *et al.* (2012) and Schulte-Herbrüggen *et al.* (2012):

- Specific: the indicator is precisely defined, not vague.
- Measurable: it is feasible to quantify the indicator.
- Achievable: the required data and information can actually be collected.
- Relevant: the indicator is valid and describes the underlying issue.
- Time-bound: a temporal reference is given.

The following criteria were used for the selection of indicators and have been assigned to the relevant SMART principles.

Specific

- Linked to important regional pressures and impacts on waterway health as identified through the Report Card Conceptual framework and diagram.
- Established scientific and conceptual basis - i.e. indicators based on well-defined or validated cause-and-effect linking of human-related pressures to ecosystem response.
- Represent community environmental values.

Measurable

- Availability of appropriate benchmarks (e.g. water quality guideline values) which allow for the generation of Report Card scores.
- Sensitive to change.

Achievable

- Availability of data (currently and likely in future).
- Cost effective and able to be resourced.

Relevant

- Linked to an objective of the Report Card (relevant).
- Align with indicators that are currently monitored as part of ongoing waterway monitoring programs and Report Cards particularly relating to the GBR regions.
- Use the minimum indicators required to represent the targeted pressure and waterway impact, and thereby reduce possible redundancy and doubling up of indicators.
- Able to be effectively communicated and understood by stakeholders and/or the target audience.

Time-bound

- Sensitive to change.
- Linked to specific management objectives and responsive to related management actions.

During indicator selection consideration was given to maintaining consistency of indicators where appropriate across waterway environments (freshwater, estuary, inshore marine and offshore marine) to provide continuity and allow comparison between environments. This could only be achieved for assessments of waterway health that had very similar attributes (e.g. water quality), where similar waterway impacts occurred, and where the monitoring programs collected equivalent data.

The terminology used in this document for defining the level of aggregation of environmental indicators is as follows:

- An indicator is a measured variable (e.g. particulate nitrogen) or generated from more than one measure, for example the flow indicator is generated from multiple hydrological measures.
- Indicator categories are single indicators (e.g. Chlorophyll-*a*) or aggregated from multiple related indicators (e.g. nutrients).
- Indices (e.g. water quality) are aggregated from indicator categories.
- The overall score is aggregated from all the indices of the reporting zone.

The sections below provide the rationale for the selection of indicators used for environmental assessments for the Report Card. The sections present each index within which the indicators and indicator categories are grouped.

5.1. Indicator Selection

5.1.1. Water Quality (Surface Water)

To assist with the selection of water quality indicators some of the criteria listed above were re-worded to specifically address requirements for water quality indicators. The water quality-specific criteria for selecting indicators were as follows:

- Water quality parameters that are currently monitored as part of ongoing monitoring programs within each waterway environment.
- Parameters within each waterway environment linked to potential impacts on water quality and ecosystem health arising from land management practices in the Wet Tropics region.
- Water quality parameters used for other report cards in GBR regions.
- Water quality parameters that have scheduled guideline values (GVs) for an appropriate level of protection (slightly disturbed and moderately disturbed waters) to enable scoring.
- Frequency of monitoring sufficient to detect change in the measured indicator.

Availability of possible water quality indicators was determined through an analysis of current ongoing monitoring programs that collect water quality data in each of the waterway environments. The water quality monitoring programs include the Catchment Loads Monitoring Program, managed by the Department of Environment and Science (DES) which predominantly monitors freshwater basins, the DES and Local Government (Douglas Shire Council, Cairns Regional Council and Cassowary Coast Regional Council) estuary monitoring for the WTHWP, the Marine Monitoring Program conducted by AIMS and JCU on behalf of

the Great Barrier Reef Management Authority (GBMRPA) for inshore marine waters, and remote sensing assessments sourced from the Marine Water Quality Dashboard (Bureau of Meteorology 2014) for offshore waters. Further details of the monitoring programs is provided in the Inventory of Monitoring Programs (Appendix A). The selected indicators for each waterway environment are presented in Table 3.

Table 3. Water quality indicators, (with abbreviations and units) selected for the four waterway environments: freshwater, estuary, inshore marine and offshore marine.

Indicator	Indicator Abbreviation	Indicator Unit	Fresh-water	Estuary	Inshore marine	Offshore marine
Total suspended solids	TSS	mg/L	●		●	●*
Turbidity	Turb	NTU		●	●	
Dissolved oxygen	DO	% Saturation		●		
Dissolved Inorganic nitrogen	DIN	µg/L	●	●		
Filterable reactive phosphorus	FRP	µg/L	●	●		
Particulate nitrogen	PN	µg/L			●	
Particulate phosphorus	PP	µg/L			●	
Nitrogen oxides	NO_x	µg/L			●	
Chlorophyll-*a*	Chl-*a*	µg/L		●	●	●*
Pesticides – multi substances potentially affected fraction	ms-PAF	% species affected	●	●		
Pesticides PSII herbicide equivalent concentrations	PSII-HEq	ng/L			●	

*shows indicators using remotely sensed data.

In the case of the inshore marine environment water quality assessment is conducted by *in-situ* monitoring for the MMP for a range of indicators and also by satellite data, which as from 2015-16 is now underpinned by the eReefs biogeochemical model, for sediment and Chlorophyll-*a* indicators. For the Report Card preference in selection was given to parameters collected *in situ* for all indicators in the inshore marine environment. For the offshore environment the water quality indicators for Chlorophyll-*a* and sediment were only available from remote sensing assessments sourced from the Marine Water Quality Dashboard (Bureau of Meteorology 2014).

Sediment, nutrient and pesticide run-off are recognised in the Reef 2050 Plan (Reef 2050 Long-term Sustainability Plan, Commonwealth of Australia 2015) as the key threats to water quality resulting from anthropogenic activities, and which impact upon the health of the Great

Barrier Reef (GBR). They are also known to impact on the health of freshwater and estuary environments in the Wet Tropics (Wet Tropics Water Quality Improvement Plan, Terrain NRM 2015). Consequently for waterway environments where monitoring for sediment, nutrient and pesticide indicators (or effective proxy indicators) is conducted they have been included within the water quality indices for each environment. Additional water quality indicators specific to particular waterway environments were also selected.

The selected water quality indicators can be revised with appropriate technical recommendations if new information is presented. The rationale and explanation on the selection of the water indicators is described below.

Sediment and water clarity

Total suspended solids (TSS) is a measure of particulate matter in the water column, which influences water clarity and sedimentation regimes. This indicator is a common representative of sediment levels in aquatic systems, and is very strongly linked to land management practices and erosion. In marine environments concentrations of suspended solids are controlled by sediment inputs from rivers and oceanographic factors such as wind, waves and tides.

Turbidity is a measure of the scattering and absorption of light through water which results from suspended material and soluble coloured organic compounds. Turbidity can be a cost-effective indicator for impacts from sediment run-off in the water column and also allows for continuous logging of measurements.

TSS was selected to represent sediment in the freshwater environment. The concentration of TSS is used to estimate sediment loads delivered to the GBR and relates to the Wet Tropics Water Quality Improvement Plan (Terrain NRM 2015), the Reef 2050 Long-term Sustainability Plan (Commonwealth of Australia 2015) and the Reef 2050 Water Quality Improvement Plan 2017–2022 (www.reefplan.qld.gov.au) sediment load targets. Turbidity was also investigated (it is used in the estuary and inshore marine environments), but in the freshwater system the availability of data for turbidity was more limited than for TSS. TSS was the preferred indicator for sediment because: scheduled TSS GVs exist for Wet Tropics basins under the Environmental Protection (Water) Policy (EPP) 2009 (DEHP 2014); it is relevant to sediment loads targets; and there is a volume of data and ongoing monitoring of TSS as part of the Great Barrier Reef Catchment Loads Monitoring Program (GBR CLMP).

Turbidity was selected as an indicator for sediment in the estuary environment and is linked to sediment loads entering estuaries as a result of land use management practices. Turbidity is measured as part of current ongoing monitoring programs of estuaries in the Wet Tropics including those of local government (Cairns Regional Council, Cassowary Coast Regional Council and Douglas Shire Council) and DES (Appendix A). Unlike turbidity, TSS is not sampled as part of the current ongoing monitoring programs of estuaries in the Wet Tropics. Additionally, turbidity does not have any analysis costs (unlike suspended sediments) and site-

specific relationships between sediment and turbidity can often be derived if necessary when funds can be found for periodic analysis of TSS.

For the inshore marine environment both turbidity and TSS were selected as indicators for water clarity. They are both monitored as part of the MMP by AIMS and JCU for the GBMRPA. Whilst TSS is sampled using grab samples during manual monitoring activities the turbidity is measured by loggers which provide much higher frequency of data collection. The selection of both TSS and turbidity in the inshore environment allows for close alignment of reporting of the Wet Tropics Report Card with the MMP for water clarity indicators.

Water quality monitoring in the offshore marine environment is from the remote sensed water quality indicators sourced from the Marine Water Quality Dashboard (Bureau of Meteorology 2014). The data set includes remote-sensed annual exceedances of total TSS which was selected as the water clarity indicator for the offshore marine environment.

Dissolved oxygen

Dissolved oxygen (DO) is an effective indicator to include for estuarine environments as it is affected by the organic matter load entering estuaries as a result of land use management practices and other anthropogenic activities. Low concentrations of DO are often linked to fish kills, and such events often result in community concern. Events of low DO concentrations can occur over short time periods, for example several days, but can have substantial impacts on waterway health particularly fish assemblages. Consequently assessment of dissolved oxygen concentrations need to take account of the potential occurrence of short lived but severe impacts which may not be revealed from long term summary statistics such as annual medians.

Nutrients

A range of possible nutrient forms that are associated with the major agricultural land uses (sugar cane, bananas and irrigated cropping) within the Wet Tropics region were considered as indicators for each waterway environment. Two key nutrients identified as impacting on waterways in the Wet Tropics Water Quality Improvement Plan are nitrogen and phosphorus (Terrain 2015). Nutrient indicators for nitrogen and phosphorus that were considered included the following:

- Total nitrogen
- Dissolved inorganic nitrogen (DIN)
- Total phosphorus
- Particulate nitrogen (PN)
- Particulate phosphorus (PP)
- Filterable reactive phosphorus (FRP)
- Oxidised nitrogen (NO_x)

For freshwater and estuary waterways dissolved inorganic nitrogen (DIN) and filterable reactive phosphorus (FRP) were selected as the most representative of the pressures and impacts. For both environments, single indicators for each of the key nutrients were chosen to avoid potential duplication in reporting.

DIN is recognised as a pollutant of greatest concern to water quality in the GBR (Terrain 2015). The Wet Tropics region contributes the highest annual DIN load to the GBR of the six GBR regions (Bartely *et al*. 2017). DIN was selected as the most relevant indicator of nitrogen for the Wet Tropics Report Card to assess land use pressures that can increase concentrations and loads of bioavailable nitrogen in waterways. DIN is readily available for uptake by aquatic plants such as phytoplankton, macroalgae and algal symbionts and presents risks to freshwater and estuarine ecosystems, as well as being recognised as the largest risk of all the nutrients constituents to the GBR ecosystems (Schaffelke *et al*. 2017).

Water quality guideline values for nutrients provided in the water quality objectives (WQOs) for the Wet Tropics basins (DEHP 2014) do not include concentrations values for DIN. DIN is comprised of oxidised nitrogen (NOx) and ammonia nitrogen (NH3) forms, and water quality objectives for both are specified for freshwater and estuary water types for the Wet Tropics (DEHP 2014). To derive guideline values for DIN (DIN-N) the WQO concentration values for oxidised nitrogen (NOx-N) and ammonia nitrogen (NH3-N) were summed for each water type. This approach was determined to be appropriate by the Technical Working Group based upon the following.

- The high rate of exceedance of both NOx and NH3 demonstrates that both forms of bioavailable nitrogen are important to assess.
- There is a precedent for creating the DIN guideline value from NOx and NH3 in the 2013 scheduled water quality objectives for the Proserpine River, Whitsunday Island and O'Connell River basins for which the DIN guideline values are the sum of the NOx and NH3 guideline values.
- Assessing DIN from the summed WQOs is a more stringent approach than from assessing NOx and NH3 separately and averaging the scores.

Risk to ecosystems from the effects of constituents of DIN include NH3 toxicity to aquatic fauna, in particular fish. However the selection of nitrogen as an indicator for the Wet Tropics Report Card was specifically aimed to assess the risk it presents in its bioavailability to aquatic plants and therefore DIN was determined as the most appropriate form of nitrogen as an indicator. Note that the WQOs for NH3 toxicity to fish are provided for the aquaculture Environmental Values and concentrations are substantially higher than the WQOs for the protection of aquatic ecosystems (DEHP 2014).

For the inshore marine environment the nutrient indicators selected were oxidised nitrogen (nitrite and nitrate) and particulate nitrogen for nitrogen, and particulate phosphorus for phosphorus. These nutrient forms were selected due to their relevance as indicators of

nutrient impacts in the inshore marine environment and as such are used as the nutrient indicators for the MMP water quality index for inshore waters. The selection of these nutrient indicators for the inshore marine environment allows for close alignment of reporting of the Wet Tropics Report Card with the MMP.

Nutrients were not selected as indicators for the offshore marine environment due its large distance from land and consequently a lower impact from land based nutrient run-off compared to waterway environments closer to the source of nutrient inputs.

Chlorophyll-*a*

Chlorophyll-*a* concentration provides an estimate of phytoplankton biomass, and is also widely considered as a useful proxy for nutrient availability and the productivity of a system. Chlorophyll-*a* was selected as indicator for estuaries particularly because high concentrations can provide an indicator of eutrophication in estuary environments. Chlorophyll-*a* was also selected as an indicator for the inshore and offshore waterways due to its effectiveness as an indicator of nutrient availability in marine ecosystems. Chlorophyll-*a* is an indicator included in the MMP water quality index for inshore waters. For coastal and estuarine waters the potential of measurement errors associated with remotely sensed Chlorophyll-*a* are avoided by the use of *in situ* monitoring.

Pesticides

Up to 28 pesticides with different modes of action are detected from the GBR catchments and are progressively being included in the pesticide indicators for the Wet Tropics Report Card. In the freshwater and estuary environments pesticides are monitored by the Catchment Loads Monitoring Program (CLMP). Pesticide reporting from the CLMP has expanded since the Pilot Report Card reporting from five PSII herbicides (Ametryn, Atrazine, Diuron, Hexazinone and Tebuthiuron) previously identified as the pesticides of greatest concern to the health and the resilience of the GBR (DPC, 2013) to thirteen PSII herbicides detected in the GBR (Ametryn, Atrazine, Diuron, Hexazinone, Tebuthiuron, Bromacil, Fluometuron, Metribuzin, Prometryn, Propazine, Simazine, Terbuthylazine, Terbutryn) and insecticides including imidacloprid. CLMP reporting is expected to expand to include the full suite of pesticides detected in the region and results can be presented in subsequent report cards.

The Report Card uses the Multiple Substances-Potentially Affected Fraction (ms-PAF) method to report on pesticides in freshwater and estuary environments. The ms-PAF method (Traas *et al*. 2002) can estimate the effect of all pesticides in a mixture, with multiple modes of action, if the toxicity data are available to do so. The ms-PAF estimations reported thus far have only included the PSII herbicides in the detected pesticide mixtures. Now that the required toxicity data for other pesticides that are detected is becoming available, these pesticides will progressively be included in reporting.

In the inshore environment pesticides are monitored as part of the MMP and indicators using passive samplers were selected for the Report Card which inform on the nearshore pesticide

concentrations (Gallen *et al*. 2017). Pesticides in these monitoring activities included photosystem II (PSII) inhibiting herbicides (such as ametryn, atrazine, diuron, hexazinone and tebuthiuron), and levels are reported as PSII herbicide equivalent concentrations (PSII-HEq) (ng L^{-1}) which is a measure of the ecotoxicity of PSII herbicide mixtures.

Pesticides were not selected as an indicator for the offshore environment due its large distance from land and consequently a lower impact from land based pesticide run-off compared to waterway environments closer to the source of pollutant inputs.

It is recognised that other contaminants that are relevant in the Wet Tropics region in addition to pesticides may be included as indicators in future report cards, for example, metals.

eReefs

The eReefs research project provides information and data on physical processes, sediment transport, biogeochemistry and ocean colour which can provide improved spatial and temporal representation of water quality for marine waters within the Wet Tropics region. The eReefs modelling is likely to be very relevant for Report Card assessment of marine water quality in the future. eReefs is a collaboration between the Great Barrier Reef Foundation, CSIRO, the Australian Institute of Marine Science, Bureau of Meteorology and Queensland Government. The eReefs system models a wide range of marine variables covering physical properties (temperature, current, light penetration) as well as biogeochemical parameters (such as the concentration of nutrients, sediments, plankton and Chlorophyll-*a*). Three-dimensional model outputs are generated for the entire Great Barrier Reef lagoon (from South East Queensland to Torres Strait) at various resolutions (1km and 4km) on a daily basis.

Given the scale of the Great Barrier Reef, it would be impractical to measure and report water quality through the entire domain and at a reasonable frequency using *in situ* monitoring data alone. Satellite imaging can be employed to cover this wide spatial domain but is generally considered to present a lower relative accuracy and is affected by cloud cover. Therefore, the eReefs deterministic modelling framework is used in conjunction with the *in situ* information collected in the Marine Monitoring Program and satellite observations to extrapolate water quality across the entire Great Barrier Reef.

In addition, marine models can assess the impact of individual rivers flowing into the Great Barrier Reef and estimate the extent and properties of flood plumes (contributing to risk assessments). They can also be used to simulate the impact of different management practices on downstream marine water quality (scenarios and target setting).

The application of eReefs for the Wet Tropics Report Card will apply to water quality for both inshore and offshore environments with potential to inform on estuaries and the transport of nutrients, sediments and pesticides relating to basins. The integration of eReefs outputs for the Report Card will develop following the delivery of the second phase, which is

currently in progress. Improvements to the modelling framework and water quality calculations in the second phase are being implemented which can be broadly summarised as follows:

- Improving the modelling of TSS concentration and impact on water clarity by better accounting for the fate of very fine sediments and flocs.
- Improving the modelling of the impact of freshwater discharge by implementing high frequency river forecasting models developed in the first phase by the BoM, allowing the prediction freshwater and contaminant inputs from ungauged rivers and therefore expanding the number of river inputs into eReefs.
- Systematically implementing the higher resolution version of the eReefs model to improve predictions in enclosed coastal areas.
- Reviewing the indicators and relevant guidelines and thresholds underpinning the water quality metric for the Great Barrier Reef Report Card.

5.1.2. Groundwater Water Quality

Groundwater resources in the Wet Tropics are extensive and it is recognised that many of the surface water base-flows of streams and rivers in the Wet Tropics are maintained throughout the dry season by their connectivity to the groundwater (DSITIA 2013). In addition to the groundwater dependent stream ecosystems, it is likely that groundwater dependent wetlands, groundwater dependent terrestrial vegetation, and hypogean ecosystems are prevalent within the region. Despite the lack of information on groundwater dependent ecosystems in the region, spatial assessments of depth to water table, regional ecosystems and wetland mapping have determined the potential for an extensive range of terrestrial and wetland systems to be dependent on groundwater throughout all basins assessed in the Wet Tropics region (DSITIA 2013).

Impacts of land use on the water quality of groundwater are well documented and include increased salinity, salt water intrusion, acid sulphate effects, nutrient inputs and contamination from metals and pesticides. The interaction between surface water and groundwater in the Wet Topics can be closely linked as demonstrated by dynamic groundwater flow in both unconfined shallow aquifers and deeper aquifers in relation to rainfall events (Masters *et al*. 2014). Such interactions emphasise the relevance of groundwater water quality to the health of waterways and to groundwater dependent ecosystems. Water quality indicators for salinity, nutrients, acidity, metals and pesticides were selected to represent the major impacts on groundwater water quality from land use in the region.

Whilst localised examples of surface water and groundwater interactions in the Wet Topics have been well documented (e.g. Masters *et al*. 2014) there is a lack of knowledge regarding the interactions between these waters at broader scales in the Wet Tropics region including influences on water quality. To prevent issues arising from assumptions about interactions of these waters which may occur from the grouping of groundwater with surface water scores in a single water quality index for basins, the groundwater water quality index is

scored and presented separately from the other basin indices which comprise the overall basin score (surface water quality, habitat and hydrology, and fish). As more knowledge is gained about the interactions between groundwater and surface water, approaches for aggregating their water quality scores can be developed.

5.1.3. Habitat and Hydrology

Habitat and hydrology indicators were selected for the freshwater and estuary environments (Table 4). Selection of indicators differed between the freshwater and estuary environments due to the different pressures, impacts and ecosystem characteristics.

Table 4. Habitat and hydrology indicators selected for freshwater and estuary environments.

Indicator	Freshwater	Estuary
Impoundment length	●	
Fish barriers	●	●
Flow	●	●
Riparian extent	●	●
Wetland extent	●	
Mangrove and saltmarsh extent		●
Invasive weeds	●	
Seagrass		●

For freshwater environments the impoundment length and fish barrier indicators are both included in the habitat and hydrology index. Whilst both indicators relate to artificial instream structures, the impoundment length indicator is a measure of the proportion of artificially ponded habitat within a basin and results from larger instream barriers, whilst the fish barrier indicator is a measure of the potential impact on fish movement and includes smaller barriers that do not result in substantial ponding of habitat.

Variations in the methods applied for assessing habitat and hydrology indicators occurs between the environments due to the different characteristics of freshwater and estuary ecosystems. Details of these difference are described in the methods technical report (WTHWP 2017b). The rationale and explanation on the selected indicators that constitute the habitat and hydrology indices are described below.

Impoundment length

The basis for using this indicator is that impoundment of rivers and streams by the construction of artificial in-stream structures, including dams and weirs, can have a substantial impact upon stream ecology. The purpose of constructing in-stream barriers is commonly to store water for later use, and impounded areas generally have increased water depth and decreased water velocities. Cycles of wetting and drying are disrupted, decreasing the occurrence of natural disturbance and altering the nutrient processing cycle. Increased sedimentation may occur and benthic habitats may become anoxic. The spawning habitat of

some aquatic organisms may be lost. Ponded environments also provide conditions that can promote algal blooms including toxic strains of cyanobacteria.

The indicator was selected with the intention to describe how much 'natural' channel habitat remained, compared with artificially ponded channel habitat which has relatively little diversity in terms of depth (benthic light availability, oxygen availability), flow rate, and wetting and drying cycles due to the river channel being filled by impounded waters. The length of impounded channel varies according to attributes such as the height of the constructed in-stream barrier and landscape features such as gradient of the channel. Given that larger impoundments are generally permanent structures the inclusion of impoundment length for scoring habitat modification condition is open for review in future Report Cards as scores may be unlikely to change over time.

In-stream barriers constructed to store water also disrupt the movement of aquatic organisms consequently the impoundment length indicator could have some correlation with the indicator of fish barriers. However, the intended focus of the impoundment length indicator is on the ecological impact of the proportion of affected in-stream habitat and not the movement of organisms.

Fish barriers

Waterway barriers can impact the movement of fish within freshwater environments and also between estuary and freshwater environments. Consequently fish barriers was selected as an indicator for both freshwater and estuary environments.

The Wet Tropics has the highest diversity of freshwater fish species of any region in Australia and many of these species undertake migrations (Pusey *et al.* 2004). Fish barriers can have a significant impact on native fish assemblages by restricting movement between freshwater habitats and reducing reproductive success (Lawson *et al.* 2010). The Wet Tropics also has a high diversity of fish that migrate between estuary and freshwater environments. Such species are termed diadromous and include highly valued and iconic fish species that are distributed within the Wet Tropics region including barramundi, mangrove jack and jungle perch (Allen *et al.* 2003). Movement between estuary and freshwater environments is a requirement for the population viability of many diadromous fish species (Pusey *et al.* 2004). Fish barriers can have a significant impact on diadromous fish species by restricting movement between freshwater and estuary habitats. Over 3700 potential barriers to fish movement (including bridges, culverts and causeways) have been mapped in the Wet Tropics across a stream network of 18,363 km (Kroon and Phillips 2015) and of these a subset are in locations where they may also restrict movement of diadromous fish between freshwater and estuarine environments. The rehabilitation of barriers is recognised as a management strategy to improve the movement of native fish movement and reduce invasive fish abundance in the Wet Tropics region (Lawson *et al*. 2010). As of 2018 the method to assess fish barriers in freshwaters requires development whilst the initial assessment of estuary fish barriers has been completed and was first reported in the 2017 Report Card.

Flow

Flow is an important indicator category to include in the Report Card due to its relevance to ecosystem and waterway health and was selected for both freshwater and estuary waterways. Water resource development in the Wet Tropics, including, water extraction, supplementation and impoundments, affects the flow regime and due to the strong link between intact flow regimes and ecological health (Bunn & Arthington 2002), the flow indicator was selected to measure the change from natural conditions and associated impacts upon the freshwater and estuary ecosystems.

A range of ecological assets with links to water resources that are sensitive to changed water allocation and management conditions were selected to represent the key components of the natural flow regime (cease to flow - amphibians, riffles and waterholes; low flows - low flow spawning fish species, reptiles, amphibians, riffles and waterholes; medium flows - riffles; and high flows - fisheries production in estuaries). To generate indicator scores a set of hydrologic metrics are used to compare gauged flows with predicted pre-development flows, and the extent to which flow requirements of the ecological assets are not met due to flow alternation is assessed.

Riparian extent

The extent of riparian vegetation was determined to be an important indicator to include in the Report Card for freshwater and estuary environments. Riparian vegetation provides ecological functions, habitat provision and benefits to water quality including bank stabilisation and filtering of coarse sediment inputs into waterways as well as moderating stream water temperature from shading. For the Report Card the riparian vegetation for basins describes the vegetation communities that occur on the banks of rivers and for which the term riparian zone is applied. In the case of estuaries riparian vegetation also includes vegetation communities that extend from river mouths along coastal shorelines that surround estuary areas. Thus the term estuarine riparian vegetation includes vegetation communities occurring on river banks and coastal shorelines.

Indicators of condition were identified as important for the assessment of riparian vegetation. The development of methodology and suitable monitoring for riparian condition is included in the five year plan for the Report Card (section 7).

Wetland extent

Wetland extent was determined to be a relevant indicator to include within the freshwater basin assessments in the Report Card due to its importance in ecological function, provision of habitat for a range of species and benefits to water quality including sediment retention and nutrient cycling. Indicators of condition were identified as important for the assessment of wetlands. A monitoring program for wetland condition in GBR catchments has been developed within DES. The expansion of DES wetland condition monitoring to provide reporting at the regional scale has been progressed and condition monitoring of wetlands for the Wet Tropics is included in the five year plan for the Report Card (section 7).

Mangrove and saltmarsh extent

The extent of mangrove and saltmarsh vegetation was determined to be a critical indicator to include in the Report Card due to the importance of these systems in both estuarine ecological function and habitat provision, and its benefits to estuarine water quality and filtering of inputs to waterways.

Invasive weeds

Invasive weeds are recognised to have major impacts on the health of inland waterways in the Wet Tropics and in-stream weeds were selected as an indicator for freshwater environments. Impacts resulting from in-stream invasive weeds include: reduced abundance and diversity of native plant species, modification of habitat for native fauna species; blocking and choking of waterways; increased sedimentation and organic loading; decreased water quality; and hydrological modification. Programs designed to monitor and manage invasive weeds are conducted in all nine freshwater basins within the Wet Tropics region through local governments and address priority species for management identified in Local Area Pest Management Plans or Biosecurity Plans. The monitoring programs provide regional scale mapping of invasive weeds that is used to assess the distribution and impact of invasive weeds within the freshwater basins for the Report Card.

Seagrass

Seagrass was selected as a habitat and hydrology indicator for estuaries due to impacts and pressures that can occur in these environments and its important role in the ecosystem as detailed in Section 1.3 below. Seagrasses have been identified in four of the eight estuary reporting zones (Dickson Inlet, Trinity Inlet, Moresby River and Hinchinbrook Channel) and have been selected as an indicator for these estuaries due to their ecological significance and the potential impacts from pressures associated with land use and coastal activities in the Wet Tropics. Seagrass may also have been present in other estuary reporting zones in the Wet Tropics (for example the Johnstone) and further research is required to establish if it is an appropriate indicator for these estuary locations. Seagrass can only be reported at the two estuaries where it is currently monitored (Trinity Inlet and Moresby River). Monitoring of seagrass in the Wet Tropics region is conducted by the Queensland Ports Seagrass Monitoring Program (QPSMP) and the Marine Monitoring Program (MMP). Seagrass monitoring in estuarine environments of the Wet Tropics is conducted by QPSMP.

5.1.4. Coral

Coral reefs are integral to the health of the marine waters of the Wet Tropics providing critical roles for habitat, biodiversity and ecosystem processes. Coral is susceptible to a range of disturbances and impacts that occur in the Wet Tropics region including many anthropogenic related stressors (Sweatman *et al.* 2007, Thompson *et al.* 2017). Consequently coral indicators were selected for the inshore and offshore marine environments.

Coral monitoring for the Wet Tropics region is conducted by Australian Institute of Marine Science (AIMS) through the Long Term Monitoring Program (LTMP), the MMP (inshore sites only) and the Representative Areas Program (RAP) (offshore sites only) which are contracted by GBRMPA.

For inshore environments the coral indicators used are coral cover, macroalgae cover, rate of coral cover increase, density of juvenile corals and community composition and are the same set of indicators used in the GBR Report Card. For the offshore coral reporting in the Report Card the coral indicators used are coral cover, rate of coral cover increase and density of juvenile corals. The coral indicators are integrated into an overall coral reef condition index. The coral index is formulated around the concept of community resilience as detailed by Thompson *et al.* (2016). The underlying assumption is that a 'resilient' community should show clear signs of recovery after inevitable acute disturbances, such as tropical cyclones and coral bleaching events, or, in the absence of disturbance, maintain a high cover of corals and successful recruitment processes (Thompson *et al.* 2016). The coral index for inshore environments was revised for the 2015 Reef Plan report card and a detailed description including the reasoning behind threshold selection and methods used for the calculation of the coral index can be found in Thompson *et al.* (2016). The offshore coral index was revised in 2017 to include indicators that better represent the conditions of the offshore marine waters as described in WTHWP (2017b).

5.1.5. Seagrass

Seagrasses are highly productive marine habitat and provide nursery habitat for economically-important fish and crustaceans and food for grazing mega-herbivores like dugongs and sea turtles (York *et al.* 2014). Seagrasses also play a major role in the cycling of nutrients, stabilisation of sediments, improvement of water quality and recent studies suggest they are one of the most efficient and powerful carbon sinks in the marine realm (York *et al.* 2014). Seagrasses are impacted by a range of anthropogenic stressors including direct disturbance from coastal development and dredging, coupled with indirect effects through changes in water quality due to sedimentation, pollution and eutrophication (Short and Wyllie-Echeverria 1996).

The seagrass indicators were selected based on existing monitoring programs likely to continue in the future. The monitoring of seagrass is conducted by two programs: (1) the Marine Monitoring Program (MMP) through James Cook University (JCU) for GBRMPA and used in the Reef Plan report card, and (2) the Queensland Ports Seagrass Monitoring Program (QPSMP) by JCU for Queensland Ports Authorities.

The seagrass indicators selected for reporting from the MMP are described in detail by McKenzie *et al*. (2015) include seagrass percentage cover, tissue nutrient status (C:N ratio), and reproductive effort (production of spathes, flowers and fruits per unit area). The indicators selected from the QPSMP are described in detail by York *et al*. (2016) and include

mean above-ground biomass, meadow area and species composition. Both programs produce condition scores for seagrass using the three indicators specific to the program. The reporting of seagrass is planned to undergo a revision which will investigate options for integrating results from the two programs to provide a single set of indicators. The revision is being conducted by the Reef Integrated Monitoring and Reporting Program (RIMMReP) seagrass working group led by the GBRMPA.

5.1.6. Fish

Fish are integral to the ecosystem in all four waterway environments and many species move between the environments. Pressures and impacts on fish assemblages are present in each waterway environment and include poor water quality, degraded habitat and fishing pressure. The region's community also places great value on native fish species. Consequently fish were selected as indictors of ecosystem health for all four environments.

In the freshwater environment the Wet Tropics has the highest diversity of freshwater fish species of any region in Australia (Pusey *et al.* 2004) but a range of impacts that affect the health of fish assemblages within the freshwater basins have been identified as part of the Wet Tropics WQIP (Terrain NRM 2015) and the cumulative effect of these impacts may have resulted in changes in the condition of the assemblages. Impacts on freshwater fish assemblages in the Wet Tropics resulting from land use, as summarised by Godfrey and Pearson (2014) for the WQIP, include the following.

- Loss of instream habitat due to riparian and channel modification.
- Reduced movement, distribution and recruitment due to flow regulation.
- Sedimentation of benthic habitats.
- Deoxygenation due to organic inputs (dissolved and suspended) including sugar cane trash.
- Ammonia toxicity resulting from fertilizer and organic contaminants.

Indicators developed for assessment of the fish community condition in freshwater environments is are native species richness and pest fish abundance. Assessment in the report card of the two identified fish indicators is an important step towards understanding the health of the local freshwater fish communities. Inclusion of fish community composition and abundance indicators is an aspiration of the report card but will depend on funding and research for developing appropriate methods to assess these indicators.

Development of appropriate monitoring and assessment methodology are required for progressing fish indicators for the estuary, inshore and offshore environments. Development of these indicators is planned to occur in collaboration with RIMReP and other regional report card Partnerships.

5.2. Indicator Reporting for Waterway Environments

The indicators, indicator categories and indices selected for reporting state and condition are presented in the tables below for each waterway environment. The tables provide resolution to the indicator level which is also the level provided in the technical reports and the website and is equivalent to the tier two technical reports for the GBR Report Card. The tables provide the idealised range of indicators for the five year period of the Program Design and include indicators that are not reported currently. In the tables the status of the indicator refers to the stage of development of the method and monitoring for Report Card purposes. Indicators that are completed will be reported for the period of 1st July 2016 to 30th June 2017 and onwards. Indicators that are in development require methodological development and are planned for reporting in the near future (i.e. one to two years) whilst aspirational indicators, which require establishment of appropriate monitoring in addition to methodological development may require a longer period (i.e. three to five years). The circle diagrams are used to present aggregated results for each reporting zone. For the Report Card the circle diagrams are limited to the two inner circles (overall score and indices) which corresponds with the tier one reporting for the GBR Report Card. The circle diagrams presented after each table below have an additional outer circle showing the indicator categories which are provided here for greater context. For reporting of grades the standard colour coding grading scheme used for the Report Card will be applied to the circle diagrams (Table 5).

Table 5. Standard colour coding grading scheme for the Report Card.

Grade and colour scheme
Very good
Good
Moderate
Poor
Very poor
Insufficient data

Freshwater basins

The indicators and indicator categories selected for reporting the condition of freshwater basins are grouped into the three indices of water quality (surface waters), habitat and hydrology, and fish (Table 6). The indicator category, index and overall score are presented as a circle diagram (Figure 8) and the standard colour coding grading scheme will be applied.

Table 6. Indicators used to determine a score for the environmental condition of each freshwater basin.

Index	Indicator category	Indicator	Frequency of reporting	Indicator status
Water quality	Sediment	Total suspended solids	Annually	Completed
	Nutrients	DIN (summed from NH_4-N and NO_x-N),		Completed
		FRP		
	Pesticides	ms-PAF for PSII herbicides*		Completed
Habitat & hydrology	Habitat modification	Impoundment length	4 yearly	Completed
		Fish barriers		In development
	Flow	30th Percentile of 10 flow metrics	Annually	Completed
	Riparian vegetation	Extent	4 yearly	Completed
		Condition†		In development
	Wetlands	Extent		Completed
		Condition†		In development
	Invasive weeds	Extent, diversity and impact		Completed
Fish	Native fish	PONSE$^{\#}$	3-5 years	In development
	Pest fish	Proportion pest fish		

†Condition indicator to be developed. *Report cards released 2016-18 report on Multiple Substances-Potentially Affected Fraction (ms-PAF) for 13 PSII herbicides (Ametryn, Atrazine, Diuron, Hexazinone, Tebuthiuron, Bromacil, Fluometuron, Metribuzin, Prometryn, Propazine, Simazine, Terbuthylazine and Terbutryn). #PONSE: percentage of native species expected. TBC: to be confirmed. Water quality data is sourced from the Department of Environment and Science (DES) Catchment Loads Monitoring Program. Habitat extent (wetlands and riparian vegetation) mapping is sourced from DES and Queensland Herbarium. Flow data is sourced from the Department of Natural Resources and Mines and DES. Invasive weeds data is sourced from Local Government Pest Working Groups through the Far North Queensland Regional Organisation of Councils. Fish data is sourced from DES.

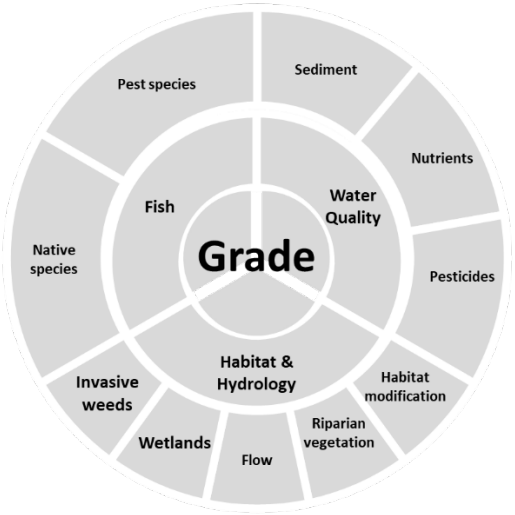


Figure 8. Example of circle diagram with indicator categories and indices for each of the nine freshwater basins.

The indicators used to determine a score for the water quality condition of groundwater for each freshwater basin shown in Table 7. The groundwater water quality index and indicator categories are presented as a separate circle diagram (Figure 9) from the overall basin indicators. The standard colour coding and grading scheme will be applied to the circle diagram.

Table 7. Indicators used to determine groundwater water quality scores for each freshwater basin.

Index	Indicator category	Indicator	Frequency of reporting	Indicator status
Ground-water water quality	Salinity	Electrical conductivity	Annually (three year running mean)	In development
	Nutrients	NO_3		
	Acidity	pH		
	Metals	Manganese, Zinc, Copper		
	Pesticides	TBC		

Groundwater water quality data is sourced from the Department of Natural Resources and Mines groundwater database.

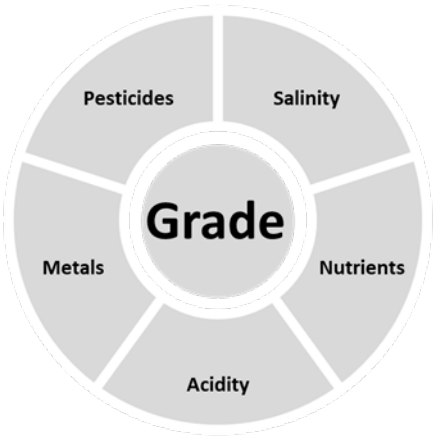


Figure 9. Example of separate circle diagram for groundwater water quality with proposed indicator categories for each of the nine freshwater basins.

Estuaries

The indicators and indicator categories selected for reporting the condition of estuarine environments are grouped into the three indices of water quality, habitat and hydrology, and fish (Table 8). The indicator category, index and overall grades are presented as a circle diagram (Figure 10) and the standard colour coding and grading scheme will be applied.

For the habitat and hydrology indicator flow is reported for all estuaries where an end of system gauging station is present for a major inflowing waterway. Of the eight estuary reporting zones, two do not have an existing or planned end of system gauging station present (Dickson Inlet and Moresby). Seagrass was recommended to be included in the habitat and hydrology index at the four estuaries where it is present (Dickson Inlet, Trinity Inlet, Moresby

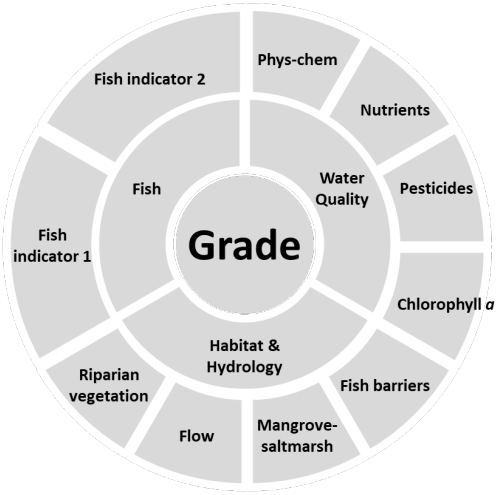
River and Hinchinbrook Channel) although scores can only be reported for the two estuaries where it is currently monitored (Trinity Inlet and Moresby River).

Table 8. Indicators used to determine a score for the environmental condition of each estuary.

Index	Indicator category	Indicator	Frequency of reporting	Indicator status
Water quality	Physical-chemical	Turbidity	Annually	Completed
		Dissolved oxygen		
	Nutrients	DIN (summed from NH_4-N and NO_x-N)		
		FRP		
	Chlorophyll-*a*	Chlorophyll-*a*		
	Pesticides	ms-PAF for PSII herbicides*		
Habitat & hydrology	Mangroves and salt marsh	Extent	4 yearly	Completed
		Condition†	TBC	Aspirational
	Estuarine riparian vegetation	Extent	4 yearly	Completed
		Condition†	TBC	Aspirational
	Fish barriers (between freshwater and marine environments)	Barrier density	4 yearly	Completed
		Distance to first barrier		
		Distance to first low passability barrier		
	Flow	30th Percentile of 10 flow metrics	Annually	Completed
	Seagrass**	Biomass¥	Annually	Interim approach completed
		Area¥		
		Species composition¥		
Fish	Fish	TBC	TBC	Aspirational

*Report cards released 2016-18 report on Multiple Substances-Potentially Affected Fraction (ms-PAF) for 13 PSII herbicides (Ametryn, Atrazine, Diuron, Hexazinone, Tebuthiuron, Bromacil, Fluometuron, Metribuzin, Prometryn, Propazine, Simazine, Terbuthylazine and Terbutryn) at estuary locations where Catchment Loads Monitoring Program sampling is conducted. †Condition indicator to be developed. **only at reporting locations where seagrass occurs. ¥Interim display for seagrass indicator. Water quality data is sourced from Department of Environment and Science (DES), Douglas Shire Council, Cairns Regional Council, and the Cassowary Coast Regional Council. Pesticide data is sourced from the Catchment Loads Monitoring Program (DES). Habitat extent (mangroves, salt marsh and estuarine riparian vegetation) mapping is sourced from DES and Queensland Herbarium. Fish barrier data is sourced from the Wet Tropics Healthy Waterways Partnership. Flow data is sourced from the Department of Natural Resources and Mines and DES. Seagrass data is scoured from the Queensland Ports Seagrass Monitoring Program (JCU).

A



B

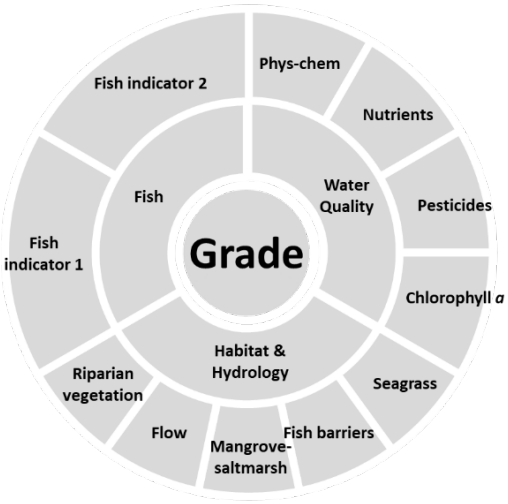


Figure 10. Example circle diagrams with indicator categories and indices for the eight estuaries. A applies to estuaries without seagrass, B applies to estuaries with seagrass.

Inshore marine

The indicators and indicator categories selected for reporting the condition of inshore environments are grouped into the four indices of water quality, seagrass, coral and fish (Table 9). The indicator category, index and overall grades are presented as a circle diagram (Figure 11) and the standard colour coding and grading scheme will be applied. Reporting seagrass at the inshore zones requires a combined seagrass index for the major seagrass

monitoring programs (Queensland Ports and MMP). The Report Card will use an interim display approach as described in the *Wet Tropics 2016 Report Card Methods* (WTHWP 2017b). This interim display approach has been approved by the Independent Science Panel and has been in use since the Pilot Report Card. An integrated approach is being developed through RIMReP and will be available for future Report Cards.

Table 9. Indicators used to determine a score for the environmental condition of the inshore marine environments.

Index	Indicator category	Indicator	Frequency of reporting	Indicator status
Water quality	Water clarity	Total suspended solids,	Annually	Completed
		Turbidity		
	Nutrients	NO_x		
		PN,		
		PP		
	Pesticides	PSII herbicides (using PSII-HEq method)		
	Chlorophyll-*a*	Chlorophyll-*a*		
Coral	Change in coral cover	Change in coral cover	Annually*	Completed
	Juvenile density	Juvenile density		
	Macroalgae cover	Macroalgae cover		
	Cover	Cover		
	Composition	Composition		
Seagrass	Abundance†	Abundance†	Annually	Interim approach completed
	Reproductive effort†	Reproductive effort†		
	Nutrient status†	Nutrient status†		
	Biomass†	Biomass†		
	Area†	Area†		
	Species composition†	Species composition†		
Fish	TBC	TBC	TBC	Aspirational

*Each AIMS coral survey site is monitored every two years. †Interim display for seagrass indicators. Water quality data is sourced from the Marine Monitoring Program (AIMS and JCU). Coral data is sourced from the Marine Monitoring Program and the Long Term Monitoring Program (AIMS). Seagrass data is sourced from the Marine Monitoring Program and the Queensland Ports Seagrass Monitoring Program (JCU).

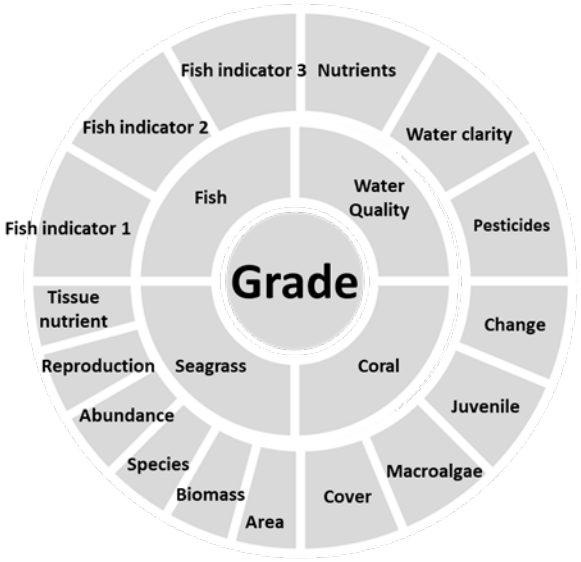


Figure 11. Example circle diagram with indicator categories and indices for each of the four inshore marine zones.

Offshore marine

The indicators and indicator categories selected for reporting the state and condition of offshore environments are grouped into the three indices of water quality, coral and fish (Table 10). The indicator category, index and overall grades are presented as a circle diagram (Figure 12) and the standard colour coding and grading scheme will be applied.

Table 10. Indicators used to determine a score for the environmental condition of the offshore marine environments.

Index	Indicator category	Indicator	Frequency of reporting	Indicator status
Water quality	Water clarity	Total suspended solids	Annually	Completed
	Chlorophyll-*a*	Chlorophyll-*a*		
Coral	Change in coral cover	Change in coral cover	Annually*	Completed
	Juvenile density	Juvenile density		
	Cover	Cover		
Fish	TBC	TBC	TBC	Aspirational

*Each coral survey site is monitored every two years. Water quality is sourced from the Bureau of Meteorology Marine Water Quality Dashboard. Coral data is sourced from the AIMS Long Term Monitoring Program

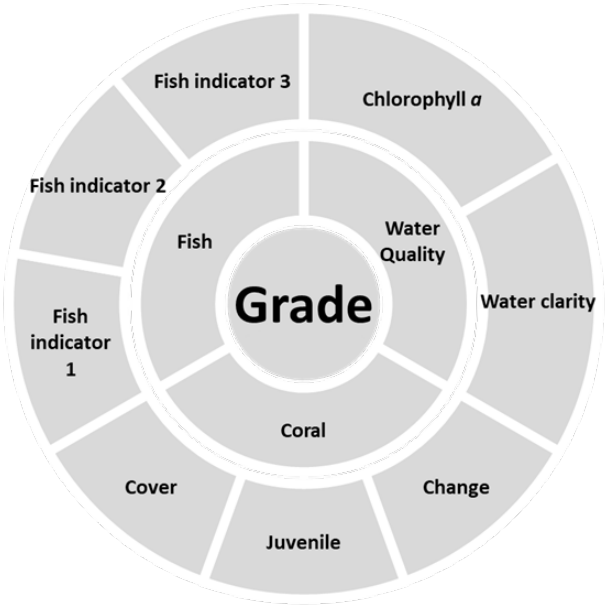


Figure 12. Example of a circle diagram with indicator categories and indices for the offshore marine zone.

5.3. Social, Economic and Cultural Reporting

Social and economic reporting has been based upon results from the GBR Social and Economic Long Term Monitoring Program (SELTMP) including the National Environmental Research Program (NERP) 10.1 and 10.2 projects. These studies were identified as key data resources which established the 2013 baseline using surveys from commercial-fishers, marine-based tourism operators, tourists, local residents, and other Australians. The collation of existing regional datasets was also a key component of the SELTMP.

Results from the SELTMP were used for reporting social and economic values in the Pilot Report Card. The programs provided data for reporting on social connection and community economic values relating to waterways associated with the marine environments. It was acknowledged that future surveys would need to be expanded to include social links and community economic values relating to freshwater environments. In 2017 the second major data-point for the SELTMP has been conducted and results are to be presented in the Report Card for the relevant reporting period.

Frameworks for the reporting of Indigenous and non-indigenous cultural values in addition to social and economic reporting are identified as key outcomes for RIMReP and are being developed through the RIMReP Human Dimensions Expert Working Group and the Indigenous Expert Working Groups. Through the working groups the advancement of a conceptual framework to identify appropriate sets of indicators for characterising the desired

state of the Great Barrier Reef's human dimensions at the whole-of-GBR and regional scales can be established. The Human Dimensions Expert Working Group has identified the use of free and readily available data sets together with a combination of the following monitoring programs as core to meeting human dimensions targets, objectives and outcomes articulated in the Reef 2050 Plan:

- Attitudinal surveys of residents, visitors, Traditional Owners, national and international stakeholders
- Surveys to elicit economic dependency on the Great Barrier Reef
- Analysis of social surveys and big data sets to elicit human use and visitation patterns
- Non-market valuation monitoring
- Recreational fishing effort
- Aesthetics monitoring
- Historic maritime heritage
- Media tracking & analysis
- Insights into stewardship and behaviour change
- Human Dimensions benchmarking
- Governance benchmarking

Through development of frameworks for assessing social, economic and cultural indicators the associated values can be reported for the Wet Tropics region as part of the Report Card. It is expected the indicators will be based upon a range of data from leading research groups and projects including CSIRO (SELTMP), Australian Bureau of Statistics, CQU and JCU, and that the framework will work to standardise core monitoring indicators and ensure cross-regional comparability of reporting.

5.4. Stewardship

Stewardship is an important aspect to include in the Report Card as it provides information on the actions land managers, industries and communities in the region implement to benefit the ecosystems. Reporting on stewardship can also guide future management and investment decisions by showing where leading and innovative practice is in place and where areas of improvement may exist. Stewardship reporting supports the Partnership and Report Card objectives of gauging and communicating stewardship activities. Stewardship reporting also presents links between the management responses that are undertaken to address the impacts and pressures affecting the state of the environment in the adaptive management cycle of the DPSIR framework (section 2.4).

The stewardship activities across different sectors are assessed from key activities relating to waterway health including the levels of best management practice that are adopted within sectors. It is important that the Report Card captures stewardship activities where they are

related to the water quality and waterway health. The following sectors have been identified as important for assessment of stewardship in relation to water quality and waterway health:

- Horticulture
- Grazing
- Sugarcane
- Urban (construction and operational activities under councils including sewage treatment plants (STPs) and developments)
- Ports
- Industry (heavy industry – mining, mills, environmentally relevant activities (ERAs), licenced activities, etc.)
- Tourism
- Fishing (commercial and recreational)
- Aquaculture
- Community

Where available "ABCD frameworks" are used to provide the basis for the stewardship reporting. The Reef Plan Report Card for the Great Barrier Reef includes agricultural stewardship at a regional scale for the grazing, sugarcane, and horticulture sectors and reports on the area (hectares) of land under different management practice levels. This reporting is incorporated into the Wet Tropics Report Card website and the indicators and presentation style used in the Reef Plan Report Card is applied. Starting in 2017 a review of non-agricultural stewardship reporting undertaken by the various Queensland Regional Report Card Partnerships was commissioned by the Department of Environment and Heritage Protection (now Department of Environment and Science). The process has included input by key stakeholders to assess and review stewardship reporting frameworks. Outputs of the review will serve to guide effective reporting of non-agricultural stewardship using appropriate frameworks for future report cards. Contextual reporting of stewardship relating to fisheries, marine debris and waterway rehabilitation for the Wet Tropics region was included in the 2015-2016 Report Card and will continue to be reported until replaced by frameworks that provide standardisation of indicators and cross-regional comparability of reporting.

5.5. Additional Information

The Report Card includes contextual information relating to waterways in the region for the reporting year. Information includes climate and rainfall data which assists with interpretation of results and scores, priority environmental, social and economic issues relating to waterways, and examples of achievements and developments in waterway management and research in the form of case studies. Reporting additional information will incorporate summary text and graphics.

6. REPORT CARD SCORING

6.1. Score Development

The methods for assigning scores for the Report Card were developed with the assistance of personnel who have specialist knowledge and experience in this field. Specific considerations were given to the following:

- Long-term targets and the ability to provide a score for the trend toward achieving the long-term target
- Incorporation of existing targets for the area
- How the current state is assessed
- The actual meaning of the final score
- Ensuring the Report Card's comparability with other report cards and programs.

The scoring methods for assessing environmental state and condition are provided in the latest methods technical report available at the Wet Tropics Healthy Waterways Website (wettropicswaterways.org.au).

6.2. Guidelines and Targets

The process of developing the scoring method incorporates identifying and applying the existing guidelines and targets that have been scheduled, endorsed and recognised for each indicator. Guidelines and targets have been developed for a wide range of metrics and include federal and state water quality guidelines, environment protection policies, water quality improvement plans, NRM plans, and the Reef Plan. The Report Card scoring methods apply the most regionally relevant recognised guidelines and targets for the Wet Tropics, provide consistency with the existing programs, and maintain alignment with the approaches and practices applied in report cards for other regions and areas. For the condition assessment of water quality the most recent scheduled guidelines for the protection of moderately and slightly disturbed waters are applied which up to June 2018 are the EPP (2009) Wet Tropics basins (DEHP 2014) guideline values for freshwater and estuarine environments and the GBRMPA (2010) guideline values for the inshore and offshore marine environments. The Queensland Department of Environment and Science is currently reviewing water quality guidelines for basin, estuarine, coastal and marine waters to provide more locally relevant values. Updated water quality guidelines will be applied to the Report Card scoring when they become scheduled.

6.3. Scoring Categories

The use of ordinal variables, which provide a clear ordering of the score results, are commonly used to categorise the scoring for report cards of waterway health and were used for the Wet Tropics Report Card. They are easy to interpret and comprehend and can be efficiently presented using colour coding in report card style publications.

The simplest option was adopted which is to use an "A" to "E" system, with the corresponding explanation (i.e. "Very Good" to "Very Poor") using "Moderate" as the middle category. This is consistent with the Mackay Whitsunday Partnership and similar to the Great Barrier Reef (GBR) Report Card.

Examples of the ordinal variables used for Report Card scoring with five categories are:

- SEQ Healthy Waterways: A (Excellent), B (Good), C (Fair), D (Poor), F (Fail)
- Fitzroy Basin: A (Excellent), B (Good), C (Fair), D (Poor), E (Fail)
- GBR Report Card: Very Good, Good, Moderate, Poor, Very Poor
- Mackay-Whitsunday Partnership: A (Very Good), B (Good), C (Moderate), D (Poor), E (Very Poor)
- Gladstone Healthy Harbours Partnership: A (Very Good), B (Good), C (Satisfactory), D (Poor), E (Very Poor).

6.4. Assigning Scores, Categories and Grades

There are a range of approaches for assigning scores, categories and grades for indicators of waterways. A popular method when assessing state or condition against guidelines/targets is to use a standardised numeric scale (e.g. 1 – 100) or a comparison against a set of targets. Each indicator value for each reporting zone is compared to the guideline value/target and its score is calculated according to the difference. A method for assessing status and progress to targets is to set a range of percentages corresponding to score categories where the percentage is calculated according to how closely the guideline value or target has been met (Table 11).

Table 11. Condition score and grading example

Range of indicator condition scores	Condition grade and colour code
81-100	Very Good
61-80	Good
41-60	Moderate
21-40	Poor
0-20	Very Poor

The Wet Tropics Report Card has used the most appropriate, up to date and effective scoring and grading method for all the analysed indicators. For example the scoring methods used by the Marine Monitoring Program for reporting in the GBR Report Card have been adopted and contribute to a consistent approach of reporting for the whole of GBR catchments. This approach has also been conducted for estuarine and freshwater environments. The methods used for the reporting of indicators of environmental condition are described in the *Wet Tropics 2016 Report Card Methods* (WTHWP 2017b).

To promote the effectiveness of the Report Card as a communication tool descriptions of grades for environmental indicators have been developed. Descriptions that apply to indicators that measure condition of water quality and ecosystem health across all environments (basins, estuaries, inshore marine and offshore marine) are provided in Table 12 and descriptions that apply to indicators that measure habitat extent for basins and estuaries are provided in Table 13.

Table 12. Descriptions of environmental condition for water quality and ecosystem health indicators.

Grade	Definition: water quality and ecosystem condition
A: Very Good	Conditions frequently meet guidelines or reference values and the majority of critical habitats are intact.
B: Good	Conditions generally meet guidelines or reference values and most critical habitats are intact.
C: Moderate	Some conditions do not meet guidelines or reference values and critical habitats are usually impacted.
D: Poor	Conditions often do not meet guidelines or reference values and most critical habitats are impacted.
E: Very Poor	Most conditions do not meet guidelines or reference values and most critical habitats are severely impacted.

Reference values are determined from reference sites that are subject to minimal/limited disturbance (DEHP 2009).

Table 13. Descriptions of habitat extent indicators for basins and estuaries (wetlands, riparian vegetation and mangrove and saltmarsh).

Grade	Habitat extent
A: Very Good	Habitat extent is at or very close to pre-development levels
B: Good	Habitat extent is close to pre-development levels
C: Moderate	Habitat extent is moderately departed from pre-development levels
D: Poor	Habitat extent is strongly departed from pre-development levels
E: Very Poor	Habitat extent is severely departed from pre-development levels

Decision rules were applied to define the minimum proportion of information required to generate aggregated scores for indicators and indicator categories. For example ≥ 50% of indicators are required to generate the indicator category score, and ≥ 60% of indicator categories are required to generate the Index score. The aggregated scores are presented in the 2016 Report Card, even if not all indicators or indicator categories are available, however the circle diagram visually shows the components of the overall grade.

6.5. Assessing Confidence of Scores

The report card includes qualitative confidence assessment of the scores for each indicator to show the confidence in the data (and thereby confidence in the subsequent score). The approach used by the GBR report card has been applied for the Wet Tropics Report Card with each indicator in each reporting zone assessed individually (i.e. all indicators for the nine basin zones, eight estuarine zones, four inshore marine zones and one offshore marine zone). Expert opinion is used to review each year's results and aims to accurately represent the scientific understanding and knowledge of the region, whilst incorporating nuances of reporting for the given reporting year.

6.6. Quality Management and Independent Science Review

To provide quality management to all aspects of the Report Card (including program design, methods, scoring calculations, guidelines, targets, benchmarks, results and conclusions) the program applies the governance charter, including the terms of reference of the Partnership's memorandum of understanding, and independent reviews conducted by the Reef Plan Independent Science Panel (ISP). The Reef Plan ISP has provided advice, reviews and endorsement of methodologies, systems and processes at key points during the development of the Report Card and operates in accordance with established Reef Plan ISP Terms of Reference.

The Reef Plan ISP was involved in the following components of the Report Card development:

- Review of the design of the Partnership program
- Review of selected indicators
- Review of scoring method used in the Report Card
- Review of the draft Report Card
- Review of data synthesis results and interpretation
- Review of the final Report Card.

7. FIVE YEAR PLAN

The Program Design provides the plan for the five years of reporting periods from 2016-17 to 2020-21. The aim of the approach is to provide stability of baselines and indicators for reporting of state and condition and the tracking trends. In line with the Wet Tropics Water Quality Improvement Plan (Terrain 2015) and the Reef 2050 Water Quality Improvement Plan the approach for assessing impacts of land use and activities upon waterway health includes urban environments and intensive rural industries in addition to agriculture. The approach involves application of consistent methods for analysis and calculation of scores so that reporting is based upon measured values of indicators, and that differences in scores are due to changes of the values and not due to changes of scoring methodology. Whilst providing stability for the Report Card is an important aim there are also Partnership objectives that may affect stability or reporting particularly though improvements that address knowledge gaps and that increase confidence. Whilst the Partnership objectives "Ensure scientific integrity, independence and transparency using a robust methodology to identify long-term trends, stimulate management action and drive positive change" and "Identify waterway health related knowledge gaps and address them" could affect the stability of reporting they will increase the effectiveness of reporting. Consequently the following procedures are applied to ensure that improvements to reporting are incorporated but minimal change to methodology occurs during the five year plan:

- Update scoring with any new scheduled guidelines for baseline calculations upon their release.
- Fill existing indicator gaps when reporting of indicators becomes available.
- Update scoring with improvements to confidence (e.g. additional sites or increased sampling frequency) when available.
- Update existing indicator methods and scoring methods at the completion of the five year plan following their assessment and review by working groups during the five year plan.
- Incorporate new indicators (i.e. indicators not currently recognised in the Program Design) into aggregated scores after the five year plan, with option to report them separately during the five year plan.

7.1. Report Card Scope and Objectives

The tables below provide the scope and objectives for the Wet Tropics Report Card for reporting years from 2016-17 through to 2020-21. The table's show the reporting periods for which improvement are proposed to be incorporated. The improvements are often dependent upon appropriate external resourcing and may not be achievable if funds are not available for their development and implementation. It is recognised that the objectives

were established during the development of the Report Card and represent valuable components of the reporting strategy which can be advocated for through the Partnership. It is also recognised that collaboration with existing or proposed projects or monitoring exercises can be an effective and efficient approach to achieving the objectives. Projects listed in Appendix A will be reviewed and updated to ensure appropriate consideration of existing and proposed monitoring opportunities is provided.

The scope and objectives for freshwater basins (Table 14) includes expansion of water quality sites and pesticide monitoring of surface waters to all nine basins and has been funded through the CLMP. Assessment of water quality will incorporate new guidelines for high flow and base-flow conditions developed by Binns and Waters (2018) when scheduled. The expansion of the spatial extent of monitoring within each basin is not currently funded and requires appropriate collaborative opportunities to be identified. The data gaps for riparian condition and fish barriers require indicator development and the resourcing for monitoring can then be determined. Expansion of the current GBR wetland condition monitoring is proposed and could address the requirements for regional reporting including that of the Wet Tropics. Initiation of groundwater, flow and fish indicators is now established.

Table 14. Scope and objectives of the five year plan for freshwater basins

Reporting period	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**
Release month	December 2018	July 2019	July 2020	July 2021	July 2022
Water quality					
Surface water: Sediment, Nutrients	Maintain current reporting	Incorporate new flow separation guidelines (Binns and Waters, 2018). Add Mossman (DSC) and Daintree (CLMP) site data:	Add Murray (CLMP) site data. Explore expansion of monitoring outside of CLMP sites: monitoring design, resourcing, collaborations.	**Initiate further** expansion of monitoring outside of CLMP sites in partnership with other programs	**Further** expansion of monitoring outside of CLMP sites in partnership with other programs
Surface water - Pesticides (ms-PAF)	Maintain current reporting	Add Daintree and Barron CLMP site data.	Add Murray (CLMP) site data. Explore expansion of monitoring outside of CLMP sites: monitoring design, resourcing, collaborations	**Initiate further** expansion of monitoring outside of CLMP sites in partnership with other programs	**Further** expansion of monitoring outside of CLMP sites in partnership with other programs

Reporting period	2016-17	2017-18	2018-19	2019-20	2020-21
Groundwater: Salinity, Nutrients, Acidity, Metals	Data gap	Initiate groundwater water quality indicators	Maintain groundwater water quality reporting	Explore monitoring for pesticides	Initiate monitoring for pesticides
Habitat and hydrology					
Riparian extent	Repeat 2013 data	Report new 2017 data	Repeat 2017 data	Repeat 2017 data	Repeat 2017 data
Riparian condition	Data gap	Develop monitoring of riparian condition		Initiate monitoring of riparian condition	Progress monitoring of riparian condition
Wetland extent	Repeat 2013 data	Report new 2017 data			
Wetland condition	Data gap	Explore monitoring of wetland condition	Initiate monitoring of wetland condition	Progress monitoring of wetland condition	
Fish barriers	Data gap	Develop monitoring of fish barriers	Initiate monitoring of fish barriers		
Impoundment	Repeat 2014-15 data		Report new 2018-19 data		
Flow	Initial flow scores reported	Maintain current monitoring. Recommend any expansion of gauging stations	Include any expansion of gauging stations		
Fish community					
Fish community (Native and Pest assessment).	Data gap	Initiate fish monitoring in Mulgrave and Russell Basins	Initiate fish monitoring in further basins	Continue monitoring in further basins	Complete fish monitoring in all basins

Note: DSC is Douglas Shire Council, CLMP is Catchment Loads Monitoring Program.

The scope and objectives for estuaries (Table 15) includes a pilot study and expansion of pesticide monitoring, and expansion of seagrass monitoring, both of which require appropriate resourcing and collaboration. The development of indicators for estuarine riparian condition, mangrove and saltmarsh condition, and fish is required and will be important to determine the extent of resourcing needed for their monitoring. Fish indicators are currently being advanced thought the RIMReP expert group for fish and outcomes from the group will determine the requirements to provide effective monitoring. The integration of eReefs data for inshore water quality reporting to provide improved spatial and temporal representation is to be evaluated (see section 5.1.1).

Table 15 Scope and objectives of the five year plan for estuaries

Reporting period	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**
Release date	December 2018	July 2019	July 2020	July 2021	July 2022
Water quality					
Nutrients, Phys-chem, Chlorophyll-*a*	Maintain current reporting	Add Dickson Inlet (DSC) site data.	Evaluate integration of eReef data with *in-situ* monitoring data		
Pesticides (ms-PAF)	Maintain current reporting (CLMP)		Install passive samplers in all non-CLMP estuaries to determine high risk.	Undertake grab samples in other estuaries identified as high risk in previous year	
Habitat and hydrology					
Estuarine riparian extent	Repeat 2013 data	Report new 2017 data			
Estuarine riparian condition	Data gap	Develop monitoring of riparian condition		Initiate monitoring of riparian condition	Progress monitoring of riparian condition
Mangrove and saltmarsh extent	Repeat 2013 data	Report new 2017 data			
Mangrove and saltmarsh condition	Data gap	Develop monitoring of mangrove and saltmarsh condition		Initiate monitoring of mangrove and saltmarsh condition	
Fish barriers	Repeat 2015-16 data			Report new 2019-20 data	

Reporting period	2016-17	2017-18	2018-19	2019-20	2020-21
Flow	Initial flow scores reported. Recommend gauging expansion to include Dickson Inlet, Moresby.	Develop expansion of gauging stations	Include any expansion of gauging stations		
Seagrass (Species composition, Area, Biomass)	Maintain current reporting	Explore monitoring for Hinchinbrook and Dickson Inlet	Expand monitoring to Hinchinbrook and Dickson Inlet		
Fish community					
Fish indicators	Data gap	Scope estuary fish indicators	RIMReP directed or develop methodology for fish indicators based on scoping study	RIMReP directed or implement data collection program if feasible	RIMReP directed or pilot reporting of estuary fish indicators

Note: DSC is Douglas Shire Council, CLMP is Catchment Loads Monitoring Program.

The scope and objectives for inshore marine (Table 16) includes extending seagrass monitoring to the central and Palm Island zone and the development and monitoring of fish indicators. Full seagrass reporting for the inshore environment requires appropriate resourcing to extend the current monitoring programs (MMP or QPSAMP). The reporting of pesticides using ms-PAF is planned for incorporation into the MMP for the 2018-19 monitoring period and will then be available for regional reporting. Fish indicators are currently being advanced thought the RIMReP expert group for fish and outcomes from the group will determine the requirements to provide effective monitoring. The integration of eReefs data for offshore water quality reporting to provide improved spatial and temporal representation is to be evaluated (see section 5.1.1).

Table 16. Scope and objectives of the five year plan for inshore marine zones

Reporting period	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**
Release date	December 2018	July 2019	July 2020	July 2021	July 2022
	Water quality inshore				
Sediment, Nutrients, Chlorophyll-*a*	Remain with current reporting - all zones reported		Evaluate integration of eReef data with *in-situ* monitoring data		
Pesticides	Remain with current PSII-HEq reporting - all zones reported		Commence reporting of ms-PAF assessment for all zones.		
	Coral inshore				
Cover, Juvenile, Change, Macroalgae, Composition	Remain with current reporting - all zones reported				
	Seagrass				
Composition, Area, Biomass (QPSMP); Abundance, Reproductive effort, Nutrient Status (MMP)	Maintain current reporting (Central and Palm Island gap)		Initiate long-term monitoring in Central and Palm Island zones	Progress long-term monitoring in Central and Palm Island zones	
	Fish community				
Fish indicators	Data gap	Scope inshore marine fish indicators	RIMReP directed or develop methodology for fish indicators based on scoping study	RIMReP directed or implement data collection program if feasible	RIMReP directed or pilot reporting of inshore marine fish indicators

The scope and objectives for offshore marine (Table 17) includes the potential development of water quality reporting for offshore waters though the RIMReP expert group for marine water quality. Fish indicators are currently being advanced through the RIMReP expert group for fish and outcomes from the group will determine the requirements to provide effective monitoring.

Table 17. Scope and objectives of the five year plan for offshore marine zones

Reporting period	2016-17	2017-18	2018-19	2019-20	2020-21
Release date	December 2018	July 2019	July 2020	July 2021	July 2022
Water quality offshore					
Sediment, Chlorophyll-*a*	Maintain current reporting		Directed by RIMReP, evaluate integration of eReef data or maintain current reporting		
Coral offshore					
Cover, Juvenile, Change,	Maintain current reporting				
Fish community					
Fish indicators	Data gap	Data gap	Scope offshore marine fish indicators	RIMReP directed or develop methodology for fish indicators based on scoping study	RIMReP directed or implement pilot reporting if feasible

The eReefs research project is a collaboration between the Great Barrier Reef Foundation, CSIRO, the Australian Institute of Marine Science, Bureau of Meteorology and Queensland Government. The eReefs system models a wide range of marine variables covering physical properties (temperature, current, light penetration) as well as biogeochemical parameters (such as the concentration of nutrients, sediments, plankton and Chlorophyll-*a).* Three-dimensional model outputs are generated for the entire Great Barrier Reef lagoon (from South East Queensland to Torres Strait) at various resolutions (1km and 4km) on a daily basis. It provides information on physical processes, sediment transport, biogeochemistry and ocean colour.

Given the scale of the Great Barrier Reef, it would be impractical to measure and report water quality through the entire domain and at a reasonable frequency using *in situ* monitoring data alone. Satellite imaging can be employed to cover this wide spatial domain but is generally considered to present a lower relative accuracy and is affected by cloud

cover. Therefore, the eReefs deterministic modelling framework is used in conjunction with the *in situ* information collected in the Marine Monitoring Program and satellite observations to extrapolate water quality across the entire Great Barrier Reef.

In addition, marine models can assess the impact of individual rivers flowing into the Great Barrier Reef and estimate the extent and properties of flood plumes (contributing to risk assessments). They can also be used to simulate the impact of different management practices on downstream marine water quality (scenarios and target setting).

The application of eReefs for the Wet Tropics Report Card will apply to both inshore and offshore environments with potential to inform on estuaries and the transport of nutrients, sediments and pesticides relating to basins. The integration of eReefs outputs for the Report Card will develop following the delivery of the second phase which is currently in progress. In a second phase of development a number of Improvements to the modelling framework and water quality calculations are being implemented which can be broadly summarised as follows.

- Improving the modelling of TSS concentration and impact on water clarity by better accounting for the fate of very fine sediments and flocs.
- Improving the modelling of the impact of freshwater discharge by implementing high frequency river forecasting models developed in the first phase by the BoM, allowing the prediction freshwater and contaminant inputs from ungauged rivers and therefore expanding the number of river inputs into eReefs.
- Systematically implementing the higher resolution version of the eReefs model to improve predictions in enclosed coastal areas.
- Reviewing the indicators and relevant guidelines and thresholds underpinning the water quality metric for the Great Barrier Reef Report Card.

The scope and objectives for reporting of human dimensions (Table 18) includes the development of core monitoring indicators with cross-regional comparability for cultural heritage, social and economic values. Reporting frameworks and indicators are being developed through the RIMReP expert working groups. Outcomes from these working groups will also inform the reporting for non-agricultural stewardship values. A framework for reporting non-agricultural stewardship values is being advanced with the OGBR as an outcome for the Regional Report Card Strategic Workshops.

Table 18. Scope and objectives of the five year plan for human dimensions

Reporting period	2016-17	2017-18	2018-19	2019-20	2020-21
Release date	December 2018	July 2019	July 2020	July 2021	July 2022
Cultural heritage		RIMReP directed			
Social/community values	Contextual	Report 2017-18 SELTMP data	RIMReP directed		
Stewardship (non-agricultural)	Contextual	Contextual	RRCSW*/RIMReP directed		
Stewardship (agricultural)	P2R directed				
Economic	Contextual	Contextual	Contextual	Contextual	Contextual
Marine debris	Contextual	RIMReP directed			

*RRCSW is the Regional Report Card Strategic Workshop

The scope and objectives for development of the Report Card website functionally and the management of data are presented in Table 19. Key developments include the incorporation of a time slider for the website scores and results to facilitate presentation of change over time for indicators, a data driven back-end for the website to provide automated updates of the scores and results, the implementation of the SSIMR data base for storage and management of data and results, and the development of a script-driven automated platform for the calculation of scores.

Table 19 Website design and data management

Reporting period	2016-17	2017-18	2018-19	2019-20	2020-21
Release date	December 2018	July 2019	July 2020	July 2021	July 2022
Website design	Initiate time slider and data driven scoring				
Data management	Initiate application of SSIMR database for data and results	Initiate automated calculation of report card scores			

7.2. Prioritisation

The future scope of the Wet Tropics report cards and 2017–2022 objectives cannot all be achieved with current resourcing. Projects required to achieve improvements will rely on additional Partnership investment, external investment and/or collaboration. To assist the Partnership in identifying priority improvements for directing resources and investment the Technical Working Group has ranked the improvements in terms of their priorities within the context of technical outcomes for the report card. The focus of the prioritisation is on environmental reporting. The prioritisation is for general improvements (Figure 13) and specific improvements (Figure 14) which relate directly to the five year objectives described in section 7.1. The prioritisation process ranks the improvement of confidence and filling data gaps for the current reporting activities the highest. The prioritisation ranking supports the Partnership objectives to "ensure scientific integrity, independence and transparency using a robust methodology" and to "identify waterway health related knowledge gaps and address them".

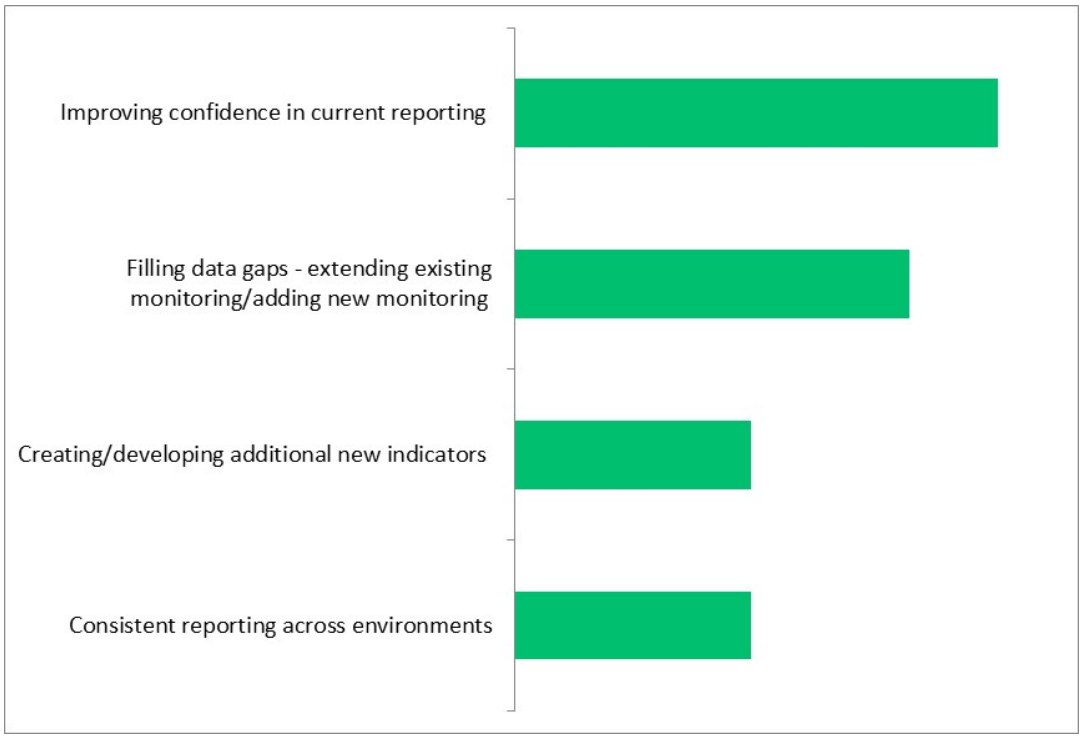


Figure 13. Prioritisation for general improvements of the Report Card

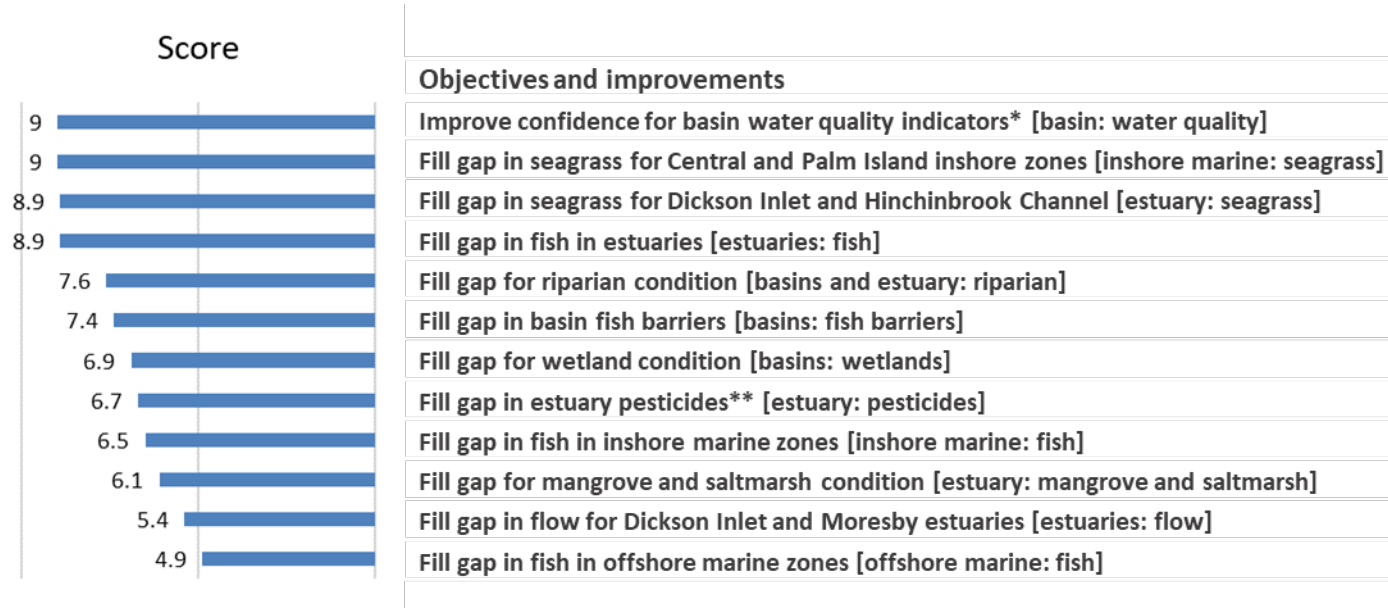


Figure 14. Prioritisation for specific improvements of the Report Card. Note *basin water quality to be improved through more sites for greater spatial representation; **the estuary zones with pesticide monitoring gaps are Dickson Inlet, Barron, Trinity Inlet, Moresby and Hinchinbrook Channel.

7.3. Release schedule

The Report Card release schedule (Table 20) is planned to reduce the period between data collection and report card release as from the 2017-18 reporting period with the month of release changing from December to July. Constraints on data availability due to quality management and review processes prevent an earlier report card release with all reporting components included. Earlier release dates will continue to be negotiated and are possible if quality management and review processes become more streamlined.

Table 20. WT reporting schedule for the five year plan period. Shades of blue identify where data is repeated for indicators reported at frequencies >1 year and thus when new data is reported for these indicators. Environments are abbreviated to FW for freshwater basins, EST for estuaries, IM for inshore marine and OM for offshore marine.

Reporting period		**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**
Release year		2018	2019	2020	2021	2022	2023
Release month		Dec	July	July	July	July	July
		Five year plan period					
Indicators and data collection	**Freq-uency (yrs)**	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**
Water quality (FW, EST, IM, OM), ,	1	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Coral (IM, OM)	1	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Seagrass (EST, IM)	1	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Flow (FW/EST)	1	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Groundwater water quality (FW)	1[#]	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Invasive weeds (FW)	4	2015-16	2015-16	2015-16	2019-20	2019-20	2019-20
Fish (FW)	3-5		2017-18	2017-19	2017-20	2017-20	2017-20
Riparian (FW and EST)	4	2013-14	2017-18	2017-18	2017-18	2017-18	2021-22
Mangrove/Saltmarsh (EST)	4	2013-14	2017-18	2017-18	2017-18	2017-18	2021-22
Wetland (FW)	4	2013-14	2017-18	2017-18	2017-18	2017-18	2021-22
Impoundment (FW)	4	2014-15	2014-15	2018-19	2018-19	2018-19	2018-19
Fish barriers (FW)	4			2018-19	2018-19	2018-19	2018-19
Fish barriers (EST)	4	2015-16	2015-16	2015-16	2019-20	2019-20	2019-20
Agricultural stewardship	1	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22

[#]Groundwater water quality is updated every year using a rolling average of the data which is collected according to the three year rostered Groundwater Ambient Network monitoring program conducted by DNRM.

7.4. Report Card Review

The report card plan provides a five year period for stable reporting and this also provides an opportunity to review the effectiveness of report card components over this duration. As described in the opening of section 7, changes that affect the scoring and reporting methodology are not introduced until the end of the five year plan period. The five year

plan allows for reviews and development of report card components to be conducted as required during the period with approved improvements and changes implemented at the end of the plan. Table 21 presents the Report Card components that are to be reviewed during the five year plan period and (Table 22) presents possible new indicators that could be developed during the five year plan period.

Table 21. Report card components and reviews to be conducted during the five year plan period.

	Report card components	Five year plan period (2018 – 2022) review
EXTENT	Nine freshwater basin reporting zones	Review effectiveness of basin scale reporting and spatial representativeness of monitoring
	Eight estuary reporting zones	Identify additional estuary locations that have regional significance for reporting and spatial representativeness of monitoring
	Four inshore reporting zones	Review effectiveness of four reporting zones for inshore representation
	One offshore	Review effectiveness of one reporting zone for offshore representation
INDICATORS	Indicator monitoring methods	Review effectiveness of indicator monitoring including aspects related to confidence such as spatial and temporal representation, error and currency of methods.
	Indicator scoring methods	Review effectiveness of indicator scoring methods including, baselines, scaling, aggregation and placement of indicators.
	Current indicators	Review effectiveness of current indicators and revise inclusion and placement as required.
	New indicators	Assess and evaluate new indicators and determine scoring methods and placement
Framework	Conceptual framework	Review application of conceptual framework and update components of framework to align with improved knowledge
	Conceptual diagram	Update conceptual diagram to align with conceptual framework advances and improved knowledge of waterway values and interactions.

Table 22. Potential new indicators to be developed during the five year plan period.

Environment	Indicator	Current limitations
Basins	Groundwater indicator for basins to assess groundwater and surface water interactions, water table levels and saltwater intrusions.	Methodology development required Appropriate monitoring and modelling of saltwater intrusion and surface water – groundwater interactions required.
Basins and estuaries	Water quality indicators for metals, micro-contaminants and endocrine disruptors	Methodology development and monitoring program required.
Inshore and offshore marine	Iconic species: turtles, dugongs.	Methodology development and monitoring program required

8. PROGRAM MANAGEMENT

The Wet Tropics Healthy Waterways Partnership program is managed by the Partnership in accordance with the Governance Charter. The Governance Charter outlines the purpose and objectives of the Partnership and contains guidelines for operational structures, responsibilities and roles, and for the Memorandum of Understanding.

It is important that steps be taken by the Partnership to make data available and accessible to inform the development of the Report Card. Where data is made available to the Partnership that is not intended for public release, the data owner reserves the right to enter into a data sharing agreement with the Partnership to maintain data confidentiality.

To ensure transparency and robustness of the Report Card and associated findings, the data will be available in its raw format, as well as in a summarised format. If required, the original data can be reviewed, which will also provide further confidence in the project.

It is essential that existing systems are utilised where possible to minimise costs and duplication and improve integration with other programs. The use of the Spatial and Scientific Information Management for Reef (SSIMR) has been identified as an effective system for data management for the program and will be trialled from 2018.

9. MANAGEMENT RESPONSE TO THE REPORT CARD

To address the Partnership objectives “identify waterway health related knowledge gaps and address them, identify priority activities and efforts and advocate for them, and participate in the coordination of a regional management response to the Report Card findings” a Management Response will be produced by the Partnership to identify and prioritise management actions in response to the Report Card. The Management Response will be produced once the Partnership has adopted targets for the region. The Management Response is developed separately to the Report Card and Program Design.

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APPENDIX A - INVENTORY OF MONITORING PROGRAMS IN THE WET TROPICS REGION

Table A1. Library of monitoring programs that currently provide data for environmental reporting in the 2016 Report Card.

Program	Lead Organisation	Objectives	Indicators	Environment	Scale/ Location	Monitoring Frequency	Currency of program	Program Links	Links	Comments
P2R Integrated Monitoring, Modelling and Reporting Program: Catchment Loads Monitoring Program (P2R)	DSITI	Large-scale water quality monitoring program conducted along the east coast of Queensland. It measures annual loads (mass) of total suspended solids and nutrients from 14 priority catchments and both annual loads and annual toxic loads of pesticides from 12 priority catchments that discharge to the Great Barrier Reef. This program is part of the Reef Water Quality Protection Plan (Reef Plan), updated in 2013, and the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (Paddock to Reef Program).	Discharge, Total nitrogen (TN), Total dissolved nitrogen (TDN), Oxidised nitrogen (NOx), Ammonia (NH3), Dissolved organic nitrogen (DON), Total phosphorus (TP), Total dissolved phosphorus (TDP), Dissolved phosphorus (DOP), Filterable reactive phosphorus (FRP), Total suspended solids (TSS), Particle size analysis (at select sites), Pesticides and herbicides (at select sites),	Freshwater Estuarine	End of System: Barron, Russell, Mulgrave, Johnstone, Tully, Herbert.	Baseflow: monthly. High flow events	Current (start: 2005)		http://www.reefplan.qld.gov.au/measuring-success/paddock-to-reef/assets/2013-2014-gbr-catchment-loads-summary.pdf	
P2R Integrated Monitoring, Modelling and Reporting Program: Riparian vegetation	DSITI	The objective of this component is to map and report on riparian vegetation extent and cover within the Great Barrier Reef catchments. Reporting covers the historic (pre-clearing) extent to 2009, 2013 and 2016 and clearing from 2001 to 2016. This work will also provide improved data on riparian vegetation extent and cover to improve water quality model parameterisation. Riparian vegetation has been identified as a key element in removing water-borne pollutants and providing stability to stream banks and adjoining areas to reduce sediment mobilisation.	Mapped riparian vegetation	Riparian	GBR - regional	Four year intervals				
P2R Integrated Monitoring, Modelling and Reporting Program: Catchment modelling	DNRM	A summary of the estimated sediment, nutrient and PSII herbicide loads discharged from all GBR catchments and secondly the progress made towards achieving the Reef Plan 2009 water quality targets	WQ - Modelling component separate to Loads monitoring. Nutrient loads, sediment loads, pesticide loads	Freshwater	All Wet Tropics basins	Annual reporting	Current (start: 2010)		http://reefplan.qld.gov.au/measuringsuccess/paddock-to-reef/assets/great-barrier-reef-catchment-modelling-report.pdf	Catchment pollutant loads. Progress to targets.
P2R Integrated Monitoring, Modelling and Reporting Program: Wetland Extent	QLD Herbarium, DSITI	To map and report on the historic (pre-clearing) and current extent of wetlands and change in wetland extent every four years from 2001 to 2013 with a repeat activity planned for 2017 (subject to resourcing).	Wetland Extent, Wetland Type, Change in Wetland Extent	Freshwater Estuarine	GBR - regions: WT	2005-2012, completed every 4 years aligned with SOE reporting	Ongoing			Change in wetland extent is already incorporated into Reef Report Card Reporting every 4 years
Surface Water Ambient Network	DNRM	Collect information to assist the management and assessment of Queensland's surface water resources and collect ambient water quality data (over a range of flow conditions) at a selection of stream gauging stations to enable the assessment and reporting of condition and trend of Queensland's freshwater aquatic ecosystem health.	Electrical conductivity at 25º C, pH at 25º C, Temperature + a range of other phys/chem indicators at selected sites including NOx, Ammonia-N, FRP, TSS, D.O. Chlorophyll-*a*, Turbidity, EC, pH.	Freshwater	The Network consists of over 200 stream gauging station sites across Queensland	Monitoring frequency is defined in the approved network list and is variable	Ongoing		https://watermonitoring.dnrm.qld.gov.au/wini/documents/SW_WQ_Network_2014.pdf	Relevant to FW basin monitoring and reporting. WQ monitoring variables and frequency for sites to be assessed
Surface Water Monitoring Network	DNRM	Collect information to assist in the management and assessment of Queensland's surface water resources and to use the data to develop water resource plans, monitor for resource operations plan compliance, assist engineering solutions in road and bridge building and inform the Bureau of Meteorology of river heights at gauging station locations	Time series data for river height, discharge and flow. Rainfall and time series water quality parameters at a subset of sites: electrical conductivity and temperature	Freshwater	The Surface Water Level Network consists of 400 stream gauging stations across Queensland	Continuous 1960-current	Ongoing		https://www.dnrm.qld.gov.au/water/water-monitoring-and-data/portal	High relevance for flow indicator
Gordonvale waste water treatment	Cairns Regional Council	Compliance monitoring	Surface water: Ammonia, NOx, Total N, FRP, Total P, Chlorophyll-*a*, pH, DO, EC, temperature, bacteria (Feacal Coiliforms,	Freshwater and estuarine	FW Upstream sites Behana Ck x 1, Mulgrave River x 2 downstream sites Mulgrave	Surface water 3/year (dry season, May-Dec) Biological - 1/year.		Part of the DSITI estuary		Ecological monitoring to cease 2016. Estuary site monitored as part

Program	Lead Organisation	Objectives	Indicators	Environment	Scale/ Location	Monitoring Frequency	Currency of program	Program Links	Links	Comments
plant - monitoring plan			Enterococci), flow rate. Ecological: Freshwater macroinvertebrates. Groundwater: Well head height, Total metals, thermotolerant Coliforms, TN, TP, ammonia, pH, EC, Temperature.		R. x 2. Estuary Mulgrave R. mouth x 1. Ecological: 6 sites. GW: WWTP site x 2	Ground water - 4/year,		monitoring program		of DSITI estuary monitoring.
Northern waste water treatment plant - monitoring plan (Barron River)	Cairns Regional Council.	Compliance monitoring	Surface water: Ammonia, NOx, Total N, FRP, Total P, Chlorophyll-*a*, pH, DO, EC, temperature, bacteria (Feacal Coiliforms, Enterococci). Ecological: Estuarine macroinvertebrates. Groundwater: Well head height, Total metals, thermotolerant Coliforms, TN, TP, ammonia, pH, EC, Temperature.	Freshwater and Estuarine	FW: upstream sites L. Placid x 1. Estuarine: upstream sites Barron River x 2 , downstream sites Barron R. x 3 . Ecological sites x 4. GW WWTP site x 4	Surface water 3/year (FW), 6/year (Estuary) (dry season, May-Dec) Ecological - 1/year. Ground water - 4/year,	Current (revised program 2013)	Part of the DSITI estuary monitoring program		Ecological monitoring to cease 2016. Some estuary sites monitored as part of DSITI estuary monitoring.
Babinda Waste water treatment plant - monitoring plan	Cairns Regional Council	Compliance monitoring	Surface water: Ammonia, NOx, Total N, FRP, Total P, Chlorophyll-*a*, pH, DO, EC, temperature, bacteria (Feacal Coiliforms, Enterococci), flow rate. Ecological: Freshwater macroinvertebrates.	Freshwater	Upstream sites Frenchmans Ck x 1, Babinda Ck x 3. Downstream sites x 2. Ecological: 4 sites.	Surface water 3/year (dry season, May-Dec) Biological - 1/year.				Shares downstream estuarine site at Mulgrave R. with Gordonvale WWTP. Ecological monitoring to cease 2016.
Tully Waste Water Treatment Plant	Cassowary Coast Regional Council	Receiving environment monitoring program (REMP)	Ammonia as N, B.O.D. 5, D.O., Daily Volume, Faecal Coliforms, Nitrogen - Oxidised (NOx as N), Nitrogen - Total, Phosphorus - Total, Suspended Solids, pH	Freshwater	Banyan Creek. Wildsoet Street, Tully. 3 sites	Monthly (12 per year)				
Ingham Sewage Treatment Plant	Hinchinbrook Shire Council	Compliance monitoring	B.O.D. 5, D.O., Daily Volume, Faecal Coliforms, Free Residual Chlorine, TSS, pH, TN, TP	Freshwater	4 sites on Palm Creek via Hinchinbrook Community Wetlands; 2 sites on Herbert River - Ingham River pump station, and Gairloch Bridge.	monthly	Ongoing			
Mossman Sewage Treatment Plant	Douglas Shire Council	Compliance monitoring	Total Nitrogen, Total Oxidised Nitrogen, Ammonia, Total Phosphorus, Faecal Coliform *In situ* measurements: pH, Conductivity, Turbidity, Temperature	Freshwater and estuarine	Mossman River upstream of the junction with South Mossman River 5.4 km AMTD. Junction Road, Mossman. 4 upstream sites (freshwater), 4 downstream sites (freshwater-estuarine)	4 + / year (excludes wet season)				
Wet Tropics Pests and Weed Monitoring and Management	FNQ RoC, Terrain, Local Governments	Monitor and map pests and weeds throughout the Wet Tropics region. Develop management plan and targets. Report on condition and progress to targets	Presence and frequency of weed species: instream and riparian vegetation	Freshwater. Estuarine. Marine: offshore islands	WT region. Subcatchments and 1 km grid mapping.	Continuous	Ongoing			Travis Sydes
Fish barrier audit	CSIRO	Identification of artificial physical barriers in the Wet Tropics bioregion, Far North Queensland, Australia, through a desktop GIS analysis of the stream/river and transport networks. A total of 5,536 potential artificial, physical barriers to fish passage were identified in a stream network of 19,764 km at a scale of 1: 100 000	instream barriers - GIS	Freshwater	WT region	2010	Complete			Study completed (Lawson *et al*. 2010). Spatial data provides baseline for fish barrier indicator. Kroon-Phillips 2015 used same data

Program	Lead Organisation	Objectives	Indicators	Environment	Scale/ Location	Monitoring Frequency	Currency of program	Program Links	Links	Comments
Seagrass habitat of Cairns Harbour and Trinity Inlet	Ports North, TROP-Water, JCU	1. Map and quantify the distribution and abundance of selected seagrass monitoring meadows. 2. Compare monitoring results with previous seagrass surveys and assess changes in relation to natural events, port and catchment activities. 3. Assess seagrass condition and recolonisation quarterly at four key locations to assess seasonal changes and act as sensitive receptor monitoring sites for the proposed Cairns Shipping Development Project. 4. Measure and analyse benthic light (Photosynthetic Active Radiation (PAR) and temperature and how these change with seagrass condition. 5. Assess the capacity for seagrass recovery and recolonisation through assessment of seed-banks and reproductive effort. 6. Use the information collected to assist in determining drivers of seagrass change and quantifying local seagrass light thresholds for use in appropriate dredge management strategies. 7. Based on the results of the first year of quarterly assessments, determine if any restoration or assisted recovery may be warranted for Cairns seagrasses.	Sea grass distribution, abundance, biomass, diversity, seedbank and recolonisation; benthic light and temperature.	Estuarine: mid estuary, lower estuary. Marine: Inshore - enclosed coastal. Inshore open coastal	Three monitoring meadows - estuarine. Three monitoring meadows - inshore. Intertidal and subtidal	Annually to 2013. Quarterly 2013	Ongoing			Negotiating access to data, confidentiality requirements / any restrictions of use Likely to be very relevant for proposed Cairns report card
Trinity inlet water quality monitoring	Ports North.	Monitor impacts of port related activities on the water quality of Trinity Inlet: Provide baseline information for comparison to dredging activities in Trinity Inlet; Provide baseline bacteriological information that will aid determination of compliance with ANZECC Water Quality Guidelines for Primary Contact (swimming).	DO, Conductivity, pH, Temperature, Turbidity (NTU profile) Metals: Arsenic, Copper, Cadmium, Lead, Zinc, Chromium, Ammonia (Selected Sites), Total Nitrogen (Selected Sites), Oxidised Nitrogen (Selected Sites), Total Phosphorus (Selected Sites), Faecal Coliform Chlorophyll-*a*, Tributyltin(Selected Sites)	Estuarine	Trinity Inlet. Nutrients at 3 selected sites. Tributyltin (anti fouling) at 3 selected sites). 9 sites in program.	4/year. Quarterly, on the new moon, starting half an hour after the high tide.		Part of the DSITI estuary monitoring program		Contact: Adam Fletcher
Mourilyan Harbour Long-term seagrass monitoring	Ports North, TROP-Water, JCU	1. Map seagrass distribution, abundance and species composition within long-term monitoring meadows in the Mourilyan Harbour. 2. Assess changes in these monitoring meadows since the previous survey in 2012, and compare results with the long-term dataset and other monitoring programs throughout Queensland. 3. Assess the seedbank of *Zostera muelleri* in Bradshaw Island (Monitoring Meadow 1) sediments to determine the likelihood of recovery from seeds. 4. Discuss the implications of monitoring results in relation to the overall health of Mourilyan Harbour and provide advice for management.	Sea grass distribution, abundance, biomass, diversity and seedbank	Estuarine - Lower estuary	Five monitoring meadows in Intertidal and shallow subtidal zones.	Annually	Ongoing		http://www.portsnorth.com.au/files/pdf/Mourilyan%20Seagrass%20Monitoring%202011.pdf	Negotiating access to data, confidentiality requirements / any restrictions of use Likely to be very relevant for proposed Cairns report card
Port Douglas Sewage Treatment Plant	Douglas Shire Council	Compliance monitoring	Total Nitrogen, Total Oxidised Nitrogen, Ammonia, Total Phosphorus, Faecal Coliform *In situ* measurements: pH, dissolved oxygen (% and mg/l), Conductivity, salinity, Temperature, Turbidity	Estuarine	Treated effluent to be released to Dicksons Inlet. Port Road.4 upstream sites, 4 downstream sites.	4 / year. Every two months (excluding wet season)				
Edmonton waste water treatment plant - monitoring plan. Southern Waste water treatment plant - monitoring plan	Cairns Regional Council	Compliance monitoring	Surface water: Ammonia, NOx, Total N, FRP, Total P, Chlorphyll-*a*, pH, DO, EC, temperature, bacteria (Feacal Coiliforms, Enterococci). Ecological: Estuarine macroinvertebrates. Groundwater: Well head height, Total metals, thermotolerant Coliforms, TN, TP, ammonia, pH, EC, Temperature.	Estuarine	Total upstream and downstream sites. Trinity Inlet x 8. Ecological sites x 9. GW WWTP sites Edmonton x 3, Southern x 3.	Surface water 3/year (dry season, May-Dec). Ecological - 1/year. Ground water - 4/year,	Current (revised program 2013)	Part of the DSITI estuary monitoring program		Edmonton and Southern programs share receiving environment monitoring sites. Groundwater monitoring sites are separate. Ecological monitoring to cease 2016

Program	Lead Organisation	Objectives	Indicators	Environment	Scale/ Location	Monitoring Frequency	Currency of program	Program Links	Links	Comments
Marlin Coast Waste water treatment plant - monitoring plan	Cairns Regional Council	Compliance monitoring	Surface water: Ammonia, NOx, Total N, FRP, Total P, Chlorphyll a, pH, DO, EC, temperature, bacteria (Feacal Coiliforms, Enterococci). Ecological: Estuarine macroinvertebrates. Groundwater: Well head height, Total metals, thermotolerant Coliforms, TN, TP, ammonia, pH, EC, Temperature.	Estuarine	Upstream and downstream sites Moon River x 5 Ecological sites x 4. GW WWTP sites x 4. McGregor Road, Smithfield Heights	Surface water 6/year. Ecological - 1/year. Ground water - Quarterly,	Current (revised program 2013)			
Innisfail Sewage Treatment Plant	Cassowary Coast Regional Council	REMP	Ammonia as N, B.O.D. 5, D.O., Daily Volume, Faecal Coliforms, Nitrogen - Total, Oil & Grease, Phosphorus - Total, Suspended Solids, pH	Estuarine	Treated effluent from the plant release point to Nind's Creek. Coquette Point Road. Four sites - 2 Ninds Creek, 2 Johnstone estuary confluence	4/year	Ongoing	Part of the DSITI estuary monitoring program		Incorporated into DSITI estuary monitoring. See that program for additional WQ indicators.
DSITI estuary monitoring program. Collaboration with Local Government.	DSITIA	Monitoring WQ and ecosystem health of key estuaries. Will co-ordinate with local government and Ports North estuary monitoring.	Temperature, EC, pH, DO, turbidity, secchi depth, Chlorophyll-a, TN, ammonia-N, Oxidised N, TP, FRP	Estuarine	Multiple sites at 8 estuaries: Daintree, Dickson Inlet, Barron, Trinity inlet, Mulgrave-Russel, Johnstone, Moresby, Hinchinbrook Channel.	6/year	Ongoing	CRC WWTTP monitoring (Barron, Trinity Inlet, Mulgrave). CCRC STP (Johnstone) PN (Trinity Inlet)		
AIMS Long-term Monitoring Program	AIMS	Monitor the status of coral reefs of the GBR Surveillance monitoring / situational awareness / tracking long-term changes	On core reefs: • Cover of ~75 categories of benthic organism • Abundance of >200 spp. of reef fishes • Size of exploited fishes • Records coral disease, Drupella, Abundance of juvenile corals. On both core reefs & manta tow only reefs: • No. of Acanthaster, reef wide cover of living and recently dead coral, abundance of coral trout and reef sharks. Three sites each with 5, 50m transects. Fishes in 7 Families are surveyed by visual census. Cover of benthic organisms (70 categories) estimated from still images along transect.	Marine	Marked sites in standard habitat (NW slope) on each reef. Survey reefs also manta towed to give reef-wide context. Intensive survey sites grouped by cross-shelf position (inner mid-shelf outer) and into 6 bands of latitude Core reefs: 9 reefs Manta tow only: 7 reefs Approx 20 sites Intensive surveys of sites on 47 reefs between Lizard Is region (14.6 S) and Lady Musgrave Is (23.8 S) Broadscale (manta tow) surveys of Acanthaster and reef-wide coral cover between Cape Grenville and Capricorn-Bunkers	Initially intensive survey sites surveyed annually up to 2005-06 season, then in alternate years 2007-08 on Core sites monitored once per year in alternate years, manta tow only reefs are surveyed more irregularly	Ongoing		http://www.aims.gov.au/docs/research/monitoring/reef/sampling-methods.html	Long term record, comprehensive sampling of a number of sites. Data available through Hugh Sweatman.

Program	Lead Organisation	Objectives	Indicators	Environment	Scale/ Location	Monitoring Frequency	Currency of program	Program Links	Links	Comments
Seagrass Watch	Seagrass Watch	To educate the wider community on the importance of seagrass resources. To raise awareness of coastal management issues. To build the capacity of local stakeholders in the use of standardised scientific methodologies. To conduct long-term monitoring of seagrass & coastal habitat condition. To provide an early warning system of coastal environment changes for management. To support conservation measures which ensure the long-term resilience of seagrass ecosystems	Extent of coverage, species composition, estimates of abundance, presence of epiphytes and macro-algae, presence of dugong feeding trails. Additional data is collected on canopy temperature and local water quality, sediment indicators, and light loggers.	Marine	Torres Strait, Cooktown to Moreton Bay	Varies locally, 1-3 surveys annually	Current in 2015		http://www.seagrasswatch.org/home.html	Initial analysis of suitability of data for inclusion in report cards may be required, and whether data can be added to other seagrass data, depending on collection methods.
(MMP) Inshore Seagrass Monitoring	JCU	To detect change in inshore seagrass meadows in response to improvements in water quality associated with improving land use practices in coastal catchments and with disturbance events.	Seagrass abundance, community composition, epiphyte cover, sediment composition, canopy height, reproductive structures (flower production, seed and seed bank monitoring), tissue samples, nutrient status (carbon, nitrogen and phosphorus) leaf isotopic signatures (carbon and nitrogen), light and temperature.	Marine	41 intertidal and 4 sub-tidal locations between Shelbourne Bay and Urangan	21 locations adjacent to key rivers are sampled twice a year: in the late monsoon and late dry seasons. All other locations are only sampled once a year in the late dry season.	Ongoing		http://www.gbrmpa.gov.au/managing-the-reef/how-the-reefs-managed/reef-2050-marine-monitoring-program	
(MMP) Inshore Coral Reef Monitoring	AIMS	To detect change in inshore coral reef communities in response to improvements in water quality associated with improving land use practices in coastal catchments and with disturbance events	Hard and soft coral cover, cover of macroalgae, density of juvenile corals, and prevalence of coral disease, crown-of-thorns starfish, Drupella, physical damage, Cliona, coral bleaching	Marine	36 locations between Snapper Island and Peak Island	Biennial surveys of all locations	Ongoing		http://www.gbrmpa.gov.au/managing-the-reef/how-the-reefs-managed/reef-2050-marine-monitoring-program	
(MMP) Inshore Water Quality Monitoring – Ambient Water Quality Sampling	AIMS and JCU	To determine the status of marine water quality in coastal and inshore regions of the GBR lagoon and assess long-term trends in water quality on the GBR, as well as to better understand how extreme weather events affect water quality conditions in the GBR.	Includes concentrations of nutrients and organic carbon (particulates and dissolved), Chlorophyll-*a*, total suspended solids, pesticides, coloured dissolved organic matter, Secchi depth, CTD casts, and salinity.	Marine	28 fixed monitoring locations, 27 wet season samples plus contingency to do additional sampling in high flow conditions between Cape Tribulation and Pioneer River	Water quality is sampled three times a year at the Cairns Transect, 11 times at Russell Mulgrave and Tully focus areas.	Ongoing		http://www.gbrmpa.gov.au/managing-the-reef/how-the-reefs-managed/reef-2050-marine-monitoring-program	Information from floods not representative of average loads but useful to show trends in flood loads over time and as a case study in flood years
Effects of rezoning on offshore coral reef systems	AIMS	To track the development of effects of rezoning the GBRMP in 2004	1. manta tow surveys for crown-of-thorns starfish and reef-wide coral cover (broadscale surveys), counts of juvenile corals, agents of coral mortality (disease, drupella). 2. surveys of sessile benthic organisms (~70 categories) using still images, visual counts of reef fishes (7 families).	Marine	5 sets of reefs between Cooktown and the Cap-Bunkers	Alternate years	Current in 2015			Limited to North QLD, may be relevant to Wet Tropics report card?

Table A2. Library of monitoring programs that could provide potentially useful data for environmental reporting for future report cards.

Program	Lead Organisation	Objectives	Indicators	Environment	Scale/Location	Monitoring Frequency	Currency of program	Program Links	Online links	Comments
P2R Integrated Monitoring, Modelling and Reporting Program: Wetland functions and values	DSITI	The objective of this component is to assess and report on wetland pressures, ecological processes and status of values to inform the ongoing management of both wetlands and catchment landscapes for improved landscape function and water quality. The project will deliver a case study assessment of a limited number of lacustrine and palustrine (lakes and freshwater vegetated swamps) wetlands. There are over 23,000 mapped wetland areas in the Great Barrier Reef catchments with over 5500 identified as having high ecological significance. This work will inform the ongoing management of both wetlands and catchment landscapes for improved landscape function and water quality in the Great Barrier Reef catchments.	Vegetation, land use, hydrology, pressures.	Wetlands	GBR - regional. Currently 8 wetlands assessed in WT region.	TBC	Ongoing.			Report on ecological processes and environmental values of natural wetland for Reef Plan targets. Contact: Maria VanderGragt
EFAP Wet Tropics	DNRM:	To assess the effectiveness of the rules and strategies specified under the Water Resource Plans and Resource Operations Plans in achieving the ecological outcomes stipulated within each Water Resource Plan.	Flow, hydraulic habitat, fish (Jungle perch). Remote camera.	Freshwater Estuarine	Behana Gorge; Teresa Ck - Milla Falls, Tully Weir	TBC	Ongoing			Further programs to be developed. Contact: Stephen Mackay
EFAP Barron	DNRM	To assess the effectiveness of the rules and strategies specified under the Water Resource Plans and Resource Operations Plans in achieving the ecological outcomes stipulated within each Water Resource Plan.	Flow, hydraulic habitat, fish recruitment (Rainbow fish), fish diversity and relative abundance, food web structure, Ecosystem metabolism, Macrophyte mapping	Freshwater	Barron R. Below falls	Dry season 2005 - 2007.	Complete			Further programs to be developed. Contact: Stephen Mackay
Groundwater ambient network (GWAN) – Water quality	DNRM	This program aims to provide: Information to assist in the management and assessment of Queensland's underground water resources; and, a minimum groundwater water quantity information dataset to assist water resource planning processes.	Manual sampling at all sites: Unfiltered nutrient samples – total nutrients (total phosphorus and total nitrogen) -Filtered nutrient samples – speciated nutrients (orthophosphate, oxidised nitrogen, ammonium) In-situ (on-site) sampling at all sites, Continuous time series measurements at a subset of sites: -Electrical conductivity at 25º C, -pH at 25º C, -Temperature	Groundwater	QLD-wide		Ongoing		Qld globe	Dependent on development of GW as an indicator
Groundwater Level Network	DNRM	The program aims to provide: Information to assist in the management and assessment of Queensland's underground water resources A minimum groundwater water quantity information dataset to assist water resource planning processes.	Bore water levels	Groundwater	QLD-wide	Sites are monitored monthly, bi-monthly, or quarterly	Ongoing		https://www.dnrm.qld.gov.au/water/water-monitoring-and-data/portal	Dependent on development of GW as an indicator
NESP Project 25. Real Time Water Quality Monitoring Program	JCU: Aaron Davies	This project will combine recent hotspot identification in GBR sugarcane catchment of the Russel/Mulgrave with targeted cane farmer interaction activities (related to subcatchment and localized monitoring activities), focusing on emerging monitoring technologies (real-time water quality monitoring) to link farmer on-farm practices with feedback from subcatchment water quality measurements.	Nutrients TBC. Real time nitrate logging	Freshwater	7 sites in the Russel Basin (Mulgrave Basin TBC)	Continuous (3 sites. Grab or suto sampling 4 sites. Frequency TBC.	To commence mid 2016 - 19. 3 year life with possibility of extension			
Babinda Wetland	Jaragun: Liz Price.	Constructed wetland assessment	DIN, DON, EC, pH	Freshwater	Babinda Ck and Russell R.					Linked to Project 25 Refer to that project for further information.

Mareeba Shire council REMP STP	Mareeba Shire council	Compliance monitoring	Receiving waters: BOD5, TSS, Faecal Coliforms, Ammonia	Freshwater	4 sites. Upstream and downstream in Jum Rum Creek, and Barron River, Kuranda.	Monthly sampling (12 / year)	Ongoing			
Herbert Water Quality Monitoring Program: sub catchment monitoring	Terrain/JCU/DAF: Michael Nash	Develop and implement a regional integrated monitoring program supporting land holders to reduce pesticide, nutrient and sediment loads to the GBR	Water quality: TSS, TN, DIN, DON, UREA, NOx, NH_4, FRP, PN, TP, PP, DOP. Pesticide suite LC/MS (including diuron).	Freshwater	Ref. sites: Nash's Crossing, Waterfall Creek. Test sites: Hawkins Creek, Boundary Creek, Stone River, John Row Bridge (CLMP)	Baseflow: Monthly, bi monthly. High flow: Event sampling (e.g. 12 samples)	2011 - 2016, possible extension dependent on funding			Relevant to Herbert Basin. Dependent on future monitoring plans. Contact: Michael Nash
Airport Waterway Monitoring	Cairns Airport	Water quality monitoring in the Barron River	D.O. E.C. , hydrocarbons, heavy metals.	Estuarine	Barron River, one upstream site, two adjacent , one at river mouth.	4/year Quarterly	Ongoing			Program to be revised in June. May include Saltwater Creek.
Aquaculture compliance monitoring - Receiving environment	Sea-Farms	Water quality of discharge and receiving environment	Depth, DO, pH, Temperature, Salinity, Turbidity, TN,TP, Chlorophyll-*a*, TSS	Estuarine	12 sites Hinchinbrook Channel (3 sites) and mainland Creeks (9 sites), Between Syemour and Herbert River.	6/year (every tow months)	Ongoing			Several indicators at reliable frequencies.
Aquaculture compliance monitoring - Receiving environment	Australian Prawn Farms Association. DEHP	Water quality of discharge and receiving environment	WQ - TBC	Freshwater Estuarine	Daintree to Herbert basins	Variable	Ongoing			Request made to DEHP and to direct to Seafarms
Fish Spawning Aggregation Monitoring	GBRMPA	Track the size and numbers of coral trout at two spawning aggregations sites on Scott and Elford Reefs near Cairns	Aggregation once a year on the new moon in October	Marine	Survey sites on two reefs, Scott Reef (closed to fishing 2004) & Elford	Annually Oct or Nov new moon	Ongoing			Local relevance / focus, may be useful for Cairns report card?
Qld Statewide Monitoring of Commercial Fisheries	DAFF	Monitor harvest and population dynamics of selected species	Logbooks (catch &effort data); Biological information (e.g. Length, sex & age of fish being harvested) from fishers, wholesalers, retailers; Programs for important species collect data (& otoliths) from processors, commercial fishers, or during surveys onboard commercial vessels.	Marine	Statewide	Continuous	Ongoing		https://www.daf.qld.gov.au/fisheries/monitoring-our-fisheries/commercial-fisheries	Statewide long term record useful indicator for condition of fisheries stocks. May also be useful for economic indicators? Data available through http://qfish.fisheries.qld.gov.au/
SUNTAG	Info-Fish	Suntag is a recreational fish tagging program in Queensland. It is a joint program between Fisheries Queensland and the Australian National Sportfishing Association Qld Inc (ANSAQ) and is managed by Infofish Australia.Suntag allows members of ANSAQ or individual members of Suntaggers to take part in the tagging of fish. Tagging is directed towards key species and projects to ensure that the data can be used to address key questions. Suntag also collects data on catch and effort from its taggers to assist in monitoring trends in fisheries. Suntag data are used in various ways by fisheries researchers, fisheries managers, environmental managers and fishers.	Species are tagged and fish length measured, location recorded Estuary Species such as Barramundi, Bream, Mangrove Jack, Threadfin, Javelin or Flathead, Inshore Species such as Giant Trevally, Mulloway, Snapper, Queenfish or Fingermark Impoundment species such as Bass, Yellowbelly, Mary River or Murray River Cod and Saratoga, Reef Species such as the Emperors, Pearl Perch, Rockcod or Nannygai	Freshwater Estuarine Marine	Statewide along Queensland coast	Continuous	Current in 2015		http://suntag.org.au/	Long term records for several species, possibility to integrate data into report cards should be investigated in more detail.

eReef	CSIRO, AIMS.	Using the latest technologies to collate data, and new and integrated modelling, eReefs will produce powerful visualisation, communication and reporting tools. It will provide for the Reef information akin to that provided by the Bureau of Meteorology for weather. This information will benefit government agencies, Reef managers, policy makers, researchers, industry and local communities.	Remote Sensing and Water Quality. Catchment flow and water quality forecasting. Regional hydrodynamic, sediment and water quality modelling. Operational hydrodynamic coastal ocean forecasting. Relocatable fine scale coastal models (RECOM)	Inshore. Offshore.	GBR wide	Project dependent	Ongoing			Multiple modelling projects. May have relevance for future reporting including progress to targets.
Effectiveness of zoning monitoring (inshore)	JCU	To track differences between reefs that are open to fishing and reefs that became no-take areas in July 2004	• Cover of benthic organisms • Abundance of >200 spp. of reef fishes • Size of exploited fishes • Records coral disease, discarded fishing line. Underwater visual census - Although 150 species of reef fish are surveyed, the analysis has been focused on coral trout (Plectropomus spp.), fishes that are coral trout prey, and fishes of particular interest such as stripey sea perch (Lutjanus carponotatus). The biological characteristics of the coral reef are also recorded	Marine	12 sites in no-take areas and 12 sites open to fishing in the Whitsundays (Hook Whitsunday & Border Islands)	Annual	Future funding is uncertain		http://www.gbrmpa.gov.au/zoning-permits-and-plans/rap/monitoring-the-ecological-effects-of-the-2004-rezoning-of-the-great-barrier-reef-marine-park	WT spatial coverage limited to Palm Islands, uncertain future funding

Table A3. Library of monitoring programs that currently provide data for social, economic, cultural and stewardship reporting for report cards.

Program title	Lead organisation	Objectives	Indicators	Scale / Location	Monitoring frequency	Start date	Currency of program	Links	Comments	Report card use	Indicator group
Socio-Economic Long Term Monitoring Program	CSIRO	To provide sufficient social and economic data to assist the GBRMPA and industry bodies to understand changes that are occurring within the region and to make plans for the future.	Social Relationship with the Environment; Economic Relationship with the Environment; Use of the Environment: Where, When, How, How Much, and Why; drivers of social and economic change.	GBRWHA and catchment	Annual	2012	Ongoing		Under review by RIMReP	Yes	Social, Economic
P2R Integrated Monitoring, Modelling and Reporting Program: Paddock Monitoring	DNRM: Glynis Orr; Terrain: Deb Bass	The paddock monitoring and rainfall simulation components of the P2R program provide input to the modelling through measured evidence of the relative effectiveness of on-ground management practices at a realistic scale and under local climatic conditions. Plot scale rainfall simulation experiments provide opportunities to manipulate single management practices and provide a degree of control over climate conditions.	Sediment, nutrients (dissolved inorganic nitrogen/total nitrogen, dissolved inorganic phosphorus/total phosphorus) and herbicides (specifically PSII). Management practices – agricultural.	Johnstone Basin; Herbert Basin	Various		Ongoing		Inform on management practices - stewardship	Maybe	Steward-ship

Qld Statewide Monitoring of Recreational fishing	DAFF	To improve the understanding of recreational fishing in Queensland. To contribute to the sustainable management of our fisheries resources.	Statewide recreational fishing survey 2010: 12 mo. diary collection data: - Statewide and regional annual catch (harvest and release), effort and catch per unit effort for species commonly caught by recreational fishers - fishing participation rates of Queenslanders among various subgroups (e.g. age, gender, area of residence) - other recreational fishing industry-related data (e.g. boat ownership, fishing club membership) - fishers' awareness and opinions on fisheries-related issues. Programs for important species collect data at boat ramps.	All population centres (but skewed to SE Qld)	Random telephone surveys were conducted in 1996, 1998, 2001 and 2004 to obtain fishing participation information and also to recruit around 5000 volunteers to participate in the diary programs. Diary programs were completed in 1997, 1999, 2002 and 2005.	1996	Ongoing	https://www.daf.qld.gov.au/fisheries/monitoring-our-fisheries/recreational-fisheries	Coverage restricted to main population centres and snapshots in time. May be useful for case study or stewardship/social indicator development Data available through http://qfish.fisheries.qld.gov.au/	Maybe	Stewardship
Australian Marine Debris Initiative	Tangaroa Blue Foundation	The program aims to: • raise public awareness about marine debris and its impact on the marine environment • clean up beaches, coastline and islands • collect detailed data and information on the amount and types of marine debris being found • collate the marine debris data and distribute to all parties with an interest in the ocean and coast, highlighting areas that can be worked on to reduce marine debris in our local waters.	Items of marine debris are removed by community groups and catalogued following an identification manual into a national database	Australia-wide, including GBR coast, Cape York & Torres Strait	Variable among local community groups; some groups in N Qld have clean ups monthly	2007 in N Qld	Current in 2016	http://www.tangaroablue.org/amdi/amdi-program.html	Limited link to reef management initiatives. Possibly useful for pollution reporting under LTSP? Case study. Social, stewardship.	Yes	Social, Stewardship

Table A4. Library of monitoring programs that could provide potentially useful data for social, economic, cultural and stewardship reporting for report cards.

Program title	Lead organisation	Objectives	Indicators	Scale / Location	Monitoring frequency	Start date	Currency of program	Links	Comments	Report card use	Indicator group
International Visitor Survey	Tourism Australia - Dept of Resources, Energy and Tourism	To provide statistics, research and analysis to support industry development, policy development and marketing for the Australian tourism industry	Characteristics and travel behaviour of international visitors in Australia	About 40,000 visitors are interviewed each year at 8 major airports.	Continuous	1999	Ongoing	http://www.ret.gov.au/tourism/research/tra/Pages/default.aspx		Maybe	Economic
National Visitor Survey	Tourism Australia - Dept of Resources, Energy and Tourism	To provide statistics, research and analysis to support industry development, policy development and marketing for the Australian tourism industry	Characteristics and travel behaviour of Australian residents	Australia-wide	Continuous	1998	Ongoing	http://www.ret.gov.au/Department/archive/tourismreview/tra/domestic/national/Pages/default.aspx		Maybe	Economic
GBR Environmental Management Charge	GBRMPA	To assess the numbers of visitors to the GBR via commercial operations	number of tourists visiting the Great Barrier Reef Marine Park	GBR-wide	Continuous	1993	Ongoing	http://www.gbrmpa.gov.au/zoning-permits-and-plans/environmental-management-charge		Maybe	Social, Economic
Measuring the Economic and Financial Value of the GBRMP	?		quantitative estimates of the economic and financial value of selected types of activity undertaken within the Great Barrier Reef Marine Park Catchment Area (GBRCA)	GBR-wide	5 - 10 years	2006	Ongoing	https://www.environment.gov.au/sustainability/publications/economic-contribution-great-barrier-reef-march-2013	Very infrequent reports	Maybe	Economic

Recreational Vessel Registration	Qld Transport and Main Roads	Registration statistics for recreational craft	Vessel registration in Qld	State-wide	Continuous	2001	Ongoing	http://www.tmr.qld.gov.au/About-us/Corporateinformation/Open-data-datasets.aspx		Maybe	Social
Queensland Shark Control Program	DAFF	To reduce populations of large sharks to minimise the threat of shark attack on humans in particularlocations.	Sharks caught (and bycatch)	Lines and/or nets set near Cairns, Townsville, Mackay, Yeppoon/Emu Park, Tannum Sands, Bundaberg	Nets checked every two days	1962	Ongoing	http://www.daff.qld.gov.au/28_21844.htm		Maybe	Social
Field Management Compliance Program for the Great Barrier Reef World Heritage Area (GBRMPA/QPWS)	GBRMPA/ QPWS Field Management Program	Ensuring compliance with the *Great Barrier Reef Marine Park Act 1975* and Queensland's *Marine Parks Act 2004* and *Nature Conservation Act 1992,* and their subordinate regulations and plans to prevent environmental harm. Key issues include commercial and recreational fishing, vulnerable species protection, shipping, permissions and island national park compliance.	• Incident and offence numbers • Intelligence reports received • Patrol days undertaken (vessel, aircraft, land-based) • Compliance rates amongst users identified during patrols • Enforcement actions taken • Spatial and temporal variability in the above • Emerging compliance trends • Changes in user behaviour • Social and behavioural research of drivers of compliance and non-compliance	Across Great Barrier Reef World Heritage Area	Variable - includes annual, quarterly and monthly.	1981	Ongoing	http://www.gbrmpa.gov.au/managing-the-reef/how-the-reefs-managed/field-management-of-the-great-barrier-reef-marine-park/Compliance-management		Maybe	Social
Reef Water Quality Research and Development Program (EHP)	EHP, DSITI, DAF,	This project will use an adaptive management approach to demonstrate the water quality and economic benefits of implementing management practices designed to increase nitrogen use efficiency while maintaining yield.	Nitrate in run off. Yield. Management practices - agricultural	Paddock scale	Variable	2015 - 2016	Current in 2016		Paddock scale projects. May be relevant to stewardship management practices.	Maybe	Steward-ship
Qld Statewide Monitoring of Recreational fishing	DAFF	To improve the understanding of recreational fishing in Queensland To contribute to the sustainable management of our fisheries resources	Statewide recreational fishing survey 2010: 12 mo. diary collection data: - Statewide and regional annual catch (harvest and release), effort and catch per unit effort for species commonly caught by recreational fishers - fishing participation rates of Queenslanders among various subgroups (e.g. age, gender, area of residence) - other recreational fishing industry-related data (e.g. boat ownership, fishing club membership) - fishers' awareness and opinions on fisheries-related issues. Programs for important species collect data at boat ramps.	All population centres (but skewed to SE Qld)	Random telephone surveys were conducted in 1996, 1998, 2001 and 2004 to obtain fishing participation information and also to recruit around 5000 volunteers to participate in the diary programs. Diary programs were completed in 1997, 1999, 2002 and 2005.	1996	Ongoing	https://www.daf.qld.gov.au/fisheries/monitoring-our-fisheries/recreational-fisheries	Coverage restricted to main population centres and snapshots in time. May be useful for case study or stewardship/social indicator development Data available through http://qfish.fisheries.qld.gov.au/	Maybe	Stewardship

Eyes and Ears Incident Reporting Network	GBRMPA	Reef users report activity that is not allowed in the Marine Park. Extends compliance monitoring.	Reef users report activity that is not allowed in the Marine Park.	GBR-wide	Continuous	2005	Current in 2016	http://onboard.gbrmpa.gov.au/home/marine_park/management_arrangements/eyes_ears_reporting	Incident / compliance reporting, limited relevance to condition indicators or effectiveness of reef management. May be relevant to Stewardship.	Maybe	Stewardship
Great Barrier Reef and Torres Strait Vessel Tracking Service (REEFVTS)	AMSA	Avoidance of impact from shipping activities on the ecosystems of the GBRWHA	All ships of 50 metres or greater in overall length; All oil tankers (see note below), liquefied gas carriers, chemical tankers or ships coming within the INF Code, regardless of length; Ships engaged in towing or pushing where the towing or pushing ship or the towed or pushed ship is a ship prescribed within the categories shown above or where the length of the tow, measured from the stern of the towing ship to the after end of the tow, exceeds 150 metres.	GBR-wide	Continuous	2004	Ongoing		Useful for LTSP reporting?	Maybe	Stewardship
Marine Safety Qld	MSQ		Responsive - clean up of spill, but not long term monitoring of effects.				Ongoing		Useful for LTSP?	Maybe	Stewardship