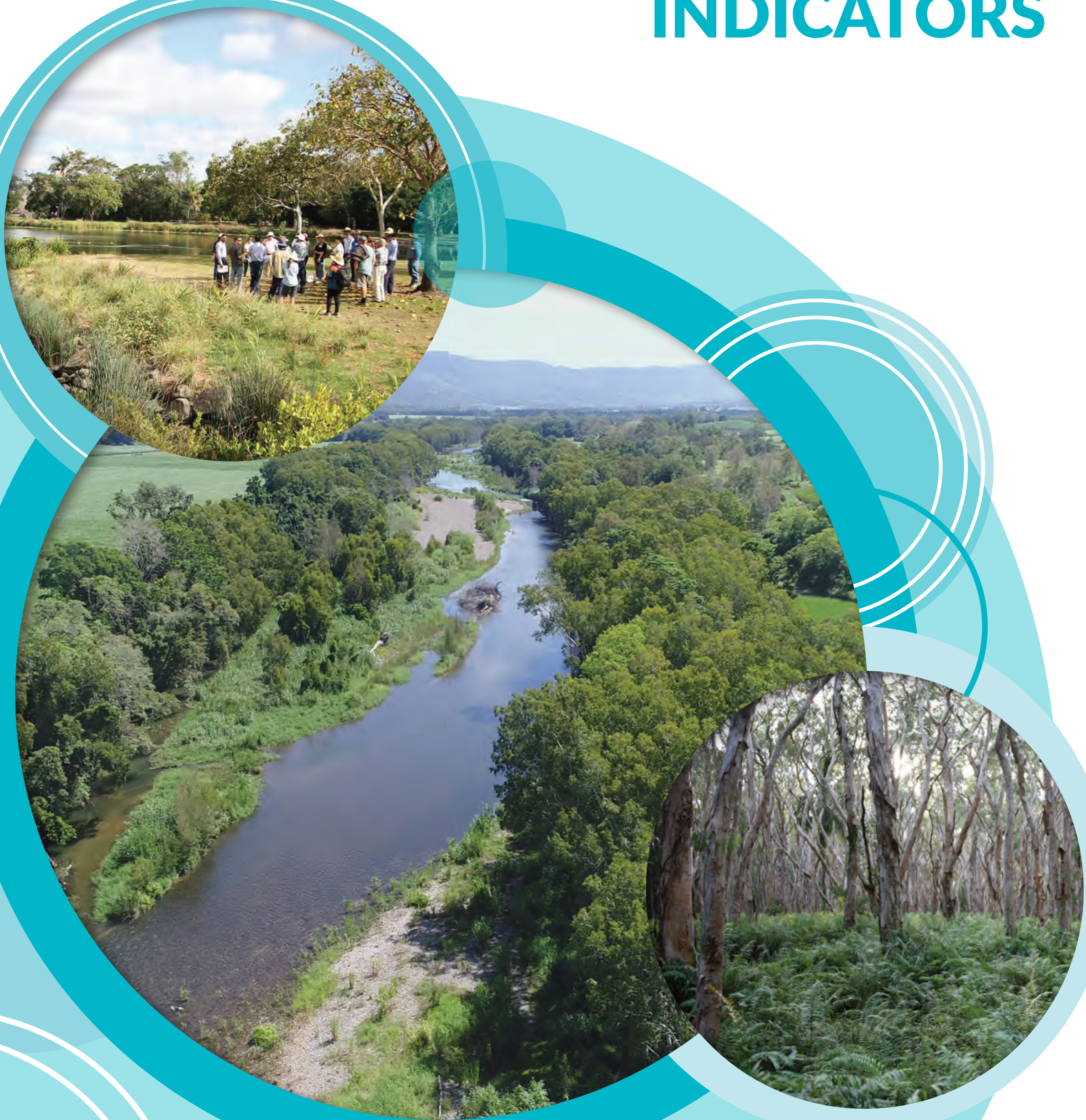
HEALTHY RIVERS TO REEF PARTNERSHIP
MACKAY-WHITSUNDAY-ISAAC

**RESULTS FOR**
THE MACKAY-WHITSUNDAY-ISAAC
2019 REPORT CARD

# ENVIRONMENTAL INDICATORS



## Authorship statement

The Mackay-Whitsunday-Isaac Healthy Rivers to Reef Partnership (henceforth referred to as 'the Partnership') Results for the Mackay-Whitsunday-Isaac 2019 Report Card technical report was compiled by the Partnership's Technical Officers, Alysha Lee, Jessica Gillespie, Talen Rimmer, and Elly Pratt.

Substantial input was received from the Regional Report Cards Technical Working Group (TWG) members. Some content was also drawn from technical reports from earlier Mackay-Whitsunday-Isaac report cards.

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# Contents

## Terms and Acronyms

| | |
|---|---|
| **Basin** | An area of land where surface water runs into smaller channels, creeks or rivers and discharges into a common point and may include many sub-basins or sub-catchments. Also known as river basin or catchment |
| **Best management practice** | Best management practices articulate a reasonable best practice level which can be expected to result in a moderate-low risk to water quality |
| **Chl-*a*** | Chlorophyll-*a*: A measure of overall phytoplankton biomass. It is widely considered a useful proxy to measure nutrient availability and the productivity of a system |
| **Climate** | Climate refers to both climate variability and climate change |
| **DDL** | Declared Downstream Limit |
| **DIN** | Dissolved inorganic nitrogen |
| **DO** | Dissolved oxygen |
| **Driver** | An overarching cause of change in the environment |
| **Ecosystem** | A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit |
| **Fish (as an index)** | Fish community health is assessed and included in the ecosystem health assessments (coasters). Inclusion in the report card will contribute to an assessment of the health of local fish communities |
| **Fish Barriers (as an indicator)** | Fish barriers relate to any barriers which prevent or delay connectivity between key habitats which has the potential to impact migratory fish populations, decrease the diversity of freshwater fish communities and reduce the condition of aquatic ecosystems (Moore, 2015). |
| **Flow (as an indicator)** | Flow relates to the degree that the natural river flows have been modified in the Region's waterways. This is an important indicator due to its relevance to ecosystem and waterway health |
| **FRP** | Filterable reactive phosphorus |
| **GBR** | Great Barrier Reef |
| **GBR report card** | Great Barrier Reef Report Card developed under the Reef 2050 Water Quality Improvement Plan (2018) |
| **GBRMPA** | Great Barrier Reef Marine Park Authority |
| **GV** | Guideline Value |
| **Impoundment (also impoundment length)** | An indicator used in the 'in-stream habitat modification' indicator for freshwater basins in the Region. This index reports on the proportion (%) of the linear length of the main river channel inundated at the Full Supply Level of artificial in-stream structures such as dams and weirs |

| | |
|---|---|
| **Index** | Is generated by indicator categories (e.g. water quality made up of nutrients, water clarity, chlorophyll-*a* and pesticides) |
| **Indicator** | A measure of one component of an environmental dataset (e.g. particulate nitrogen) |
| **Indicator category** | Is generated by one or more indicators (e.g. nutrients made up of particulate nitrogen and particulate phosphorus) |
| **Inshore (as a reporting zone)** | Inshore is a reporting zone in the Mackay-Whitsunday report card that includes enclosed coastal, open coastal and mid-shelf waters. |
| **In-stream Habitat Modification (as an indicator)** | This basin indicator category is made up of two indicators; fish barriers and impoundment length |
| **ISP** | Independent Science Panel established under the Reef Water Quality Protection Plan (now Reef 2050 Water Quality Improvement Plan), who have independently reviewed the methodologies involved in the report card assessments |
| **LOR** | Limit of reporting |
| **Macroalgae (cover)** | An indicator used in part to assess coral health. Macroalgae is a collective term used for seaweed and other benthic (attached to the bottom) marine algae that are generally visible to the naked eye. Increased macroalgae on a coral reef is often undesirable, indicating reef degradation (Diaz-Pulido and McCook, 2008) |
| **Measure** | A measured value that contributes to an indicator score for indicators that are comprised of multiple measures (e.g. flow, estuary fish barriers). |
| **MMP** | Marine Monitoring Program: The Great Barrier Reef Marine Park Authority's Marine Monitoring Program, which provided water quality data for the Central and Whitsunday reporting zones in the report card |
| **ms-PAF** | Multisubstance-Potentially Affected Fraction derived using a concentration addition model which estimates the cumulative toxicity for contaminants with different modes of action. |
| **$NO_x$** | Oxidised nitrogen (nitrate and nitrite) |
| **NQBP** | North Queensland Bulk Ports Corporation Ltd |
| **Offshore (reporting zone)** | Offshore is a reporting zone in the Mackay-Whitsunday report card that includes mid-shelf and offshore water bodies. |
| **Overall Score** | The overall scores for each reporting zone used in the report card are generated by an index or an aggregation of indices. |
| **Palustrine Wetlands** | Primarily vegetated non-channel environments of less than 8 hectares. Examples of palustrine wetlands include billabongs, swamps, bogs, springs, etc. |

| | |
|---|---|
| **Pesticides (as an indicator)** | Formerly limited to the PSII herbicides; now incorporating up to 22 herbicides and insecticides with different modes of action. A list of the relevant analytes is provided in Table 6. |
| **Pesticide Risk Metric** | Refers to the multisubstance-Potentially Affected Fraction (ms-PAF) methodology for estimation of ecological risk associated with pesticide pollution |
| **Phys-chem** | The physical-chemical indicator category that includes two indicators: dissolved oxygen (DO) and turbidity |
| **PN** | Particulate nitrogen |
| **PONSE** | Proportion of Native (fish) Species Expected |
| **Ports** | NQBP port authority |
| **PP** | Particulate phosphorus |
| **PSII herbicides** | Photosystem II inhibiting herbicides (Ametryn, Atrazine, Diuron, Hexazinone, Tebuthiuron, Bromacil, Fluometuron, Metribuzin, Prometryn, Propazine, Simazine, Terbuthylazine, Terbutryn) |
| **PSII-HEq** | Photosystem II herbicide equivalent concentrations, derived using relative potency factors for each individual PSII herbicide with respect to a reference PSII herbicide, Diuron. |
| **QPSMP** | Queensland Ports Seagrass Monitoring Program |
| **RIMReP** | Reef 2050 Integrated Monitoring and Reporting Program |
| **Riparian Extent (as an indicator)** | An indicator used in the assessments of both basin and estuarine zones in the Mackay-Whitsunday-Isaac report cards. This indicator uses mapping resources to determine the extent of the vegetated interface between land and waterways in the Region |
| **Secchi** | Secchi depth (m) – measure of water clarity |
| **SF** | Scaling factor. A value used to set scoring range limits for indicators |
| **TSS** | Total suspended solids |

# 1 Executive Summary

The Mackay-Whitsunday-Isaac Healthy Rivers to Reef Partnership (the Partnership) was established in October 2014 with the primary focus of producing an annual report card on the health of the Region's waterways. The Partnership's 2014 Pilot report card was released in October 2015. The 2019 report card (reporting on data from 2018-2019) is the sixth report card released by the Partnership.

The purpose of this document is to provide detailed information on the results relating to the Mackay-Whitsunday-Isaac 2019 report card. This includes condition assessments of the environmental indicators in freshwater basins, estuaries, inshore and offshore marine environments, in addition to agricultural stewardship results. Specifically, this document describes:

- Scaled scores and grades for indicators;
- Indicator categories and indices;
- Overall reporting zones; and
- Confidence levels associated with the results

The scores for freshwater basins, estuaries, inshore marine and offshore marine environments are provided for the 2013-14, 2014-15, 2015-16, 2016-17, 2017-18, and 2018-19 reporting periods where possible and are presented together to allow comparisons, where applicable, of results between years.

Freshwater basins scored moderate to good overall in the 2018-19 reporting year. Water quality has remained relatively consistent in freshwater basins (ranging from good to moderate) throughout reporting years across all Mackay-Whitsunday-Isaac report cards, with pesticides continuing to be the poorest scoring water quality indicator. The fish barrier indicator for freshwater basins was updated for the 2019 report card (following its four-year reporting cycle) with an improvement in grade in the Don basin due to improvements in data accuracy. The wetland extent indicator was also updated in the 2019 report card, based on refinements to available wetland mapping data. Due to availability of mapping updates scheduled for release post development of the 2019 report card, and review of revised mapping and methods required by the regional report card's Technical Working Group (TWG), riparian extent indicators were not updated for this report card. It is anticipated that the riparian extent indicator will be updated for the 2020 report card. Overall habitat and hydrology scores ranged from poor to good across all freshwater basins. Freshwater fish community results were repeated from the 2018 report card (aligning to its three- year reporting frequency) and were good and very good across all basins assessed.

Overall estuary grades in the Mackay-Whitsunday-Isaac report card have remained relatively stable since they were first reported in 2014, ranging from moderate to good across reporting years. For the first time in the 2019 report card, estuary pesticide scores were based on monthly ambient monitoring plus additional data from a Partnership-funded estuary monitoring program, designed to supplement existing monitoring to increase temporal representativeness of data. Pesticides were the poorest scoring water quality indicator for estuaries in the 2019 report card. Similar to freshwater basins, the fish barrier indicator was updated for the 2019 report card. There was no change to the overall fish barrier grade in any of the estuaries assessed since the last update in the 2015 report card. Mangrove and saltmarsh extent, and riparian extent indicators were also updated in the 2019 report card, where no grades changed for riparian extent with respect to the previous reporting period (2014-2018 report cards).

For inshore marine zones, overall grades ranged from poor to moderate, with an improvement in the overall grade occurring in the Northern inshore zone. Although overall marine grades for the Whitsunday and Central zone remained as poor, there were declines in the water quality index scores from poor to very poor, and moderate to poor respectively. Coral index scores ranged from poor to very poor across inshore marine zones for the 2019 report card. Coral was reported for the first time in the Southern inshore zone as part of the Partnership-funded Southern Inshore Monitoring Program, with condition reported as very poor. Seagrass condition ranged from moderate to poor across North, Whitsunday and Central inshore zones but showed improvements in seagrass condition following declines subsequent to Tropical Cyclone Debbie, a significant weather event that affected the region in late March 2017.

In the offshore zone, overall grades remained good for the sixth consecutive year, with water quality and coral remaining in a very good and moderate condition respectively. The juvenile density indicator category, which forms part of the coral index score, scored very good, indicating a greater potential for coral recovery.

The summary scores and grades for the 2019 report card, along with 2018-2014 report cards, are presented in Tables i – iii below.

**Table i. Condition grades of freshwater basins for the 2019 report card in comparison to 2018, 2017, 2016, 2015 and 2014 report card scores.**

| Freshwater basin | 2019 report card | | | | | 2018† | 2017†* | 2016^ | 2015^ | 2014^ |
|---|---|---|---|---|---|---|---|---|---|---|
| | Water quality | Habitat and hydrology | Fish | Basin score and grade | | Basin score | Basin score | Basin score | Basin score | Basin score |
| Don | 66 | 75 | | **71** | **B** | 69 | 59 | 48 | 48 | 54 |
| Proserpine | | 50 | 79 | **65** | **B** | 65 | 52 | 53 | 53 | 52 |
| O'Connell | 55 | 43 | 92 | **63** | **B** | 66 | 53** | 58 | 57 | 52 |
| Pioneer | 46 | 40 | 82 | **56** | **C** | 55 | 40 | 41 | 41 | 34 |
| Plane | 37 | 37 | 79 | **51** | **C** | 50 | 50** | 52 | 51 | 35 |

**Scoring range:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

†denotes scores which have been back-calculated to incorporate changes associated with refinements to the source mapping used to assess wetland extent.

*denotes scores which have been back-calculated to incorporate updates to freshwater pesticides made in the 2018 report card.

**2017-2014 scores do not incorporate additional sites that were included for the first time in the 2018 report card.

^ 2016-2014 report card scores do not include back-calculated pesticide updates that were established for the 2018 report card.

**Table ii. Condition grades of estuaries for the 2019 report card in comparison to 2018, 2017, 2016 and 2015* report card scores. *Data from the 2015 report card is repeated from the 2014 report card.**

| Estuary | 2019 report card: Water quality | Habitat and hydrology | Fish | Estuary score and grade | | 2018 Estuary score* | 2017 Estuary score** | 2016 Estuary score** | 2015 Estuary score**^ |
|---|---|---|---|---|---|---|---|---|---|
| Gregory | 77 | 83 | | **80** | **B** | 82 | 79 | 80 | 79 |
| O'Connell | 56 | 57 | | **56** | **C** | 51 | 61 | 54 | 57 |
| St Helens/Murray | 59 | 69 | | **64** | **B** | 57 | 61 | 61 | 63 |
| Vines | 50 | 65 | | **57** | **C** | 68 | 64 | 72 | 73 |
| Sandy | 57 | 45 | | **51** | **C** | 58 | 52 | 50 | 52 |
| Plane | 70 | 56 | | **63** | **B** | 68 | 67 | 59 | 61 |
| Rocky Dam | 60 | 73 | | **66** | **B** | 76 | 70 | 73 | 70 |
| Carmila | 64 | 92 | | **78** | **B** | 67 | 66 | 73 | 79 |

**Scoring range**: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

*2018 scores do not include pesticide monitoring data and, therefore, are not directly comparable

**2017, 2016 and 2015 scores include pesticide monitoring data, but have not been back-calculated to address changes to the method of assessment and, therefore, are not directly comparable.

^Data from 2015 report card is repeated from the 2014 report card.

**Table iii. Condition grades of marine scores for inshore and offshore zones reported in the 2019 report card (2018-19 data) in comparison to final scores in the 2018, 2017, 2016, 2015 and 2014 report cards.**

| Zone | 2019 report card: Water quality | Coral index | Seagrass | Fish | Marine score and grade | | 2018 Marine score | *2017 Marine score | ^2016 Marine score | ^2015 Marine score | ^2014 Marine score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Northern | 48 | 29 | 52 | | **43** | **C** | 35 | 44 | 43 | 21 | 40 |
| Whitsunday | 18 | 30 | 27 | | **25** | **D** | 27 | 27 | 47 | 39 | 28 |
| Central | 36 | 23 | 52 | | **36** | **D** | 37 | 31 | 41 | 51 | 25 |
| Southern | 48 | 20 | | | **34** | **D** | 22 | | | | |
| Offshore | 99 | 55 | | | **77** | **B** | 77 | 76 | 77** | 77** | 74** |

**Scoring range:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap| ■ Not applicable

*2017 overall marine score results were back-calculated to incorporate changes to methods for pesticides and seagrass that were applied in the 2018 report card. 2016-2014 scores have not been back-calculated.

^2016-2014 report card scores do not include back-calculated pesticide updates that were established for the 2018 report card.

**Offshore coral scores were amended due to error detected in methods.

# 2 Introduction

## 2.1 Purpose of this Document

The purpose of this document is to provide detailed results to support the 2019 Mackay-Whitsunday-Isaac report card on waterway health. The results provided in this document relate to the condition of environmental indicators and agricultural stewardship. This report does not include human dimension reporting for social and economic, non-agricultural stewardship and cultural heritage components of waterway health in the Mackay-Whitsunday-Isaac region.

This document presents indicator scores in their original scale along with standardised scores that (where relevant) were used for aggregation. Confidence in the results is also reported.

Where practicable, the 2019 results are compared to 2018, 2017, 2016, 2015 and 2014 results that have been calculated using the same methods. Where this is not the case, previous results calculated using alternate methods are presented for reference. The data collection period is outlined with associated results.

This document describes:

- The 2019 condition assessments for environmental indicators;
- The confidence associated with 2019 results;
- Where practicable, comparison of 2019 results to 2018, 2017, 2016, 2015 and 2014 results
- Additional information associated with 2019 environmental results contained in Appendices; and
- 2019 results for agricultural stewardship.

## 2.2 General

The Mackay-Whitsunday-Isaac Healthy Rivers to Reef Partnership (herein the Partnership) was established in October 2014. The primary focus of the Partnership is to produce an annual report card on the ecological condition of the Region's waterways. The 2014- 2017 Mackay-Whitsunday-Isaac report cards were typically released in October/November each year, reflecting the previous financial reporting year. In a commitment to provide the Mackay-Whitsunday-Isaac region with relevant data closer to the reporting period, the Partnership successfully released the 2018 report card in July 2019, approximately four months earlier to previous report card releases. As a result of this success, all future report cards are expected to be released no later than July.

The report card includes condition assessments of five freshwater basins, eight estuaries, four inshore marine zones and one offshore marine zone (to the eastern boundary of the Great Barrier Reef Marine Park). Different indicators are assessed to provide the overall scores for these reporting areas throughout the Mackay-Whitsunday-Isaac Region. Agricultural stewardship information relevant to waterways and the marine environment is also provided; it is derived from best management practice assessment data for relevant agricultural land uses in the region.

Since the release of the 2017 report card, the Program Design[1] outlining the guiding framework for the development and scope of the 2017 – 2022 report cards was finalised. Some changes to the scope

[1] https://healthyriverstoreef.org.au/wp-content/uploads/2018/12/mackay-whitsunday-report-card-program-design-2017-2022.pdf

of assessment (monitoring sites and methods) have occurred since the 2017 report card and are highlighted throughout this document where relevant. Otherwise, methods for developing the scores for the 2019 report card are consistent with those used in the previous report card.

For more detail on the methods used to produce the Mackay-Whitsunday-Isaac report card and for more information on the Partnership, refer to the Methods for the Mackay-Whitsunday-Isaac 2019 report card document[1] and the Mackay-Whitsunday-Isaac Report Card Program Design 2017 to 2022 document[2].

## 2.3 Terminology

The report card assesses different indicators of ecosystem health to report on overall condition. Scores for indicators are aggregated together depending on the aspect of the environment they are assessing, such as water quality, coral or fish. The terminology used in this document for defining the level of aggregation of indicators is as follows:

- An indicator is a component of the environment that can be measured or calculated (e.g. particulate nitrogen);
- Indicator categories (e.g. nutrients) are generated by one or more related indicators;
- Index/indices (e.g. water quality) are generated by the aggregation of indicator categories; and
- Overall score is generated by the aggregation of indices or by a single index score.

In the report card, overall scores and scores for indices are represented in the format of a coaster (Figure 1). Presentation of the coasters can be with or without the outer ring (i.e. indicator categories).

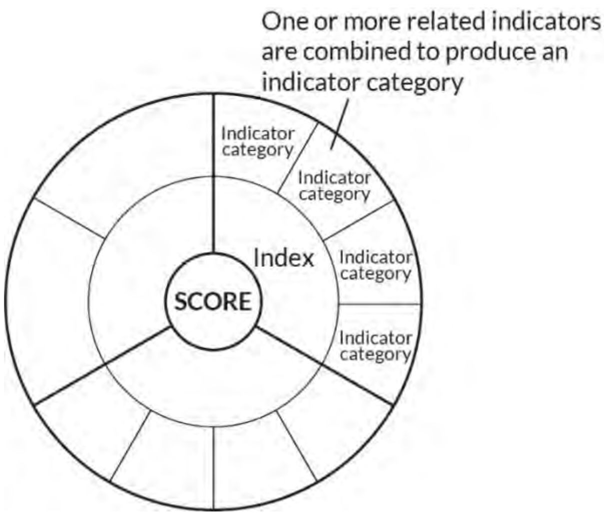


**Figure 1. Terminology used for defining the level of aggregation of indicators and how they are displayed in the coasters in the report card.**

## 2.4 General scoring of condition assessments

Ordinal categories are used to describe the scores for condition of indicators, indicator categories and the overall score. This follows a five-point scoring system:

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

[2] https://healthyriverstoreef.org.au/wp-content/uploads/2018/12/mackay-whitsunday-report-card-program-design-2017-2022.pdf

Very Good (A), Good (B), Moderate (C), Poor (D), Very Poor (E).

All indicators have applicable scoring ranges and bandwidths which correspond to the five-point system. Individual scoring ranges are listed below the results tables presented throughout this document.

Results for indicators that had divergent scoring ranges and bandwidths were required to be translated into a common scoring range before aggregating (rolling up). The common scoring range used for reporting is based on that used by the Great Barrier Reef (GBR) Water Quality report card (Table 1). Once standardised (where necessary), relevant scores were averaged to aggregate into the higher category.

Decision rules were developed for the minimum proportion of information required to generate the rolled-up scores, as follows:

- ≥ 50% of measured indicators to generate the indicator category score (where relevant);
- ≥ 60% of indicator categories to generate an index score; and
- Overall scores for reporting zones are presented in the report card, even if not all indicator categories are available.

**Table 1. Overall range of scores within the report card.**

| Scoring range | Condition grade and colour code |
|---|---|
| 81 to 100 | Very Good |
| 61 to <81 | Good |
| 41 to <61 | Moderate |
| 21 to <41 | Poor |
| 0 to <21 | Very Poor |

## 2.5 Data used in the 2019 report card

Results for indicators that are reported annually in the 2019 report card are largely based on data collected between July 1st 2018 and June 30th 2019. This includes:

- Water quality indicators;
- Habitat and hydrology (vegetation extent, fish barriers and flow) indicators;
- Coral indicators; and
- Seagrass indicators

This data collection period is not completely consistent for certain measures of water quality and coral in some of the marine zones. Where this occurs, it is identified within the document. Results for indicators that are reported less frequently are repeated from previous report cards and are based on data collected during:

- July 1st 2013 to June 30th 2014 for freshwater basins riparian extent indicator (updated every four years and was due for updating in the 2018 report card), however, the data collected in 2017 is subject to considerable change. The updated mapping is scheduled to be released in mid-2020, after the development of the 2019 report card. Therefore, it is anticipated this information will be available in the 2020 report card.
- July 1st 2017 to June 30th 2018 for freshwater basin impoundment indicator scores (updated every four years, with scores updated for the 2018 report card).
- July 1st 2017 to June 30th 2018 for freshwater fish indicators (updated every three years, with scores updated for the 2018 report card).

## 2.6 Regional Setting

### 2.6.1 Drivers of condition assessments during the 2018 – 2019 reporting period

Climate, population and the economy are the key external forces that influence the condition of waterways in the Mackay-Whitsunday-Isaac region, either directly or by driving activities that put pressure on local waterways[1] (Figure 2). The region includes the Proserpine, O'Connell, Pioneer and Plane basins, and is made up of 33 sub-catchments that flow into eight receiving waters, from Edgecombe Bay in the north to the Carmilla coast in the south. For the purposes of the Partnership and Mackay-Whitsunday-Isaac report cards, the region also includes the Don basin which consists of the Don River, that flows to the west of Proserpine and empties into the receiving waters north of Bowen. Land use in the region is predominated by agricultural activities including sugarcane, grazing and horticulture, as well as other practices such as mining and urban development. These on-land activities can put pressure on local freshwater and estuarine waterways, as a result of the mobilisation of excess sediment, nutrient, pesticide and other contaminants via surface water run-off. Increased loads of these pollutants are ultimately received by coastal waters through river discharge and move to inshore and offshore waterbodies (Figure 2). Additional pressures that can impact the region's aquatic ecosystems in marine waters include ports and marinas, shipping, fishing, and tourism and recreational activities (Figure 2).

In the reporting period from July 1st 2018 to June 30th 2019, the key drivers likely to directly affect scores of some of the environmental indicators relate to climate variability, including high rainfall and very dry periods, and the residual impacts of Tropical Cyclone Debbie that impacted the region in March 2017. Additionally, anthropogenic pressures such as excessive sediment, nutrient and pesticide loads within land-based run-off were anticipated to directly affect some of the environmental indicators.

[1] https://healthyriverstoreef.org.au/our-region/pressures/


**Figure 2. Conceptual diagram of the key drivers, pressures, and ecological processes in the Mackay-Whitsunday-Isaac Region.**

### 2.6.2 Climate

Geographically, the Mackay-Whitsunday-Isaac region is situated in North Queensland, north of the Tropic of Capricorn circle of latitude and typified by a tropical to subtropical climate. Regionally, climate is characterised by two seasons: a wet (November to May) and a dry (April to October) season. During the wet season, the Mackay-Whitsunday-Isaac area may experience elevated rainfall, tropical lows and cyclones. Upon making landfall, cyclones may generate considerable rainfall and flooding.

Shifts in year-to-year weather and climate influence the frequency and severity of environmental events including drought, bushfires and floods within natural ecosystems. Such variability also extends to changes in modified environments, including agricultural land, and can dictate how land management activities evolve within and between seasons.

### 2.6.3 Rainfall

Annual rainfall totals for the 2018-19 reporting year varied from 60-80% below, to 100-125% above the long-term mean in the Mackay-Whitsunday-Isaac region (Figure 3). In comparison to long-term means, above average rainfall fell in the northern area of the region, between Bowen and Mackay (Don, Proserpine and O'Connell basins), while below average rainfall was recorded in the southern (Pioneer and Plane) region during 2018-19 (**Error! Reference source not found.**). Total annual rainfall across basins in 2018-19 were higher than the 2017-18 reporting year (Figure 4).

In terms of historical rainfall records and comparisons against a five-year moving average, the annual totals for the 2018-19 reporting year were above average for the Don, Proserpine, O'Connell and Pioneer, with slightly higher annual rainfall occurring compared to some preceding years. Annual rainfall across Mackay-Whitsunday-Isaac basins from 2011 to 2018 was lower than 2010, where a peak in rainfall occurred across basins (Appendix F).

Annual average rainfall patterns obscure the variation in rainfall observed throughout the year, with some months recording above average rainfall and others being much below average (Figure 5). The majority of rainfall occurred during typical wet season months, between December 2018 and April 2019, whilst very dry periods occurred between July 2018 and November 2018, with some basins including the Don, Proserpine, O'Connell and Plane, recording very much below-average rainfall (Figure 5). Regionally in the cane industry, the very dry period during the 2018-19 reporting year produced conditions that were unsuitable for spraying, including no weed growth, small stunted cane and unfavourable winds. This was ultimately reflected in the very low levels of pesticides that were detected in the December 2018 rain event (P. Trendell (TWG), pers comms) (section 2.1.3). Adversely, cane farmers in the northern part of the Mackay-Whitsunday-Isaac region were impacted the greatest by the monsoon trough event, following the very dry conditions, that flooded Townsville in late January/early February 2019, with many cane farms having flooding and water logging issues that would have impacted their 2019/20 season (P. Trendell (TWG), pers comms). The very dry conditions between August and November caused many regional streams to stop flowing, with aquatic refuge habitats retracting considerably over this period. Many of the region's shallow coastal wetlands dried completely (T. Power (TWG), pers comms).

Despite the periods of below average rainfall that occurred in the 2018-19 reporting year, annual discharge of the major rivers in the basins across the Mackay-Whitsunday-Isaac generally met or were above the long-term mean (Figure 6).

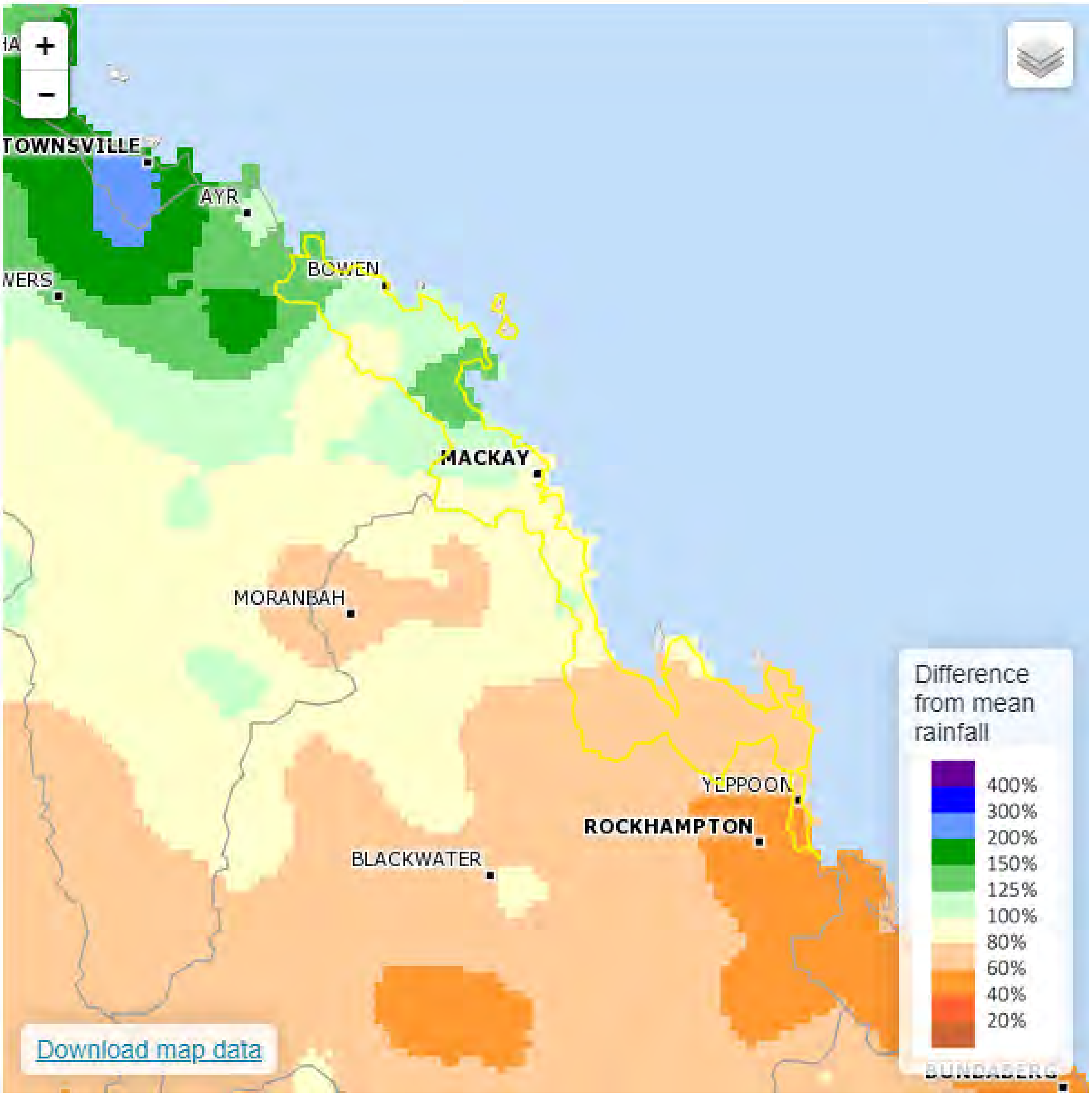


**Figure 3. Difference of total annual rainfall (2018-19) from long-term mean annual rainfall for the Mackay-Whitsunday-Isaac region. The long-term mean is represented as a 'difference from mean rainfall' of 100% and was based upon historical rainfall records from 1912 to 2019. (Data source: Bureau of Meteorology Regional Water Information http://www.bom.gov.au/water/rwi/#ra_pa/048/2019).**

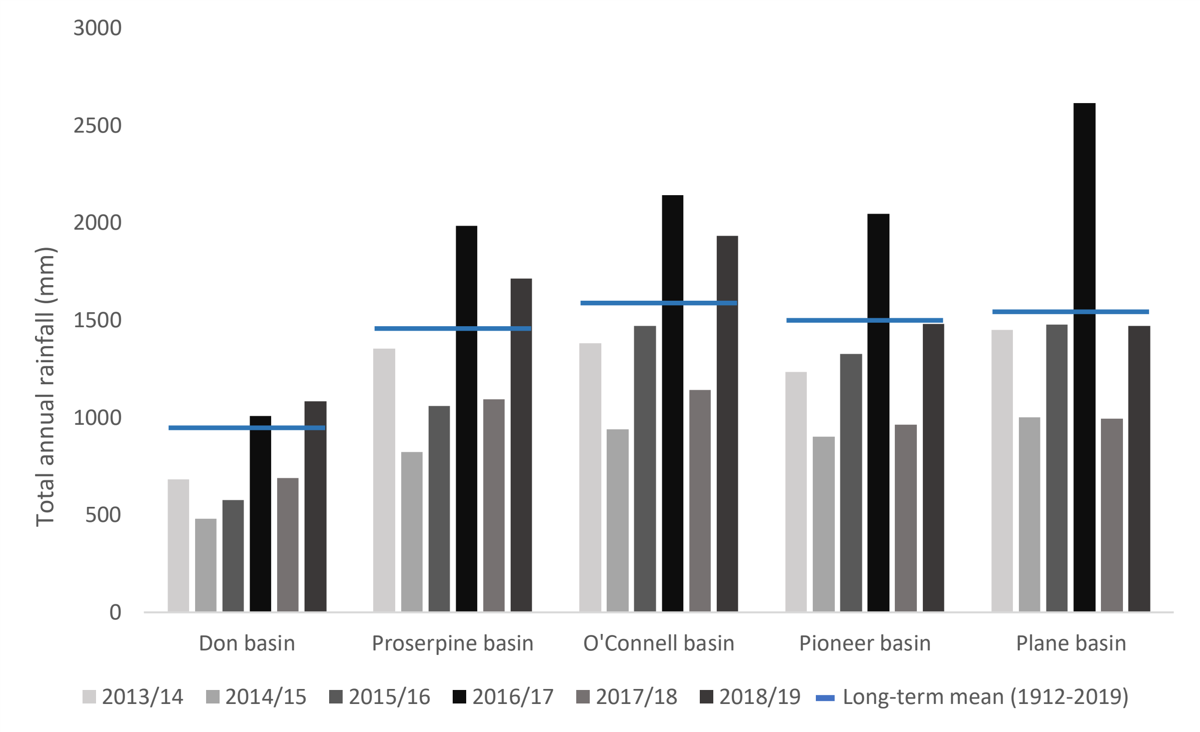


**Figure 4. Total annual rainfall across the Mackay-Whitsunday-Isaac region for the 2018-19 reporting period compared to previous reporting periods and the long-term mean (1912-2019). (Data source: Bureau of Meteorology Regional Water Information http://www.bom.gov.au/water/rwi/#ra_pa/048/2019).**

**Table 2. Annual rainfall statistics for basins in the Mackay-Whitsunday-Isaac region for 2018-19.**

| | Total (mm) | Long-term mean 1912-2019 (mm) | Decile (average) | Anomaly (mm) (+/- long-term mean | Percentage (%) of long-term mean |
|---|---|---|---|---|---|
| **Don** | 1085 | 948 | 4-7 | 137 + | 114 |
| **Proserpine** | 1715 | 1458 | 8-9 | 257 + | 118 |
| **O'Connell** | 1933 | 1589 | 8-9 | 344 + | 122 |
| **Pioneer** | 1483 | 1500 | 4-7 | 17 - | 99 |
| **Plane** | 1472 | 1544 | 4-7 | 72 - | 95 |

**Decile category**: 1= very much below average, 2-3: below average, 4-7: average, 8-9: above average, 10: very much above average.

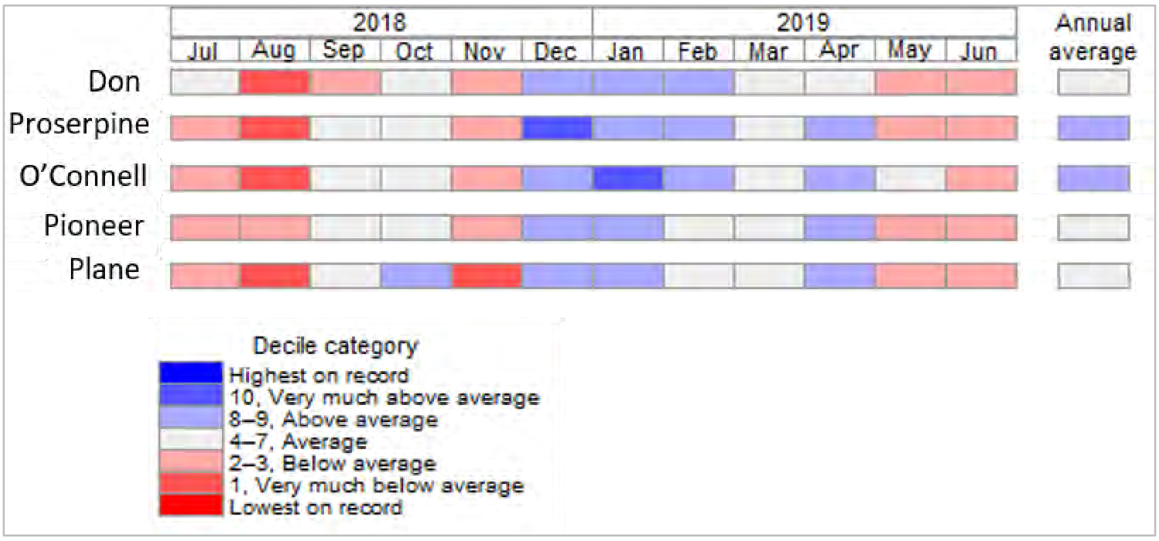


**Figure 5. Monthly rainfall deciles and annual average decile for basin areas for the Mackay-Whitsunday-Isaac. (Data source: Bureau of Meteorology Regional Water Information http://www.bom.gov.au/water/rwi/#ra_pa/048/2019)**

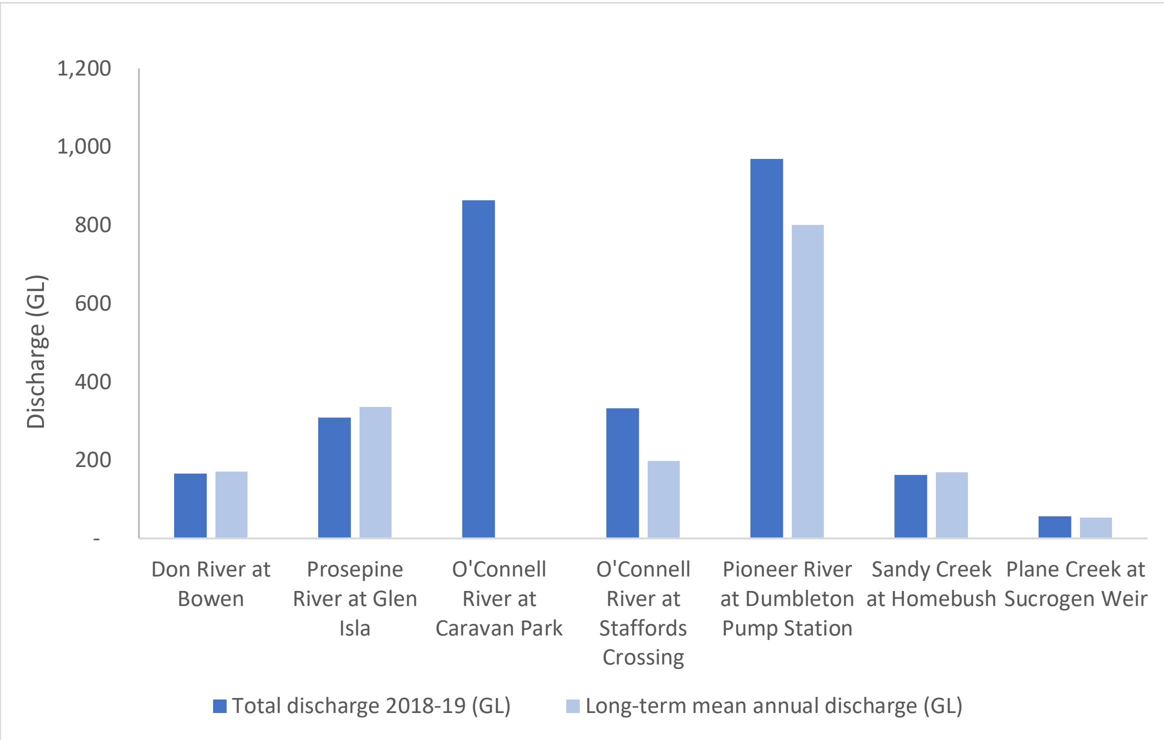


**Figure 6. 2018-19 discharge recorded from gauging stations at major river channels in Mackay-Whitsunday-Isaac region compared to the long-term mean. (Data source: Department of Environment and Science and Department of Natural Resources, Mines and Energy. Long-term mean annual discharge is based on available historical gauging station records until present (water-monitoring.information.qld.gov.au). Long-term mean discharge was not available at O'Connell River at Caravan Park was not available.**

### 2.6.4 Tropical cyclones and bushfires

Tropical cyclone systems in the region develop from tropical lows, typically between November and April. For the 2018-19 reporting year, no tropical cyclones made landfall over the Mackay-Whitsunday-Isaac region. The cyclone season across Queensland was average with four tropical cyclones occurring-

Owen (December 2018), Penny (January 2019), Oma (February 2019) and Trevor (March 2019). In addition, a fifth cyclone, Ann, occurred out of season in mid-May 2019. Tropical cyclone Trevor and ex-tropical cyclone Penny caused extensive rainfall and flooding of Far Northern river systems, leading to large flood plumes.

Flow-on effects arising from Tropical Cyclone (TC) Debbie continue to impact some indicator scores, particularly in the inshore marine environment, despite occurring outside the reporting period. Coral scores presented in the 2019 report card now capture the full extent of the impact from TC Debbie as a result of coral monitoring reporting alignments. TC Debbie made landfall near Airlie Beach on Queensland's Whitsunday coast on Tuesday 28th March 2017, after crossing the Whitsunday Islands as a large and powerful category 4 storm system[1].

During the 2018-19 reporting year, unprecedented bushfires occurred across the Mackay-Whitsunday-Isaac region in November and December 2018 (Figure 7). Major fires occurred at Eungella, Finch Hatton and Darlymple Heights and burned approximately 160,000 hectares of forest and farming lands, affecting many communities[2]. Across Central Queensland, approximately 1.4 million hectares of land was burned. Fires in the region occurred during widespread heatwave conditions combined with gusty westerly winds, and the region had very low soil moisture in the upper soil levels[3].

### 2.6.5 Climate change

Earth's climate has always been changing. Since the 1950's, many of the observed changes have been unprecedented over decades to millennia, with each of the last three decades successively warmer at the Earth's surface than any preceding decade since 1850 (IPCC 2014). Anthropogenic greenhouse gases have increased since the pre-industrial era, driven largely by economic and population growth. These effects, together with other anthropogenic drivers have been detected throughout the climate system and are extremely likely to have been the dominant cause of observed global warming since the mid-20th century (IPCC 2014).

In recent decades, changes in climate have caused impacts on both natural and human-made systems across the globe's continents and oceans. Increases in sea surface temperature, ocean acidification, short-duration heavy rainfall, more frequent severe cyclones, and a rising sea level are some of the variables highlighted for their potential to impact aquatic ecosystems within Australia, under a warming climate regime. More specifically, longer and more frequent periods of elevated sea surface temperatures, resulting in 'marine heatwaves', pose a major threat to the long-term health and resilience of coral reef ecosystems due to their propensity to result in widespread coral bleaching. Climate change is the primary factor affecting the health of the Great Barrier Reef (Great Barrier Reef Marine Park Authority 2019).

### 2.6.6 Coral bleaching

Coral bleaching occurs when corals are stressed by a change in environmental conditions. Historically, global-scale coral bleaching has been associated with strong El Nino events and increases to global

[1] http://www.bom.gov.au/cyclone/history/debbie17.shtml
[2] https://www.igem.qld.gov.au/2018-queensland-bushfires-review
[3] https://www.qra.qld.gov.au/sites/default/files/2019-05/0330%20QRA%20CenQLD%20Bushfire%20RecPlan%202018-21%20HRes_0.pdf

sea-surface temperatures (Great Barrier Reef Marine Park Authority 2017). During the 2018-19 summer period, sea surface temperatures were above average throughout the Marine Park for most of the summer, peaking in January and February 2019. However, the cooler regional weather conditions (associated with the monsoonal trough and tropical cyclones) reduced sea surface temperatures back to average or slightly below, providing several weeks of reduced thermal stress and associated threat of mass coral bleaching to corals[1]. As a result, there was no significant large-scale coral bleaching event in the Marine Park over 2018-19. Minor bleaching was recorded from all management zones in the Marine Park; however, these instances were generally at the scale of individual colonies.

Mass coral bleaching events in the Great Barrier Reef Marine Park occurred consecutively in 2016 and 2017 as a result of extreme sea surface temperatures. The 2016 event caused severe bleaching in the northern third of the Great Barrier Reef, while in 2017 severe bleaching mainly affected the central region (Great Barrier Reef Marine Park Authority 2019). Whilst the 2019 report card covers the reporting period of 2018/19, a third mass bleaching event occurred on the Great Barrier Reef during the 19/20 summer. Future report card scores may reflect impacts to coral from this event.

[1] http://www.gbrmpa.gov.au/the-reef/reef-health

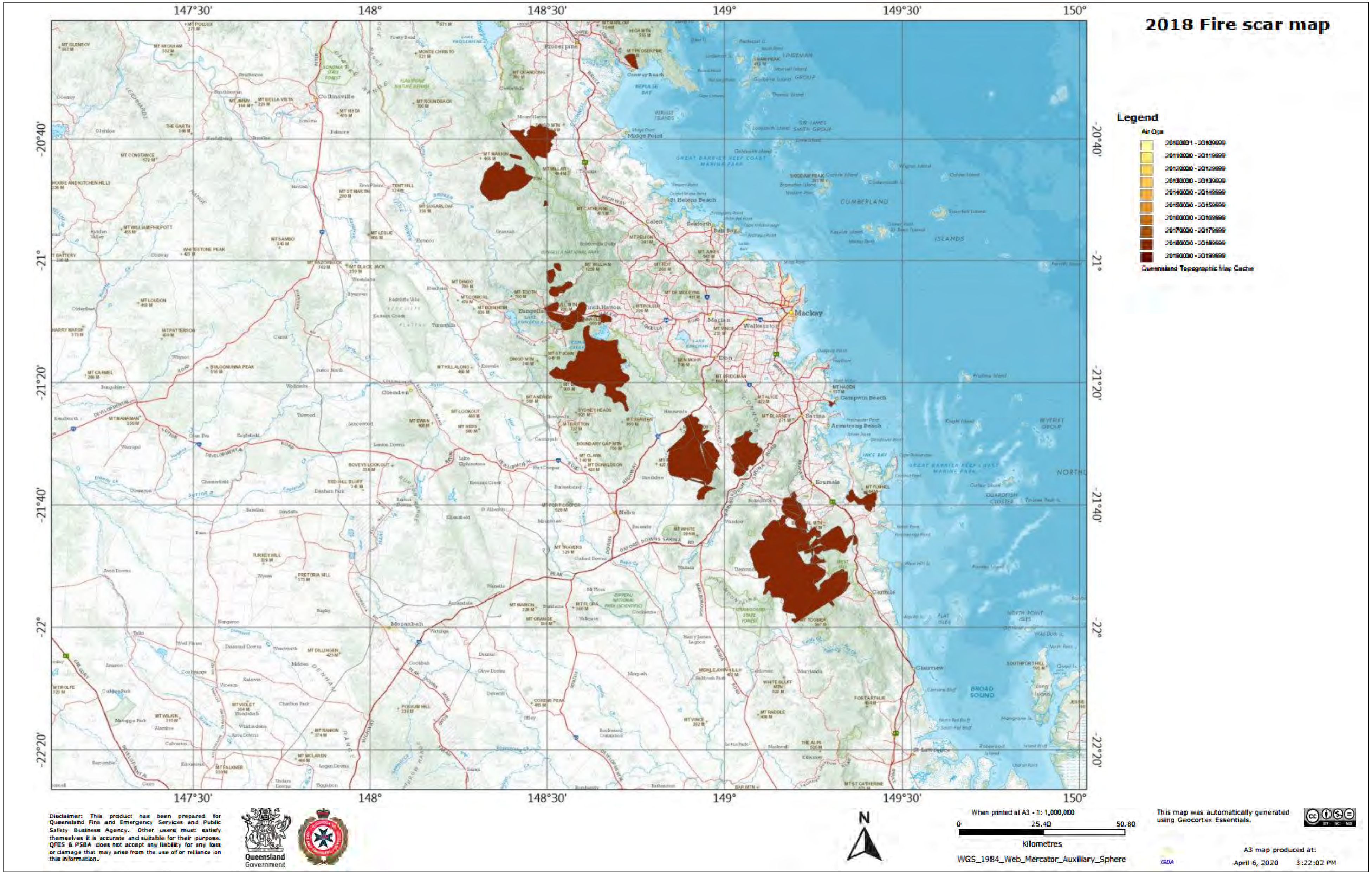


**Figure 7. Fire scar map for the 2018-19 fire season in the Mackay-Whitsunday-Isaac region. Source: Queensland Government and Queensland Fire and Emergency Services.**

# 3 Freshwater basin results

The indicators, relevant indicator categories and overall indices that are assessed for the basins are presented in Figure 8.

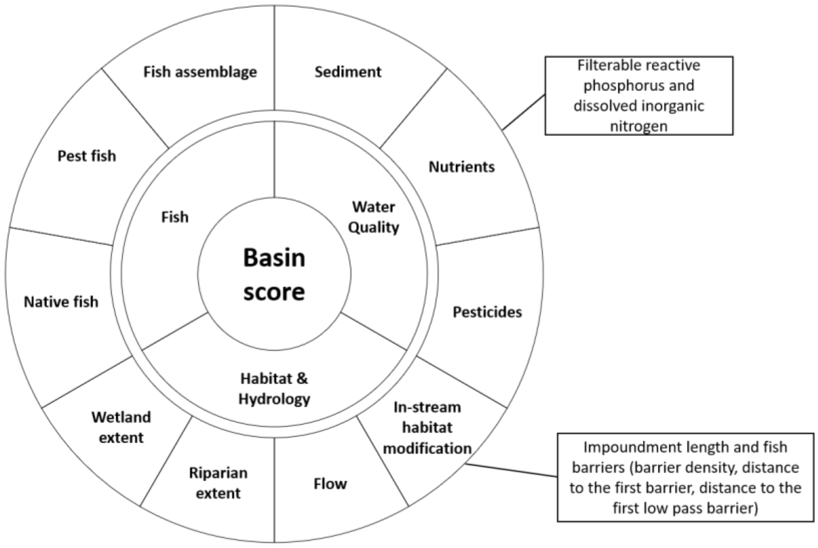


**Figure 8. Indicator categories (outer ring) and indices (inner ring) that contribute to overall basin scores. Where multiple indicators are aggregated to determine the indicator category, these are listed in break-out boxes.**

The overall freshwater basin grades were derived from three indicator categories, namely water quality, habitat and hydrology, and fish. Consistent with the reporting frequency[1], all water quality indicators were updated in the 2019 report card. Several habitat and hydrology indicators were updated for the 2019 report card including fish barriers, freshwater flow and wetland extend indicators, where impoundment and riparian extent scores were based on repeated data. As monitoring occurs only every three years, freshwater fish scores are repeated from the 2018 report card; this reflects the gradual nature of change associated with these indicators. For more information on reporting frequencies and metrics for each indicator, refer to the 2019 Report Card Methods document[2].

The overall freshwater basin grades were similar when compared to the 2018 report card, ranging from C (moderate) to B (good) (Table 3). Based on the results, the northern basins (Don and Proserpine) appeared to be in better condition with respect to waterway health, where the southern basins of the Pioneer and Plane scored poorer. Whilst this reflection coincided with on-ground observations of system condition by local experts, information is not available for the state of flow and fish metrics in the Don Basin. Likewise, insufficient data is available to report on water quality within the Proserpine River. As scores for the fish indicator are based on repeated data, any changes to the overall basin scores in the 2019 report card are driven by variation in the scores for water quality and habitat and hydrology indices.

[1] https://healthyriverstoreef.org.au/report-card/program-design/
[2] https://healthyriverstoreef.org.au/report-card/report-card-download/

**Table 3. Condition grades of freshwater basins for the 2019 report card in comparison to 2018, 2017, 2016, 2015 and 2014 report card scores.**

| Freshwater basin | 2019 report card | | | | | 2018† | 2017†* | 2016^ | 2015^ | 2014^ |
|---|---|---|---|---|---|---|---|---|---|---|
| | Water quality | Habitat and hydrology | Fish | Basin score and grade | | Basin score | Basin score | Basin score | Basin score | Basin score |
| Don | 66 | 75 | | **71** | **B** | 69 | 59 | 48 | 48 | 54 |
| Proserpine | | 50 | 79 | **65** | **B** | 65 | 52 | 53 | 53 | 52 |
| O'Connell | 55 | 43 | 92 | **63** | **B** | 66 | 53** | 58 | 57 | 52 |
| Pioneer | 46 | 40 | 82 | **56** | **C** | 55 | 40 | 41 | 41 | 34 |
| Plane | 37 | 37 | 79 | **51** | **C** | 50 | 50** | 52 | 51 | 35 |

**Scoring range:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

†denotes scores which have been back-calculated to incorporate changes associated with refinements to the source mapping used to assess wetland extent.

*denotes scores which have been back-calculated to incorporate updates to freshwater pesticides made in the 2018 report card.

**2017-2014 scores do not incorporate additional sites that were included for the first time in the 2018 report card.

^ 2016-2014 report card scores do not include back-calculated pesticide updates that were established for the 2018 report card.

## 3.1 Water quality in freshwater basins

Water quality condition scores for the 2019 report card were derived using data obtained from the Great Barrier Reef Catchment Loads Monitoring Program (GBRCLMP). Scores were based on samples collected from end of catchment monitoring sties; one in each of the Don and Pioneer basins, and two in the O'Connell and Plane Basins. The location of monitoring sites is shown in Figure 9, below.

Where multiple monitoring sites exist within a reporting zone, a weighted average of site-level scores was used to determine the relevant indicator score. In each case, weightings are based upon the catchment area, draining into the waterway upstream of the gauging station (Appendix A2). Further information on combining data from multiple monitoring sites is provided in the Methods for the Mackay-Whitsunday-Isaac 2019 document[1].

Water quality samples are collected using two methods: manual grab sampling and automated grab sampling using refrigerated pump samplers. Intensive sampling (daily or every few hours) was conducted during high flow events and monthly sampling was conducted during low or base-flow

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

ambient) conditions. Where sites are tidally influenced, samples were collected on the outgoing low tide[1].

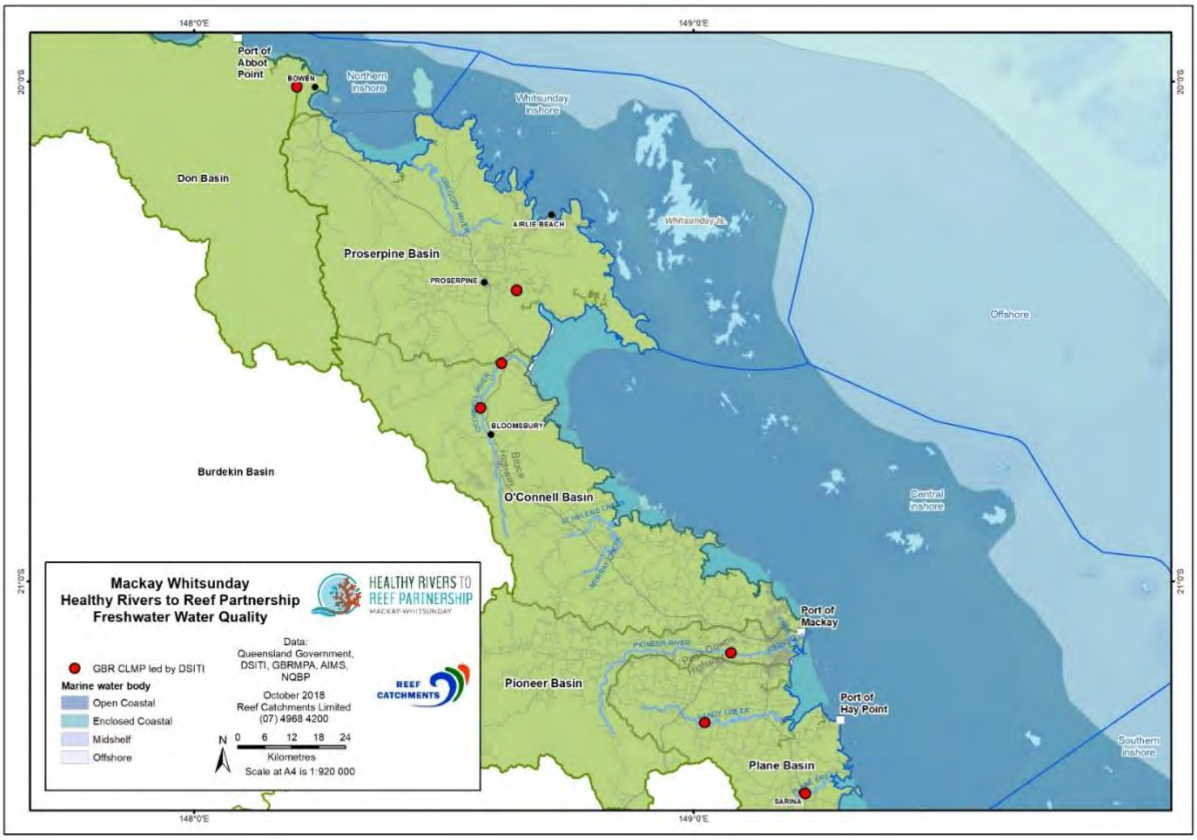


**Figure 9. Sampling locations for freshwater water quality monitoring in the Mackay-Whitsunday-Isaac Region.**

To assess water quality, criteria derived from the Queensland Water Quality Guidelines (2009) (DES 2009) were adopted. However, these do not extend to the Don basin. For the Don river, the criteria for assessment were based on the 'Draft environmental values and water quality guidelines: Don and Haughton River basins, Mackay-Whitsunday estuaries, and coastal/marine waters' (Newham et al. 2017). Condition scores were calculated by comparing the annual sample median to the guideline value, for each indicator at each site within a reporting area (basin). For further details on the adopted guidelines, refer to the Methods for the Mackay-Whitsunday-Isaac 2019 report card document[2].

While data was collected from the Proserpine River end of catchment loads monitoring site at Glen Isla, the site is located in the estuary and therefore concentration of nutrients and sediments are influenced by the ingress of seawater and tidal movements. While this data is suitable for determining pollutant loads leaving the Proserpine River (the purpose of the monitoring site), it is not suitable for reporting the ambient state (concentration) of nutrients and sediments in the freshwater ecosystem because their source (catchment or estuarine) cannot be determined with confidence. Nutrient and sediment indicator category results for the Proserpine basin are therefore not reported in the 2019 report card.

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[1] Catchment pollutant loads monitoring methods, Great Barrier Reef Report Card 2016, Reef Water Quality Protection Plan, Queensland Government.
[2] https://healthyriverstoreef.org.au/report-card/report-card-download/

Conversely, pesticides are still reported for the Proserpine basin. Data from the Glen Isla site provides a good estimate of pesticide pressure from the freshwater catchment; the dilutive potential of the tidal inflow of seawater is not anticipated to dilute the magnitude of the ms-PAF score substantially (see methods[1] document for further detail) and a ms-PAF score calculated above the tidal zone would not necessarily provide a more accurate picture of the pesticide pressures in the catchment, as it would miss some of the inputs.

### 3.1.1 Sediments

Sediment scores are based upon the reported concentrations of total suspended solids (TSS). In the 2019 report card, sediment indicator category grades were similar or improved when compared to the previous year, grading moderate across the Don, O'Connell, and Plane basins, and good in the Pioneer basin (Table 4). This demonstrates that the median annual condition for TSS at the monitored sites did not meet the guidelines for the protection of environmental values in three of the four basins assessed.

Elevated levels of TSS broadly coincided with prevailing rainfall conditions, where an active monsoon trough and slow-moving pressure system produced above average rainfall in the region from late January into early February of 2019. The maximum median concentration reported for TSS were observed in January 2019 for the Don River, O'Connell River, Pioneer River and Sandy Creek monitoring sites, with median TSS peaking in February of 2019 at the Plane River monitoring site. In all cases, maximum monthly medians exceeded the guideline values by an order of magnitude. During this time, landholders in the northern regions experienced flooding and water logging, which may have influenced the level of surface runoff transporting sediment and ultimately received in the region's rivers and streams. Despite the very high rainfall events that occurred in late January and early February 2019, the scores for sediment did not show much change with respect to the previous year.

Sediment remains a pollutant of concern for the Mackay-Whitsunday-Isaac region, where moderate to poor grades have been observed in the Don, O'Connell and Plane basin for three consecutive years.

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

**Table 4. Results for the sediment indicator category (based on a measure of TSS) score for water quality in freshwater basins for the 2019 report card (2018-19 data) in comparison to 2018, 2017, 2016, 2015 and 2014 scores. Scores for 2019 include combined additional sites in the O'Connell and Plane basins.**

| Freshwater Basin | 2019* | 2018* | 2017 | 2016 | 2015 | 2014 |
|---|---|---|---|---|---|---|
| | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| Don (Don River) | 58 | 60 | 29 | | | |
| Proserpine^ | | | | | | |
| O'Connell (O'Connell River) | 59 | 53 | 57 | 55 | 58 | 55 |
| Pioneer (Pioneer River) | 63 | 60 | 60 | 59 | 59 | 53 |
| Plane | 55 | 55 | 55 | 54 | 61 | 51 |

**Sediment:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

*denotes reporting years where data was obtained from additional monitoring sites in the O'Connell and Plane basins. Consequently, these scores are not directly comparable to the values reported in 2017, 2016, 2015 and 2014.

^ Insufficient monitoring data was available to adequately assess sediment conditions within the Proserpine basin. Consequently, no score is reported for this indicator. Further information on monitoring in the Proserpine basin is provided in Section 2.1

Additional freshwater sites were incorporated into the 2019 report card for the second consecutive year. Site-level scores for the O'Connell and Plane are provided in Table 5 below.

**Table 5. Results for the sediment indicator category (based on a measure of TSS) for sites in the O'Connell and Plane basins for the 2019 report card (2018-19 data), compared to 2018.**

| Freshwater Basin | Sediment | |
|---|---|---|
| | 2019 | 2018 |
| **O'Connell basin** | | |
| O'Connell River (Caravan Park) | 58 | 56 |
| O'Connell River (Stafford's Crossing) | 60 | 48 |
| **Plane basin** | | |
| Plane (Sandy Creek) | 55 | 54 |
| Plane (Plane Creek) | 56 | 58 |

**Sediment:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

### 3.1.2 Nutrients

The results for indicators in the nutrient category for the 2019 report card are presented in Table 6. Dissolved Inorganic Nitrogen (DIN) remains a pollutant of concern for the Mackay-Whitsunday-Isaac region, where each of the four basins assessed graded moderate or poor for this indicator for consecutive reporting years. This indicates that none of the annual medians for DIN met the relevant guidelines for protection of environmental values in the 2018-2019 reporting period. Despite this, an improvement in the score for DIN was evident in the Plane basin, increasing from 23 to 41 and consequently shifting from a poor to moderate condition grade. This was driven by changes at the site level, where the Sandy Creek score shifted from 12 to 37, resulting in an improvement of grade from very poor to poor (Table 7).

The scores for Filterable Reactive Phosphorus (FRP) were similar or improved when compared to the previous reporting year. There was a slight improvement in FRP scores for the Don and Plane basins, however, this did not translate to a change in condition grade.

Aggregated scores showed that nutrients remained in moderate condition for the fourth and sixth consecutive year in the O'Connell and Pioneer basins respectively, whilst grades for the Plane basin remained in poor condition, consistent with the previous reporting periods. Notably, there was a marked improvement in the overall nutrient score in the Plane basin, which increased from 24 to 37, owing to increases in the corresponding DIN and FRP indicator scores. As highlighted above, this did not translate to a shift in condition grade. The aggregated nutrient grade for the Don basin was good for the second consecutive year.

**Table 6. Results for DIN and FRP indicators and overall nutrients indicator category scores for water quality in freshwater basins for the 2019 report card (2018-19 data) in comparison to 2018, 2017, 2016, 2015 and 2014 report card scores. Scores for 2019 and 2018 are derived from results obtained at additional sites in the O'Connell and Plane basins. As a result, these are not directly comparable to scores reported for the preceding years.**

| Freshwater Basin | 2019 report card | | | 2018 | 2017 | 2016 | 2015 | 2014 |
|---|---|---|---|---|---|---|---|---|
| | DIN | FRP | Nutrients | Nutrients | Nutrients | Nutrients | Nutrients | Nutrients |
| Don | 58 | 74 | **66** | **62** | **33** | | | |
| Proserpine* | | | | | | | | |
| O'Connell | 56 | 59 | **57** | **59** | **60** | 60 | 90 | 55 |
| Pioneer | 33 | 60 | **46** | **53** | **45** | 52 | 53 | 46 |
| Plane | 41 | 34 | **37** | **24** | **24** | 39 | 27 | 16 |

**DIN and FRP:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = assigned 90 | No score/data gap

**Nutrients:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

*Insufficient monitoring data was available to adequately assess nutrient conditions within the Proserpine basin. Consequently, no score is reported for this indicator. Further information on monitoring in the Proserpine basin is provided in Section 2.1.

Additional freshwater sites were incorporated into the 2019 report card for the second consecutive year. Site-level scores for the O'Connell and Plane are provided in Table 7 below.

**Table 7. Results for the nutrients indicator category (based on a measure of DIN and FRP) for sites in O'Connell and Plane basins for water quality in freshwater basins for the 2019 report card (2018-19 data) compared to 2018 scores.**

| Freshwater Basin | 2019 report card | | 2018 report card | |
|---|---|---|---|---|
| | DIN | FRP | DIN | FRP |
| **O'Connell basin** | | | | |
| O'Connell River (Caravan Park) | 55 | 58 | 59 | 59 |
| O'Connell River (Staffords Crossing) | 56 | 60 | 59 | 59 |
| **Plane basin** | | | | |
| Plane (Sandy Creek) | 37 | 29 | 12 | 15 |
| Plane (Plane Creek) | 52 | 53 | 61 | 61 |

**DIN and FRP:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = assigned 90 | No score/data gap

### 3.1.3 Pesticides

The pesticide indicator scores were developed using the Pesticide Risk Metric (PRM) approach. The aim of this approach is to quantify the ecological risk associated with exposure to a mixture of pesticides. Measured concentrations of up to 22 different pesticides in a given sample are converted to a PRM that expresses risk as the percent of aquatic species that may be adversely affected by a mixture of pesticides, as detailed in Appendix E. The PRM values (expressed as percent of species protected) for 2018-2019 represent the average risk over a standardised wet season of 182 days when exposed to a mixture of different pesticides, including nine PSII herbicides (Photosystem II inhibitors), 10 non PSII herbicides and three insecticides. Of note, is that previous report cards (2017 and 2016) reported PRM scores (previously referred to as the multisubstance-Potentially Affected Fraction (ms-PAF)) for 13 PSII herbicides. The PRM scores are then allocated to a risk category (i.e. very good to very poor) consistent with that recommended by ANZG (2018) and used across multiple Reef reporting mechanisms including the Reef Report Card. For further information on the methodology adopted for calculation of the Pesticide Risk Metric, refer to the 'Methods for the Mackay-Whitsunday-Isaac 2019 Report Card' document[1]. For each basin, the PRM score is presented in Table 8 and the proportional contribution of each individual analyte to the overall pesticide risk metric is presented in Figure 10.

PRM scores were similar or improved when compared to the previous reporting year. The grades ranged from very poor in the Proserpine and Plane basins to good in the Don basin. Based on the prevailing hydrological conditions in the 2018-2019 reporting year, which required farmers to delay spraying activity until the wet season when the rate of pesticide export would be much higher, monitoring may have been expected to capture higher pesticide concentrations, yielding poorer condition scores. Instead, pesticide scores were relatively stable.

Imidacloprid, atrazine and diuron were the key contributors to the overall PRM in the Proserpine, O'Connell, Pioneer and Plane basins (Figure 10). In contrast, a high proportion of the PRM was attributed to reported metsulfuron-methyl concentrations in the Don Basin (Figure 10). This contrast in the PRM profile between regions reflect the relevant land-use applications, where the Don basin is dominated by horticultural crops as opposed to sugarcane. The remaining basins are characterised by intensive sugarcane farming. The concentrations of diuron that contributed to the 2019 PRM also resulted in multiple exceedances of the current national guidelines for the protection of moderately disturbed aquatic ecosystems (i.e. 0.2 µg/L; ANZG 2018). Similarly, the concentrations of imidacloprid that contributed to the 2019 PRM resulted in multiple exceedances of the proposed guideline for the protection of moderately disturbed aquatic ecosystems (i.e. 0.11 µg/L; King *et al.* 2017). These exceedances were not formally reported by the Queensland Department of Environment and Science in the 2018-2019 year (Pers. Comm., GBR Catchment Loads Monitoring Program).

Overall, pesticides remained the poorest scoring indicator for basin water quality in the Mackay-Whitsunday-Isaac Region in the 2018-19 reporting year, indicating a high risk of adverse effects to the region's aquatic species due to pesticide exposure. Results for the Proserpine and Plane basins are particularly concerning, where the PRM has been reported as 'very poor' for three consecutive monitoring years.

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

**Table 8. Results for the Pesticide Risk Metric indicator accounting for 22 pesticides, reporting aquatic species protected (%) and overall standardised pesticide score for freshwater basins for the 2019 report card compared to 2018 and 2017.**

| Pesticides | 2019 report card | | 2018 report card | 2017 report card* |
|---|---|---|---|---|
| Basin | Pesticide Risk Metric (% species protected) | Standardised Pesticide Score | Pesticide score | Pesticide score |
| Don | 98.3 | 75 | 70 | 75 |
| Proserpine | 65.9 | 17 | 18 | 19 |
| O'Connell | 92.3 | 48 | 48 | 36 |
| Pioneer | 84.6 | 30 | 19 | 26 |
| Plane | 70.5 | 18 | 17 | 15 |

**Species protected scoring range:** ■ Very Poor = <80% | ■ Poor = <90 to 80% | ■ Moderate = <95 to 90% | ■ Good = <99 to 95% | ■ Very Good = ≥99% | ■ No score/data gap

**Pesticides:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

* 2017 pesticides scores have been back-calculated to incorporate changes in pesticide method that occurred for the first time in the 2018 report card.

Additional freshwater sites were incorporated into the 2019 for the second consecutive year. Scores for specific freshwater sites in the O'Connell and Plane are provided in Table 9.

**Table 9. Results for the pesticides indicator category (based on a measure of 22 pesticides) for sites in O'Connell and Plane basins for water quality in freshwater basins for the 2019 report card (2018-19 data) compared to 2018.**

| Pesticides | 2019 report card | | 2018 report card |
|---|---|---|---|
| Basin | Pesticide Risk Metric (% species protected) | Standardised Pesticide Score | Pesticide score |
| **O'Connell Basin** | | | |
| O'Connell River (Caravan Park) | 92.5 | 50 | 59 |
| O'Connell River (Staffords Crossing) | 91.9 | 48 | 59 |
| **Plane Basin** | | | |
| Plane (Sandy Creek) | 63.5 | 17 | 15 |
| Plane (Plane Creek) | 95.9 | 55 | 61 |

**Species protected scoring range:** ■ Very Poor = <80% | ■ Poor = <90 to 80% | ■ Moderate = <95 to 90% | ■ Good = <99 to 95% | ■ Very Good = ≥99% | ■ No score/data gap

**Pesticides:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

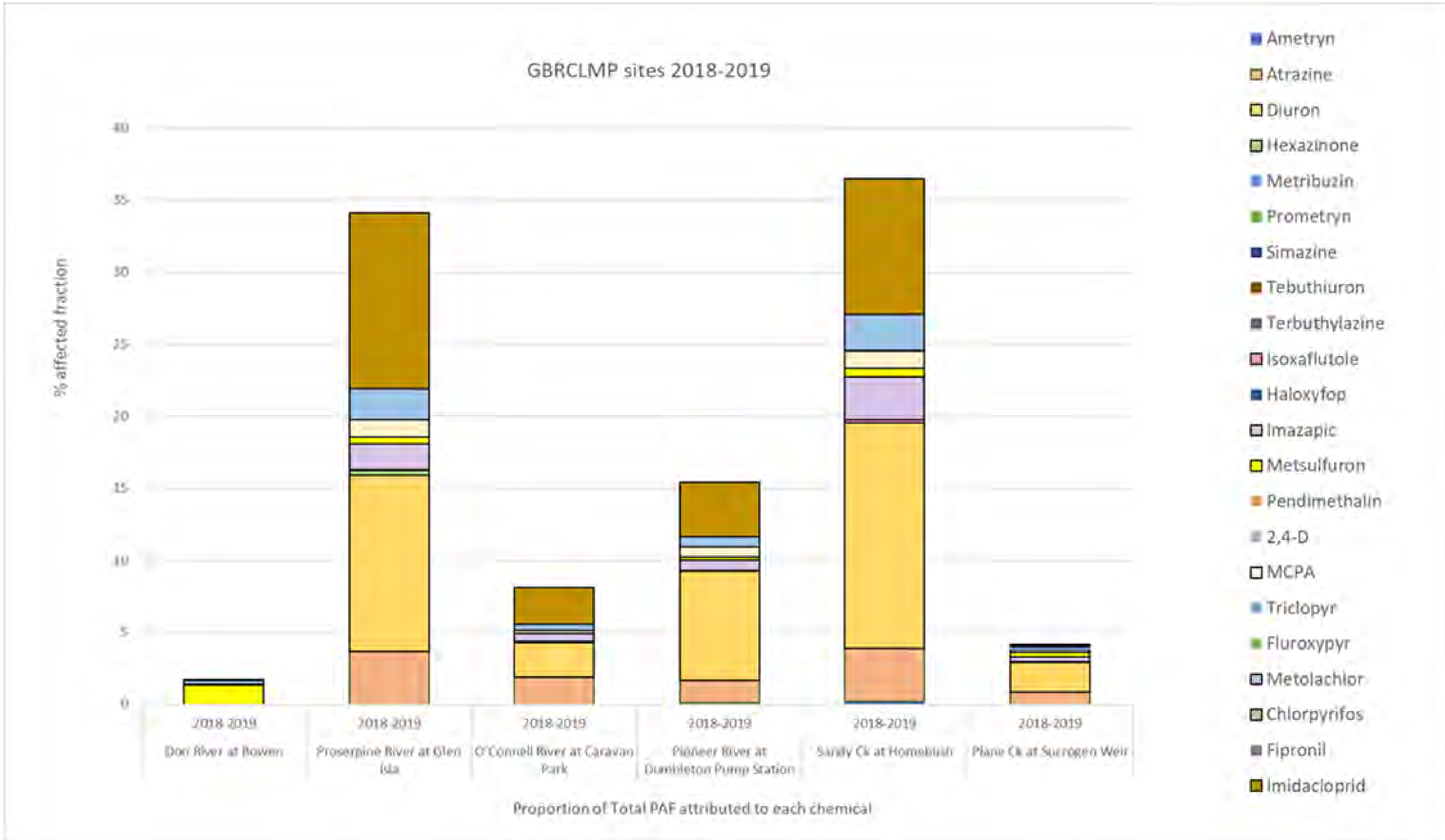


**Figure 10. Proportional contribution of each chemical to the final Pesticide Risk Metric (PRM) score, for the 2018-2019 reporting year. In this instance, the PRM is expressed as the % species affected fraction.**

### 3.1.4 Water quality index scores and confidence

In the 2018-2019 reporting year, the prevailing climate constituted an extended dry period, persisting until December 2018. High rainfall associated with a slow-moving monsoon trough impacted the region from January to February 2019. Despite a wetter than average year in northern basins of the Don and O'Connell, ambient water quality in the current assessment did not change substantially from the 2018 report card (which was a drier than average year).

Overall, water quality index grades in the Mackay-Whitsunday-Isaac basins ranged from poor to good (Table 10). This is the third consecutive year that scores for nutrients and pesticides have not met the desired criteria in the O'Connell, Pioneer and Plane basins. In addition, sediments scores continue to reflect a moderate condition for this metric in the O'Connell and Plane basin. As a result, the aggregated water quality index for these basins is reported as moderate or poor for the third consecutive year. By contrast, the Don basin received an aggregated water quality index of good for the second consecutive year.

Based on the rules for minimum proportion of information required to generate overall scores, a final water quality score could not be calculated for the Proserpine Basin.

**Table 10. Results for water quality indicator categories and final water quality index scores in freshwater basins for the 2019 report card (2018-2019 data) in comparison to 2018, 2017 2016, 2015 and 2014 report cards.**

| Water quality index | 2019 report card | | | | 2018 | *2017 | ^2016 | ^2015 | ^2014 |
|---|---|---|---|---|---|---|---|---|---|
| Basin | Sediment | Nutrients | Pesticides | Water quality | Water quality | Water quality | Water quality | Water quality | Water quality |
| Don | 58 | 66 | 75 | **66** | 64 | 46 | | | |
| Proserpine | | | 17 | | | | | | |
| O'Connell | 59 | 57 | 48 | **55** | 53 | 51 | 63 | 63 | 59 |
| Pioneer | 63 | 46 | 30 | **46** | 42 | 44 | 48 | 48 | 40 |
| Plane | 55 | 37 | 18 | **37** | 32 | 31 | 37 | 35 | 28 |

**Scoring range:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

*2017 scores have been back-calculated to incorporate updates to freshwater pesticides made in the 2018 report card. 2017 scores do not incorporate additional sites that were included for the first time in the 2018 report card.

^ 2016-2014 report card scores do not include back-calculated pesticide updates that were established for the 2018 report card.

The report card scores were rated in terms of the confidence and uncertainty surrounding the methods of assessment and data used in the development of each score. To achieve this, five criteria relating to data confidence are assessed for each indicator in each reporting area, including maturity of methodology, validation, representativeness, directness, and measure error. This information is used to provide a qualitative assessment of confidence for all grades generated in the report card. A detailed summary of confidence methods and scoring are provided in Section 5.1 of the methods report[1].

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

Confidence in water quality scores for the four basins is presented in Table 11. Confidence in water quality scores for the three basins was moderate (Table 11). This is primarily due to the low spatial representativeness of the monitoring program. Scores are calculated based on data from one to two sites per basin, and therefore can only be inferred as representing the entire basin with moderate confidence.

**Table 11. Confidence associated with water quality index results in freshwater basins in the 2019 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level. Unless specified, confidence in results is the same across basins.**

| Indicator category | Maturity of methodology (x0.36) | Validation (x0.71) | Representativeness (x2) | Directness (x0.71) | Measured error (x0.71) | Final | Rank |
|---|---|---|---|---|---|---|---|
| Sediment | 3 | 3 | 1 | 3 | 2 | 8.8 | 3 |
| Nutrients | 3 | 3 | 1 | 3 | 2 | 8.8 | 3 |
| Pesticides | 1 | 2 | 1 | 2 | 2 | 6.6 | 2 |
| | | | | | **Water quality index** | **8.8** | **3** |

**Rank based on final score:** 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

## 3.2 Habitat and Hydrology in freshwater basins

The habitat and hydrology index is comprised of three longer-term indicator categories that are updated every three to four years depending on the indicator, and flow. These long-term indicators include in-stream habitat modification (impoundment length and fish barriers), riparian extent and wetland extent.

### 3.2.1 In-stream habitat modification

The fish barrier indicator category was re-assessed for the 2019 report card, in accordance with its four-year reporting cycle and presented in Table 12 below. This reporting cycle was adopted during the development of the 2014 pilot report card due to a combination of logistical constraints and to align with the monitoring frequency of riparian and wetland extent indicators. This indicator was last updated in the 2015 report card.

The fish barrier indicator category is based on an assessment of three indicators: 'barrier density', 'proportion of stream length to the first barrier' and 'proportion of stream length to the first low/no passability barrier'. For the purpose of assessment, only barriers located on 'Major' (Strahler stream orders 4 -7) and 'High' risk (Strahler stream orders 2 – 3 with low gradient; Strahler stream order 3 with medium gradient) category waterways were included in the analysis. This information should be acknowledged when interpreting the results. Low passability barriers located on high ordered waterways close to the tidal interface have the greatest impact, preventing and impeding juvenile diadromous species from undertaking life-cycle dependant migrations into critical upstream nursery habitats. In this way, it is not just the density of barriers fragmenting the connectivity of channel habitat, but the relative position of barriers in the waterway, which may impact fish health.

Definitions for each of the three indicators are outlined in the Mackay-Whitsunday-Isaac 2019 methods document[1].

Northern freshwater basins of the Don and O'Connell recorded higher fish barrier grades (good and moderate respectively) when compared to the Proserpine basin and southern freshwater basins of the Plane and Pioneer, which graded moderate and poor respectively. The Proserpine, Pioneer and Plane freshwater basins comprise large population centres in the region (Proserpine, Mackay and Sarina respectively) and land use activities includes both urban developments and intensive agriculture. To support these activities, construction of transport infrastructure (e.g. roads and causeways) as well as irrigation and water supply storages (e.g. weirs) has been required, forming barriers to fish passage. Many of the low passability barriers are weirs. The impacts of these structures are particularly pronounced in the Pioneer which scored very poor for the indicator 'proportion of stream length to the first low/no passability barrier' (T.Power, pers comms, 29/04/2020). These factors also contributed to the poorer barrier condition grades in the Proserpine, Pioneer and Plane freshwater basins (Moore 2016).

As a component of the current assessment, field validation works were undertaken in the Don and Proserpine basins to investigate potential fish barriers which were identified through a desktop review process. Based on the findings of these works, several potential fish barriers were re-classified as it was determined they did not impede fish passage and were subsequently removed from the assessment. As a result, there was an increase in the condition of each of the reported fish barrier indicators, and ultimately, the overall fish barrier score for the Don basin. These findings are encouraging, as the freshwater streams of the Don basin are ephemeral in nature; they are typified by episodic flow, channels comprising of sandy substrate and characterised by few permanent freshwater habitats. Therefore, the unimpeded connectivity between limited permanent waterholes is important to prevent fragmented fish populations and for sustaining aquatic ecosystem health (Moore, 2019).

The rating for 'distance to the first low passability barrier' decreased from good to moderate for the Proserpine basin, where field validation works resulted in the identification of a large low passability barrier close to the estuarine interface on the Proserpine River. This barrier blocks connectivity to a large proportion (>60%) of the Proserpine River. This dam has been established for the purpose of impounding water for irrigation. Consequently, the final fish barriers score declined from 50 to 41 in the current assessment.

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

**Table 12. Results for fish barrier indicators in freshwater basins in the 2019 report card (2018-2019 data) compared to the 2018 report card (2014-2015 data). Indicators were assessed on Stream Orders (SO) ≥3 or ≥4 as indicated.**

| | 2019 report card | | | | | | | | 2018 report card (2014-2015 data) |
|---|---|---|---|---|---|---|---|---|---|
| | Barrier density | | Stream to the 1st barrier | | Stream to the 1st low "passability" barrier | | Fish barriers | | Fish Barriers |
| Basin | km per barrier on SO ≥3 | Score | % of stream before first barrier on SO ≥3 | Score | % of stream before first low pass barrier on SO ≥4 | Score | Total score | Fish barriers (standardised) | Fish barriers (standardised) |
| Don | 18.2 | 5 | 44.3 | 3 | 93.0 | 4 | **12** | **70** | **60** |
| Proserpine | 2.7 | 2 | 38.5 | 3 | 63.9 | 3 | **8** | **41** | **50** |
| O'Connell | 5.5 | 3 | 41.7 | 3 | 85.3 | 4 | **10** | **60** | **60** |
| Pioneer | 5.6 | 3 | 0.1 | 1 | 0.5 | 1 | **5** | **21** | **21** |
| Plane | 2.4 | 2 | 27.9 | 2 | 70.5 | 4 | **8** | **41*** | **41*** |

**Barrier density (km):** ■ Very Poor/score of 1 = 0 to 2km | ■ Poor/score of 2 = >2 to 4km | ■ Moderate/score of 3 = >4 to 8km | ■ Good/score of 4 = >8 to 16km | ■ Very Good/score of 5 = >16km | ■ No score/data gap

**Stream to 1st barrier (%):** ■ Very Poor/score of 1 = 0 to <10% | ■ Poor/score of 2 = 10 to <30% | ■ Moderate/score of 3 = 30 to <50% | ■ Good/score of 4 = 50 to <100% | ■ Very Good/score of 5 = 100% | ■ No score/data gap

**Stream to 1st low "passability" barrier (%):** ■ Very Poor/score of 1= 0 to 50% | ■ Poor/score of 2 = >50 to 60% | ■ Moderate/score of 3 = >60 to 70% | ■ Good/score of 4 = >70 to 95% | ■ Very Good/score of 5= >95% | ■ No score/data gap

**Total score:** ■ Very Poor = 3 to 4 | ■ Poor = 5 to 7 | ■ Moderate = 8 to 10 | ■ Good = 11 to 13| ■ Very Good = 14 to 15 | ■ No score/data gap

**Fish barriers (standardised):** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

*A data discrepancy for the Plane Basin was identified in the scoring for the previous assessment, which was recorded as having a score of 3 for 'proportion of stream length to the first low passability barrier (%)'. Instead, the Plane basin recorded a score of 4 and corresponding grade of good for this indicator. This correction resulted in a change in grade from moderate to good. This discrepancy has been rectified in the current report, including in the presentation of previous (2015) assessment results.

The impoundment length indicator was updated for the 2018 report card, aligning with its four-year reporting cycle (Table 13). Consequently, impoundment scores presented in the 2019 report card are based on repeated data. A permitted sand dam on the Proserpine River, impounding approximately 4km of linear stream length, was incorporated in the impoundment assessment for the first time in the 2018 report card. The presence of this sand dam was of concern as water impoundment may result in extended inundation of riparian vegetation contributing to potential increased erosion if submerged vegetation dies. This impoundment may also affect the efficacy of the fish way, which enables migratory fish to travel upstream. The inclusion of the sand dam shifted scores in the Proserpine basin from moderate to poor.

The Pioneer Basin also graded poor with 9.8% of the total length of streams of order three or higher impounded by artificial structure. There were no impoundments on streams (of order three or higher) in the Don Basin, giving it a condition score of very good. All basins, excluding the Proserpine, remained at similar condition for the 2018 report card, indicating there has been little change in the net proportion of ponded channel habitat within each basin since the last assessment conducted in 2015.

**Table 13. Results for the impounded stream indicator in freshwater basins in the 2019 report card (2017-18 data).**

| Basin | Not impounded (km) | Impounded (km) | Total (km) | % total | Standardised impoundment |
|---|---|---|---|---|---|
| Don | 954 | 0 | 954 | 0.0 | **100** |
| Proserpine | 524 | 41 | 565 | 7.3 | **39** |
| O'Connell | 598 | 16 | 614 | 2.6 | **70** |
| Pioneer | 498 | 54 | 552 | 9.8 | **22** |
| Plane | 671 | 28 | 698 | 4.0 | **60** |

**Impoundment (% total):** ■ Very Poor = ≥10% | ■ Poor = 7 to <10% | ■ Moderate = 4 to <7% | ■ Good = <4 to 1% | ■ Very Good <1% | ■ No score/data gap

**Standardised impoundment:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

The Impoundment and fish barrier indicators are aggregated up to form the in-stream habitat modification indicator category. As highlighted above, impoundment scores for the 2019 report card are based on repeated data (2017-2018 data), therefore, any variance observed in the overall score for in-stream habitat modification are explained by variance in the condition of the fish barrier indicator for the reporting area of interest. In-stream habitat modification scores and grades are provided in Table 14.

The in-stream habitat modification grade changed from good to very good in the Don basin, owing to improvements in the condition of the fish barrier indicator which shifted from moderate to good in the current assessment. Conversely, there was a slight decline observed in the aggregated score for the Proserpine basin owing to reductions in the condition of the fish barrier indicator. Although the fish barrier indicator remained in moderate condition, the score reduced from 50 (2015 assessment) to 41 in the current assessment. There were no changes to the in-stream habitat modification scores for the O'Connell, Pioneer and Plane, which ranked good, poor and moderate respectively (Table 14).

**Table 14. Results for the in-stream habitat modification indicator category in freshwater basins in the 2019 report card, compared to 2018.**

| | 2019 report card | | | 2018 |
|---|---|---|---|---|
| Basin | Impoundment | Fish barriers | In-stream habitat modification | In-stream habitat modification |
| Don | 100 | 70 | **85** | **80** |
| Proserpine | 39 | 41 | **40** | **44** |
| O'Connell | 70 | 60 | **65** | **65** |
| Pioneer | 22 | 21 | **21** | **21** |
| Plane | 60 | 41 | **50** | **50** |

**Scoring range:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

### 3.2.2 Riparian and wetland extent

In the 2019 report card, the same data was used for percent loss of riparian extent as in the preceding 2018, 2017, 2016, 2015 and 2014 report cards. The riparian extent scores and grades are shown in Table 16, below. Overall, the percent loss of riparian extent since pre-development ranged from 20 – 30% within the basins assessed. As a result, all basins were graded moderate for the condition of riparian extent.

The riparian extent indicator is updated in broad accordance with mapping updates produced by the Remote Sensing Centre, Department of Environment and Science. Consequently, the reporting frequency period is generally every four years. However, the data collected in 2017 is subject to considerable change, including amendments to the satellite imagery and data processing, in order to improve the resolution and accuracy of vegetation mapping. The updated mapping is scheduled to be released in mid-2020, after the development of the 2019 report card. Additionally, revised mapping and methods for calculating riparian extent will need to be reviewed by the regional report cards Technical Working Group (TWG), to ensure they are compatible to report in regional report cards. Therefore, it is anticipated this information will be available in the 2020 report card.

Conversely, based on available refinements to the wetland mapping data (version 5), the scores for wetland extent were updated for the 2019 report card. The changes to wetland extent, expressed as percent loss since pre-development and hectares lost since pre-development, and associated indicator scores are presented in Table 15. The scores for wetland extent were highly variable, ranging from very poor to very good. The Don basin was graded very good and the Proserpine basin graded moderate, with the remaining basins in poor to very poor condition relating to wetland extent. Whilst no natural or modified wetlands have been lost since the previous assessment, these scores reflect the significant historical loss estimated in regional wetlands. It is estimated that there has been a 44% reduction in the areal extent of wetlands in the region as a result of development. Declines at the basin level are particularly pronounced for the O'Connell and Pioneer, where palustrine wetlands have lost 66% and 71% of their pre-development extent, respectively.

In the Don basin, net increases in the extent of freshwater wetland observed were attributed to the conversion of estuarine wetlands to freshwater wetlands through damming or bunding. These increases mask a loss amongst other freshwater wetlands. For example, the historical loss of 1109 hectares of freshwater wetland in the Don catchment is masked by a gain of 1184 hectares due to conversion from estuarine to freshwater wetland[1]. In this instance, decreases in the areal extent of wetlands, driven by land modification and filling, are moderated by increases associated with anthropogenically driven changes in hydrology. Whilst the ecological value of new or expanded modified wetlands is acknowledged, it is important to emphasise that net increases in the extent of freshwater wetland are not necessarily an indication of a healthy riverine system. Instead, they are indicative of modification activity.

It should be noted that updated datasets and scores based on new wetland mapping methodology (Queensland Regional Ecosystem Version 5.1 Wetland Mapping), including the 2018-2019 scores, supersede all previously reported results pertaining to wetland extent. Consequently, scores from the previous assessment (2013) have been back calculated using the new maps in order to evaluate any change in wetland extent over time. The updated 2013 results, and more information about the back calculated assessment, are provided in Appendix A.3.

[1] https://www.reefplan.qld.gov.au/__data/assets/pdf_file/0020/82910/report-card-2017-2018-results-wetland-extent.pdf

**Table 15. Results showing % of wetland extent loss when compared to pre-development conditions for the 2019 report card, as assessed in 2017. This assessment pertains to palustrine wetlands only.**

| | 2019 report card | | | | 2019 report card | |
|---|---|---|---|---|---|---|
| | Wetland extent | | Riparian extent | | | |
| Basin | Hectares lost since pre-development | (% loss since pre-development) | Hectares lost since pre-development | (% loss since pre-development) | Standardised wetland extent | Standardised riparian extent |
| Don | 0* | -3* | | 29 | 100 | 41 |
| Proserpine | 848 | 15 | | 22 | 59 | 50 |
| O'Connell | 334 | 66 | | 22 | 14 | 51 |
| Pioneer | 1,279 | 70 | | 20 | 12 | 54 |
| Plane | 930 | 47 | | 29 | 23 | 41 |

**Riparian and Wetland extent (% loss):** ■ Very Poor = >50% | ■ Poor =>30 to 50% | ■ Moderate = >15 to 30% | ■ Good = >5 to 15% | ■ Very Good ≤5% | ■ No score/data gap

**Standardised riparian and wetland extent:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap* negative values denote scenarios where there has been an increase in the total area of riparian or wetland extent, since pre-development. Further investigation of these values is provided in Section 2.2.2.

### 3.2.3 Flow

Freshwater flow from waterways was reported as a component of the habitat and hydrology index within basins for the second consecutive year in the 2019 report card. Flow was assessed upon the 30$^{th}$ percentile value from 10 indicator categories at each assessment site and requires an operational stream gauging station and time series modelled pre-development daily flows to provide a reference condition. To account for differences in climate between years and natural variances in flow patterns from prevailing climate conditions, historical daily rainfall (100+ years) was utilised (Stewart-Koster et al. 2018). Further information on the methods employed for the flow indicator are available in the Mackay-Whitsunday-Isaac 2019 methods report[1].

For the 2019 report card, flow scores for both the Pioneer and Plane basin were reported (Table 16). The O'Connell flow basin score was excluded from reporting due to concerns of the score providing an inaccurate reflection of on-ground flow observations, when scores from the flow tool, a product developed for regional report cards to report on freshwater flow, were reviewed by the regional report card's TWG. Unseasonably low flows were recorded in the O'Connell River from July- November 2018 relating to the very dry climate conditions and effects of water extractions that occurred during this period. The resulting low to no flows interrupted important riverine processes that support healthy river ecosystems, including maintenance of riffle habitats, deterioration of water quality in water holes (such as dissolved oxygen and high water temperatures) and a reduced capacity for fish migration (B. Cockayne, pers comms, 22/04/2020). It is expected the flow tool will go through a review process for future report cards in collaboration with the report card's TWG and aquatic ecology experts to identify further refinements to the tool and methods, including rainfall seasonality.

The Pioneer basin dropped slightly in score in the 2019 report card, however the grade remained in a good condition for the second consecutive year. The flow score in the Pioneer was assessed from five stream gauging stations, with individual stations grading moderate to very good (Appendix A1, Table AA2). The Plane basin was scored for the very first time in the 2019 report card due to availability of

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

time series modelled pre-development daily flow data. Scores were based from one monitoring location and was graded in poor condition overall (Table 16).

Rainfall type was classed as average during the reporting year for both the Pioneer and Plane basins (Table 16). Climate conditions were dry prior to the commencement of rainfall events in December 2018, with the period between July 2018- November 2018 having monthly totals that were below average for all basins (Figure 5). Note that some differences can occur between rainfall classification produced by the flow indicator tool and the Bureau of Meteorology (BoM) climate reporting. This is due to differences in spatial coverage and the analysis applied to assess rainfall in the flow indicator tool. Further information on climate for the 2018-19 reporting year are available in section 2.6.3.

Flow was not assessed for the Don or Proserpine basins due to the lack of either pre-development modelled data or availability of open gauging stations. Considerable work has been undertaken between the release of the 2018 and 2019 report cards to explore opportunities to fill data gaps and is currently progressing in collaboration with the TWG and BoM.

**Table 16. Results for the flow indicator for freshwater basins for the 2019 report card.**

| Flow | Rainfall type | 2019 report card | 2018 |
|---|---|---|---|
| Basin | | Flow index | Flow index |
| Don | | | |
| Proserpine | | | |
| O'Connell* | | | 78 |
| Pioneer | Average | 72 | 66 |
| Plane | Average | 35 | |

**Standardised flow scoring range:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap
***The O'Connell score was omitted from reporting due to anomalous score.**

### 3.2.4 Habitat and hydrology index scores and confidence

The overall habitat and hydrology index grades for basins in the 2019 report card ranged from poor to good across the Mackay-Whitsunday-Isaac Region (Table 17). Consistent with the previous report card, the grades for the Proserpine and O'Connell basin were moderate, despite flow being excluded from the O'Connell basin for the 2019 report card. Similarly, the Pioneer and Plane basins remained in poor condition, despite the incorporation of the flow indicator for the first time in the Plane basin. The Don basin was the only basin reported in good condition for habitat and hydrology. The grade for the Don basin was similar to the previous report card, even though there was a substantial improvement in the wetland extent indicator, which shifted from poor to very good in the 2019 report card.

As data for the habitat and hydrology index includes repeated data from 2013-14 (riparian extent), these scores do no not fully capture changes in condition associated with climatic events, including Tropical Cyclone Debbie, or potential anthropogenic impacts to riparian extent which may have occurred between 2014 and 2019. Updates to the riparian extent indicator are scheduled for the 2020 report card, as described in section 3.2.2.

**Table 17. Results for habitat and hydrology indicator categories and the aggregated index in freshwater basins in the 2019 report card (using data repeated from 2016, 2015 and 2014 report cards for riparian extent), compared to the 2018 and 2017 report cards.**

| Habitat & hydrology | 2019 report card | | | | | 2018* | *2017 |
|---|---|---|---|---|---|---|---|
| Basin | In-stream habitat modification | Flow | Riparian extent | Wetland extent | Habitat and hydrology | Habitat and hydrology | Habitat and hydrology |
| Don | 85 | | 41 | 100 | 75 | 73 | 73 |
| Proserpine | 40 | | 50 | 59 | 50 | 51 | 52 |
| O'Connell | 65 | | 51 | 14 | 43 | 52 | 43 |
| Pioneer | 21 | 72 | 54 | 12 | 40 | 38 | 29 |
| Plane | 50 | 35 | 41 | 23 | 37 | 38 | 38 |

**Scoring range:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

* Scores have been back-calculated to incorporate changes associated with refinements to the source mapping used to assess wetland extent.

Confidence scoring for habitat and hydrology is provided in Table 18.

**Table 18. Confidence associated with habitat and hydrology index results in freshwater basins for the 2019 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level. Where confidence in results for the Don basin differ to the other basins, the relevant confidence score for the Don is presented in square parenthesis. Unless otherwise specified, confidence in results is the same across basins.**

| Indicator category | Maturity of methodology (x0.36) | Validation (x0.71) | Representativeness (x2) | Directness (x0.71) | Measured error (x0.71) | Final | Rank |
|---|---|---|---|---|---|---|---|
| In-stream habitat modification[1] | | | | | | 10.4 [7.7] | 4 [2] |
| Riparian extent | 2 | 2 | 2 | 2 | 2 | 9 | 3 |
| Wetland extent | 2 | 2 | 2 | 2 | 2 | 9 | 3 |
| Flow | 1 | 1 | 2 | 2 | 1 | 7.2 | 2 |
| | | | | | **Habitat and hydrology index** | **9** | **3** |
| | | | | | | | |
| Impoundment | 2 | 2 | 3 | 2 | 1 | 10.3 | 4 |
| Fish barriers | 1 | 2 [1] | 3 [1] | 2 | 2 [1] | 10.6 [5.2] | 4 [1] |

[1]The in-stream habitat modification rank is based on the median final score of impoundment and fish barriers indicators.

**Rank based on final score:** 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

## 3.3 Fish in freshwater basins

Assessments of fish in freshwater basins are updated every three years and were updated for the 2018 report card, where scores for freshwater fish in the Proserpine basin were reported on for the first time (Table 20). Consequently, freshwater fish scores presented in the 2019 report card are repeated data. Results for freshwater fish assessments were based on electrofishing, which was used to identify the fish species present at 46 randomly selected sampling sites. The majority of Australian freshwater

[1] In-stream habitat modification is the median of impoundment and fish barrier final scores.

fish are small, e.g. less than 10-15 cm in length, therefore results presented here do not necessarily reflect the expected catch from line-fishing.

Fish survey results were expressed as the Proportion of Native Species Expected (PONSE), which is the number of native fish species caught in relation to the number predicted to occur, based on a numeric model. Median values of PONSE across Mackay-Whitsunday-Isaac basins ranged from very good to moderate. The O'Connell basin was in very good condition, whilst those for the Proserpine and Pioneer basins were rated as good. Results for the Plane basin were considered to represent freshwater fish communities in moderate condition.

The proportion of alien (pest) fish in catches were graded as very good across all of the basins assessed, which was an improvement to 2017 results (repeated from 2015 report card due to reporting frequency), for which only the Plane was in a very good condition. The very good scores for the relative abundance of pest fish in the Mackay-Whitsunday-Isaac region are encouraging and highlight the importance of minimising the impact of pest fish through management and eradication programs. It is worth noting that the Mackay-Whitsunday-Isaac region has fewer introduced fish than other parts of Queensland such as South East Queensland and some basins within the Wet Tropics.

Unfortunately, a small number of Peacock Bass were caught from the Pioneer River and The Gooseponds at Mackay, in 2019 at the time of reporting. Peacock Bass are a voracious predator native to central South America and have the potential to spread and cause major impacts on the region's local waterways. Pest fish may affect aquatic plants and animals through direct competition for food and space, predation, driving habitat changes and the introduction of exotic diseases and parasites. For this reason, it is important to prevent the introduction of pest fish into local waterways and eradicate new incursions wherever possible. Continuing the management of existing pest fish populations such as Tilapia and Peacock Bass are critical to reduce threats to native fish species.

Overall, results for the 2018-19 reporting period (based on 2017-2018 data) indicated that local freshwater fish communities, at a catchment scale, are generally in good to very good condition, with results for the Pioneer and O'Connell basins improving from the previous monitoring year to very good, and the Plane maintaining a stable score of good (Table 19).

On face value, the good to very good fish grades appear to be inconsistent with the grades for freshwater pesticides, which are very poor in two of the five basins (Table 8). However, it is important to note that the fish and pesticide scores represent two quite different measures. Further research is required to understand the impacts of high pesticide concentrations and links to fish health.

The fish indicators used to produce these scores were improved from the 2015 reporting period.

**Table 19. Results for fish indicators in freshwater basins in the 2019 report card (2017-18 data).**

| | 2019 report card | | | 2017 (2014-2015 data) |
|---|---|---|---|---|
| Basin | Native fish richness (PONSE) | Pest fish (proportion of sample) | Fish (standardised) | Fish (standardised) |
| Don | | | | |
| Proserpine | 70 | 89 | 79 | |
| O'Connell | 84 | 100 | **92** | **65** |
| Pioneer | 65 | 100 | **82** | **48** |
| Plane | 59 | 100 | **79** | **79** |

**Scoring range:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

Confidence associated with freshwater fish results is presented in Table 29, below.

**Table 20. Confidence associated with fish index results in freshwater basins for the 2019 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level. Unless otherwise specified, confidence in results is the same across basins.**

| Indicator category | Maturity of methodology (x0.36) | Validation (x0.71) | Representativeness (x2) | Directness (x0.71) | Measured error (x0.71) | Final | Rank |
|---|---|---|---|---|---|---|---|
| Native richness | 2 | 2 | 2 | 2 | 2 | 9.0 | 3 |
| Pest fish abundance | 2 | 2 | 2 | 2 | 2 | 9.0 | 3 |
| | | | | | **Fish index** | **9.0** | **3** |

**Rank based on final score:** 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

## 3.4 Key messages for freshwater basins

- Freshwater basins in the Mackay-Whitsunday-Isaac region scored moderate to good for the 2019 report card overall, similar to the 2018 report card.
- Water quality has remained relatively consistent in freshwater basins (ranging from good to moderate) throughout reporting years in Mackay-Whitsunday-Isaac report cards.
- Sediment scores in freshwater basins has remained relatively stable across reporting years. In the 2019 report card, the Pioneer basin shifted from moderate to good for the first time since the report card's establishment.
- The Plane basin had the lowest water quality score, reporting as poor for the sixth consecutive year.
- Pesticides continued to be the poorest scoring water quality indicator, with the Proserpine and Plane basins scoring very poor. The Pioneer basin scored poor for the 2019 report card, which was an improvement on its score of very poor in the 2018 report card, however is consistent with previous reporting years (2015-2017).
- Imidacloprid, atrazine and diuron were the key contributors to the overall Pesticide Risk Metric in the Proserpine, O'Connell, Pioneer and Plane basins and are key constituents of many pesticides used in sugar cane production. This was the first year that the proportional contributions of the different types of pesticides were quantified in the report card.

- The fish barrier indicator for freshwater basins was updated for the 2019 report card, following its four-year reporting cycle. There was an improvement of the grade in the Don basin from moderate to good, which was attributed to improvements in data accuracy.
- Updated fish barrier assessments in the Don basins showed that the system in this area comprises large areas of connected stream habitat. The Don basin has reported on water quality for three consecutive years.
- Based on recommendations provided as a result of the 2014-15 fish barrier assessment, additional ground truthing of potential fish barriers was undertaken in the Don basin. Ground truthing determined that some identified potential fish barriers did not impede fish passage. These barriers were removed from assessment and the fish barrier score improved from moderate to good.
- The riparian extent indicator follows a four-year reporting cycle and broadly follows mapping updates produced by the Remote Sensing Centre, Department of Environment and Science, and as such, freshwater basin riparian scores are based on data used in the 2014-2018 report cards. Updated mapping is scheduled to be released in mid-2020, after the development of the 2019 report card, and will result in a review of revised mapping and methods conducted by the report card's Technical Working Group. It is anticipated that riparian extent information will be available for the 2020 report card.
- Scores for wetland extent were updated for the 2019 report card, based on available refinements to the wetland mapping data. Scores for wetland extent were highly variable, ranging from very poor to very good. Whilst no natural or modified wetlands have been lost since the previous assessment, these scores reflect the significant historical loss estimated in regional wetlands. It is estimated that there has been a 44% reduction in the areal extent of wetlands in the region as a result of development.
- Wetland extent loss is particularly pronounced for the O'Connell and Pioneer, where palustrine wetlands have lost 66% and 71% of their pre-clear extent, respectively.
- As the habitat and hydrology index includes repeated data from 2013-14 (riparian extent), these scores do no not fully capture changes in condition associated with climatic events, including Tropical Cyclone Debbie, or potential anthropogenic impacts to riparian extent that may have occurred between 2014 and 2019.

# 4 Estuary results

The indicators, relevant indicator categories and overall indices that are assessed for estuaries are presented in Figure 11.

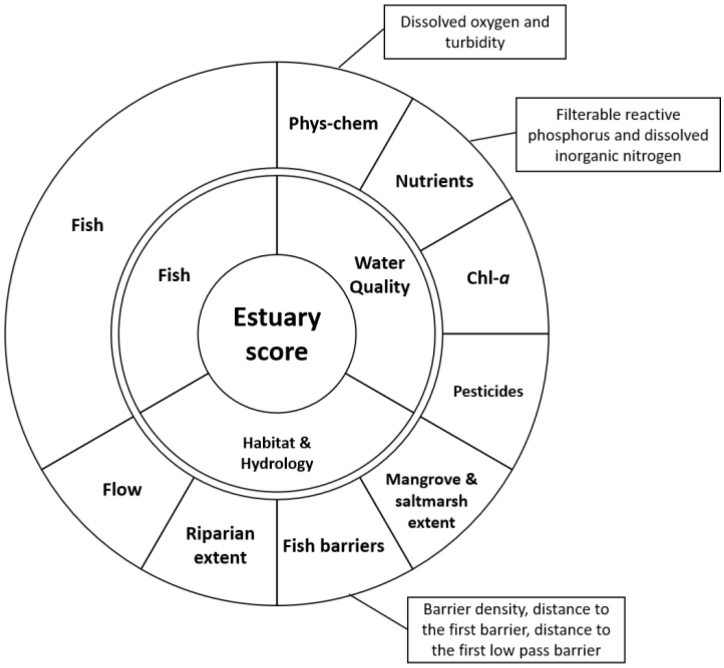


**Figure 11. Indicator categories (outer ring) and indices (inner ring) that contribute to overall estuary scores. Where multiple indicators are aggregated to determine the indicator category, these are listed in break-out boxes.**

For the 2019 report card, the estuary grades were derived from two indicator categories: water quality and habitat and hydrology. In contrast to the previous reporting year, all indicators comprising the water quality category were updated in the 2019 report card. Of the four indicators comprising the habitat and hydrology category, three were updated in the 2019 report card, namely riparian extent, fish barriers and mangrove and saltmarsh extent.  At this stage, there is no established methodology for the assessment of estuarine fish, therefore, no score is reported for this index.

The overall estuary grades have remained relatively stable since the first full report card in 2015, ranging from moderate to very good across all reporting years (Table 21). In 2019, the condition grades for estuaries ranged from C (moderate) to B (good), as shown in Table 21. With the exception of St Helens/Murray Creek, scores for the habitat and hydrology index were similar to the 2018 report card. As a result, any variance in the 2019 estuary scores are explained by variance observed in the water quality index.

It should be noted that changes in the water quality index were, in part, influenced by the incorporation of pesticide information in the current assessment. Additionally, estuary scores and grades are based upon results obtained through increased sampling effort in the assessment of pesticides, for the first time in the 2019 report card. This follows the successful establishment of a Partnership funded pesticide monitoring program, spanning eight of the region's estuaries. Consequently, the 2019 pesticide indicator scores represent the most reliable estimate of estuary pesticide condition reported in the history of the Mackay-Whitsunday-Isaac report card. Because pesticide scores are typically lower than those for other indicators, the inclusion of additional data into the score for the 2019 report card may confound interpretation of change observed between reporting years.

Compared to the previous reporting year, overall estuary scores varied slightly with no consistent directional change in condition across the region. Notable changes included a decrease in the estuary score for Rocky Dam Creek, driven primarily by declines in the chlorophyll-*a* indicator and the incorporation of the pesticide score which graded poor. The overall grade for Rocky Dam however remained as good. An equivalent decrease in estuary score was observed in Vines Creek, shifting from good to moderate, owing principally to declines in the DIN indicator and the incorporation of pesticides scores which graded poor. In contrast, there was an improvement in the estuary score for Carmila Creek, due to improvements in the upper DO indicator.

**Table 21. Condition grades of estuaries for the 2019 report card in comparison to 2018, 2017, 2016 and 2015* report card scores.**

| Estuary | 2019 report card: Water quality | Habitat and hydrology | Fish | Estuary score and grade | | 2018: Estuary score* | 2017: Estuary score** | 2016: Estuary score** | 2015: Estuary score** ^ |
|---|---|---|---|---|---|---|---|---|---|
| Gregory | 77 | 83 | | **80** | **B** | 82 | 79 | 80 | 79 |
| O'Connell | 56 | 57 | | **56** | **C** | 51 | 61 | 54 | 57 |
| St Helens/Murray | 59 | 69 | | **64** | **B** | 57 | 61 | 61 | 63 |
| Vines | 50 | 65 | | **57** | **C** | 68 | 64 | 72 | 73 |
| Sandy | 57 | 45 | | **51** | **C** | 58 | 52 | 50 | 52 |
| Plane | 70 | 56 | | **63** | **B** | 68 | 67 | 59 | 61 |
| Rocky Dam | 60 | 73 | | **66** | **B** | 76 | 70 | 73 | 70 |
| Carmila | 64 | 92 | | **78** | **B** | 67 | 66 | 73 | 79 |

**Scoring range**: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

*2018 scores do not include pesticide monitoring data and, therefore, are not directly comparable

**2017, 2016 and 2015 scores include pesticide monitoring data, but have not been back-calculated to address changes to the method of assessment and, therefore, are not directly comparable.

^Data from 2015 report card is repeated from the 2014 report card.

## 4.1 Water quality in estuaries

The scores and grades for estuaries reported in the Mackay-Whitsunday-Isaac (MWI) Region are based on monitoring conducted in the following tidal rivers and streams: Gregory River, O'Connell River, St Helens Creek, Murray Creek, Vines Creek, Sandy Creek, Plane Creek, Rocky Dam Creek and Carmila Creek (Figure 12). Indicators used to report on the water quality index in estuaries include Dissolved Inorganic Nitrogen (DIN), Filterable Reactive Phosphorus (FRP) turbidity, dissolved oxygen (DO), chlorophyll-*a* (chl-*a*) and pesticides, where pesticides are reported using multisubstance potentially affected fraction (ms-PAF). The results for DIN and FRP are aggregated to form the nutrients indicator category; turbidity and DO are aggregated to form the physical-chemical (phys-chem) indicator category (Figure 11).

Water quality monitoring data used to report on the condition of eight estuaries was obtained through an estuary monitoring program led by the Department of Environment and Science (DES). This program commenced in October 2014 and includes the assessment of one, two or three monitoring sites in each of the eight estuaries assessed. To better understand the health of the region's waterways, a supplementary monitoring program was established in order to increase the temporal representativeness of pesticide data. The estuaries and associated water quality monitoring sites are further detailed in Appendix B.

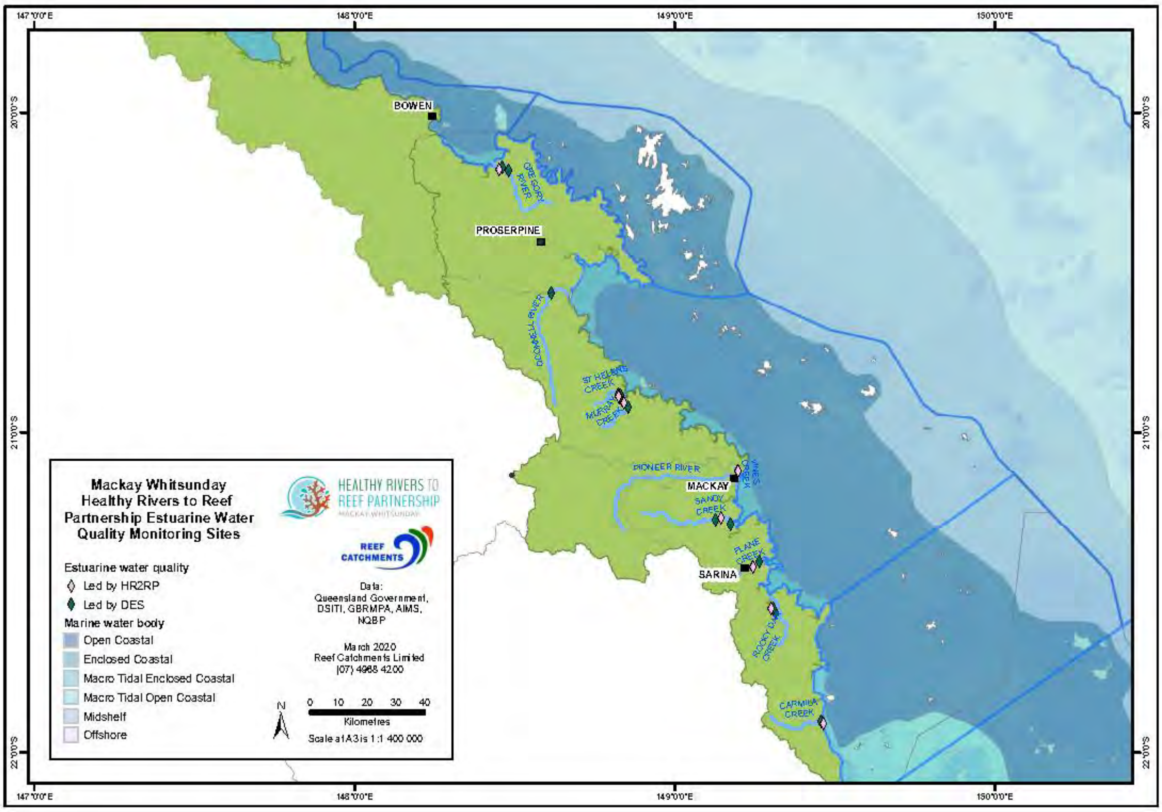


**Figure 12. Locations of grab sampling sites for estuarine water quality monitoring in the Mackay-Whitsunday-Isaac Region. Black squares and circles indicate towns.**

To assess water quality, criteria that are locally relevant to the coastal and estuarine waters of the Mackay-Whitsunday-Isaac Region, were adopted. In accordance with the Environmental Protection (Water) Policy 2009 (DES 2009), guideline values were derived from the 'Draft environmental values and water quality guidelines: Don and Haughton River basins, Mackay Whitsunday estuaries, and coastal/marine waters' (Newham et al. 2017). For further information regarding the adopted guidelines, refer to the Methods for the Mackay-Whitsunday-Isaac 2019 report card document[1].

### 4.1.1 Nutrients

Nutrient scores were based upon the reported concentrations of dissolved inorganic nitrogen (Oxidised nitrogen [$NO_2 + NO_3$]) plus ammonia [$NH_3$] and filterable reactive phosphorus (FRP) which comprise the DIN and FRP indicators, respectively. Grades for the overall nutrient indicator category were typically rated good or above, however three estuaries received moderate grades (St Helens, Vines and Sandy Creek estuaries) (Table 22). In the Vines Creek and Sandy Creek estuaries, moderate nutrient scores were driven by declines in the condition of the DIN indicator, which shifted from moderate to poor in both instances. Similar to the 2017 report card, the Gregory River and Plane Creek estuaries were the only estuaries to meet the desired guideline for DIN; a slight improvement from the previous reporting year where all eight estuaries ranked moderate for this indicator. In this regard, median annual condition exceeded the water quality guideline for this indicator in six of the eight

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

estuaries assessed (Table 22). In these six estuaries, poor to moderate DIN scores were moderated by good to very good scores for the FRP indicator. Consequently, final nutrient indicatory category grades were similar to the 2018 report card; Vines creek and the Gregory were the only estuaries to change condition, from good to moderate for Vines Creek and good to very good for the Gregory.

**Table 22. Results for DIN and FRP indicators and nutrient indicator category in estuaries for the 2019 report card in comparison to 2018, 2017, 2016 and 2015* report card scores.**

| | 2019 report card | | | 2018 | 2017 | 2016 | 2015* |
|---|---|---|---|---|---|---|---|
| **Estuary** | **DIN** | **FRP** | **Nutrients** | **Nutrients** | **Nutrients** | **Nutrients** | **Nutrients** |
| Gregory | 90 | 90 | **90** | **74** | 78 | 78 | 90 |
| O'Connell^ | 53 | 90 | **71** | **73** | 74 | 75 | 78 |
| St Helens/Murray | 48 | 71 | **60** | **56** | 54 | 60 | 62 |
| Vines | 30 | 69 | **49** | **67** | 50 | 61 | 64 |
| Sandy | 32 | 73 | **52** | **54** | 49 | 46 | 41 |
| Plane | 62 | 90 | **76** | **74** | 75 | 74 | 74 |
| Rocky Dam | 47 | 90 | **68** | **68** | 66 | 66 | 66 |
| Carmila | 52 | 90 | **71** | **74** | 69 | 63 | 65 |

**DIN and FRP**: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = assigned 90 | ■ No score/data gap

**Nutrients**: ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

^ DIN and FRP concentration data for the O'Connell estuary are taken from the basin monitoring site.

* Data from the 2015 report card is repeated from the 2014 report card.

### 4.1.2 Chlorophyll-a

The results of the chlorophyll-*a* assessment are presented in Table 23, below, with grades ranging from moderate to good. Overall, scores were similar or reduced when compared to the previous reporting year, with declines in the Gregory River, Plane Creek and Rocky Dam Creek estuaries being most pronounced. In the Gregory, score declines resulted in a shift of grade from very good to good. By contrast, a slight decline in the score for Vines Creek resulted in a shift of grade from good to moderate.

Chlorophyll-*a* conditions in Carmila estuary were equivalent to those in the previous report card, ranking moderate and scoring the lowest of the regions eight estuaries for the fourth consecutive year. Carmila estuary experiences strong tidal flushing. Tidal exchange is known to impact chlorophyll-a concentrations through increased mixing activity, which subsequently dilutes nutrient loads and reduces the residence time of algae in the photic zone. Despite this, the maximum chlorophyll-a concentration (116.6 µg/L) observed throughout the monitoring period across the region was reported in the Carmila estuary and was an order of magnitude higher than any other site level maximum. The cause of the high chlorophyll-a values is not clear. Nutrient concentrations are similar to those in estuaries with much lower chlorophyll-a levels so do not appear to be a direct cause. It is possible that the large tides may import algae into the estuary from adjoining coastal waters but this is conjecture at this stage (A. Moss, pers comms, 29/04/2020), until further research is conducted.

**Table 23. Chlorophyll-a indicator scores within estuaries for the 2019 report card, compared to the 2018, 2017, 2016 and 2015 reporting years.**

| | 2019 report card | 2018 | 2017 | 2016 | 2015 |
|---|---|---|---|---|---|
| Estuary | Chlorophyll-*a* | Chlorophyll-*a* | Chlorophyll-*a* | Chlorophyll-*a* | Chlorophyll-*a* |
| Gregory | 73 | 90 | 90 | 90 | 90 |
| O'Connell^ | 53 | 58 | 63 | **33** | |
| St Helens/Murray | 58 | 52 | 58 | 54 | 62 |
| Vines | 60 | 62 | 55 | 74 | 90 |
| Sandy | 68 | 66 | 51 | 60 | 63 |
| Plane | 62 | 77 | 75 | 69 | 69 |
| Rocky Dam | 62 | 76 | 65 | 58 | 90 |
| Carmila | 43 | 43 | 0 | 0 | 62 |

**Scoring range:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

^ Data used to evaluate the O'Connell estuary are taken from an end-of-catchment monitoring site within the O'Connell River, which is also used to monitoring nutrients within freshwater basins

### 4.1.3 Phys-Chem

The phys-chemical indicator category scores were generated by the aggregation of the turbidity and dissolved oxygen (upper and low (DO)) indicators. In accordance with the guideline values, the reported DO indicator scores are based upon the % saturation of dissolved oxygen. To avoid over-representation of the DO indicator in the final score, the most conservative result of the two is adopted for aggregation. Further, a turbidity score was not calculated for the four estuaries south of Mackay (Sandy C reek, Plane Creek, Rocky Dam Creek and Carmila Creek estuaries) as the draft guidelines for Mackay-Whitsunday-Isaac estuaries (Newham et al. 2017) characterised turbidity as too variable to derive a suitable guideline.

Changes in the phys-chem indicator results were evident between 2018 and 2019 reporting years (Table 24). For the turbidity indicator, there was an improvement in the scores for the O'Connell and St Helens/Murray reporting areas; the O'Connell estuary increased from very poor (4) to good (77), whilst the St Helens/Murray estuary increased from very poor (9) to poor (30).

Similarly, considerable improvements were observed in the O'Connell and Carmila estuaries for upper DO. Throughout the monitoring period, DO concentrations in the O'Connell estuary frequently exceeded the adopted guidelines for upper DO thresholds, indicating super-saturation of oxygen, and did not show a seasonal pattern of variation. The main driver for this is that the O'Connell site receives only limited tidal mixing and is thus subject to intermittent thermal stratification. Under these conditions, the photosynthetic activities of phytoplankton near the surface result in oxygen supersaturation in the surface layers. All the other estuary sites in this program are subject to stronger tidal mixing, which prevents the occurrence of stratification. Despite this, there was a modest improvement in this indicator, shifting from very poor to poor. This score was distinct from all other estuaries in the region, which graded good to very good for upper DO.

By comparison, variation in oxygen saturation was intermittent in Carmila estuary where the minimum reported concentration (75%) was observed in March and punctuated by a distinctly high concentration of 225% oxygen saturation, in April. This was the maximum DO concentration reported throughout the monitoring program. Of note is that elevated levels of DO coincide with peak chlorophyll-*a* concentrations, suggesting increased photosynthetic activity was the key driver for this result. Despite this, supersaturated concentrations of DO were moderated by low DO readings in the calculation of the annual median and the reported condition grade was good. This was a significant improvement from the previous reporting year, which graded very poor. To better understand the mechanisms driving supersaturation of DO and, indeed, the water quality of tidal systems within the region (such as the Carmila estuary), a preliminary review of existing data for the Carmila estuary has been conducted in collaboration with local researchers. The aim of this work is to identify funding opportunities and inform finer scale monitoring and assessment of the Carmila estuary.

The lower DO scores were similar across estuaries, grading very good, with the exception of Vines Creek which ranked good. The overall Phys-Chem grades were similar or improved when compared to the previous reporting year, with the exception of Plane Creek which declined from very good to good in the current assessment (Table 24).

**Table 24. Results for Turbidity, lower DO and upper DO indicators and the aggregated Phys-Chem indicator category within estuaries, for the 2019 report card in comparison to 2018, 2017, 2016 and 2015* report card scores. The aggregated Phys-Chem score is calculating by averaging the poorer DO scores with the turbidity score. In the absence of a suitable turbidity score, Phys-Chem results will be based upon the condition of DO.**

| | 2019 report card | | | | 2018 | 2017 | 2016 | 2015* |
|---|---|---|---|---|---|---|---|---|
| Estuary | Turbidity | lower DO | upper DO | Phys-Chem | Phys-Chem | Phys-Chem | Phys-Chem | Phys-Chem |
| Gregory | 81 | 90 | 90 | **85** | **79** | 84 | 84 | 85 |
| O'Connell^ | 77 | 90 | 27 | **52** | **2** | 63 | 18 | 53 |
| St Helens/Murray | 30 | 90 | 90 | **60** | **49** | 60 | 52 | 81 |
| Vines | 64 | 65 | 90 | **64** | **77** | 64 | 90 | 84 |
| Sandy | | 90 | 90 | **90** | **78** | 90 | 77 | 90 |
| Plane | | 90 | 67 | **67** | **90** | 90 | 68 | 67 |
| Rocky Dam | | 90 | 90 | **90** | **90** | 90 | 90 | 90 |
| Carmila | | 90 | 62 | **62** | **0** | 0 | 90 | 65 |

**DO and turbidity:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = assigned 90 | ■ No score/data gap

**Phys-chem:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap*Data from the 2015 report card is repeated data from the 2014 report card.

^ Data used to evaluate the O'Connell estuary are taken from an end-of-catchment monitoring site within the O'Connell River, which is also used to monitoring nutrients within freshwater basins

### 4.1.4 Pesticides

Reporting of pesticides in the Mackay-Whitsunday-Isaac estuaries follow similar methods to those adopted for freshwater basins. As with the freshwater basin assessments, results for the Pesticide Risk Metric (PRM) were based on the measured concentrations of up to 22 different pesticides, including PSII herbicides, 10 non-PSII herbicides and three insecticides. Of note is that previous report cards (2017, 2016 and 2015) reported PRM scores (formerly referred to as the multisubstance-Potentially Affected Fraction (ms-PAF)) based on the measured concentrations of up to 13 PSII herbicides only. Following a data gap in the 2018 report card where there were insufficient data available to report on the condition of pesticides, estuary pesticide scores are based on an expanded suite of 22 different pesticides for the first time in the 2019 report card.

The number of samples used to derive the pesticide score have increased since measurements were last reported for this indicator, in 2017. Historically, the pesticide monitoring program for estuaries was limited to monthly grab samples collected throughout the wet season period (six months) when runoff levels, which transport pesticides from land to the receiving waterway, are expected to be higher. For the 2018-2019 reporting year, approximately three grab samples were collected per month; one via the existing ambient monitoring program and two via a supplementary monitoring program, funded by the Partnership. Sampling activities were limited to the wet seasons period, occurring from November 2018 to May 2019 and broadly coincided with large rainfall events. The maximum number of pesticide samples obtained from a given location in the monitoring year was 19. Information obtained through the addition of new monitoring sites and increased sampling effort, as achieved through the supplementary monitoring program, are used to inform the PRM score for the first time in the 2019 report card. Therefore, the 2019 pesticide scores provide a more reliable estimate of the condition of pesticide risk in estuaries. This being the case, the 2019 report card scores are not directly comparable to those in previous report cards.

At two of the eight estuaries assessed, additional data were obtained through alternate monitoring programs including the GBRCLMP in the O'Connell River and via a landholder engagement monitoring program in Sandy Creek. In all cases, sample collection was completed by personnel trained to a standard consistent with the Department of Environment and Science Monitoring and Sampling Manual (2018). The location of pesticide monitoring sites is further detailed in Appendix B.

Further information on the method for assessing pesticide condition are presented in the Methods for the Mackay-Whitsunday-Isaac 2018 Report Card[1].

In the 2018-2019 reporting year, pesticide scores ranged from very poor in Sandy Creek estuary to good in the Plane and Carmila Creek estuaries, with the remaining basins graded moderate to poor (Table 25). A rating of very poor equates to a very high risk of toxicity related impacts. Conversely, a rating of very good equates to a very low risk of toxicity related impacts (Appendix E).These results highlight that species are often at moderate to high risk of experiencing toxic effects due to exposure to pesticide concentrations within the region's estuaries, indicating that there is a strong need to adopt management measures that will mitigate impacts to aquatic biota. Further, as was the case in the freshwater pesticide assessment, Sandy Creek was the poorest scoring estuary for this indicator, lending further weight to the contention that aquatic biota in this watercourse are at a very high risk of experiencing toxic effects due to pesticide exposure.

Imidacloprid and diuron were key contributors to the overall pesticide risk metric in all of the estuaries assessed (Figure 13), suggesting that these are regionally significant chemicals for use in suppressing pest insects and weeds, respectively. There was a notably higher proportion of metsulfuron-methyl in the Vines Creek estuary compared to other sites. Metsulfuron-methyl has the third highest toxicity relative to the other 22 pesticides in the PRM and is the most toxic herbicide (Warne and Neale 2020, King et al. 2017a; King et al. 2017b). Therefore, even just a small concentration of this herbicide would contribute a notable proportion to the total pesticide risk compared to other herbicides detected. Metsulfuron-methyl is registered for the control of brush and broadleaf weeds in some agricultural land uses (native pastures, cereals and forestry), as well as in rights of way, commercial and industrial areas.

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

**Table 25. Results for the Pesticide Risk Metric indicator accounting for 22 pesticides, expressed as aquatic species protected (%) and associated standardised pesticide score, for eight estuaries in the Mackay-Whitsunday-Isaac region and compared to 2018 and 2017.**

| Pesticides | 2019 report card | | 2018 report card | 2017 report card* |
|---|---|---|---|---|
| **Basin** | **Pesticide Risk Metric (% species protected)** | **Standardised Pesticide Score** | **Standardised Pesticide Score** | **Standardised Pesticide Score** |
| Gregory | 94.6 | 59 | | 39 |
| O'Connell | 91.9 | 48 | | 36 |
| St Helens/Murray | 94.5 | 58 | | 62 |
| Vines | 83.0 | 26 | | 64 |
| Sandy | 72.6 | 18 | | 18 |
| Plane | 97.7 | 74 | | 73 |
| Rocky Dam | 80.7 | 22 | | 40 |
| Carmilla | 98.7 | 79 | | 96 |

**Species protected scoring range:** ■ Very Poor = <80% | ■ Poor = <90 to 80% | ■ Moderate = <95 to 90% | ■ Good = <99 to 95% | ■ Very Good = ≥99% | ■ No score/data gap

**Pesticides:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

* 2017 pesticides scores have been back-calculated to incorporate changes in pesticide method that occurred for the first time for the 2018 report card. Hindcasted scores do not account for changes associated with the addition of new monitoring sites or increased sampling effort. In this way, scores cannot reasonably be compared.

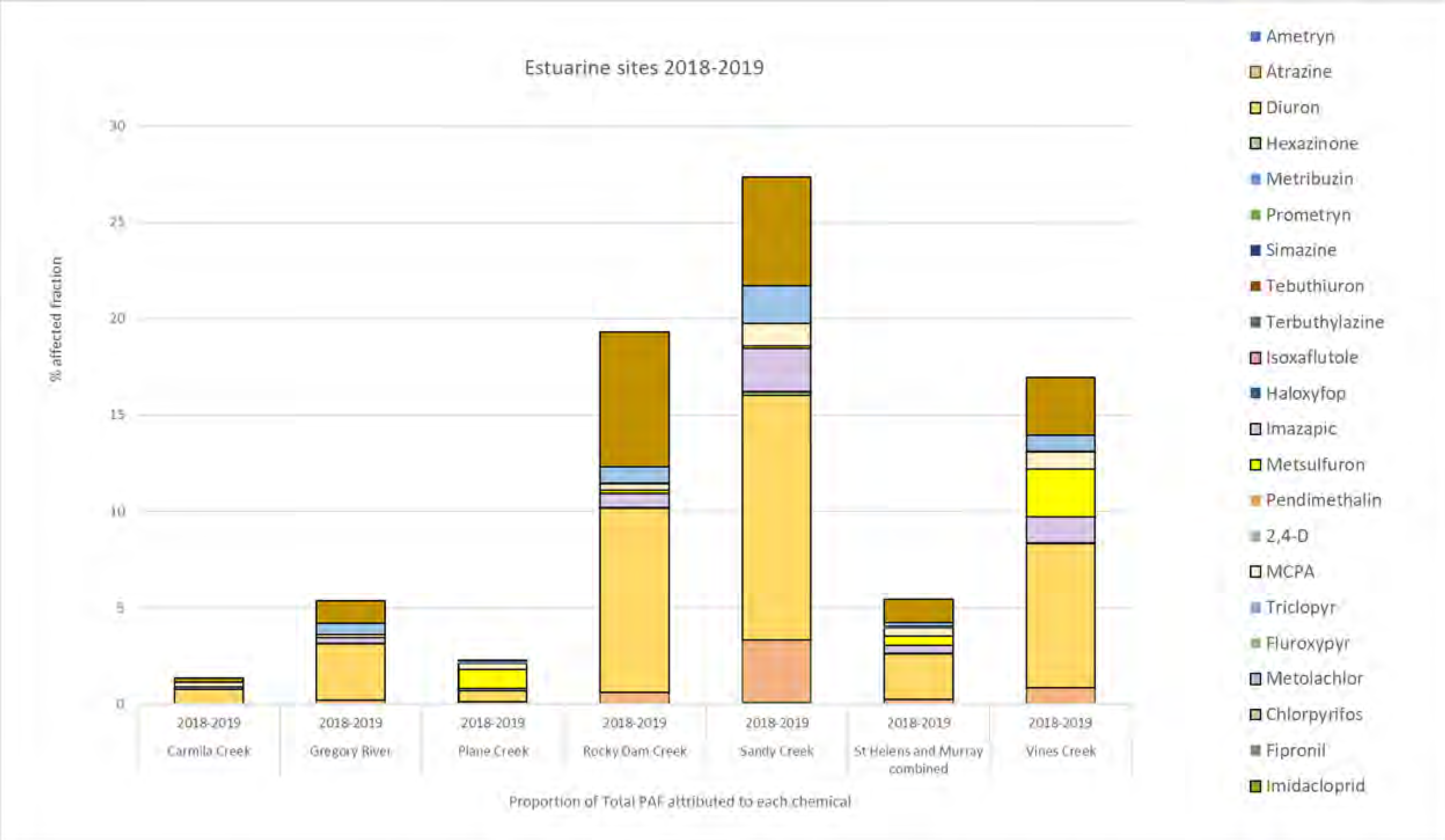


**Figure 13. Proportional contribution of each pesticide to as the total percentage of species affected as calculated using the pesticide risk metric, for the 2018-2019 reporting year.**

### 4.1.5 Water quality index scores and confidence

Overall, water quality index grades in the Mackay-Whitsunday-Isaac estuaries ranged from moderate to good (Table 26). Of the eight estuaries, three were reported to meet the desired ambient condition of good, being the Gregory, Plane and Carmila Creek estuaries. Following a data gap in the 2018 report card, where the impact of pesticides was not captured for estuaries, it is difficult to delineate changes in condition between reporting years through direct comparison of the water quality index. Instead, it is of interest to consider how scores have changed since the previous assessment, excluding the contribution of the pesticide indicator.

Compared to the previous year, scores for the phys-chem group improved in six of the eight estuaries. In the northern estuaries, including the O'Connell River and St Helens/Murray Creek, this was driven primarily by higher scores for turbidity. Improvements in the phys-chem indicator category for Sandy Creek, Rocky Dam Creek and Carmila Creek, were attributed solely to improvements in the DO indicator, where the absence of a suitable guideline value precludes the assessment of turbidity levels in these systems. In contrast, nutrient and chlorophyll-*a* grades were similar when compared to the previous reporting year.

There was an improvement in the water quality index score for the Carmila estuary, irrespective of any variance associated with the inclusion of pesticide scores. The score improved from poor to good, owing primarily to improvements in the upper DO indicator which shifted from very poor to good for the first time since 2017. As previously highlighted, it is anticipated that such fluctuations are a product of natural system processes, as there are no apparent substantial anthropogenic pressures on this estuary. Since 2019, the Partnership has worked in collaboration with regional researchers to better understand the relationship between nutrients, phys-chem properties and chlorophyll-*a* concentrations within the Carmila estuary; and, ultimately, to understand the ecological impacts of high dissolved oxygen and chlorophyll-*a* which have been observed in this system. To date, a preliminary desktop assessment has been conducted, the findings of which are being used to identify funding opportunities for finer scale monitoring and assessment in the Carmila estuary.

As observed in the freshwater assessment, pesticides scored the lowest of the water quality indicators, with only two of the eight estuaries assessed meeting the desired low risk criteria, the Plane and Carmila estuaries, protective of 95% of species (less than 5% of species are affected).

**Table 26. Results for water quality indicator categories and final water quality index scores in estuaries for the 2019 report card (2018-2019 data) in comparison to 2018, 2017, 2016 and 2015* scores. *Data from 2015 report card is repeated from the 2014 report card.**

| | 2019 report card | | | | | 2018 | 2017* | 2016 | 2015^ |
|---|---|---|---|---|---|---|---|---|---|
| Estuary | Phys-chem | Nutrients | Pesticides | Chlorophyll-*a* | Water Quality | Water Quality | Water quality | Water quality | Water quality |
| Gregory | 85 | 90 | 59 | 73 | 77 | **81** | 72 | 76 | 75 |
| O'Connell | 52 | 71 | 48 | 53 | 56 | **44** | 59 | 50 | 57 |
| St Helens/Murray | 60 | 60 | 58 | 58 | 59 | **53** | 58 | 61 | 66 |
| Vines | 64 | 49 | 26 | 60 | 50 | **69** | 58 | 75 | 79 |
| Sandy | 90 | 52 | 18 | 68 | 57 | **66** | 52 | 51 | 53 |
| Plane | 67 | 76 | 74 | 62 | 70 | **80** | 78 | 62 | 66 |
| Rocky Dam | 90 | 68 | 22 | 62 | 60 | **78** | 65 | 71 | 66 |
| Carmila | 62 | 71 | 79 | 43 | 64 | **39** | 37 | 50 | 63 |

**Scoring range:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

*denotes scores which have been back-calculated to incorporate

^data from the 2015 report card is repeated from the 2014 report card

Confidence in water quality index scores in estuaries is shown in Table 27, below. Lower confidence in the O'Connell, Vines and Carmila Creek estuary water quality (excluding pesticides) scores is due to data collection occurring at only one sample site. In other estuaries, there is higher confidence in water quality scores as data is collected at either two or three monitoring sites, resulting in scores which are more spatially representative.

**Table 27. Confidence associated with water quality index results in estuaries for the 2019 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level. Where confidence in results for the O'Connell, Vines and Carmila Creek estuaries differ from the other estuaries, the relevant confidence scores for these estuaries are presented in square parenthesis. Unless otherwise specified, confidence in results is the same across estuaries. *Pesticides were not incorporated into report card scores for the 2018 report card.**

| Indicator category | Maturity of methodology (x0.36) | Validation (x0.71) | Representativeness (x2) | Directness (x0.71) | Measured error (x0.71) | Final | Rank |
|---|---|---|---|---|---|---|---|
| Phys-chem | 3 | 3 | 2 [1] | 3 | 1 | 10.1 [8.1] | 4 [2] |
| Nutrients | 3 | 3 | 2 | 3 | 1 | 10.1 [8.1] | 4 [2] |
| Chl-a | 3 | 3 | 2 | 3 | 1 | 10.1 [8.1] | 4 [2] |
| Pesticides* | 3 | 3 | 1 | 3 | 2 | 8.8 | 3 |
| | | | | | **Water quality index** | **10.1 [8.1]** | **4 [2]** |

**Rank based on final score:** 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

## 4.2 Habitat and hydrology in estuaries

Habitat and hydrology assessments in the estuaries are distinct from those in the basins, comprising four indicators including fish barriers, two indicators of vegetation (riparian and mangrove/saltmarsh) extent and flow. Impoundments are not assessed as a component of the estuaries. Vegetation assessments also differ from those conducted in the basins, which are taken from the Reef Water Quality Report Card programs for evaluating riparian vegetation extent within the GBR lagoon catchments. To assess vegetation condition in the estuaries, the same broad principles of assessment are applied within the assessment area which included from the estuary mouth, upstream to the tidal limit.

Results for indicators and indicator categories that contribute to the habitat and hydrology index are presented below.

### 4.2.1 Fish barriers

Similar to freshwater basins, estuary fish barrier indicators are updated every four years and were last updated in fulfillment of the 2015 report card. As such, the fish barrier assessment results and associated indicator scores have been updated in the 2019 report card and are detailed in Table 28, below. This reporting frequency reflects the expected infrequent nature of change associated with these indicators.

Since the previous assessment, there has been no change to the overall fish barrier grade in any of the estuaries assessed. By contrast, there was a slight improvement in the 'barrier density' indicator in the St Helens and Murray Creek estuary reporting area, which shifted from poor to moderate. This improvement was driven by the remediation of a high priority fish barrier located on Niddoe Creek with the construction of a rock ramp fishway. In addition, field validation of two potential barriers in the Murray Creek reporting area determined that these structures were not barriers to fish passage and were subsequently removed from the assessment.

The Carmila Creek estuary assessment area reported no barriers to fish passage, scoring a grade of very good. Fish barriers in Carmila Creek are primarily located in the middle and upper river reaches, falling outside the estuary extent (18.5 m above the DDL). Plane Creek estuary recorded the lowest fish barrier grade of poor. Plane Creek flows through Sarina, a large population centre with the catchment comprising a high proportion of sugar cane, including a sugar mill located adjacent to the creek. Several low "passability" fish barriers have been constructed in the lower reaches of Plane Creek to provide drinking water for the Sarina community, irrigation and water supplies for the sugar mill. These low "passability" barriers contributed to the poor score recorded for the Plane Creek estuary. Vines Creek, the O'Connell River and Gregory River estuary assessment areas all received barrier grades of good, where systems comprise large areas of connected stream habitats upstream from the estuary mouth, with only a few fish barriers located on smaller tributaries and no low "passability" barriers (Moore, 2016).

**Table 28. Results for fish barrier indicators in estuaries in the 2019 report card (2018-2019 data) compared to the 2018 report card (2014-2015 data). Indicators assessed on Stream Order (SO) ≥3 or ≥4 as indicated. NB: no barriers. NLPB: no low "passability" barriers.**

| | 2019 report card | | | | | | | | 2018 |
|---|---|---|---|---|---|---|---|---|---|
| | Barrier density | | Stream (%) to the first barrier | | Stream (%) to 1st low "passability" barrier | | Fish barriers | | Fish barriers |
| Estuary | km per barrier on | Score | % of stream before first barrier on SO ≥3 | Score | % of stream before 1st low pass barrier on | Score | Total score | Fish barriers (standardised) | Fish barriers (standardised) |
| Gregory | 35 | 5 | 96 | 4 | 97 | 4 | 13 | 80 | 80 |
| O'Connell | 5 | 3 | 85 | 4 | NLPB | 5 | 12 | 70 | 70 |
| St Helens/Murray | 4 | 3 | 67 | 3 | 83 | 3 | 9 | 50 | 41 |
| Vines | 13 | 4 | 96 | 4 | NLPB | 5 | 13 | 80 | 80 |
| Sandy | 3 | 2 | 44 | 2 | 90 | 4 | 8 | 41 | 41 |
| Plane | 2 | 1 | 48 | 2 | 76 | 2 | 5 | 21 | 21 |
| Rocky Dam | 5 | 3 | 74 | 3 | NLPB | 5 | 11 | 61 | 61 |
| Carmila | NB | 5 | NB | 5 | NLPB | 5 | 15 | 100 | 100 |

**Barrier density (km):** ■ Very Poor/score of 1 = 0 to 2km | ■ Poor/score of 2 = >2 to 4km | Moderate/score of 3 = >4 to 8km | ■ Good/score of 4 = >8 to 16km | ■ Very Good/score of 5 = >16km | ■ No score/data gap
**Stream to 1st barrier (%):** ■ Very Poor/score of 1 = 0 to <40% | ■ Poor/score of 2 = 40 to <60% | Moderate/score of 3 = 60 to <80% | ■ Good/score of 4 = 80 to <100% | ■ Very Good/score of 5 = 100% | ■ No score/data gap
**Stream to 1st low "passability" barrier (%):** ■ Very Poor/score of 1 = 0 to 60% | ■ Poor/score of 2 = >60 to 80% | Moderate/score of 3 = >80 to 90% | ■ Good/score of 4 = >90 to <100% | ■ Very Good/score of 5 = 100% | ■ No score/data gap
**Total score:** ■ Very Poor = 3 to 4 | ■ Poor = 5 to 7 | ■ Moderate = 8 to 10 | ■ Good = 11 to 13| ■ Very Good = 14 to 15 | ■ No score/data gap
**Fish barriers (standardised):** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

### 4.2.2 Riparian and mangrove/saltmarsh extent

Coastal and near-shore marine ecosystems are among the most diverse and productive in the world, providing critical habitat for a range of plants, fish, and other wildlife. Coastal wetlands such as mangrove and salt marsh environments also provide a manifold of ecosystem services including coastal protection, erosion control, water filtration, maintenance of coastal fisheries and carbon sequestration. Despite this, coastal river systems and vegetation have been significantly impacted by land development activity, die back, altered hydrology and pollution (Chamberlain et al. 2020; Duke and Wolanski, 2001). To understand continuing threats to estuarine riparian vegetation extent and mangrove/saltmarsh extent, indicators are assessed every four years and were updated in the 2019 report card. The results show the historical loss of riparian and mangrove/saltmarsh extent since pre-clearing, expressed in hectares and proportional loss, as presented in Table 29, below. Of note, is that these scores represent changes only in the extent of vegetation since pre-clearing, not changes in the condition of the vegetation assessed.

The riparian extent grades ranged from very poor in the O'Connell estuary to very good in the Gregory, Rocky Dam and Carmila estuaries. The St Helens/Murray, Vines and Plane Creek estuaries were in moderate condition for riparian extent, whilst the Sandy Creek estuary graded poor.

Carmila Creek estuary yielded the highest score, where the extent of riparian vegetation assessed in 2017 was equal to the pre-clearing extent, suggesting no net loss has occurred in this area (Table 29).

Overall, there was no change in the extent of riparian vegetation observed between the preceding 2013 assessment and the current assessment. To evaluate any change in extent between assessment years, back-calculated values were developed for 2013 using the Queensland Herbarium (2019) Regional Ecosystem Description Databases, version 11.1. Back-calculated 2013 results are provided in Appendix B.

The mangrove/saltmarsh extent grades ranged from moderate in the Vines Creek estuary to very good in the Gregory, O'Connell, St Helens/Murray and Plane Creek estuaries. The remaining estuaries were reported to be in good condition for mangrove/saltmarsh extent. In the Sandy Creek estuary, approximately 2.9 hectares of mangrove and saltmarsh vegetation had been lost since the previous assessment (Appendix B). This included approximately 2.58 hectares of Regional Ecosystem 8.1.3 (*Sporobolus virginicus* tussock grassland on marine sediments) and 0.27 hectares of Regional Ecosystem 8.1.2 (Samphire open forbland on saltpans and plains adjacent to mangroves). Both Regional Ecosystem types are listed with a biodiversity status 'Of concern' and are valued, in part, for the habitat they provide to endangered and significant species, respectively. A coarse review of the Regional Ecosystems Mapping and Land use layers, using Queensland Globe, suggests that the prevailing land use activity in Sandy Creek estuary, surrounding these vegetation types, is agriculture. Such activities may pose a risk to these vegetation communities through direct encroachment or changes to hydrology which may occur as a result of irrigation and extraction activities (Chamberlain et al. 2020).

Finally, there was a net increase in the areal extent of mangrove/saltmarsh vegetation in the St Helens and Murray Creek estuary since pre-development. Such changes may occur as a result of extensive sediment deposition in nearshore environments; material is transported from the catchment to the estuaries where it is ultimately deposited and accumulated in banks.  This sediment provides new areas of substrate in which mangroves can colonise. This process has previously been documented in the Pioneer River, to the south of St Helens and Murray Creek (Duke and Wolankski, 2001, A. Moss, pers comms, 08/04/2020). It is important to emphasise that such increases in net mangrove/saltmarsh extent are not necessarily indicative of a healthy estuarine system, rather they are indicative of increased muddiness (Duke and Wolanski, 2001).

**Table 29. Results for riparian and mangrove/saltmarsh extent loss since pre-development (%), hectares remaining and standardised riparian and mangrove & saltmarsh extent in estuaries in the 2019 report card (2017 data). Hectares were rounded to the nearest whole number.**

| | 2019 report card | | | | | 2019 report card | |
|---|---|---|---|---|---|---|---|
| | Mangrove/saltmarsh extent | | Riparian extent | | | | |
| Estuary | Hectares lost since pre-development | (% loss since pre-development) | Hectares lost since pre-development | (% loss since pre-development) | | Standardised mangrove/ saltmarsh extent | Standardised riparian extent |
| Gregory | 96.2 | 3.2 | 9.4 | 4.9 | | 87 | 81 |
| O'Connell | 108.9 | 4.0 | 40.5 | 57.2 | | 84 | 17 |
| St Helens/Murray | -6.5* | -0.2* | 54.2 | 17.1 | | 100 | 58 |
| Vines | 114.0 | 15.6 | 8.6 | 18.1 | | 60 | 56 |
| Sandy | 411.0 | 14.0 | 70.0 | 38.3 | | 63 | 32 |
| Plane | 26.1 | 2.2 | 23.0 | 17.0 | | 91 | 58 |
| Rocky Dam | 432.2 | 7.1 | 11.9 | 4.7 | | 76 | 82 |
| Carmila | 29 | 6.9 | 0 | 0.0 | | 77 | 100 |

**Riparian and mangrove/saltmarsh extent (% loss):** ■ Very Poor = >50% | ■ Poor =>30 to 50% | ■ Moderate = >15 to 30% | ■ Good = >5 to 15% | ■ Very Good ≤5% | ■ No score/data gap

**Standardised riparian and mangrove/saltmarsh extent:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

*negative values denote scenarios where there has been an increase in the total area of riparian or mangrove/saltmarsh extent, since pre-development. Further investigation of these values is provided in Section 3.2.2.

### 4.2.3 Flow

The flow indicator tool was applied to the Mackay-Whitsunday-Isaac report for the second consecutive year. Due to minimal data availability, scores for flow in estuaries were not able to be developed across most estuaries and have not been included in the Habitat and Hydrology index for the 2019 report card. Considerable work has been undertaken between the release of the 2018 and 2019 report cards to explore opportunities to fill data gaps and is currently progressing in collaboration with the TWG and BoM. A review of the tool to identify further refinements and updates is expected for future report cards.

### 4.2.4 Habitat and hydrology index scores and confidence

The overall habitat and hydrology index scores for estuaries in the 2019 report card ranged from moderate to very good across the Mackay-Whitsunday-Isaac Region (Table 30). In accordance with the reporting frequency for these indicators, being due for update every four years, scores for riparian extent, mangrove/saltmarsh extent and fish barriers were all updated in the 2019 report card. To assess change in the habitat and hydrology index over time, scores have been back-calculated using new methodologies to facilitate comparison between datasets.

There has been no change to the condition grades for the habitat and hydrology index since the previous assessment. Whilst the overall grade remained the same, there was a modest increase in the habitat and hydrology score for St Helens/Murray Creek estuary. This change was driven by an improvement in the fish barriers condition score from 41 to 50 in the current assessment. The consistency of scores between assessments reflects the gradual or infrequent nature of change associated with these indicators. In this regard, whilst these scores highlight the positive effect of implementing management measures to mitigate threats to habitat via direct clearing, development or changes to hydrology, it also emphasises the investment required to remediate historic impacts and ultimately drive an improvement in condition grades.

**Table 30. Results for habitat and hydrology indicator categories and index in estuaries for 2019 report card compared to the 2018 report card (2014-2015 data)**

| Estuary | 2019 report card | | | | 2019 | 2018 (2014-2015 data) * |
|---|---|---|---|---|---|---|
| | Mangrove/ saltmarsh extent | Riparian extent | Fish barriers | Flow | Habitat and hydrology | Habitat and hydrology |
| Gregory | 87 | 81 | 80 | | 83 | 83 |
| O'Connell | 84 | 17 | 70 | | 57 | 57 |
| St Helens/Murray | 100 | 58 | 50 | | 69 | 66 |
| Vines | 60 | 56 | 80 | | 65 | 66 |
| Sandy | 63 | 32 | 41 | | 45 | 45 |
| Plane | 91 | 58 | 21 | | 56 | 56 |
| Rocky Dam | 76 | 82 | 61 | | 73 | 77 |
| Carmila | 77 | 100 | 100 | | 92 | 96 |

**Scoring range:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap

*Scores have been back-calculated to incorporate changes associated with refinements to the source mapping used to assess vegetation (riparian and mangrove/saltmarsh) extent.

Confidence in habitat and hydrology scores for estuaries are shown in Table 31.

**Table 31. Confidence associated with habitat and hydrology index results in estuaries for the 2019 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level. Unless otherwise specified, confidence in results is the same across estuaries.**

| Indicator category | Maturity of methodology (x0.36) | Validation (x0.71) | Representativeness (x2) | Directness (x0.71) | Measured error (x0.71) | Final | Rank |
|---|---|---|---|---|---|---|---|
| Fish barriers | 1 | 2 | 3 | 2 | 1 | 9.9 | 3 |
| Riparian extent | 2 | 2 | 2 | 1 | 2 | 8.3 | 3 |
| Mangrove & saltmarsh extent | 2 | 2 | 2 | 1 | 2 | 8.3 | 3 |
| | | | | | **Habitat and hydrology index** | **8.3** | **3** |

**Rank based on final score:** 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

## 4.3 Fish in estuaries

There is no score for condition of fish in estuaries. Identification of appropriate indicators and development of methodology are required to progress assessment of fish community condition in estuaries. Development of these indicators is anticipated to occur in collaboration with the TWG and other regional report card Partnerships.

## 4.4 Key messages for estuaries

- Overall estuary grades in the Mackay-Whitsunday-Isaac report card have remained relatively stable since the first full report card in 2015, ranging from moderate to good across reporting years.
- Pesticides are the poorest scoring water quality indicator within Mackay-Whitsunday-Isaac estuaries.

- For the first time in the 2019 report card, estuary pesticide scores were based on monthly ambient monitoring plus additional data. This was obtained through a Partnership-funded monitoring program designed to supplement existing monitoring to increase the temporal representativeness of data. Due to the successful establishment of the locally funded pesticide monitoring program, estuary pesticide scores in the 2019 report card represent the most reliable estimate of pesticide condition to date.
- Imidacloprid and diuron were the key contributors to the overall Pesticide Risk Metric in Mackay-Whitsunday-Isaac estuaries, suggesting that these are regionally significant chemicals for use in suppressing pest insects and weeds. As in freshwater basins, this was the first year that proportional contribution of the different types of pesticides in estuaries were quantified in the report card.
- Improvements in the Carmila estuary are attributed to an improvement in the indicator score for upper dissolved oxygen; however, more information is needed to understand the natural ranges in this system. The Partnership has started preliminary exploration to further understand the Carmila estuary.
- Fish barriers were updated for the 2019 report card, following its four-year reporting cycle. There has been no change to the overall fish barrier grade in any of the estuaries assessed since the scores were last updated in 2015.
- Vines Creek, the O'Connell River, the Gregory River, and Rocky Dam estuary all received grades of good for fish barrier scores, where systems comprise large areas of connected stream habitat upstream of the estuary mouth, with only a few fish barriers located on smaller tributaries and no low 'passability' barriers.
- Carmila Creek was the only estuary that scored very good for fish barriers and did not have any barriers to fish passage. By contrast, there was a slight improvement in the 'barrier density' indicator in the St Helens and Murray Creek estuary reporting area, which shifted from poor to moderate. This improvement was driven by the remediation of a high priority fish barrier located on Niddoe Creek with the construction of a rock ramp fishway.
- The condition of mangrove and saltmarsh extent in Mackay-Whitsunday-Isaac estuaries ranged from moderate to very good, with scores updated for the 2019 report card.
- Riparian extent scores were updated for the 2019 report card. Scores varied across estuaries, ranging from very poor in the O'Connell to very good in the Gregory, Rocky Dam and Carmila. Similarly to mangrove and saltmarsh extent, there were no changes in grade for any estuary with respect to the previous reporting period (2014-2018 report cards).

# 5 Inshore and offshore marine results

The indicators, relevant indicator categories and overall indices that are assessed for the inshore and offshore marine zones are presented in Figure 14.

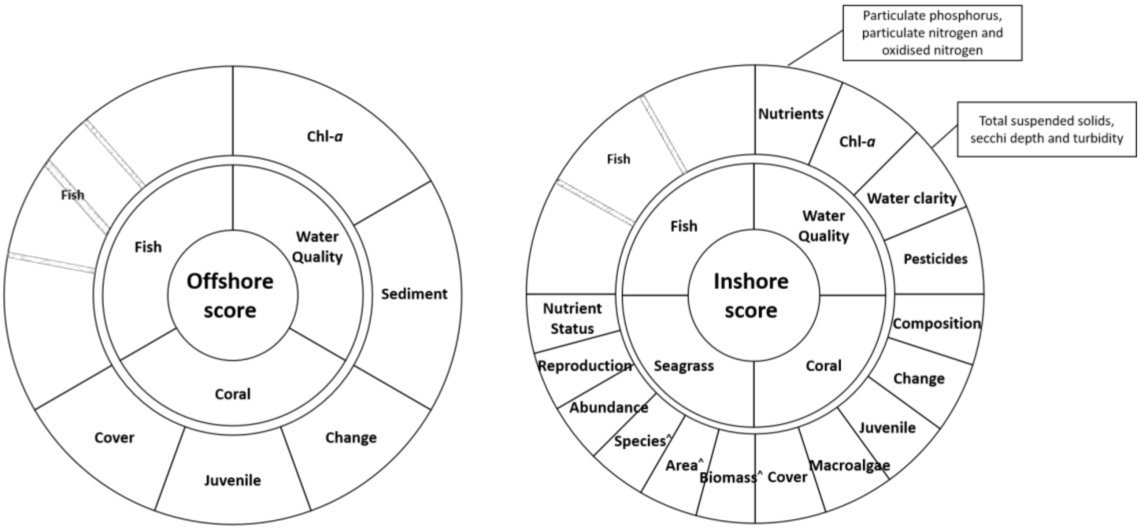


**Figure 14. Indicator categories (outer ring) and indices (inner ring) that contribute to overall offshore and inshore marine scores for each zone. Where multiple indicators are aggregated to determine the indicator category, these are listed in break-out boxes.**

The overall condition grades for inshore marine zones in the 2019 report card ranged from D (poor) to C (moderate), as shown in Table 32. In contrast, the offshore marine zone remained as a B (good) for the sixth consecutive year.

In the Northern zone, there was an improvement in overall condition grade from poor to moderate when compared to the 2018 report card, however preceding report cards (2017 and 2016) reported the zone in moderate condition (Table 32). Whilst overall marine grades for the Whitsunday and Central zones remained as poor, declines in water quality from poor to very poor and moderate to poor occurred for Whitsunday and Central zones respectively. Seagrass condition however, across the Northern, Whitsunday and Central zones all improved in grades, resulting in a shift from poor to moderate in the Northern zone and very poor to poor in the Whitsunday zone (Table 40). Whilst the seagrass score improved in the Central zone, this did not result in a change in grade, which was moderate for the 2019 report card.

An overall score and grade for coral was reported in the Southern inshore marine zone for the first time, enabled by the successful establishment of a Partnership funded monitoring program in the zone. Water quality condition was captured for the second consecutive year and included pesticide condition for the first time. Seagrass monitoring is currently funded for the program and condition scores are expected to be reported in the 2021 report card (released in 2022).

**Table 32. Results for indices and overall marine scores for inshore and offshore zones reported in the 2019 report card (2018-19 data) in comparison to final scores in the 2018, 2017, 2016, 2015 and 2014 report cards.**

| Zone | 2019 report card | | | | | | 2018 | *2017 | ^2016 | ^2015 | ^2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Water quality | Coral index | Seagrass | Fish | Marine score and grade | | Marine score | Marine score | Marine score | Marine score | Marine score |
| Northern | 48 | 29 | 52 | | **43** | **C** | 35 | 44 | 43 | 21 | 40 |
| Whitsunday | 18 | 30 | 27 | | **25** | **D** | 27 | 27 | 47 | 39 | 28 |
| Central | 36 | 23 | 52 | | **36** | **D** | 37 | 31 | 41 | 51 | 25 |
| Southern | 48 | 20 | | | **34** | **D** | 22 | | | | |
| Offshore | 99 | 55 | | | **77** | **B** | 77 | 76 | 77** | 77** | 74** |

**Scoring range:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap | Not applicable

*2017 overall marine score results were back-calculated to incorporate changes to methods for pesticides and seagrass that were applied in the 2018 report card. 2016-2014 scores have not been back-calculated.

^2016-2014 report card scores do not include back-calculated pesticide updates that were established for the 2018 report card.

**Offshore coral scores were amended due to error detected in methods.

## 5.1 Water quality in inshore and offshore marine ecosystems

The location of water quality sites used in the 2019 report card are shown in Figure 15. Following the Marine Monitoring Program (MMP) approach for scoring and reporting *in-situ* water quality data, the condition scores for nutrients, chlorophyll-*a* and water clarity were derived for the inshore marine zones (Thompson et al. 2014). For the pesticide indicator category, data obtained from passive sampler deployments were used to derive pesticide condition scores. Grab sample data in the Northern and Central zones were used as a reference only to provide an indication of pesticide condition at a point in time and were not incorporated into the overall pesticide scores. Condition of water quality in the offshore marine zone is assessed based on two indicators, chlorophyll-*a* and TSS. Water quality condition in the offshore zone is assessed using available remote sensing data sourced from the Bureau of Meteorology. This contrasts with water quality reporting across other zones within the report card, which are based on monitoring data collected *in-situ.*

To assess water quality, scheduled guideline values that are more localised to the marine waters in the Mackay-Whitsunday-Isaac region (DES 2013) as per the Environmental Protection (Water) Policy 2009 (DES 2009) were adopted in the Whitsunday, Central and Southern inshore marine zones, however these do not extend to the Northern inshore zone. Localised guidelines for the coastal waters of the Haughton, Burdekin and Don Basins are in draft (Newham et al. 2017). To remain consistent with 2018, 2017 and 2016 reporting, the current GBRMPA (2010) guidelines were used for marine waters in the Northern inshore zone until local guidelines are developed. It should be recognised that while the GBRMPA guidelines are still current, they do not currently account for natural environmental conditions or smooth transitions between water type boundaries. For further details on the adopted guidelines, refer to the Methods for the Mackay-Whitsunday-Isaac 2019 report card document[1].

Conceptually, inshore marine water quality in the Mackay-Whitsunday-Isaac region is influenced by five major river basins; the Proserpine, O'Connell, Pioneer, Plane (located in the Mackay-Whitsunday-Isaac region) and Fitzroy Basins. More specifically, the Pioneer and Fitzroy Rivers appear to have the

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

greatest influence on the Whitsunday region. Under strong discharge conditions, the Pioneer influences the waters inshore of the Whitsunday Islands with the offshore coast of Whitsunday Islands being influenced by the Fitzroy (Baird et al. 2019). The region is also potentially influenced by run-off from the Burdekin Basin during extreme events or through longer-term transport and mixing. The region is typified by higher variability in discharge and loads compared to surrounding regions such as the Wet Tropics Basins (Waterhouse et al. 2018).

Results for inshore and offshore marine indicators, indicator categories and the overall water quality index are presented in the sections below.

### 5.1.1 Nutrients, chlorophyll-*a* and water clarity

Nutrient scores are based upon reported concentrations of oxidised nitrogen (NOx), particulate phosphorus (PP) and particulate nitrogen (PN), while the water clarity indicator category is informed by Secchi depth, Total Suspended Solids (TSS) and turbidity indicators.

Condition scores are calculated by comparing annual means or medians to guideline values (with the appropriate statistic identified within the guidelines), for each indicator at each site within a zone. Preliminary scores are aggregated across sites and indicators to produce the final nutrients, chlorophyll-*a* and water clarity indicator category scores within a zone.

In the 2019 report card, nutrient, chlorophyll-*a* and water clarity scores ranged from moderate to very poor across the inshore marine waters assessed within the Mackay-Whitsunday-Isaac region (Table 33). Scores for nutrients, chlorophyll-*a* and water clarity within the Southern zone were reported for the second consecutive year, as part of the Partnership funded Southern Inshore Monitoring Program. Appendix C presents site scores for individual indicators based on available data.

Changes in these water quality indicators were evident between the 2018 and 2019 reporting years (Table 33). For the nutrient indicator, scores dropped in the Northern, Whitsunday and Central zones, resulting in a shift of grade from very good to moderate in the Northern zone, and good to poor in the Central zone. On review of the nutrient indicators, PN scores appeared to have declined across multiple sites in the Northern and Central zones. The nutrient grade in the Whitsunday zone remained as poor despite the drop in score. In the Southern zone, there was an improvement in the nutrient score, however this did not result in a change of grade, which remained moderate.

Chlorophyll-*a* grades ranged from moderate to very poor across all inshore marine zones, with a decline in grades in the Northern and Whitsunday zones (Table 33). Similar to the 2017 report card, the Whitsunday zone scored the lowest chlorophyll-*a* grade across all Mackay-Whitsunday-Isaac inshore marine zones, scoring very poor.

Water clarity was very poor across three of the four inshore marine sites and had dropped to very poor in the Whitsunday zone for the first time since the 2014 report card. The water clarity score for the Whitsunday zone in the 2017 report card was however close to the scoring range between poor and very poor. There was a reasonable improvement of the score in the Northern zone, whilst the Southern zone derived a score of 0 for water clarity for the second consecutive year (Table 33).

The only grade improvements occurred for water clarity in the Northern zone and chlorophyll-*a* in the Southern zone, both of which shifted from very poor to poor when compared to the 2018 report card.

Notably, NOx and TSS did not contribute consistently to final indicator scores within the Northern, Central and Southern zones due to availability of data. Likewise, intermittent gaps in turbidity data, primarily in the wet season, were identified for sites within the Northern and Central zones and therefore may preclude some of the high turbidity events. Despite this, condition associated with water clarity was poor and very poor across all inshore marine zones.

The measurements of Secchi depth, TSS and turbidity (which inform the water clarity indicator category) in the Great Barrier Reef evaluate water clarity and the amount of photosynthetically active radiation (PAR), or light, that can reach the seafloor which is a critical requirement for seagrass and coral. Turbidity measurements allow for a direct and continuous measure with Secchi depth and TSS providing point in time measurements. Secchi depth data can be used to support turbidity measures, and whilst being point in time data, can provide more spatial resolution. While these indicators are related, they are not completely comparable and have their own pros and cons associated with use, largely related to the spatial and temporal coverage of the measurements. For example, the characteristics of suspended sediments can greatly influence turbidity measurements where darker and finer grained sediment will result in much higher turbidity readings than lighter-coloured and coarser sediments. In that regard, the darker and finer-grained sediments are considered the most damaging in the marine environment (Storlazzi et al. 2015; Bainbridge et al. 2018). Secchi depth, TSS and turbidity were adopted for the water clarity indicator category for the Mackay-Whitsunday-Isaac report card due to availability of data in the region, both temporally and spatially, and opportunities to incorporate citizen science data into the report card program.

**Table 33. Results for inshore water quality indicator categories for the 2019 report card (2018-19 data) compared to 2018, 2017 and 2016 report cards.**

| | 2019 | | | 2018 | | | 2017 | | | 2016 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Inshore zone** | **Nutrients** | **Chl-a** | **Water clarity** | **Nutrients** | **Chl-a** | **Water clarity** | **Nutrients** | **Chl-a** | **Water clarity** | **Nutrients** | **Chl-a** | **Water clarity** |
| Northern | 52 | 57 | 36 | 88 | 61 | 17 | | 89 | 50 | | 89 | 40 |
| Whitsunday | 24 | 11 | 20 | 32 | 22 | 30 | 1 | 0 | 21 | 28 | 53 | 38 |
| Central | 27 | 37 | 20 | 63 | 27 | 30 | 55 | 29 | 25 | 36 | 38 | 52 |
| Southern | 57 | 35 | 0 | 49 | 18 | 0 | | | | | | |

**Scoring range:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

Data from grab samples was used to develop water quality scores, with the exception of turbidity which is recorded in 15-minute intervals using data loggers. A summary of the grab sampling program is detailed below (Table 34).

Table 34. Dates that grab samples were taken in the inshore marine zones and parameters sampled for 2018-19.

| Northern | | Whitsunday | | Central | | Southern | |
|---|---|---|---|---|---|---|---|
| **Date sampled** | **Parameters analysed** | **Date sampled** | **Parameters analysed** | **Date sampled** | **Parameters analysed** | **Date sampled** | **Parameters analysed** |
| Aug-2018 | PN, PP, Chl-*a*, Secchi | Sep-2018 | NOx, PP, PN, Chl-*a*, Secchi, TSS | Jul-2018 | PP, PN, Chl-*a*, Secchi | Jul-2018 | PP, PN, Chl-*a*, NOx |
| Oct-2018 | PN, PP, Chl-*a*, Secchi | Feb-2019 | NOx, PP, PN, Chl-*a*, Secchi, TSS | Aug-2018 | PP, PN, Chl-*a*, Secchi, | Aug-2018 | PP, PN, Chl-*a*, NOx |
| Nov-2018 | PN, PP, Chl-*a*, Secchi | Mar-2019 | NOx, PP, PN, Chl-*a*, Secchi, TSS | Sep-2018 | PP, PN, Chl-*a*, Secchi, TSS, NOx | Oct-2018 | PP, PN, Chl-*a*, NOx |
| Feb-2019 | PN, PP, Chl-*a*, TSS, Secchi | May-2019 | NOx, PP, PN, Chl-*a*, Secchi, TSS | Oct-2018 | PP, PN, Chl-*a*, Secchi | Jan-2019 | PP, PN, Chl-*a*, NOx |
| Mar-2019 | PN, PP, Chl-*a*, TSS, Secchi | | | Jan-2019 | PP, PN, Chl-*a*, Secchi, NOx, TSS | Mar-2019 | PP, PN, Chl-*a*, NOx |
| May-2019 | PN, PP, Chl-*a*, TSS, Secchi | | | Feb-2019 | PP, PN, Chl-*a*, Secchi, NOx, TSS | | |
| | | | | Mar-2019 | PP, PN, Chl-*a*, Secchi, NOx, TSS | | |
| | | | | May-2019 | PP, PN, Chl-*a*, Secchi, NOx, TSS | | |

### 5.1.2 Pesticides

Pesticide risk in inshore marine zones was reported as the '% species protected'. This method was adopted in the 2018 report card to align pesticide reporting with that of freshwater basins, the Reef 2050 Water Quality Improvement Plan pesticide targets, and the Australian and New Zealand Water Quality Guidelines (ANZG 2018). The % species protected is estimated from the concentrations of multiple pesticides detected using passive samplers deployed in the inshore marine zones. As a result, the risk of the most commonly detected pesticides to the marine environment through land-based run-off are captured.

In the 2019 report card, 19 pesticides were reported in the inshore marine zone for the second consecutive year. The list of pesticides used for the inshore marine zones for the 2019 report card are presented in the Methods for the Mackay-Whitsunday-Isaac 2019 report card[1]. Previous Mackay-Whitsunday-Isaac report cards reported pesticides in the inshore marine zone using the PSll-HEq (PSll Herbicide Equivalent Concentration) which provided an indication of the aggregated risk of 13 herbicides. The current approach for estimating the % species protected for the inshore marine zone, i.e the multisubstance Potentially Affected Fraction (msPAF) method (Traas et al. 2002), has allowed the report card to expand the number of pesticides to be included in the risk estimate. This is because the msPAF method can account for the effects of multiple chemicals with different modes of action (MoA), which exert their toxicity by different means and target different types of organisms. Pesticide scores from 2017-2019 are directly comparable (Table 35). For further information regarding the Pesticide Risk Metric, see Appendix E.

Pesticide data for the 2019 report card were collected using a combination of passive samplers and grab samples. Passive samplers were deployed as part of the MMP and Partnership funded Southern Inshore Monitoring Program to assess long-term trends in pesticide concentrations and were deployed at locations within the Central and Southern zones. Deployment and retrieval times for passive samplers are provided in Table 35. Grab samples were collected in August 2018 and February/March 2019, conducted at each site at Abbot Point and Mackay/Hay Point, as commissioned by North Queensland Bulk Ports Ltd (NQBP) in the Northern and Central zones. As the report card endeavours to assess ambient water quality, only passive sampler data were employed to derive pesticide scores, resulting in a score within the Central and Southern zones only. Grab sample data from the Northern and Central zones provide a snapshot of pesticide condition from points in time and were used as a reference only, and as such not incorporated into the overall pesticide score (Table 35). It is expected that a score for pesticides in the Northern zone will be captured in future report cards as passive samplers will be incorporated into the NQBP Marine Monitoring Program.

Passive sampler deployments record a time-averaged estimate of pesticide concentrations (approximately a monthly average). The % species affected is calculated from the average concentrations (of the 19 pesticides) for each passive sampler. The maximum percentage of species affected for the site is reported to express the minimum percent of species known to be protected[2] over the year. For example, if the maximum value is 10% of species affected, then it is known that at least 90% of species were protected over the year. This is taking a more conservative approach than the methods used for freshwater basins, which report a 182 day (six month) average of the % species protected, i.e. the Pesticide Risk Metric. The reason for the more conservative approach was chosen for multiple reasons: (i) the marine zone is a high ecological value ecosystem and therefore is afforded the highest level of protection, (ii) chronic impacts from pesticides can occur within 24 hours for some phototrophic species and within 21 days for animal species (e.g athropods)- the deployment of passive samples is usually 1-2 months, (iii) passive samplers don't give an indication of the highest concentrations that the ecosystem was exposed during deployment, so greater affects are possible.

[1] https://healthyriverstoreef.org.au/report-card/report-card-download/

[2] For the purpose of reporting, the percentage of species protected (the inverse of percentage of species affected) is reported alongside the final pesticide report card score.

The overall score for pesticides in the Central zone was moderate for the 2019 report card, and was produced by averaging maximum percent species protected values from sites at Repulse Bay, Flat Top Island (previously known as Round Top Island), Sandy Creek and Sarina Inlet (Table 36). Flat Top Island, which continues to be a site of concern, was reported to be in a moderate condition, compared to the previous report card where the site was graded as very poor. Repulse Bay was also reported in a moderate condition, where previously reported to be in very good condition. Both Flat Top and Repulse Bay yielded the highest pesticide risk observed throughout the December 2018- February 2019 deployment period. A review of pesticide grades for upstream catchments from Flat Top Island, including the Pioneer, indicated they rated poor.

The Sandy Creek site was reported as being in very good condition for the 2019 report card, similar to 2018 reporting (Table 36). Across the five passive deployments that ranged from May 2018- May 2019, all reported in very good condition. A review of upstream pesticide scores in Sandy Creek indicated a very poor condition in the fresh and estuarine waters for this waterway, suggesting a high level of mixing occurs as pesticides reach the inshore marine environment in that region.

A score for pesticides in the Southern inshore zone was reported for the first time in the 2019 report card and was reported in very good condition (Table 36). Pesticide sampling was captured in reporting due to the successful establishment of the Southern Inshore Monitoring Program, funded by the Partnership. The methods used to monitor pesticides in the Southern inshore zone aligns with methods utilised by the MMP pesticide monitoring program. At this site, the passive samplers were deployed over three deployments from January 2019 to August 2019, with one deployment, 14$^{th}$ March to 12$^{th}$ July 2019, unable to derive a score. This was due to the passive being deployed for a timeframe that was longer than was considered optimal and raised concerns over the reliability of the pesticide scores determined for this deployment. However, the very good score likely provides a reasonable representation of the condition of pesticides in the Southern inshore zone, when comparing to estuary pesticide scores in the region (a grade of good in Carmila) and considering land use in the surrounding region, which is predominately grazing. The pesticide score in the Southern inshore zone provides a baseline assessment of pesticides, and on-going monitoring will further capture pesticide condition in the zone.

The grab sample scores in the Northern zone indicated very good pesticide condition for the points in time assessed in August 2018 and February 2019. These were used as a reference only to provide an indication of condition in the region and were not captured in overall report card scores.

**Table 35. Passive sampler deployment and retrieval dates for the 2019 report card. Dates highlighted in grey are the passive samplers of which the maximum was taken to derive the 2019 pesticide score. *A passive sampler deployed between 14 March- 12 July 2019 was unable to derive data due to longer than normal deployment times.**

| Inshore marine zone | Location | Start date | End date |
|---|---|---|---|
| Central | Repulse Bay | 24/05/2018 | 24/07/2018 |
| | | 24/07/2018 | 13/09/2018 |
| | | 13/09/2018 | 8/11/2018 |
| | | 18/12/2018 | 17/01/2019 |
| | | 17/01/2019 | 14/02/2019 |
| | | 14/02/2019 | 12/03/2019 |
| | | 12/03/2019 | 10/04/2019 |
| | | 10/04/2019 | 8/05/2019 |
| | Flat Top Island | 24/05/2018 | 24/07/2018 |
| | | 24/07/2018 | 13/09/2018 |
| | | 18/12/2018 | 17/01/2019 |
| | | 17/01/2019 | 14/02/2019 |
| | | 14/02/2019 | 12/03/2019 |
| | | 12/03/2019 | 10/04/2019 |
| | | 10/04/2019 | 8/05/2019 |
| | Sandy Creek | 24/05/2018 | 24/07/2018 |
| | | 24/07/2018 | 13/09/2018 |
| | | 14/02/2019 | 12/03/2019 |
| | | 12/03/2019 | 10/04/2019 |
| | | 10/04/2019 | 8/05/2019 |
| | Sarina Creek | 5/05/2018 | 6/07/2018 |
| | | 6/07/2018 | 3/09/2018 |
| | | 3/09/2018 | 30/11/2018 |
| | | 30/11/2018 | 7/01/2019 |
| | | 7/01/2019 | 17/02/2019 |
| | | 9/04/2019 | 2/05/2019 |
| Southern* | Aquila Island | 21/01/2019 | 14/03/2019 |
| | | 12/07/2019 | 14/08/2019 |

**Table 36. Results for the pesticide indicator in inshore marine zones accounting for 22 pesticides, reporting aquatic species protected (%) and overall standardised pesticide score for the 2019 report card, compared to 2018 and 2017. The pesticide score reported for each passive sampler site is the maximum % species protected value out of n deployments per site.**

<table>
<tr><th colspan="7">2019 report card</th><th>2018 report card</th><th>2017 report card</th></tr>
<tr><th>Zone</th><th>Sample</th><th>Program</th><th>Site/s</th><th>Value obtained</th><th>% species protected</th><th>Pesticide score</th><th>Pesticide score</th><th>Pesticide score</th></tr>
<tr><td>Northern</td><td>Grab</td><td>Ports</td><td>5 sites, 1 sample in August 2018, 1 sample in February 2019</td><td></td><td>99</td><td>Used for reference only</td><td></td><td></td></tr>
<tr><td>Whitsunday</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">Central</td><td rowspan="4">Passive (monthly average)</td><td rowspan="4">MMP</td><td>Repulse 24/05/2018-8/05/2019 n = 8</td><td>max</td><td>92</td><td rowspan="4">60</td><td rowspan="4">54</td><td rowspan="4">50</td></tr>
<tr><td>Flat Top 24/05/2018-8/05/2019 n = 7</td><td>max</td><td>92</td></tr>
<tr><td>Sandy Creek 24/05/2018-8/05/2019 n = 5</td><td>max</td><td>99</td></tr>
<tr><td>Sarina 5/05/2018-2/05/2019 n = 6</td><td>max</td><td>97</td></tr>
<tr><td>Grab</td><td>Ports</td><td>9 sites, 1 sample in August 2018, 1 sample in March 2019</td><td></td><td>99</td><td>Used for reference only</td><td></td><td></td></tr>
<tr><td>Southern</td><td>Passive (monthly average)</td><td>Southern inshore program</td><td>Aquila 21/01/2019-14/08/2019 n=2</td><td>max</td><td>100</td><td>100</td><td></td><td></td></tr>
</table>

**Species protected scoring range:** ■ Very Poor = <80% | ■ Poor = <90 to 80% | ■ Moderate = <95 to 90% | ■ Good = <99 to 95% | ■ Very Good = ≥99% | ■ No score/data gap

**Pesticides:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

Previous report card scores (2016, 2015, and 2014) have not been back-calculated to reflect method updates to inshore marine pesticides.

### 5.1.3 Water quality index scores and confidence

Overall water quality scores are presented in Table 37. Overall, the Northern and Central zones scored moderate and poor respectively, resulting in a shift in grade in the Central zone from moderate to poor. The water quality score improved in the Southern inshore zone from poor to moderate, incorporating pesticides into the score for the very first time; with this being the likely driver behind the improvement in score. Due to limited data availability, pesticide scores were not derived for the Northern or Whitsunday zone. The Whitsunday zone scored the lowest water quality score across marine zones grading very poor. Water quality condition continues to be a concern in the Whitsunday zone.

Water quality within the offshore zone was very good for the sixth consecutive year (Table 37).

**Table 37. Final 2019 report card score for water quality index scores for Mackay-Whitsunday-Isaac marine zones and final scores compared to 2018, 2017, 2016, 2015 and 2014 report cards. Scores from 2015 and 2014 report cards have been back-calculated to exclude pesticide scores in the Whitsunday zone so that they are directly comparable to 2016 and 2017 scores. 2017 scores were back-calculated to reflect method changes to pesticides and seagrass.**

| Inshore zone | 2019 report card | | | | | 2018 | 2017 | 2016 | 2015 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nutrients | Chl-a | Water clarity | Pesticides | Water quality index | WQ index | WQ index | WQ index | WQ index | WQ index |
| Northern | 52 | 57 | 36 | | 48 | 55 | | | | 40 |
| Whitsunday | 24 | 11 | 20 | | 18 | 28 | 7 | 40 | 42 | 4 |
| Central | 27 | 37 | 20 | 60 | 36 | 44 | 40 | 44 | 54 | |
| Southern | 57 | 35 | 0 | 100 | 48 | 22 | | | | |
| Offshore | | 99 | 99 | | 99 | 99 | 92 | 93 | 94 | 95 |

**Scoring range:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap | Not applicable

Confidence in water quality index scores generated for inshore and offshore marine zones is shown in **Error! Reference source not found.**8, below. The low confidence in the water quality index for the offshore zone was due to the use of remote sensing data to inform indicator scores. Improvements to QAQC of turbidity are continuing as part of North Queensland Bulk Ports Ltd (NQBP) marine monitoring program, with measured error confidence for water quality in Northern and Central zones adjusted for the 2019 report card. It is expected confidence scores for measured error will change in future report cards to reflect these changes in QAQC measures.

**Table 38. Confidence associated with water quality index results in marine zones for the 2019 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level. Where confidence in results for the Northern and Central zones differ to other zones, the relevant confidence score is presented in square parenthesis. Unless otherwise specified, confidence in results is the same across basins.**

| Indicator category | Maturity of methodology (x0.36) | Validation (x0.71) | Representativeness (x2) | Directness (x0.71) | Measured error (x0.71) | Final | Rank |
|---|---|---|---|---|---|---|---|
| Nutrients | 3 | 3 | 1 | 3 | 3 | 9.5 | 3 |
| Chl-a | 3 | 3 | 1 | 3 | 3 | 9.5 | 3 |
| Water clarity | 3 | 3 | 1 | 3 | 3 [2] | 9.5 [8.8] | 3 |
| Pesticides | 2 | 2 | 1 | 2 | 1 | 6.3 | 1 |
| | | | | | **Inshore water quality index** | **9.5** | **3** |
| Offshore chl-a | 3 | 2 | 2 | 1 | 1 | 7.9 | 2 |
| Offshore TSS | 3 | 2 | 2 | 1 | 1 | 7.9 | 2 |
| | | | | | **Offshore water quality index** | **7.9** | **2** |

**Rank based on final score:** 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

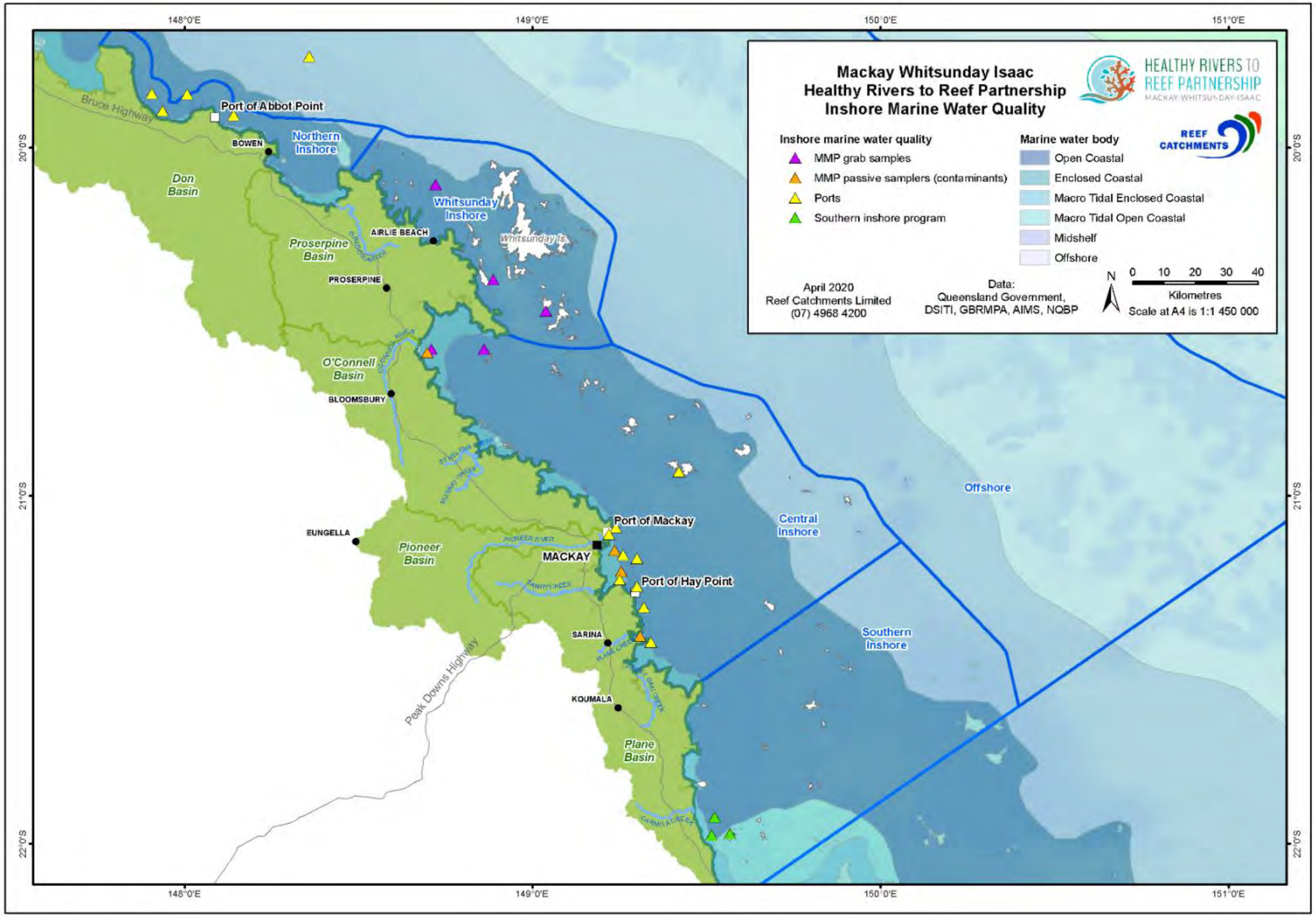


Figure 15. Inshore marine water quality monitoring sites in the Mackay-Whitsunday-Isaac region for the 2019 report card.

## 5.2 Coral in inshore and offshore marine zones

The location of coral sites used in the 2019 report card are shown in Figure 16 and 17. Coral reef assessments are undertaken with the general understanding that healthy and resilient coral communities exist in a dynamic equilibrium, following a cycle of recovery interjected by acute disturbance events. Disturbance events may include cyclones, thermal bleaching and outbreaks of crown-of-thorns starfish (COTS) (Thompson et al. 2018). The condition of coral indicators for the inshore and offshore zones for the 2019 report card are presented in Table 39.

Coral in the Offshore marine zone has remained in moderate condition for the sixth consecutive year (Table 39). There were no major disturbances recorded in the year preceding surveys undertaken in the 2018-19 reporting year. The underlying offshore score remained very similar to the 2018 report card score (overall offshore coral scores of 55 and 56 respectively). The 2019 report card scores in the offshore zone were derived from surveys of the six northern reefs in the Mackay-Whitsunday-Isaac reporting zone in 2019, which had not been surveyed since Cyclone Debbie, which impacted the region in March 2017, along with surveys of the more southern reefs undertaken in 2018. Overall, the recovery of coral communities on the northern group of offshore reefs since Cyclone Debbie has balanced any impacts that occurred, levelling the index scores presented in the 2019 report card. The juvenile coral indicator, which assesses the abundance of hard coral recruits, scored very good, indicating that the density of juvenile corals remains very high. Coral recruits require suitable space amongst the corals on which to settle and are susceptible to poor water quality. The very good juvenile score suggests there was no considerable environmental limitation to hard coral recruitment within the offshore marine zone during the monitoring period.

The coral index scores ranged from very poor to poor for all inshore marine zones within the Mackay-Whitsunday-Isaac region in the 2019 report card (Table 39). Similar to the Offshore marine zone, no major disturbances occurred in the inshore marine zones preceding surveys undertaken for the reporting year. Coral recovery from the impacts of Cyclone Debbie in the Northern inshore zone remains slow. Crown-of-thorn starfish, a voracious native predator of live coral on the Great Barrier Reef, observed at Holbourne West coral monitoring site are likely contributing to this slow recovery. Whilst coral in the Northern and Central zones remained in poor condition for the third and fourth consecutive years respectively, the overall coral score in the Whitsunday inshore zone dropped from moderate to poor when compared to the 2018 report card. The further declines in scores for Whitsunday inshore reefs reflect the full capture of Cyclone Debbie impacts with all reefs now surveyed subsequent to the cyclone's passing. The low cover change and juvenile indicator scores in the Whitsunday inshore marine zone demonstrate poor recovery potential on these reefs. Macroalgae scores, whilst moderate across the Whitsunday zone, scored lower than previously reported. The trend in macroalgae indicator scores reflects both the colonisation by macroalgae at some heavily impacted reefs where macroalgae cover was low prior to the cyclone, and the return of pre cyclone levels at other reefs where macroalgae was temporarily removed by the cyclone.

The Southern inshore zone reported coral scores for the very first time in the 2019 report card due to the establishment of the coral monitoring program formed as part of the Partnership funded Southern Inshore Monitoring Program. Coral monitoring methods in the zone align to GBRMPA's MMP coral monitoring program. Condition of coral in the Southern inshore zone was reported as very poor, with scores heavily influenced by the very high proportion of macroalgae amongst the algal community, with scores of 0 returned at all sites monitored. Macroalgae are known to suppress coral recruitment processes (Davidson et al. 2019), and this is reflected in the very poor score for the juvenile indicator. Despite clear limitations to coral resilience indicated by the very poor macroalgae and juvenile scores, coral cover was sufficient across many of the sites to be scored moderate overall. These scores present a baseline assessment from reefs included in the monitoring program, and future monitoring and report cards will continue to capture the condition of coral in the Southern inshore zone and report on the pressures that influence coral community condition. As additional data is collected as part of this program, further coral indicators will be captured including coral change and composition, which will further improve understanding of coral condition within the region.

**Table 39. Results for inshore and offshore coral indicators for marine zones reported in the 2019 report card (2018-19 data) in Mackay-Whitsunday-Isaac compared to 2018, 2017, 2016 2015 and 2014 report cards. *Offshore coral scores are not directly comparable to previously reported values, due to revision of the coral change metric, scores presented are back calculated using the revised method.**

| | 2019 report card | | | | | | 2018 | 2017 | 2016 | 2015 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Zone** | **Cover** | **Macroalgae** | **Juvenile** | **Change** | **Composition** | **Coral index** | **Coral index** | **Coral index** | **Coral index** | **Coral index** | **Coral index** |
| Northern | 14 | 62 | 8 | 30 | | **29** | 25 | 31 | 45 | | |
| Whitsunday | 22 | 51 | 22 | 24 | 29 | **30** | 42 | 52 | 61 | 58 | 56 |
| Central | 38 | 0 | 13 | 39 | | **23** | 23 | 23 | 31 | | |
| Southern | 49 | 0 | 13 | | | **20** | | | | | |
| Offshore | 32 | | 93 | 41 | | **55** | 56 | 60 | 57* | 57* | 54* |

**Scoring range:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap | ■ Not applicable

Confidence in scores for coral indicators is high and presented in Table 40.

**Table 40. Confidence associated with coral index results in marine zones for the 2019 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level. Unless otherwise specified, confidence in results is the same across marine zones where relevant.**

| **Indicator category** | **Maturity of methodology (x0.36)** | **Validation (x0.71)** | **Representativeness (x2)** | **Directness (x0.71)** | **Measured error (x0.71)** | **Final** | **Rank** |
|---|---|---|---|---|---|---|---|
| Cover | 3 | 3 | 2 | 3 | 2 | 10.8 | 4 |
| Change | 3 | 3 | 2 | 3 | 2 | 10.8 | 4 |
| Juvenile | 3 | 3 | 2 | 3 | 2 | 10.8 | 4 |
| Macroalgae | 3 | 3 | 2 | 3 | 2 | 10.8 | 4 |
| Composition | 3 | 3 | 2 | 3 | 2 | 10.8 | 4 |
| | | | | | **Inshore coral index** | **10.8** | **4** |
| Cover | 3 | 3 | 1 | 3 | 1 | 8.1 | 2 |
| Change | 3 | 3 | 1 | 3 | 1 | 8.1 | 2 |
| Juvenile | 3 | 3 | 1 | 3 | 1 | 8.1 | 2 |
| | | | | | **Offshore coral index** | **8.1** | **2** |

**Rank based on final score:** 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5.

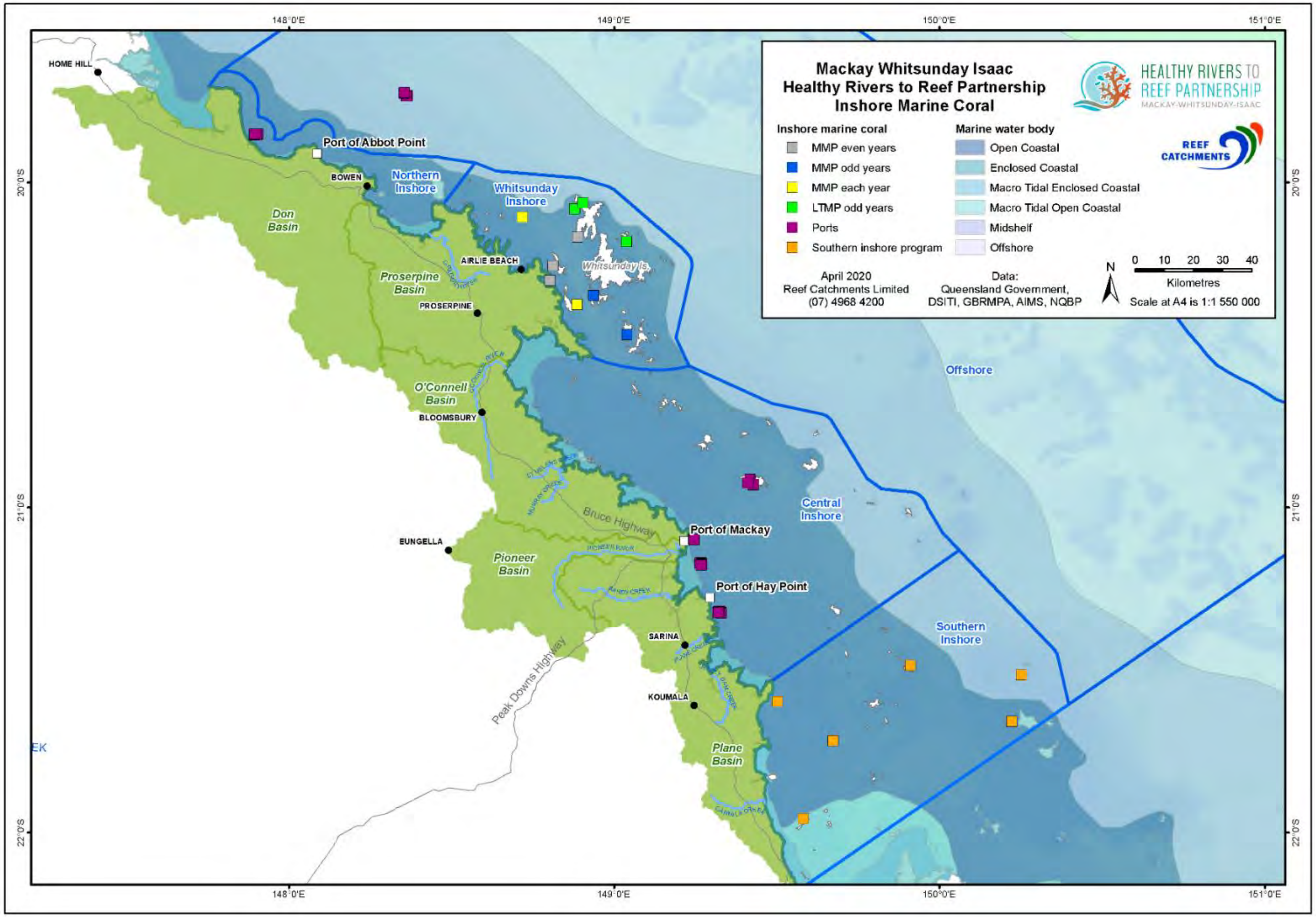


**Figure 16. Inshore marine coral monitoring sites in the Mackay-Whitsunday-Isaac region for the 2019 report card.**

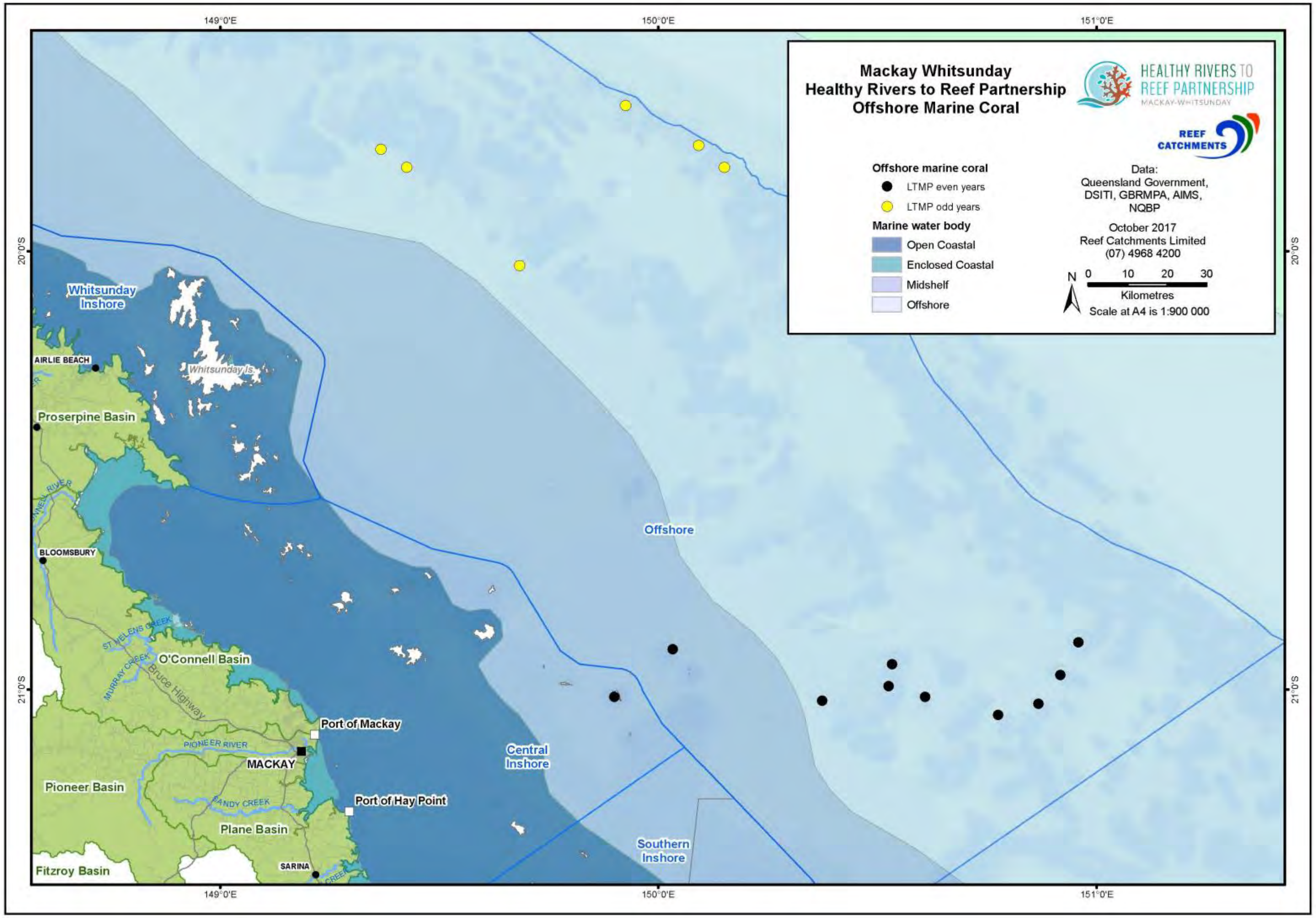


**Figure 17. Offshore marine coral monitoring sites in the Mackay-Whitsunday-Isaac region for the 2019 report card.**

## 5.3 Seagrass in inshore marine zones

The location of seagrass sites used in the 2019 report card are shown in Figure 18. Seagrass condition for the 2019 report card assessment was based on indicators measured as part of either the Marine Monitoring Program (MMP) and/or the Queensland Ports Seagrass Monitoring Program (QPSMP). Different indicators are used across the two programs, with MMP-associated indicators being abundance (percent cover), reproductive effort and tissue nutrient status, while the QPSMP associated indicators are area, biomass and species composition. To combine these programs, the seagrass index score is derived from averaging site/meadow scores from within a zone, as opposed to averaging the indicator scores within a zone. This is because there is a key difference between the two programs in how they derive site/meadow scores; the MMP takes the average of indicator scores while the QPSMP takes a conservative approach and allocates the lowest of the indicator scores to the site/meadow. If species composition drives the score because it is the lowest indicator, it is given a 50% weighting.

Seagrass condition was moderate to poor across zones assessed for the 2019 report card (Table 41). Overall scores for the Northern, Whitsunday and Central inshore zones increased when compared to the 2018 report card, where condition grades improved from poor to moderate in the Northern inshore zone, and very poor to poor in the Whitsunday inshore zone. The Central inshore zone remained in moderate condition. Improvements in seagrass condition followed declines between 2017 reporting (2016-17 reporting period) and 2018 reporting (2017-18 reporting period) due to Tropical Cyclone Debbie, a significant weather event that affected the region in late March in 2017. During Cyclone Debbie, meadows sustained high rainfall, flood plumes, increased wave height and strong winds which severely impacted seagrass in the region.

Scores in the Northern inshore zone are derived from North Queensland Bulk Ports Ltd marine monitoring program at Abbot Point and is composed of four offshore sites and five inshore coastal sites. Overall condition improved from poor to moderate, with varying levels of recovery between individual monitoring sites. In offshore areas, seagrass in deeper waters recovered better than seagrass in shallow waters, with this difference in recovery similar to previous cyclone disturbances in the area. Deeper meadows are generally able to recover faster due to differences in reproductive strategies of seagrass species. Environmental factors that can affect seagrass growth including rainfall, river flow and light, were generally favourable in the Northern zone.

Whitsunday inshore zone scores for seagrass are comprised of MMP sites at six locations. Overall zone condition improved from very poor to poor, driven largely by increases in abundance (% cover) at several locations. Recovery was strongest at Hydeaway Bay where seagrass improved from poor to very good condition between the 2018 and 2019 report cards. Seagrass at Hamilton Island and Tongue Bay sites remained in very poor condition for the third consecutive year (Table 41).

Scores in the Central inshore zone are a combination of MMP and QPSMP seagrass monitoring sites; four MMP sites and four QPSMP sites. Overall zone condition remained moderate, although there was a score increase within the grade. Increases in seagrass abundance occurred at Newry Bay from poor to good condition and increases in biomass scores occurred at all QPSMP sites which include Hay Point, Dudgeon Point, St Bees Island and Keswick Island.

The Partnership has funded a seagrass monitoring program in the Southern inshore zone as part of the Southern Inshore Monitoring Program, where scores will be included in the 2022 report card. An active citizen science Seagrass Watch program occurs at Clairview in the Southern inshore zone which was able to provide some insight into seagrass abundance condition in this zone for the 2019 report card. Whilst an overall seagrass score was not produced for the Southern inshore zone using the Seagrass Watch program data, the abundance score from this citizen science program is provided in Appendix C, Table AC 18. The Mackay-Whitsunday-Isaac report card recognises and acknowledges the valuable input from active citizen science programs in monitoring ecosystem health in the Mackay-Whitsunday-Isaac Region.

**Table 41. Results for inshore seagrass indicators for marine zones reported in the 2019 report card (2018-19 data) in Mackay-Whitsunday-Isaac compared to 2018, 2017, 2016, 2015 and 2014 report cards. Indicators are based on data collected from the Marine Monitoring Program (MMP) or the Queensland Ports Seagrass Monitoring Program (QPSMP). Seagrass scores were back-calculated in for 2017-2014 to reflect updates to method changes relating to MMP that occurred in 2018.**

| Zone | 2019 report card | | | | | | | 2018 | 2017 | 2016 | 2015# | 2014*# |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Abundance | Reproductive effort | Nutrient status | Biomass | Area | Species Composition | Seagrass Index | Seagrass Index | Seagrass Index | Seagrass Index | Seagrass Index | Seagrass Index |
| Northern | | | | 58 | 60 | 67 | **52^** | **25** | 58 | 42 | 21 | |
| Whitsunday | 27 | 13 | 13 | | | | **27^** | 13 | 24 | 34 | 18 | 24 |
| Central | 42 | 0 | 38 | 68 | 85 | 92 | **52^** | **45** | 30 | 50 | 39 | 26 |
| Southern | | | | | | | | | | | | |

**Scoring range:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap | ■ Not applicable

^To derive the seagrass index an average of *site/meadow* scores is calculated, not an average of indicator. To determine a site/meadow score the MMP takes the average of the indicator scores and QPSMP take the lowest of the indicator scores or if species composition derives score, a 50% weighting is applied. This can sometimes lead to overall seagrass index scores and ratings that appear inconsistent with the indicator scores.
*Seagrass scores from 2014 are only from MMP.
#Seagrass scores in 2015 and 2014 do not account for subtidal sites in the MMP.

Confidence for seagrass condition indicators associated with the MMP and QPSMP and the overall seagrass condition index are shown in Table 42.

**Table 42. Confidence associated with seagrass index results in marine zones for the 2019 report card. Confidence criteria are scored 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5 – 13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low – very high), which indicates final confidence level.**

| Indicator category | Maturity of methodology (x0.36) | Validation (x0.71) | Representativeness (x2) | Directness (x0.71) | Measured error (x0.71) | Final | Rank |
|---|---|---|---|---|---|---|---|
| Abundance | 3 | 3 | 1 | 3 | 2 | 8.8 | 3 |
| Reproductive effort | 3 | 3 | 1 | 3 | 2 | 8.8 | 3 |
| Nutrient status | 3 | 3 | 1 | 3 | 2 | 8.8 | 3 |
| Biomass | 3 | 3 | 1 | 3 | 2 | 8.8 | 3 |
| Area | 3 | 3 | 1 | 3 | 2 | 8.8 | 3 |
| Species composition | 3 | 3 | 1 | 3 | 2 | 8.8 | 3 |
| | | | | | **Seagrass index** | **8.8** | **3** |

**Rank based on final score:** 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5

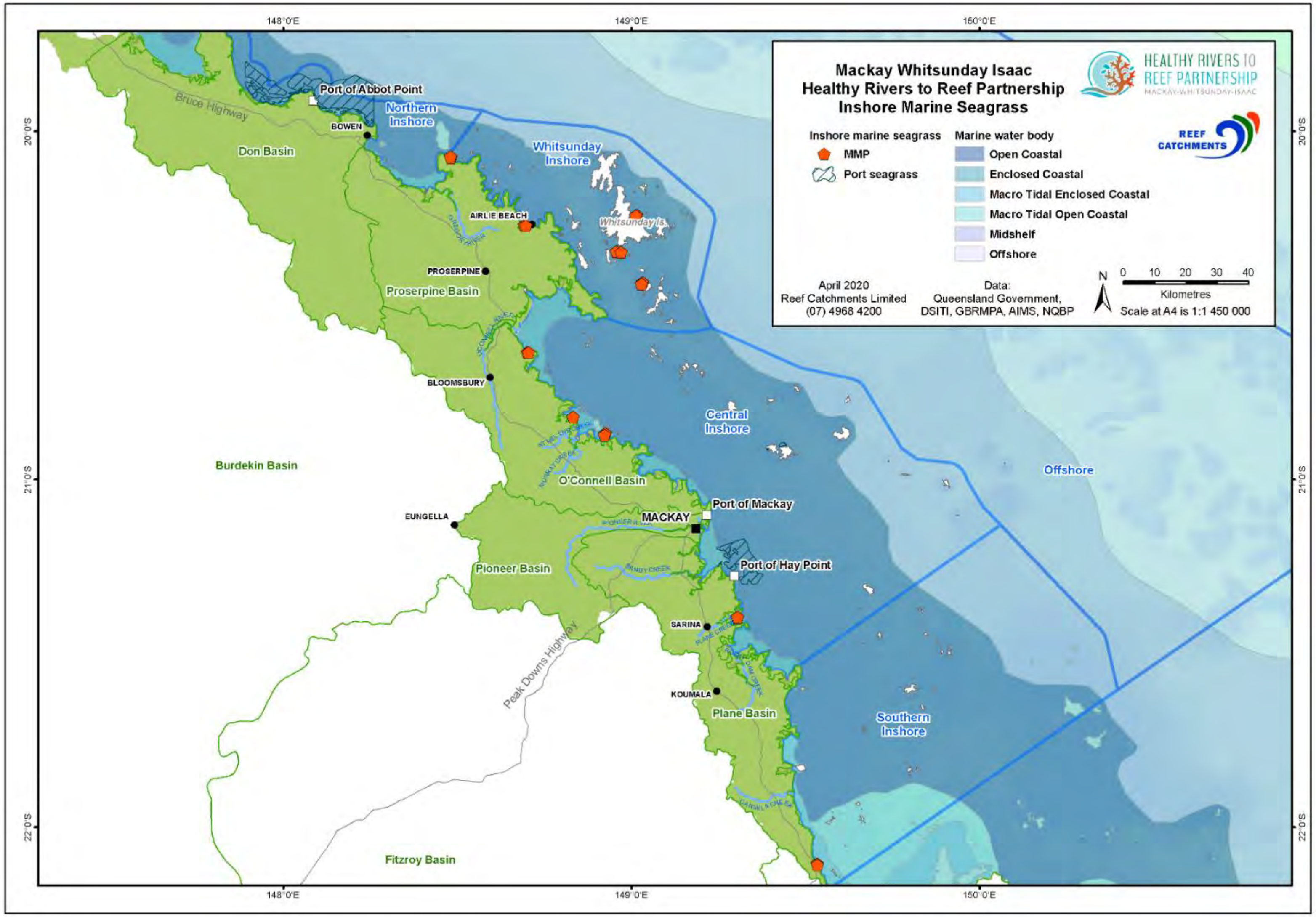


**Figure 18. Inshore marine seagrass Queensland Ports Seagrass Monitoring Program (QPSMP) and Marine Monitoring Program (MMP) monitoring sites in the Mackay-Whitsunday-Isaac region for the 2019 report card.**

## 5.4 Fish in inshore and offshore marine zones

There is no score for condition of fish in inshore and offshore marine zones. Identification of appropriate indicators and development of methodology are required for progressing fish assessment indicators in inshore and offshore marine zones. The TWG continued to explore the development of a marine fish indicator at a strategic workshop held in July 2019. Further development of these indicators is planned to occur in collaboration with RIMReP, TWG and other regional report card Partnerships.

## 5.5 Key messages for inshore and offshore marine

- Overall water quality for the 2019 report card in inshore marine zones ranged from moderate to very poor.
- Although overall marine grades for the Whitsunday and Central zones remained as poor, declines in the water quality index scores from poor to very poor, and moderate to poor occurred for Whitsunday and Central inshore zones respectively.
- Water quality in the Whitsunday inshore zone was lowest across the inshore marine zones, scoring very poor, with nutrients, chlorophyll-*a* and water clarity indicators declining in scores.
- Pesticides in the Southern inshore zone were reported for the first time in the 2019 report card due to the addition of pesticide monitoring to the Partnership-funded Southern Inshore Monitoring Program. This highlights the Partnership's continued commitment to improve report card indicators and fill identified knowledge gaps in the region.
- Coral index scores ranged from poor to very poor across inshore marine zones.
- The further declines in scores for Whitsunday inshore reefs reflect the full capture of Tropical Cyclone Debbie impacts, with all reefs now surveyed following the cyclone's passing. The low cover, change and juvenile indicator scores (that assess the level of coral cover, the change in coral cover and the density of juvenile corals respectively) in the Whitsunday inshore marine zone demonstrate poor recovery potential for these reefs.
- Coral was reported for the first time in the Southern inshore zone as part of the Partnership-funded Southern Inshore Monitoring Program, with condition reported as very poor. This presents a baseline of understanding coral condition within this zone.
- Seagrass condition ranged from moderate to poor across North, Whitsunday and Central inshore zones but showed improvements in seagrass condition following declines subsequent to Tropical Cyclone Debbie, a significant weather event that affected the region in late March, 2017.
- The Partnership currently funds a seagrass monitoring program in the Southern inshore zone, with scores expected to be reported in the 2021 report card (released in 2022).

# 6 Agricultural stewardship

Stewardship is defined as 'the responsible and sustainable use, and protection of water resources, waterways and catchments to enhance the social, cultural, environmental and economic values of the region'. Agricultural management practice adoption assessments used in the Mackay-Whitsunday-Isaac report cards align to agricultural stewardship reported through the GBR water quality report card. Agricultural stewardship reporting provides a snapshot in time of the percentage (%) of area managed using best practice management systems. These systems are defined in the Paddock to Reef Integrated Monitoring, Modelling and Reporting[1] (Paddock to Reef) program water quality risk frameworks[2]. The risk levels described for each practice, where relevant, are described in the methods report[3].

It is important to acknowledge that changing management practice can be a long and complex process for many landholders, with each component of practice requiring new skills and knowledge to varying degrees, and in some cases considerable investment in farm equipment and infrastructure. Best management practices may also be achieved by landholders who are not formally part of a practice adoption program, and therefore are unlikely to be captured in annual reporting.

For the release of the 2018 report card (released in 2019), management practice adoption benchmarks were revised for each agricultural industry practice. The 2016-17 year was set as the benchmark year from which to show improvements (Australian and Queensland Governments 2019). Previously reported agricultural stewardship results for sugarcane, grazing and horticulture for the 2014, 2015 and 2016 report cards are reported on a different benchmark scale, and therefore cannot be compared to agricultural stewardship results released post changes to this benchmark scale. The 2018 and 2019 report cards are based on the 2016-17 benchmark, and as such results are comparable. For further information relating to methods for agricultural stewardship, refer to Section 2.2.3 of 'Methods for the Mackay-Whitsunday-Isaac Report Card 2018 Human Dimension Indicators[4]' and the Great Barrier Reef report card 2017 and 2018.

## 6.1 Sugarcane

The stewardship results for the sugarcane industry for the 2019 report card are from the Proserpine, O'Connell, Pioneer and Plane basins only. The Don basin was not included due to a limited sugarcane industry in this reporting area.

For the 2019 report card, there was an increase of sugarcane farming land being managed by best practice of approximately 1.1% relating to soil, 2.2% for nutrients and 0.6% for pesticides from the 2018 report card in the Mackay-Whitsunday-Isaac region (Table 43).

Farming practices identified as moderate-high risk to water quality were highest for nutrients at 62.9% however this was a decrease from the 2018 report card, where moderate-high practices for nutrients were 66% (Figure 19).

[1] https://www.reefplan.qld.gov.au/tracking-progress/paddock-to-reef
[2] https://www.reefplan.qld.gov.au/tracking-progress/paddock-to-reef/management-practices
[3] https://healthyriverstoreef.org.au/report-card/report-card-download/
[4] https://healthyriverstoreef.org.au/report-card/report-card-download/

Adoption levels of sugarcane key management practices targeting pollutants for the 2019 report card are provided in Appendix D. Compared to 2018, management practice adoption either increased or remained similar across the Proserpine, O'Connell, Pioneer and Plane basins for soil, nutrient and pesticide management (Appendix D).

**Table 43. Sugarcane area managed under best management practices systems (%) for the 2019 report card, compared to the 2018 report card. Benchmark reporting in the Mackay-Whitsunday-Isaac report card aligns with the GBR report card, where the benchmark was set from 2016.**

| Management area | 2016 Benchmark | 2018 report card | Sugarcane under best practice (%) for 2019 report card |
|---|---|---|---|
| Soil | 2.3% | 2.3% | 3.4% |
| Nutrients | 7.0% | 7.1% | 9.3% |
| Pesticides | 5.1% | 6.0% | 6.6% |

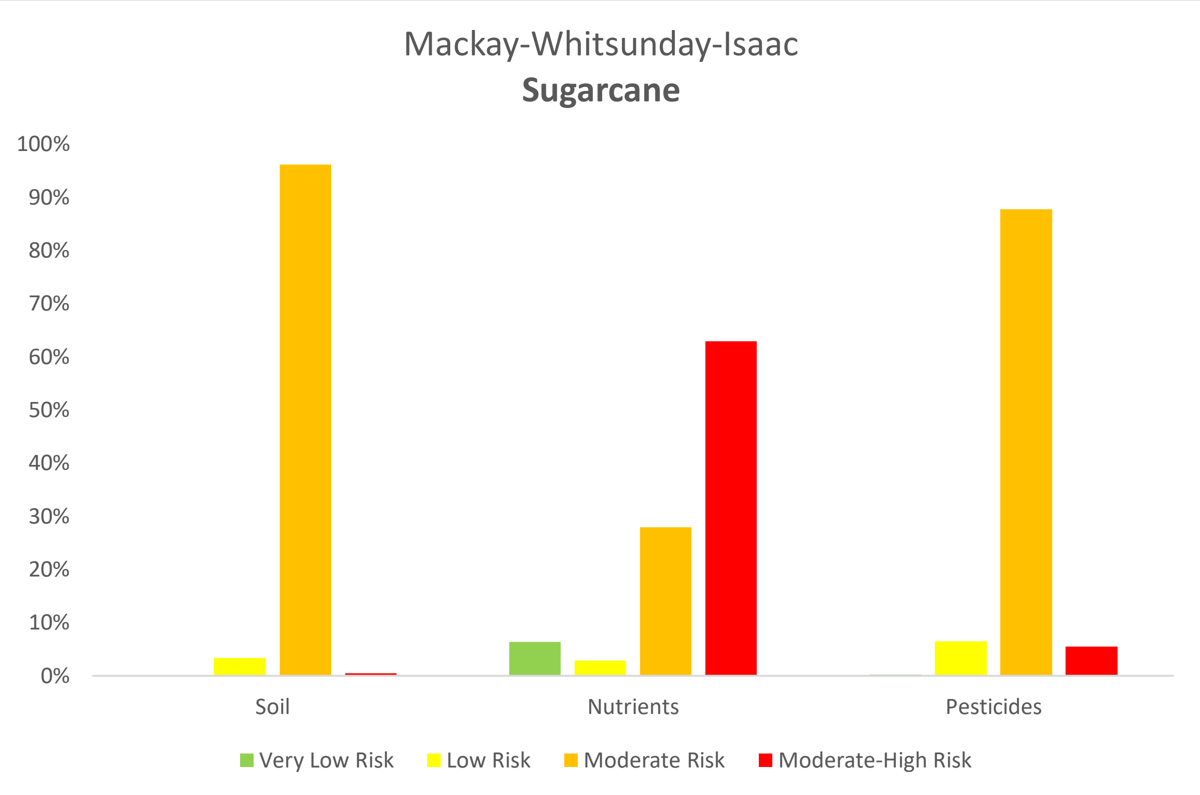


**Figure 19. Mackay-Whitsunday-Isaac proportional area (%) of sugarcane water quality risk (very low-high risk) by management systems for the 2019 report card.**

## 6.2 Horticulture

The stewardship results for the horticulture industry for the 2019 report card include data from the Don basin only as the most significant area under horticulture. Whilst horticulture is limited across other basins, the Mackay-Whitsunday-Isaac region has a well-established and strong horticulture industry growing fruit and vegetables including mangoes, citrus fruits, pineapples, passion fruit, strawberries, avocados and seasonal vegetables.

For the 2019 report card, horticulture land managed under best management practice was approximately 41.2% for soil, 4.2% for nutrients and 61.3% for pesticides (Figure 20). This was similar for the 2018 report card, resulting in no practice change adopted between the reporting years (Table 44).

**Table 44. Horticulture area managed under best management practices systems (%) for the 2019 report card, compared to the 2018 report card. Benchmark reporting in the Mackay-Whitsunday-Isaac report card aligns with the GBR report card, where the benchmark was set from 2016.**

| Management area | 2016 Benchmark | 2018 report card | Horticulture under best practice (%) for 2019 report card |
|---|---|---|---|
| Soil | 41.2% | 41.2% | 41.2% |
| Nutrients | 3.6% | 4.2% | 4.2% |
| Pesticides | 61.3% | 61.3% | 61.3% |

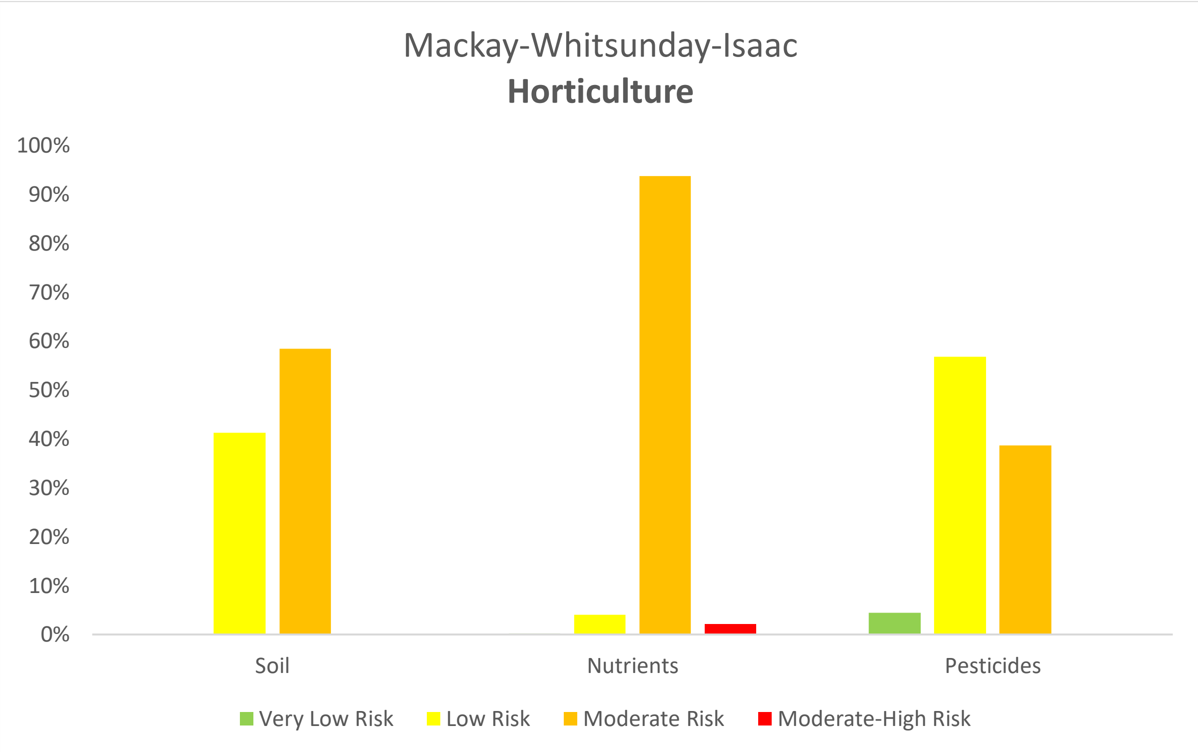


**Figure 20. Mackay-Whitsunday-Isaac proportional area (%) of horticulture water quality risk (very low-high risk) by management practice systems for the 2019 report card.**

## 6.3 Grazing

The management practice levels within the grazing industry address the three main erosion pathways (pastures (hillslope), streambanks and gullies) across the five basins in the region. Results for grazing cover a slightly different area when compared to the GBR report card as the Mackay-Whitsunday-Isaac report card, which includes the Don basin for reporting grazing stewardship.

For the 2019 report card, approximately 38.1% of grazing land was being managed using best management practice systems related to pasture (hillslope) erosion, 33.7% for practices relating to streambank erosion and 31.9% for practices relating to gully erosion (Figure 21).

There was an increase of 0.2% in the area managed for pasture management when compared to the 2018 report card (Table 45). There was no increase in the area of gullies or streambanks managed using best practice (Figure 21).

**Table 45. Grazing area managed under best management practices systems (%) for the 2019 report card, compared to the 2018 report card. Benchmark reporting in the Mackay-Whitsunday-Isaac report card aligns with the GBR report card, where the benchmark was set from 2016.**

| Management area | 2016 Benchmark | 2018 report card | Grazing under best practice (%) for 2019 report card |
|---|---|---|---|
| Pastures | 36.1% | 37.9% | 38.1% |
| Streambanks | 33.7% | 33.7% | 33.7% |
| Gullies | 31.9% | 31.9% | 31.9% |

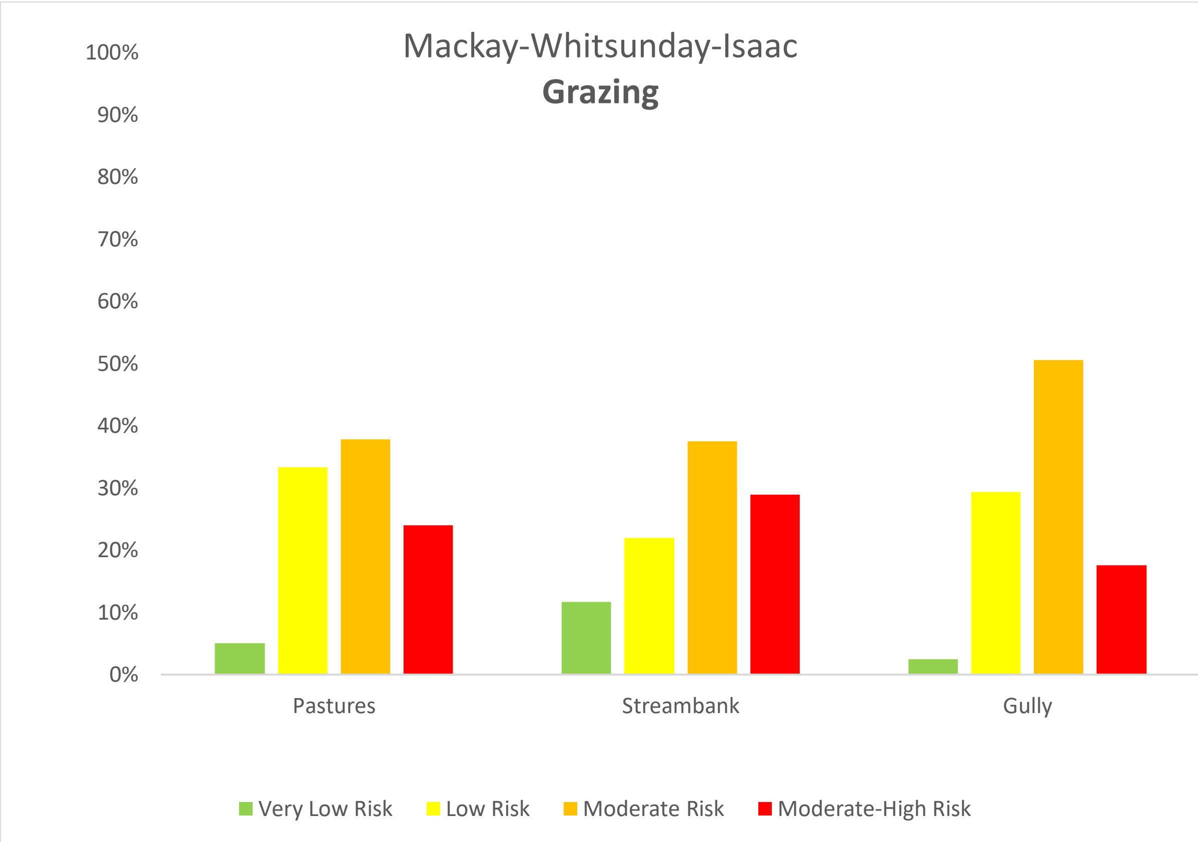


**Figure 21. Mackay-Whitsunday-Isaac proportional area (%) of grazing water quality risk (very low- high risk) by management systems for the 2019 report card.**

Confidence for agricultural stewardship are shown in Table 46.

**Table 46. Confidence associated with non-agricultural stewardship results in the Mackay-Whitsunday-Isaac 2019 report card. Confidence criteria are score 1-3 and then weighted by the value identified in parenthesis. Final scores (4.5-13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1-5 (very low- very high), which indicates final confidence level.**

| Indicator category | Maturity of methodology (x0.36) | Validation (x0.71) | Representat-iveness (x2) | Directness (x0.71) | Measured error (x0.71) | Final | Rank |
|---|---|---|---|---|---|---|---|
| Horticulture | 1 | 2 | 3 | 2 | 1 | 9.9 | 4 |
| Grazing | 1 | 2 | 2 | 1 | 1 | 7.2 | 2 |
| Sugar cane | 1 | 3 | 3 | 2 | 1 | 10.6 | 4 |
| agricultural stewardship | | | | | | 9.9 | 4 |

**Rank based on final score:** 1 (very low): 4.5 – 6.3; 2 (low): >6.3 – 8.1; 3 (moderate): >8.1 – 9.9; 4 (high): >9.9 – 11.7; 5 (very high): >11.7 – 13.5

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# Appendix A – Freshwater Environment

## Appendix A.1 - Basins Summary Statistics and Boxplots

Table AA 1. Summary statistics for monitored water quality in the Mackay-Whitsunday-Isaac basin reporting areas, from July 2018 to June 2019. Summary statistics are presented to three significant figures. Presented alongside summary statistics are relevant guideline values and the adopted statistic for comparison. In the estuaries, the 50th percentile (the median) concentration value should be compared against the applicable water quality guideline.

| | | | | | | | | | Guidelines | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site | Indicator | n | Mean | Minimum | 25th %ile | Median | 75th %ile | Maximum | Comparison statistic | Guideline values (mg/L) |
| Don River at Bowen | TSS | 54 | 46.292 | 3.000 | 6.875 | 14.500 | 45.125 | 309.000 | median | 5 |
| | DIN | 54 | 0.117 | 0.007 | 0.018 | 0.060 | 0.093 | 0.768 | median | 0.03 |
| | FRP | 54 | 0.037 | 0.001 | 0.014 | 0.021 | 0.044 | 0.117 | median | 0.045 |
| Proserpine River at Glen Isla | TSS | 70 | 151.773 | 43.000 | 109.750 | 146.000 | 198.250 | 250.000 | median | 5 |
| | DIN | 70 | 0.307 | 0.064 | 0.215 | 0.333 | 0.396 | 0.457 | median | 0.03 |
| | FRP | 70 | 0.087 | 0.054 | 0.067 | 0.084 | 0.098 | 0.162 | median | 0.025 |
| O'Connell River at Caravan Park | TSS | 84 | 33.136 | 4.000 | 8.500 | 13.000 | 39.500 | 115.000 | median | 2 |
| | DIN | 84 | 0.110 | 0.003 | 0.099 | 0.096 | 0.141 | 0.395 | median | 0.03 |
| | FRP | 84 | 0.014 | 0.001 | 0.003 | 0.012 | 0.025 | 0.032 | median | 0.006 |
| O'Connell River at Stafford’s Crossing | TSS | 86 | 39.045 | 0.500 | 1.000 | 3.500 | 51.250 | 202.000 | median | 2 |
| | DIN | 86 | 0.103 | 0.005 | 0.014 | 0.089 | 0.137 | 0.459 | median | 0.03 |
| | FRP | 86 | 0.012 | 0.001 | 0.003 | 0.007 | 0.020 | 0.032 | median | 0.006 |
| Pioneer River at Dumbleton Weir | TSS | 102 | 10.600 | 2.500 | 3.000 | 3.500 | 14.000 | 35.000 | median | 5 |
| | DIN | 102 | 0.212 | 0.003 | 0.036 | 0.195 | 0.351 | 0.580 | median | 0.008 |
| | FRP | 102 | 0.017 | 0.001 | 0.001 | 0.006 | 0.028 | 0.057 | median | 0.005 |
| Plane Creek at Surcogen Weir | TSS | 80 | 22.950 | 5.000 | 12.625 | 19.500 | 30.000 | 59.000 | median | 5 |
| | DIN | 81 | 0.086 | 0.004 | 0.014 | 0.063 | 0.143 | 0.229 | median | 0.03 |
| | FRP | 81 | 0.032 | 0.001 | 0.003 | 0.026 | 0.054 | 0.084 | median | 0.015 |
| Sandy Creek at Homebush | TSS | 120 | 31.950 | 2.000 | 4.125 | 24.500 | 58.500 | 73.000 | median | 3 |
| | DIN | 121 | 0.341 | 0.050 | 0.226 | 0.336 | 0.436 | 0.745 | median | 0.008 |
| | FRP | 121 | 0.080 | 0.012 | 0.028 | 0.084 | 0.127 | 0.157 | median | 0.008 |

**Table AA 2. Flow measure scores and summary scores for freshwater flow values across the Mackay-Whitsunday-Isaac region, weighted by catchment area for the 2018-19 reporting year. Flow measures are scored between 1-5 and the 30th percentile is used as a summary score. Scores are then converted from 1-5 scale to the standardised 0-100 for aggregation.**

| Site | Gauging station # | MDF: %benchmark | CTF: Duration | CTF: Frequency | Below 10%ile: Duration | Below 10%ile: Frequency | Ratio dry/total | CV dry season | Above 50%ile: Duration | Above 50%ile: Frequency | Above 90%ile: Duration | Above 90%ile: Frequency | 30th percentile | Standardised score | Gauge catchment (km^2) | Adjusted catchment (km^2) | Proportion (based on using gauged catchment area) (for Basins) | Standardised score x proportion | **Aggregated basin score** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pioneer** | | | | | | | | | | | | | | | | | | | 72.8 |
| CattleCk@Gargett | 125004B | 1.6 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4.7 | 75 | 326 | 326 | 0.1 | 11.0 | |
| BlacksCk@Whitefords | 125005A | 0.9 | 5 | 5 | 5 | 5 | 5 | 1 | 4 | 5 | 5 | 5 | 5 | 80 | 509 | 702 | 0.3 | 25.2 | |
| FinchHattonCk@GorgeRd | 125006A | 1.9 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 2 | 5 | 4 | 5 | 85 | 35 | 35 | 0.0 | 1.3 | |
| PioneerR@MiraniWeirTW | 125007A | 1.3 | 4 | 4 | 5 | 5 | 5 | 5 | 4 | 5 | 5 | 5 | 4.7 | 75 | 1211 | 885 | 0.4 | 29.8 | |
| PioneerR@DumbletonWeirTW | 125016A | 1.1 | 1 | 1 | 1 | 5 | 4 | 4 | 4 | 4 | 5 | 5 | 3.1 | 43 | 1488 | 277 | 0.1 | 5.4 | |
| **Plane** | | | | | | | | | | | | | | | | | | | 35.0 |
| SandyCreek@Homebush | 126001A | 1.0 | 5 | 5 | 1 | 4 | 1 | 3 | 4 | 5 | 2 | 5 | 2.7 | 35 | 326 | 326 | 1.0 | 35.0 | |

**Scoring range:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

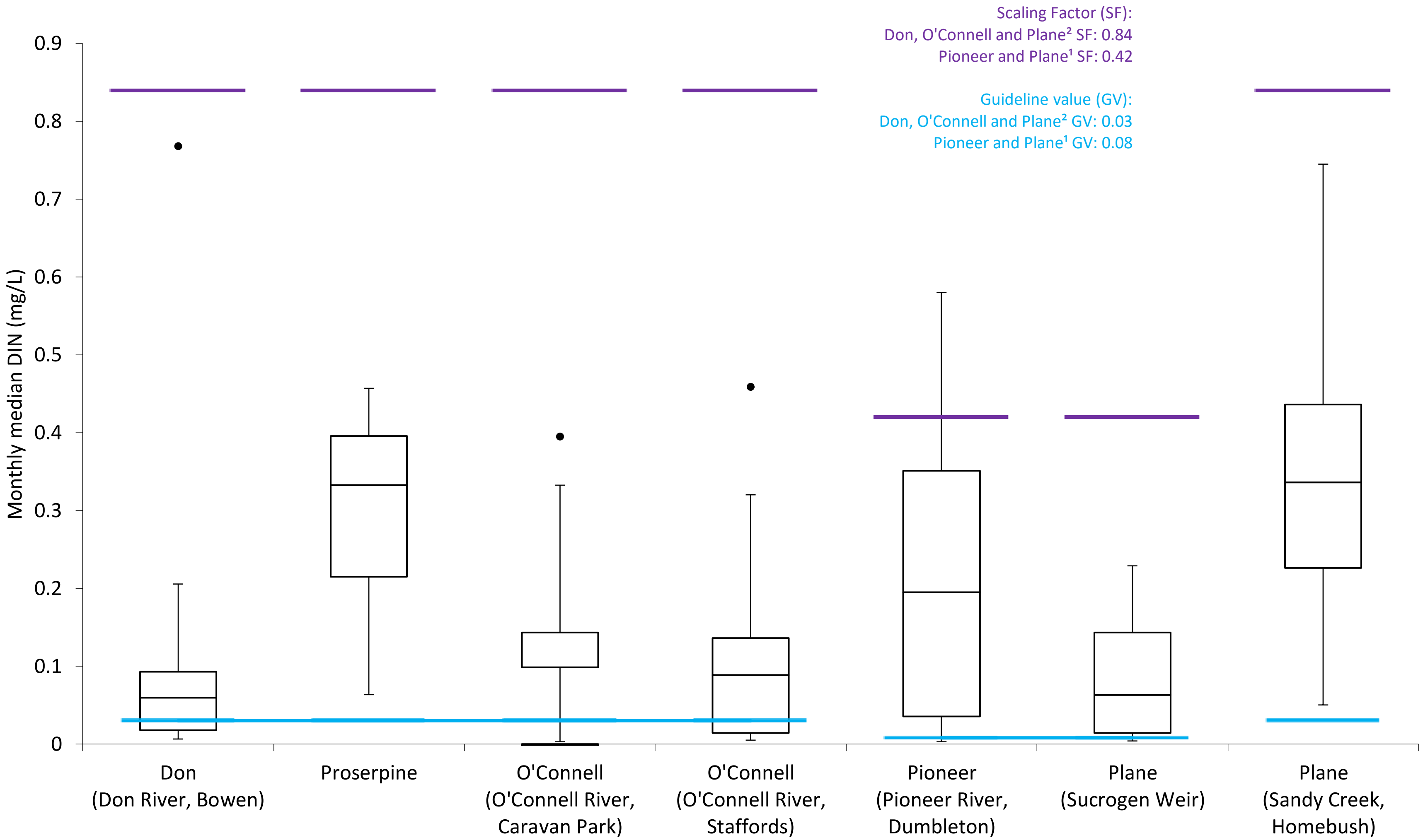



**Figure AA 1. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of monthly DIN concentrations in the Mackay-Whitsunday-Isaac basins. Scaling factors (SF) and guideline values (GV) are provided for each basin, where information is available. Outliers (>1.5 x IQR) are also pictured.**

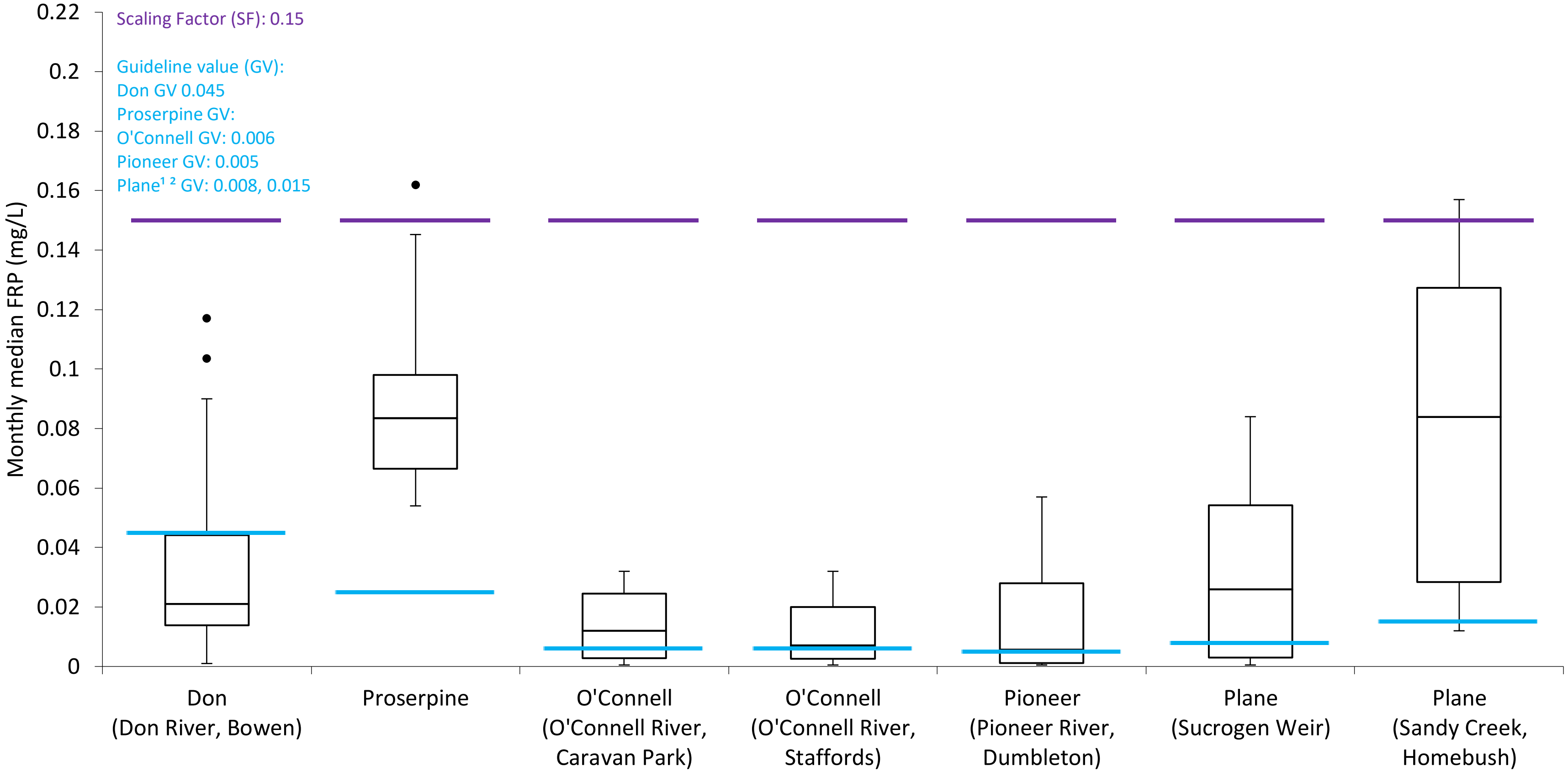



**Figure AA 2. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of monthly FRP concentrations in the Mackay-Whitsunday-Isaac basins. Scaling factors (SF) and guideline values (GV) are provided for each basin, where information is available. Outliers (>1.5 x IQR) are also pictured.**

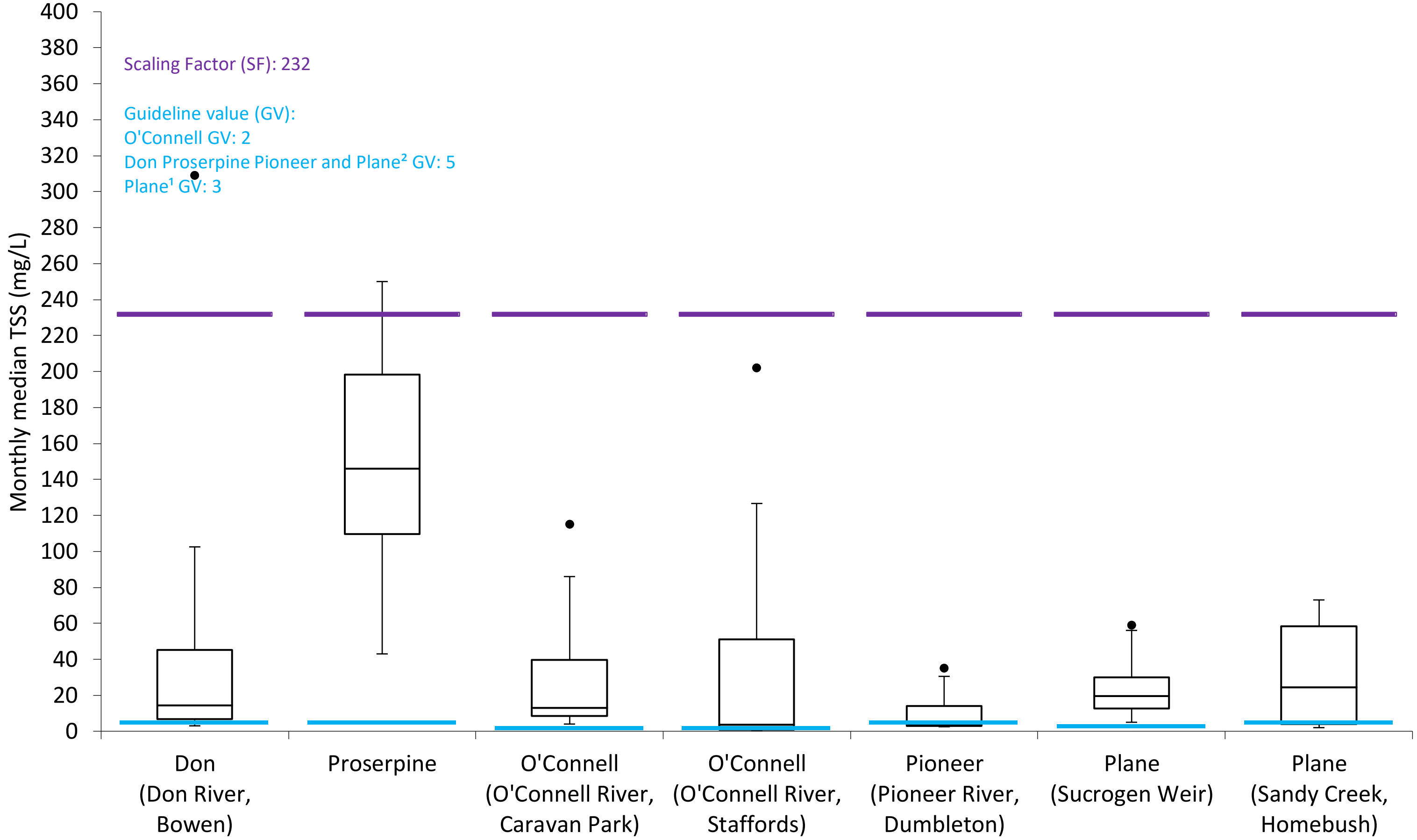



**Figure AA 3. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of monthly TSS concentrations in the Mackay-Whitsunday-Isaac basins. Scaling factors (SF) and guideline values (GV) are provided for each basin, where information is available. Outliers (>1.5 x IQR) are also pictured.**

## Appendix A.2 – Assessing Multiple Freshwater Monitoring Sites

Based on the recommendation provided at a regional report card's TWG held in Mackay in March 2019, data collected from multiple independent monitoring sites are to be aggregated using a weighted average, based on the relative catchment area upstream of each sampling site. In the Mackay-Whitsunday-Isaac region, two such instances occur; two monitoring stations are located along the O'Connell River within the O'Connell Basin and two monitoring stations are located within the Plane Basin, with one site situated on the Plane River and one on Sandy Creek.

Methods of calculation are presented in Table AA 3- AA 6 below for DIN, FRP, TSS and pesticides, respectively. For further information on assessing multiple freshwater monitoring sites, email info@healthyriverstoreef.org.au

**Table AA 3. Calculation of proportional contribution to scores for multiple monitoring sites within the O'Connell Basin for the 2019 report card, based on relative upstream catchment area. Where applicable, adjusted area is calculated and represents relative upstream catchment area to the next monitoring site.**

| Site (O'Connell Basin) | Catchment area (km²) | Adjusted catchment area (km²) | Proportion % (based on gauging catchment area) |
|---|---|---|---|
| Catchment upstream from O'Connell at Caravan Park | 825 | 483 | 0.59 |
| Catchment upstream from O'Connell at Staffords | 342 | 342 | 0.41 |
| **Total area measured** | | **825** | |

**Table AA 4. Calculation of weighted site-level scores and total scores (sum of the weighted site-level scores) for DIN, FRP, TSS and Pesticide indicators.**

| Site (O'Connell Basin) | DIN | FRP | TSS | Pesticides |
|---|---|---|---|---|
| Caravan Park standard score | 55.9 | 58.4 | 58.0 | 7.5 |
| Caravan Park x weighting | **32.8** | **34.2** | **34.0** | **4.4** |
| Staffords standard score | 56.5 | 60.5 | 60.5 | 8.1 |
| Staffords x weighting | **23.4** | **25.07** | **25.1** | **3.4** |
| **TOTAL (sum of weighted scores)** | **56** | **59** | **59** | **7** |

**Table AA 5. Calculation of proportional contribution to scores for multiple monitoring sites within the Plane Basin, based on relative upstream catchment area. Where applicable, adjusted area is calculated and represents relative upstream catchment area to the next monitoring site.**

| Site (Plane Basin) | Catchment area ($km^2$) | Adjusted catchment area ($km^2$) | Proportion % (based on gauging catchment area) |
|---|---|---|---|
| Catchment upstream from Sandy Creek at Homebush | 326 | 326 | 0.78 |
| Catchment upstream from Plane Creek | 90 | 90 | 0.21 |
| **Total area measured** | | **416** | |

**Table AA 6. Calculation of weighted site-level scores and total scores (sum of the weighted site-level scores) for DIN, FRP, TSS and Pesticide indicators.**

| Site (Plane Basin) | DIN | FRP | TSS | Pesticides |
|---|---|---|---|---|
| Sandy Creek standard score | 37.9 | 29.8 | 55.7 | 36.5 |
| Sandy Creek x weighting | **29.7** | **23.3** | **43.62** | **28.6** |
| Plane Creek standard score | 52.8 | 53.2 | 56.5 | 4.1 |
| Plane Creek x weighting | **11.4** | **11.5** | **12.2** | **0.9** |
| **TOTAL (sum of weighted scores)** | **41** | **34** | **55** | **29** |

## Appendix A.3 – Revision to Wetland Extent Scores, Basins

Based on available refinements to the wetland mapping data (version 5), the scores for wetland extent have been updated for the 2019 report card. Due to updates to the source mapping, including refinements such as fixing errors and re-mapping to a finer scale, data are not directly comparable to those previously reported, inhibiting interpretation of change observed between years. To rectify this, wetland extent scores were back-calculated for the 2013 assessment, using updated maps which more accurately depict condition in 2013. The results for back-calculated wetland extent scores are provided in Table AA 7, below. Notably, the back-calculated scores for 2013 are the same as those for the most recent 2019 assessment.

**Table AA 7. Results showing % of wetland extent loss when compared to pre-development conditions, in 2013. This assessment pertains to palustrine wetlands only.**

| Basin | 2013 Wetland extent: Hectares lost since pre-development | 2013 Wetland extent: (% loss since pre-development) | 2013 Standardised mangrove/ saltmarsh extent |
|---|---|---|---|
| Don | 0* | -3* | **100** |
| Proserpine | 848 | 16 | **59** |
| O'Connell | 334 | 66 | **14** |
| Pioneer | 1,279 | 71 | **12** |
| Plane | 930 | 47 | **23** |

**Wetland extent (% loss):** ■ Very Poor = >50% | ■ Poor =>30 to 50% | ■ Moderate = >15 to 30% | ■ Good = >5 to 15% | ■ Very Good ≤5% | ■ No score/data gap

**Standardised wetland extent:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

*negative values denote scenarios where there has been an increase in the total wetland extent, since pre-development.

# Appendix B – Estuarine Environment

## Appendix B.1 Pesticide Study Sites in Detail

The number of samples used to derive the pesticide score have increased since measurements were last reported for this indicator in 2017. Historically, the pesticide monitoring program for estuaries was limited to monthly grab samples collected throughout the wet season period (six months), when runoff levels, which transport pesticides from land to the receiving waterway, are expected to be higher. For the 2018-2019 reporting year, approximately three grab samples were collected per month; one via the existing ambient monitoring program and two via a supplementary monitoring program led by the Partnership (HR2RP). Information obtained through the addition of new monitoring sites and increased sampling effort, as achieved through the supplementary monitoring program, are used to inform the PRM score for the first time in the 2019 report card. The location of monitoring sites is outlined in further detail, below.

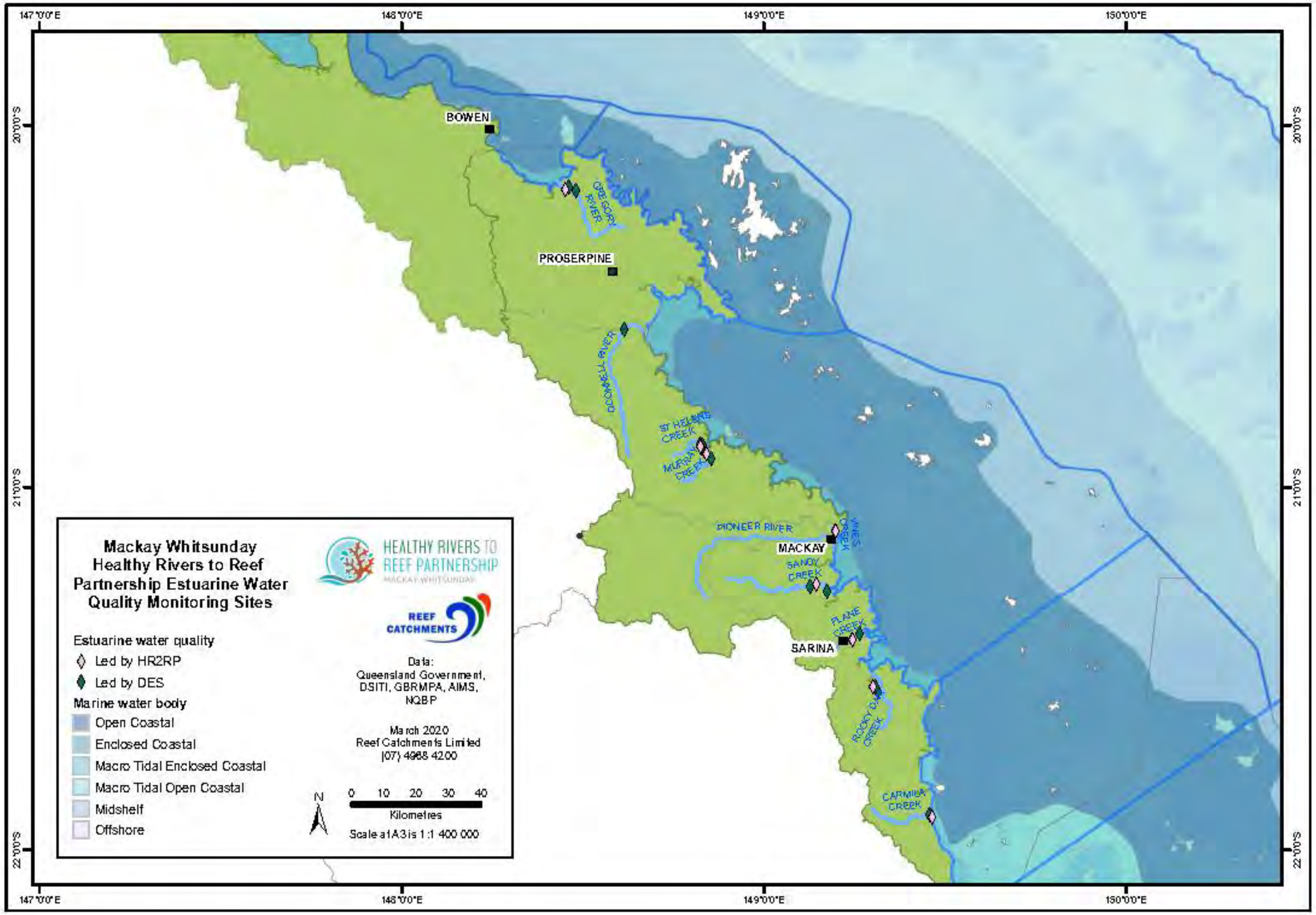



**Figure AB 1. Locations of monitoring sites for estuarine water quality sampling, including DIN, FRP, Turbidity, DO, Chlorophyll-a and pesticides in the Mackay-Whitsunday-Isaac Region. Black squares and circles indicate towns.**

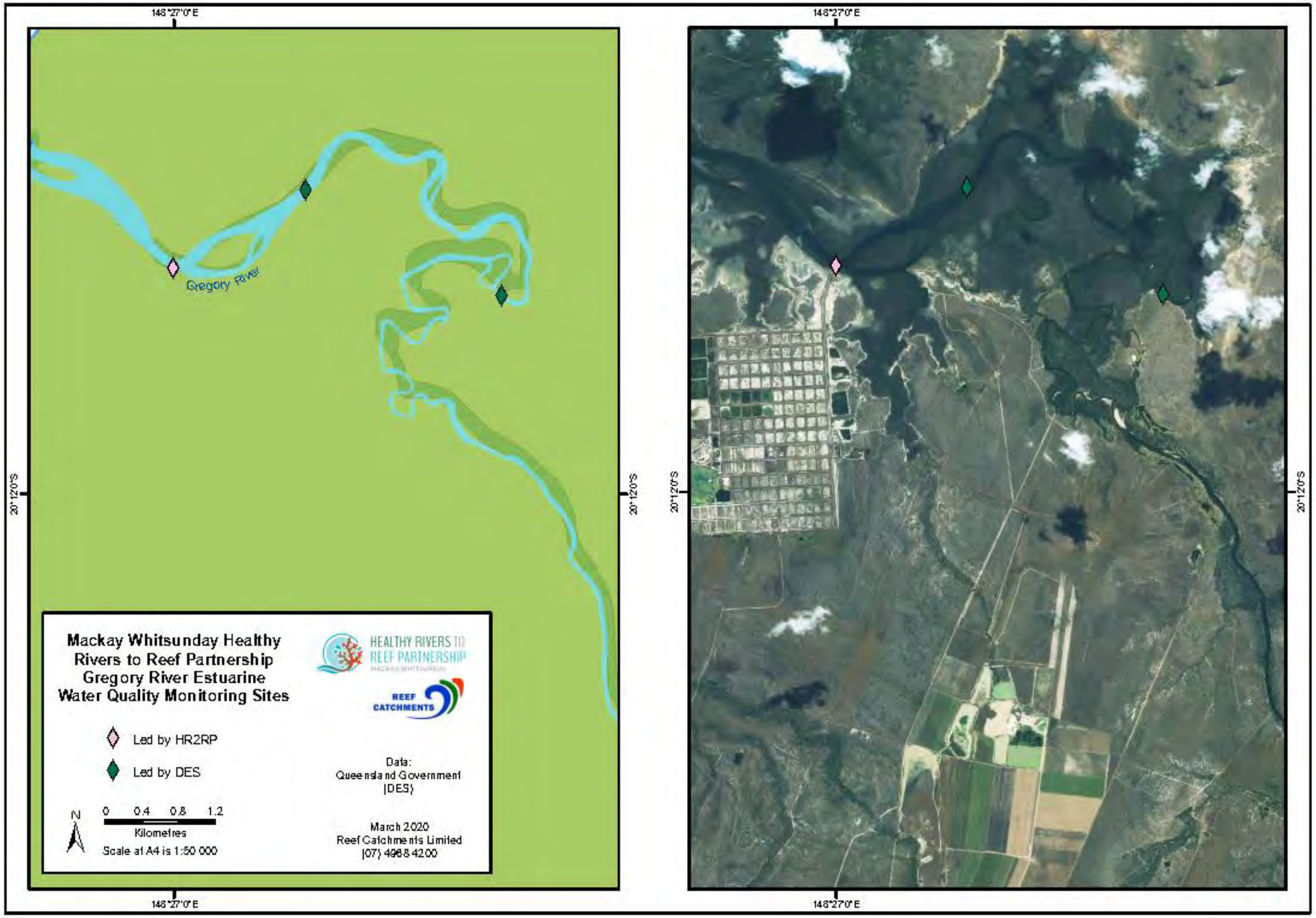



Figure AB 2. Locations of monitoring sites for estuarine sampling of pesticides in the Gregory River. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the north-west, beyond the boundary of the map.

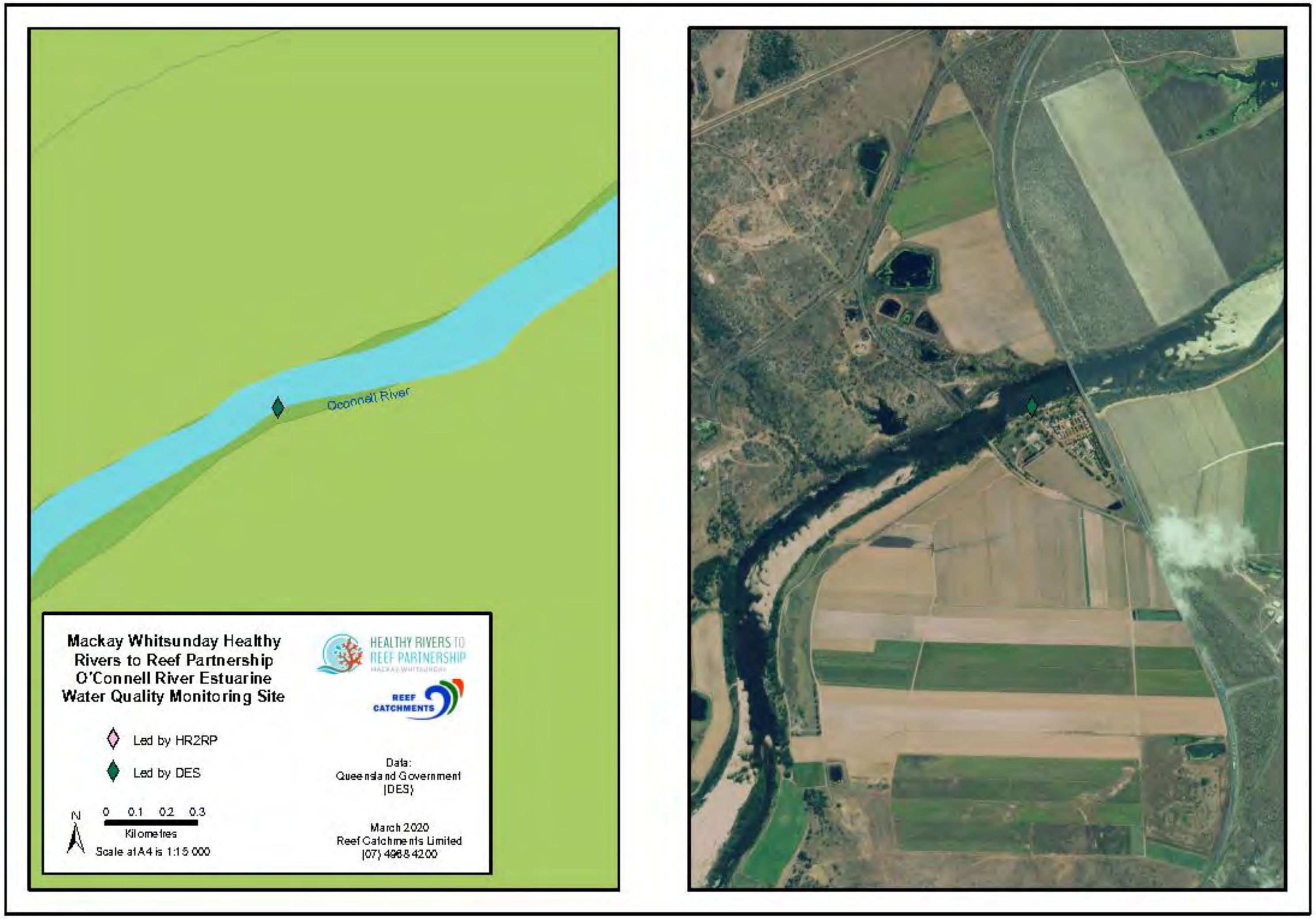



**Figure AB 3. Locations of monitoring site(s) for estuarine sampling of pesticides in the O'Connell River. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located approximately to the north-east, beyond the boundary of the map.**

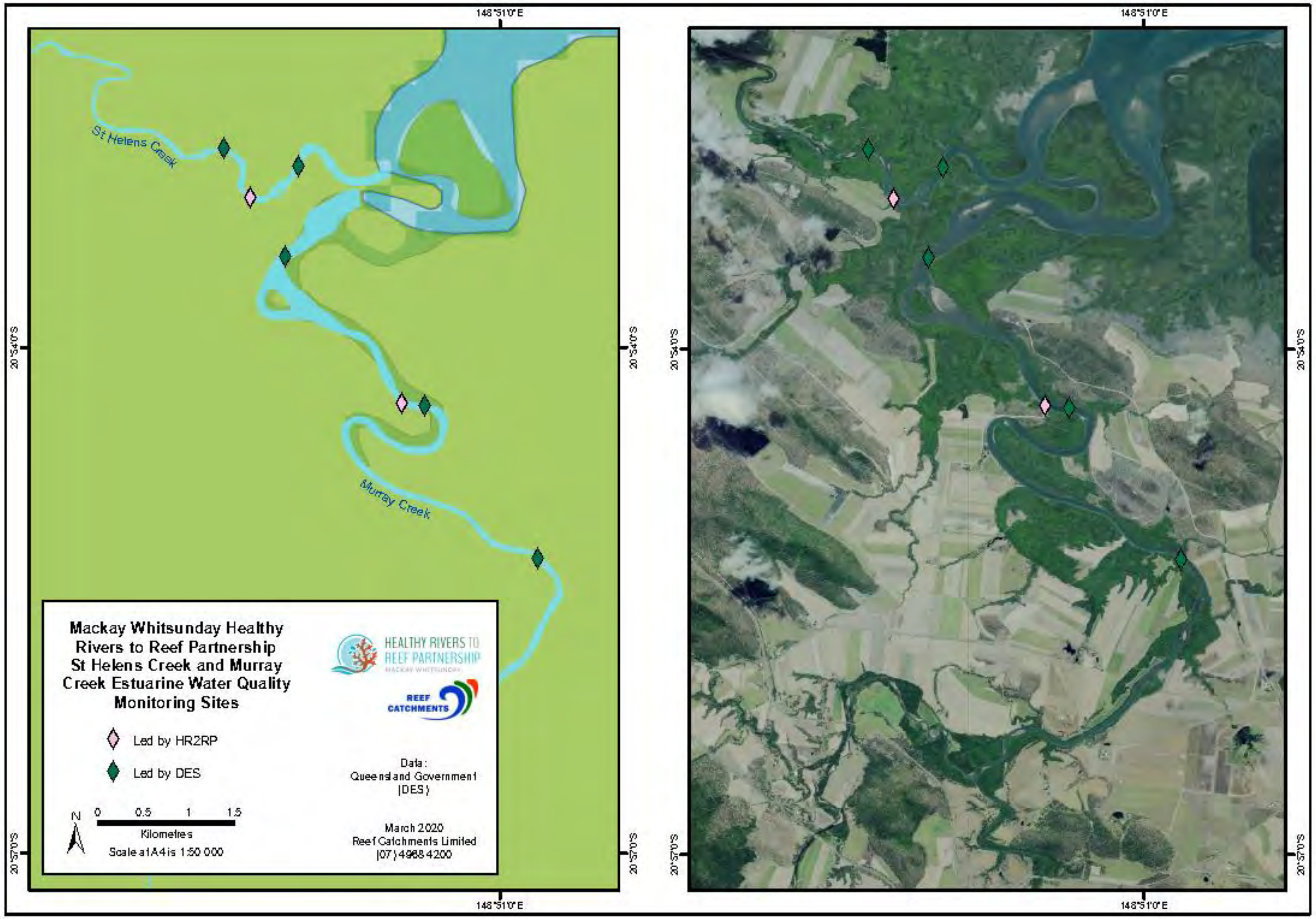



**Figure AB 4. Locations of monitoring sites for estuarine sampling of pesticides in St Helens Creek/Murray Creek estuary. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the north, beyond the boundary of the map.**

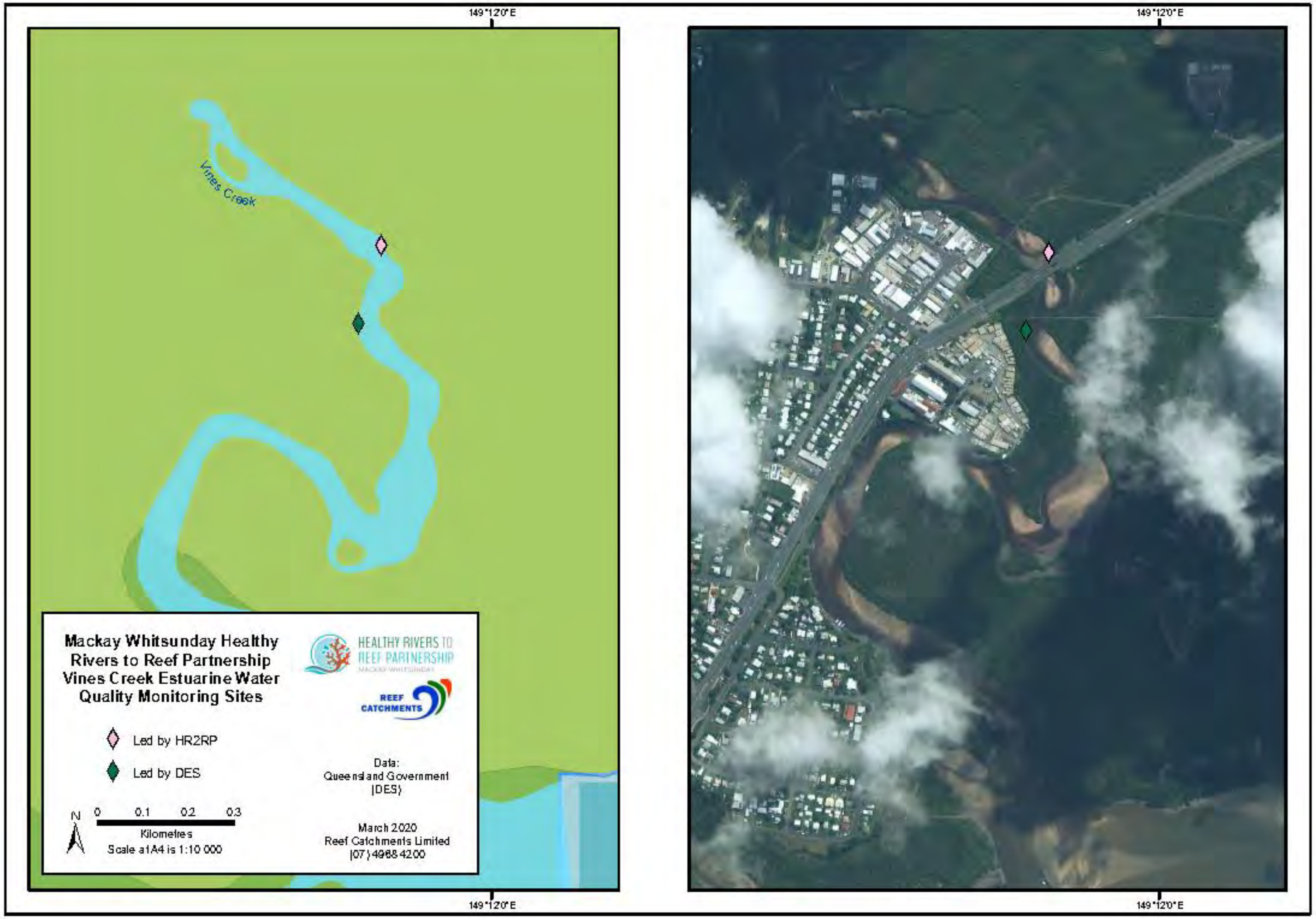



Figure AB 5. Locations of monitoring sites for estuarine sampling of pesticides in Vines Creek. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the south, beyond the boundary of the map.

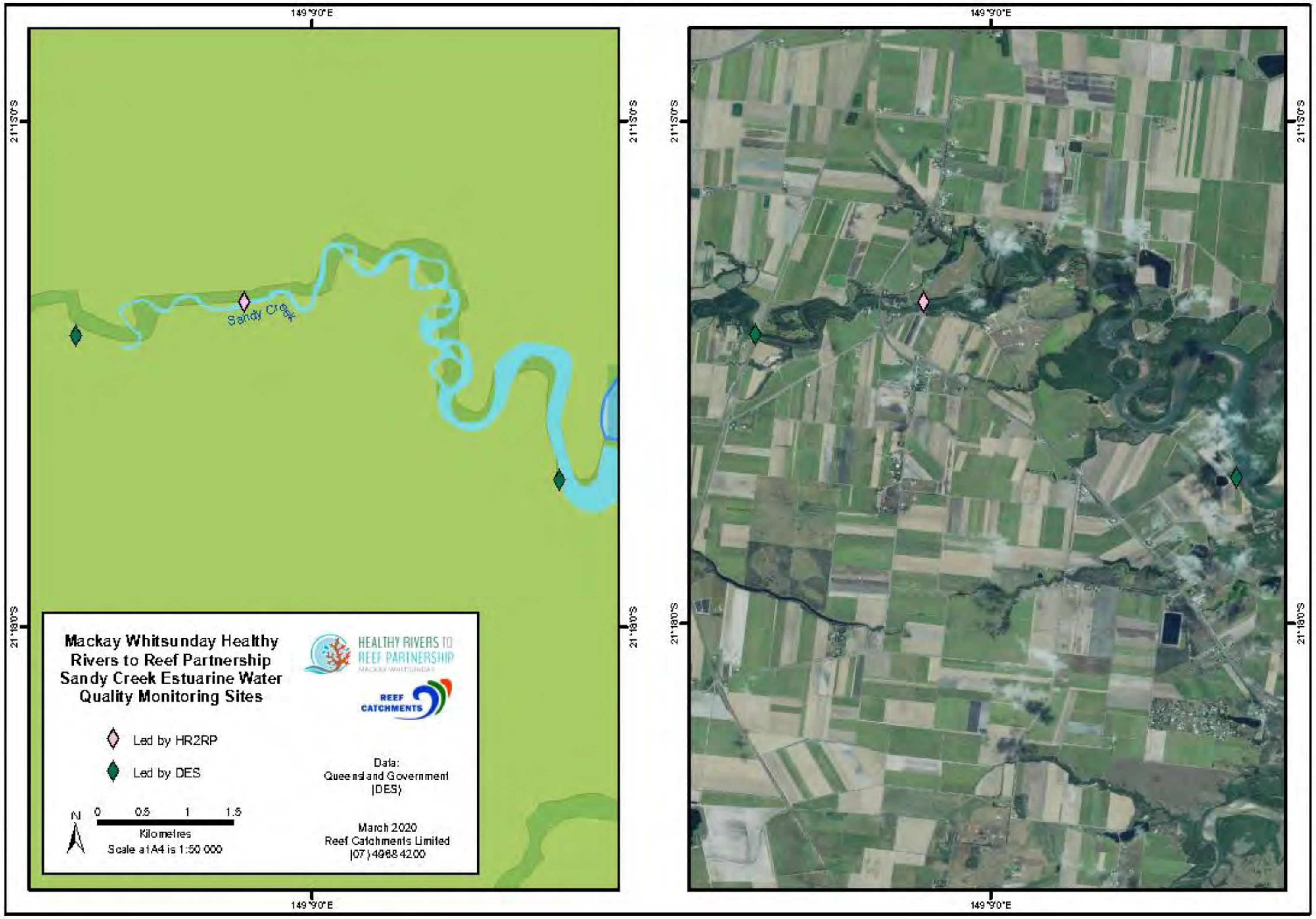



Figure AB 6. Locations of monitoring sites for estuarine sampling of pesticides in Sandy Creek. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the east, beyond the boundary of the map.

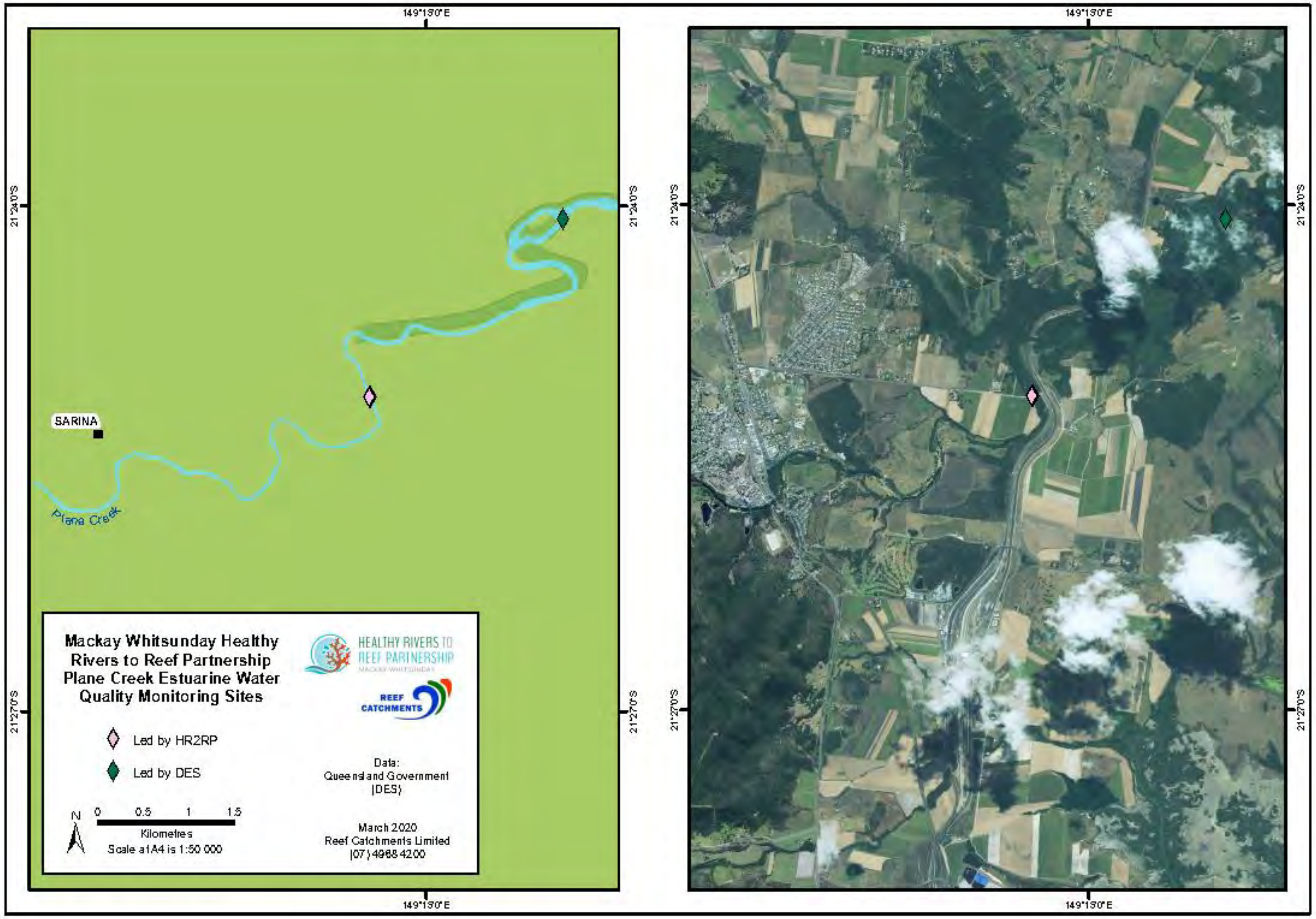



Figure AB 7. Locations of monitoring sites for estuarine sampling of pesticides in Plane Creek. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the north-east, beyond the boundary of the map.

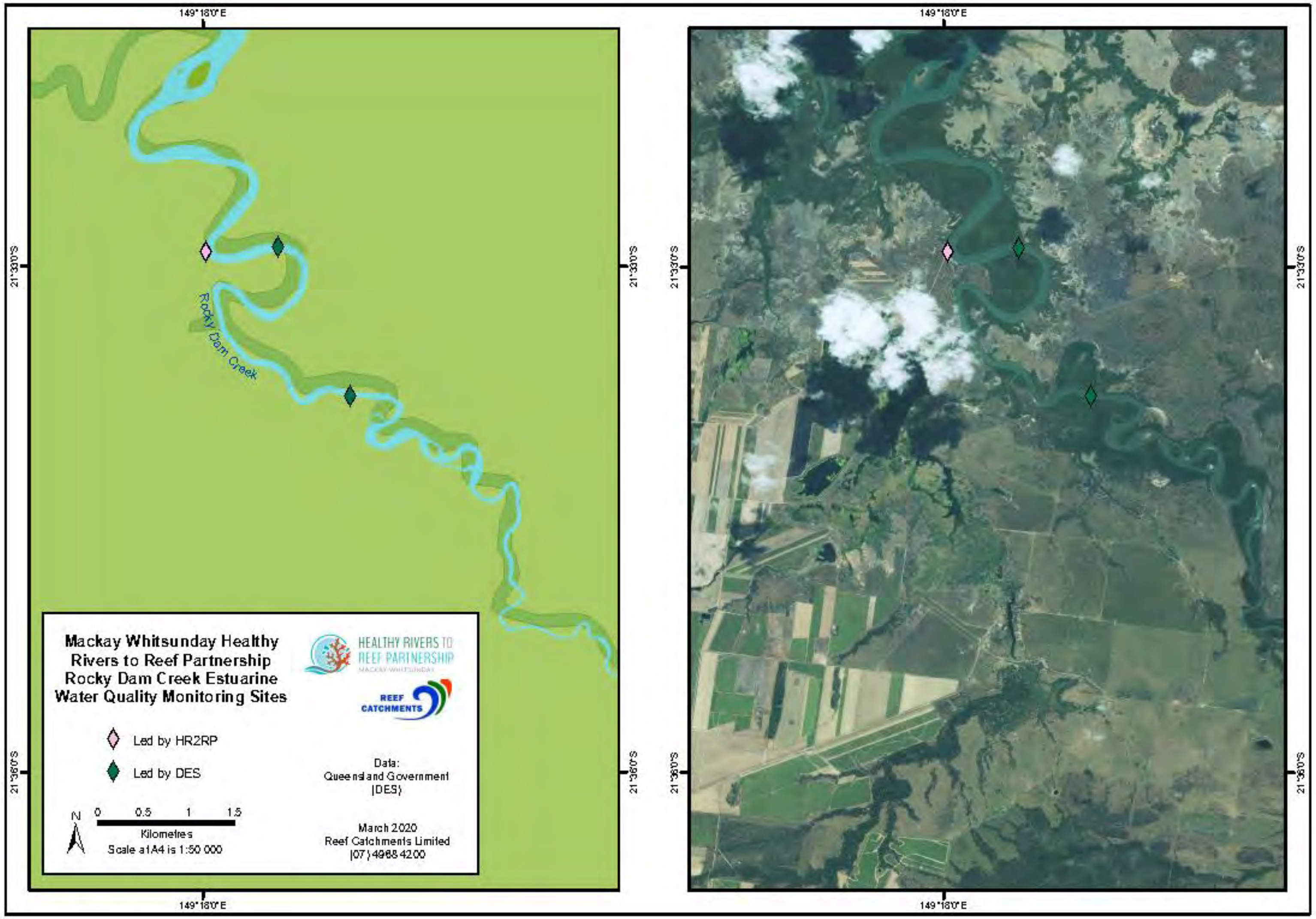



Figure AB 8. Locations of monitoring sites for estuarine sampling of pesticides in Rocky Dam Creek. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the north-west, beyond the boundary of the map.

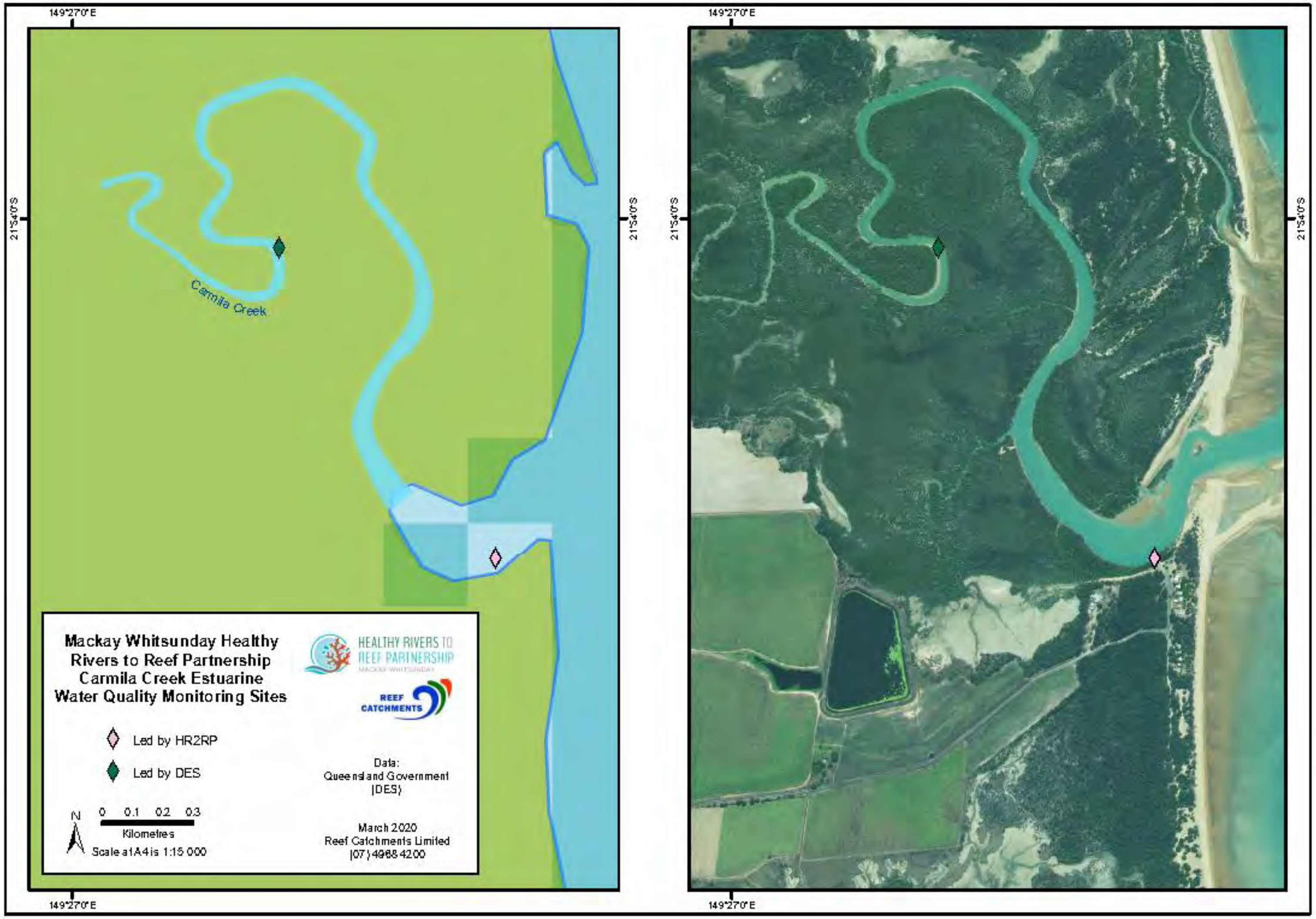



**Figure AB 9. Locations of monitoring sites for estuarine sampling of pesticides in Carmila Creek. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the east, as shown.**

## Appendix B.2 – Estuaries, Summary Statistics and Boxplots

**Table AB 1. Summary statistics for monitored water quality in the Mackay-Whitsunday-Isaac estuary reporting areas, from July 2018 to June 2019. Summary statistics are presented to three decimal places. Presented alongside summary statistics are guideline values, which represent the adopted statistic for comparison. In the estuaries, the 50th percentile (the median) concentration value should be compared against the applicable water quality guideline.**

| | | | | | | | | | Guidelines | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Site** | **Indicator** | **n** | **Mean** | **Minimum** | **25th %ile** | **Median** | **75th %ile** | **Maximum** | **Comparison statistic** | **Guideline values** |
| Gregory River 5.1 km from mouth | Chlorophyll-*a* | 11 | 1.45 | 0.468 | 0.735 | 1.40 | 1.55 | 3.61 | median | 2 µg/L |
| | DIN | 11 | 0.0140 | 0.00200 | 0.00200 | 0.00600 | 0.0130 | 0.0550 | median | 0.018 mg/L |
| | FRP | 11 | 0.0109 | 0.0050 | 0.0150 | 0.00900 | 0.0150 | 0.0210 | median | 0.03 mg/L |
| | Turbidity | 11 | 4.82 | 0.200 | 4.90 | 3.70 | 4.90 | 16.9 | median | 10 mg/L |
| | DO | 11 | 75.6 | 61.9 | 82.8 | 75.9 | 82.8 | 88.5 | median | 70-105 % |
| Gregory River 9.9 km from mouth | Chlorophyll-*a* | 11 | 1.97 | 0.534 | 1.00 | 1.56 | 2.34 | 5.61 | median | 2 µg/L |
| | DIN | 11 | 0.0161 | 0.00200 | 0.00250 | 0.0110 | 0.0145 | 0.0870 | median | 0.018 mg/L |
| | FRP | 11 | 0.0179 | 0.00300 | 0.0125 | 0.0190 | 0.0200 | 0.0870 | median | 0.03 mg/L |
| | Turbidity | 11 | 7.81 | 2.20 | 4.40 | 5.40 | 24.7 | 17.2 | median | 10 mg/L |
| | DO | 11 | 86.6 | 69.3 | 79.5 | 85.1 | 91.3 | 109.9 | median | 70-105 % |
| O'Connell River 7.5 km from mouth | Chlorophyll-*a* | 12 | 3.45 | 0.94 | 1.60 | 2.75 | 3.37 | 12.3 | median | 2 µg/L |
| | DIN | 11 | 0.100 | 0.00300 | 0.0150 | 0.0960 | 0.137 | 0.301 | median | 0.018 mg/L |
| | FRP | 11 | 0.0139 | 0.000500 | 0.00300 | 0.0120 | 0.0245 | 0.0320 | median | 0.03 mg/L |
| | Turbidity | 12 | 8.08 | 0.300 | 5.15 | 7.55 | 9.63 | 18.0 | median | 10 mg/L |
| | DO | 12 | 108 | 93.8 | 102.7 | 108.3 | 110.9 | 119.8 | median | 70-105 % |
| St Helens Creek 7.5 km from mouth | Chlorophyll-*a* | 0 | NA | NA | NA | NA | NA | NA | median | 2 µg/L |
| | DIN | 0 | NA | NA | NA | NA | NA | NA | median | 0.018 mg/L |
| | FRP | 0 | NA | NA | NA | NA | NA | NA | median | 0.03 mg/L |
| | Turbidity | 12 | 11.1 | 4.20 | 7.60 | 10.6 | 14.6 | 18.0 | median | 10 mg/L |
| | DO | 12 | 89.8 | 77.4 | 87.4 | 90.2 | 92.0 | 101 | median | 70-105 % |

Table AB 1. continued

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| St Helens Creek 8.9km from mouth | Chlorophyll-*a* | 12 | 3.21 | 0.94 | 1.33 | 2.40 | 4.68 | 9.75 | median | 2 µg/L |
| | DIN | 12 | 0.104 | 0.023 | 0.043 | 0.082 | 0.111 | 0.373 | median | 0.018 mg/L |
| | FRP | 12 | 0.010 | 0.006 | 0.008 | 0.012 | 0.012 | 0.015 | median | 0.03 mg/L |
| | Turbidity | 12 | 14.4 | 4.50 | 9.88 | 14.7 | 17.8 | 25.0 | median | 10 mg/L |
| | DO | 12 | 92.2 | 78.2 | 86.8 | 91.4 | 98.2 | 110 | median | 70-105 % |
| Murray Creek 10.0 km from mouth | Chlorophyll-*a* | 0 | NA | NA | NA | NA | NA | NA | median | 2 µg/L |
| | DIN | 0 | NA | NA | NA | NA | NA | NA | median | 0.018 mg/L |
| | FRP | 0 | NA | NA | NA | NA | NA | NA | median | 0.03 mg/L |
| | Turbidity | 12 | 14.4 | 1.50 | 3.8 | 11.4 | 20.1 | 53.6 | median | 10 mg/L |
| | DO | 12 | 84.3 | 57.9 | 77.0 | 82.5 | 94.2 | 101 | median | 70-105 % |
| Murray Creek 12.5 km from mouth | Chlorophyll-*a* | 12 | 2.67 | 0.67 | 1.52 | 2.24 | 3.82 | 5.61 | median | 2 µg/L |
| | DIN | 12 | 0.379 | 0.004 | 0.091 | 0.180 | 0.312 | 2.30 | median | 0.018 mg/L |
| | FRP | 12 | 0.030 | 0.004 | 0.019 | 0.033 | 0.042 | 0.055 | median | 0.03 mg/L |
| | Turbidity | 12 | 22.6 | 2.00 | 3.88 | 20.2 | 29.1 | 83.2 | median | 10 mg/L |
| | DO | 12 | 87.5 | 56.4 | 77.2 | 82.6 | 99.0 | 126 | median | 70-105 % |
| Murray Creek 16.5 km from mouth | Chlorophyll-*a* | 12 | 4.34 | 0.80 | 1.44 | 2.27 | 5.47 | 14.5 | median | 2 µg/L |
| | DIN | 12 | 0.356 | 0.007 | 0.106 | 0.182 | 0.308 | 2.10 | median | 0.018 mg/L |
| | FRP | 12 | 0.031 | 0.005 | 0.024 | 0.029 | 0.041 | 0.060 | median | 0.03 mg/L |
| | Turbidity | 12 | 33.8 | 2.60 | 6.45 | 22.3 | 56.4 | 89.6 | median | 10 mg/L |
| | DO | 12 | 89.2 | 63.3 | 82.4 | 86.3 | 99.2 | 112 | median | 70-105 % |
| Vines Creek 2.0 km from mouth | Chlorophyll-*a* | 12 | 4.65 | 0.534 | 1.49 | 2.00 | 3.07 | 31.1 | median | 2 µg/L |
| | DIN | 12 | 0.466 | 0.204 | 0.260 | 0.335 | 0.413 | 1.93 | median | 0.018 mg/L |
| | FRP | 12 | 0.032 | 0.005 | 0.007 | 0.013 | 0.030 | 0.170 | median | 0.03 mg/L |
| | Turbidity | 12 | 11.5 | 2.70 | 6.98 | 9.00 | 13.8 | 33.2 | median | 10 mg/L |
| | DO | 12 | 84.4 | 49.3 | 65.0 | 72.2 | 96.8 | 148 | median | 70-105 % |
| Sandy Creek 4.5 km from mouth | Chlorophyll-*a* | 12 | 6.72 | 0.954 | 2.14 | 4.48 | 7.55 | 25.7 | median | 5 µg/L |
| | DIN | 12 | 0.190 | 0.005 | 0.020 | 0.151 | 0.280 | 0.598 | median | 0.018 mg/L |

Table AB 1. continued

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FRP | 12 | 0.042 | 0.018 | 0.026 | 0.036 | 0.046 | 0.086 | median | 0.06 mg/L |
| | Turbidity | 12 | 17.7 | 2.30 | 8.20 | 15.7 | 24.9 | 39.6 | median | NA |
| | DO | 12 | 12.0 | 78.2 | 87.6 | 98.0 | 99.9 | 104 | median | 70-105% |
| Sandy Creek 13.5 km from mouth | Chlorophyll-*a* | 12 | 4.52 | 1.34 | 1.54 | 2.76 | 6.83 | 13.9 | median | 5 µg/L |
| | DIN | 12 | 0.70 | 0.004 | 0.361 | 0.424 | 1.13 | 1.62 | median | 0.018 mg/L |
| | FRP | 12 | 0.06 | 0.008 | 0.037 | 0.059 | 0.073 | 0.140 | median | 0.06 mg/L |
| | Turbidity | 12 | 26.3 | 9.70 | 15.2 | 20.2 | 23.2 | 107 | median | NA |
| | DO | 12 | 87.6 | 59.4 | 73.2 | 80.5 | 91.7 | 173 | median | 70-105% |
| Plane Creek 6.0km from mouth | Chlorophyll-*a* | 11 | 3.18 | 0.47 | 0.84 | 2.13 | 4.69 | 8.68 | median | 5 µg/L |
| | DIN | 11 | 0.045 | 0.002 | 0.004 | 0.005 | 0.010 | 0.419 | median | 0.018 mg/L |
| | FRP | 11 | 0.018 | 0.001 | 0.007 | 0.008 | 0.014 | 0.100 | median | 0.06 mg/L |
| | Turbidity | 11 | 15.5 | 3.10 | 4.95 | 13.4 | 19.9 | 43.7 | median | NA |
| | DO | 11 | 96.6 | 64.3 | 91.4 | 96.0 | 104 | 131 | median | 70-105% |
| Plane Creek 9.0km from mouth | Chlorophyll-*a* | 12 | 8.93 | 1.34 | 4.44 | 5.79 | 8.67 | 26.5 | median | 5 µg/L |
| | DIN | 12 | 0.065 | 0.007 | 0.016 | 0.050 | 0.121 | 0.147 | median | 0.018 mg/L |
| | FRP | 12 | 0.035 | 0.015 | 0.023 | 0.030 | 0.044 | 0.083 | median | 0.06 mg/L |
| | Turbidity | 11 | 10.5 | 4.60 | 7.10 | 7.70 | 12.8 | 25.1 | median | NA |
| | DO | 11 | 110 | 68.1 | 89.5 | 115 | 123 | 155 | median | 70-105% |
| Rocky Dam Creek 8.9km from mouth | Chlorophyll-*a* | 12 | 7.46 | 1.78 | 3.27 | 4.26 | 10.0 | 26.7 | median | 5 µg/L |
| | DIN | 12 | 0.196 | 0.004 | 0.046 | 0.181 | 0.287 | 0.660 | median | 0.018 mg/L |
| | FRP | 12 | 0.037 | 0.012 | 0.023 | 0.040 | 0.050 | 0.056 | median | 0.06 mg/L |
| | Turbidity | 12 | 97.4 | 11.9 | 20.5 | 71.8 | 149 | 258 | median | NA |
| | DO | 12 | 85.4 | 64.6 | 77.7 | 87.5 | 94.9 | 101 | median | 70-105% |
| Rocky Dam Creek 12.9km from mouth | Chlorophyll-*a* | 12 | 10.4 | 1.56 | 3.70 | 5.23 | 7.68 | 45.8 | median | 5 µg/L |
| | DIN | 12 | 0.211 | 0.054 | 0.084 | 0.141 | 0.272 | 0.660 | median | 0.018 mg/L |
| | FRP | 12 | 0.037 | 0.018 | 0.028 | 0.035 | 0.048 | 0.059 | median | 0.06 mg/L |
| | Turbidity | 12 | 109 | 17.6 | 23.4 | 66.6 | 143 | 376 | median | NA |

Table AB 1. continued

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DO | 12 | 88.1 | 68.6 | 82.0 | 87.8 | 95.8 | 105 | median | 70-105% |
| Carmila Creek 3.4km from mouth | Chlorophyll-*a* | 12 | 15.3 | 0.84 | 4.43 | 5.84 | 7.51 | 117 | median | 5 µg/L |
| | DIN | 12 | 0.190 | 0.002 | 0.031 | 0.101 | 0.217 | 0.820 | median | 0.018 mg/L |
| | FRP | 12 | 0.038 | 0.009 | 0.029 | 0.039 | 0.047 | 0.063 | median | 0.06 mg/L |
| | Turbidity | 12 | 66.3 | 11.4 | 21.0 | 29.9 | 33.6 | 492 | median | NA |
| | DO | 12 | 111 | 74.7 | 85.2 | 104 | 115 | 226 | median | 70-105% |

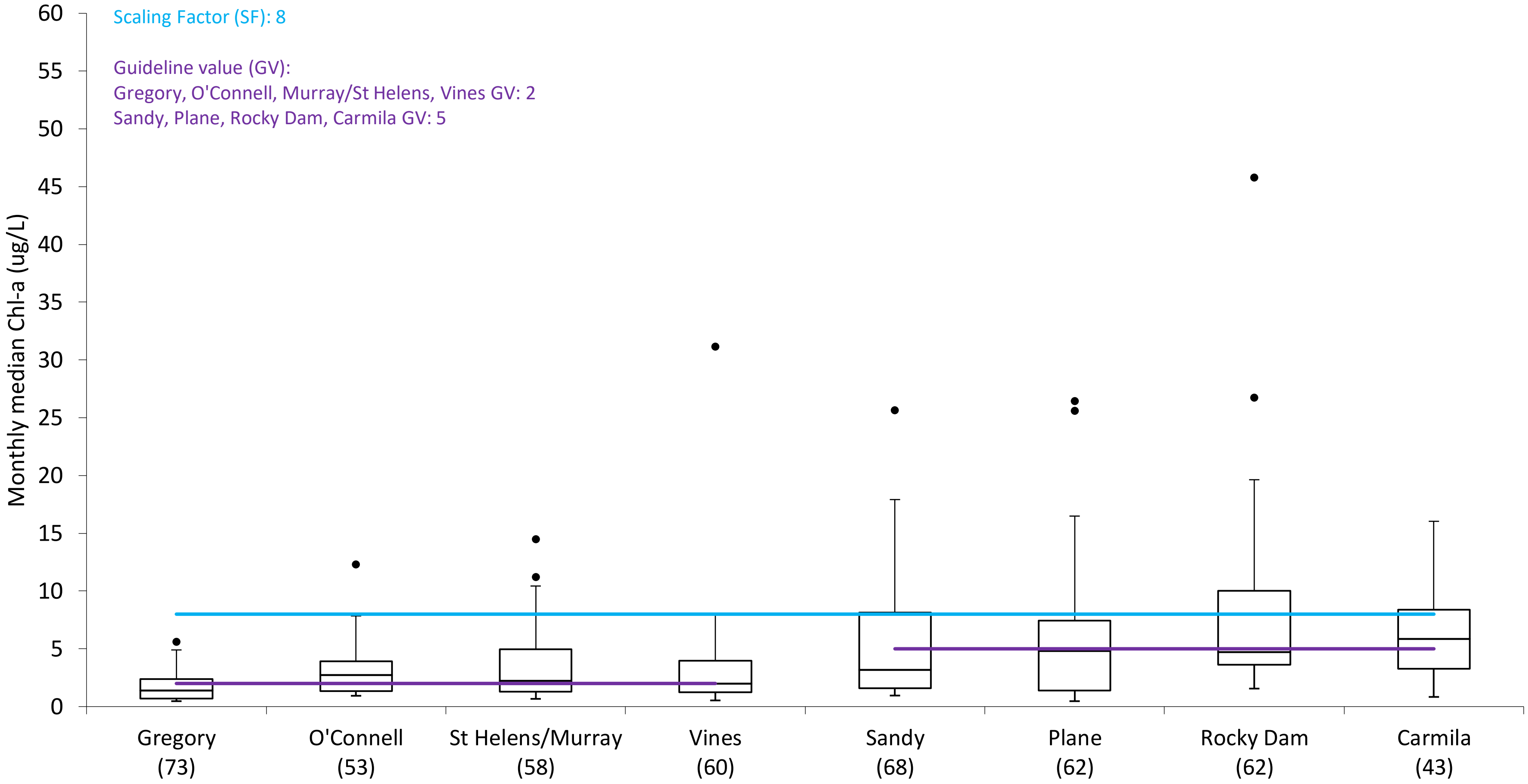



**Figure AB 10. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of monthly chlorophyll-a concentrations in the Mackay-Whitsunday-Isaac estuaries for 2018-19. Scaling factors (SF) and guideline values (GV) are provided for each estuary, where information is available. Outliers are also pictured. Carmila estuary has one outlier not pictured (116µg/L). Following estuary names are the calculated indicator scores.**

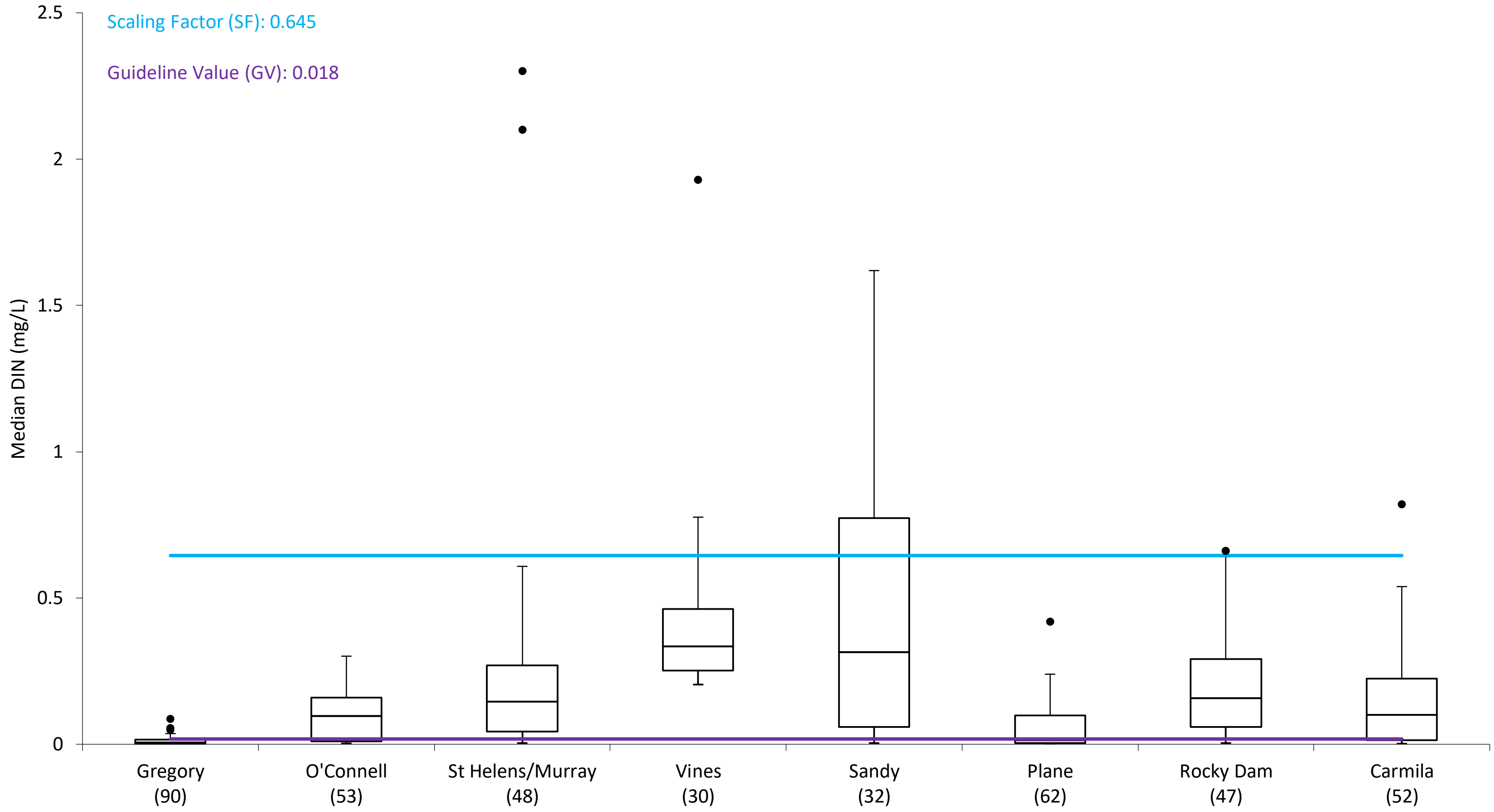



**Figure AB 11. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of DIN concentrations in the Mackay-Whitsunday-Isaac estuaries for 2018-19. Scaling factors (SF) and guideline values (GV) are provided for each estuary, where information is available. Outliers are also pictured. Following estuary names are the calculated indicator scores.**

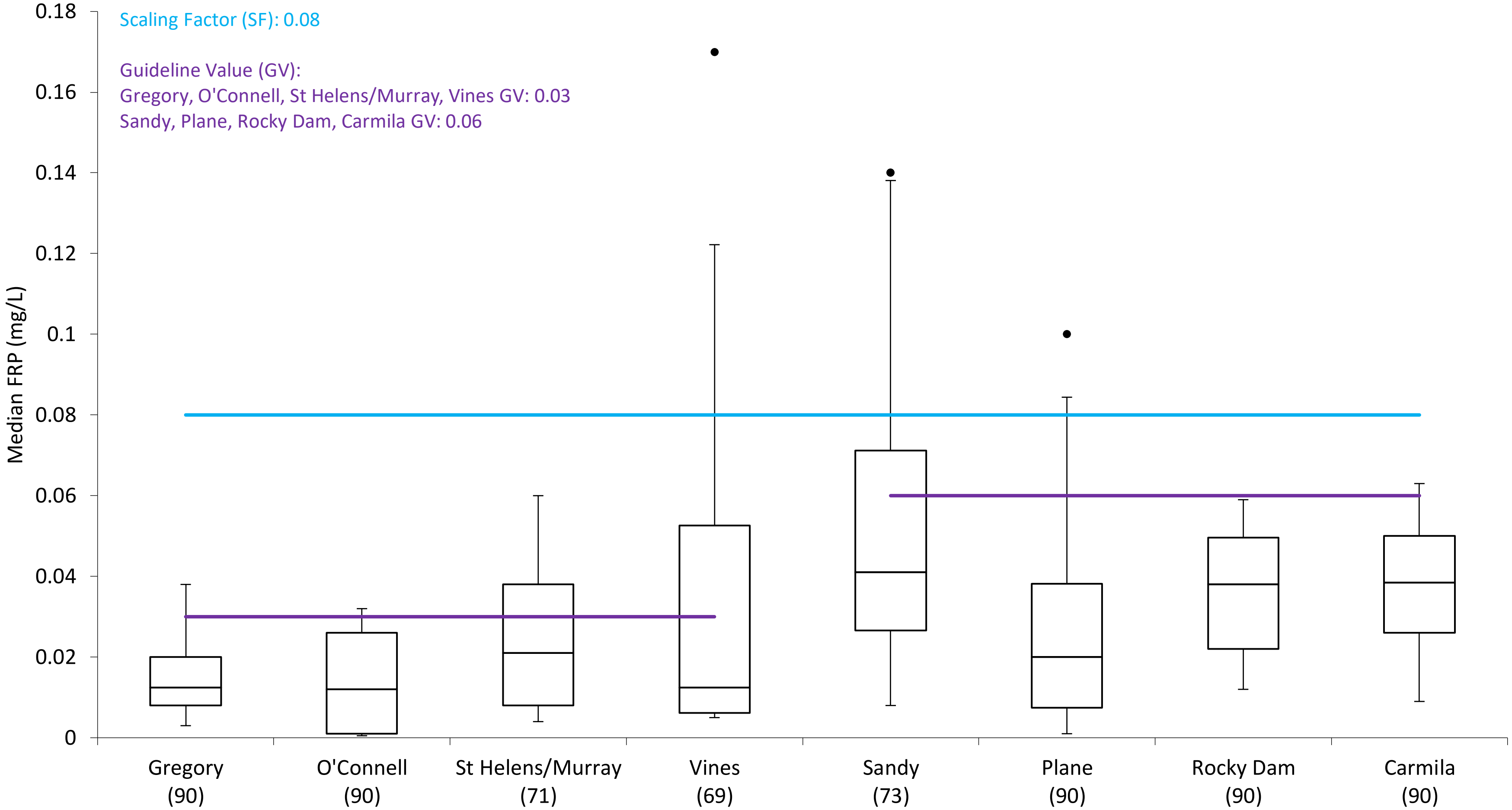



**Figure AB** 12**. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of FRP concentrations in the Mackay-Whitsunday-Isaac estuaries for 2918-19. Scaling factors (SF) and guideline values (GV) are provided for each estuary, where information is available. Outliers are also pictured. Following estuary names are the calculated indicator scores.**

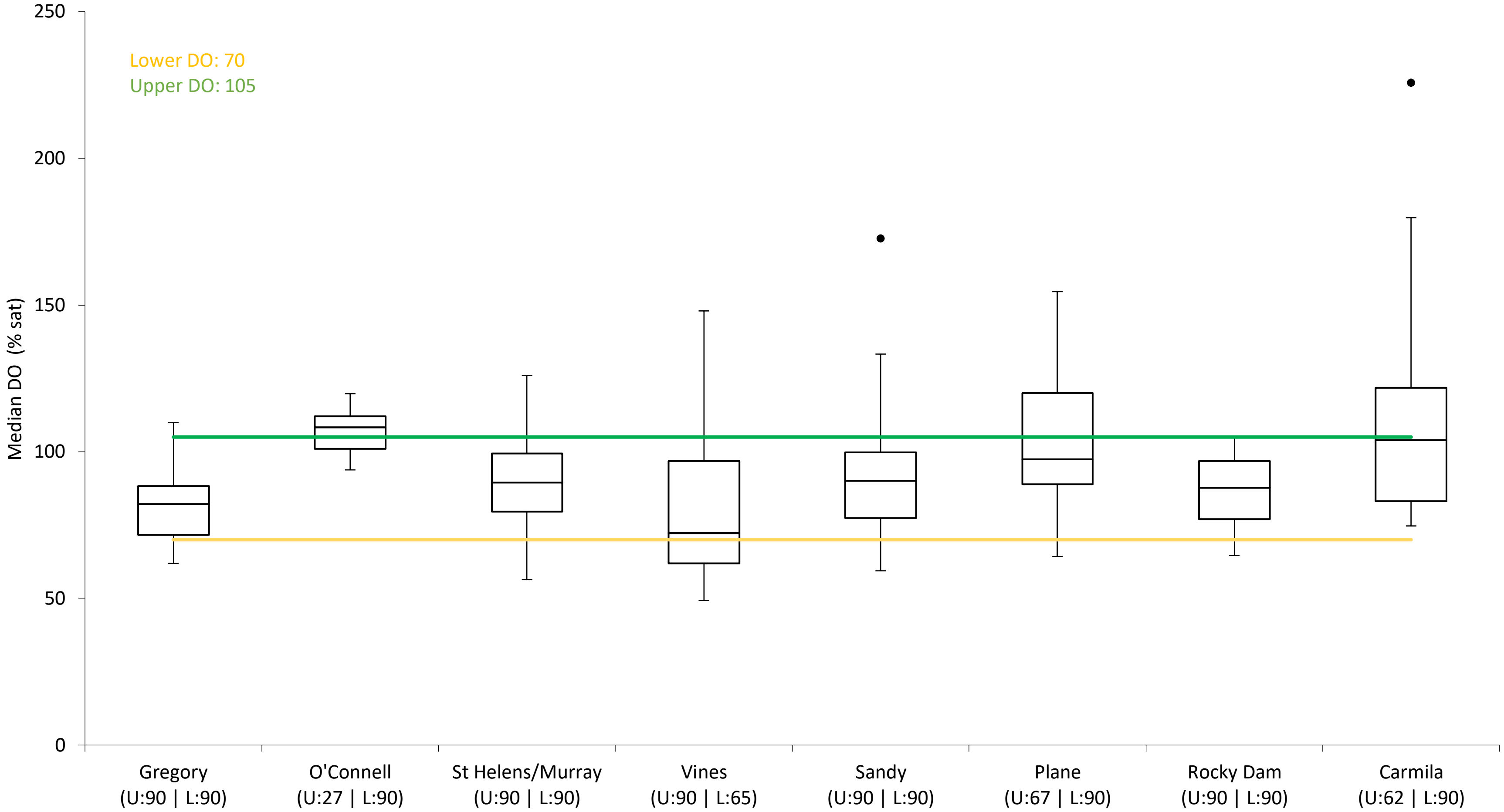



**Figure AB 13. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of DO concentrations (reported as % saturation) in the Mackay-Whitsunday-Isaac estuaries for 2018-19. Scaling factors (SF) and guideline values (GV) are provided for each estuary, where information is available. Outliers are also pictured. Following estuary names are the calculated indicator scores.**

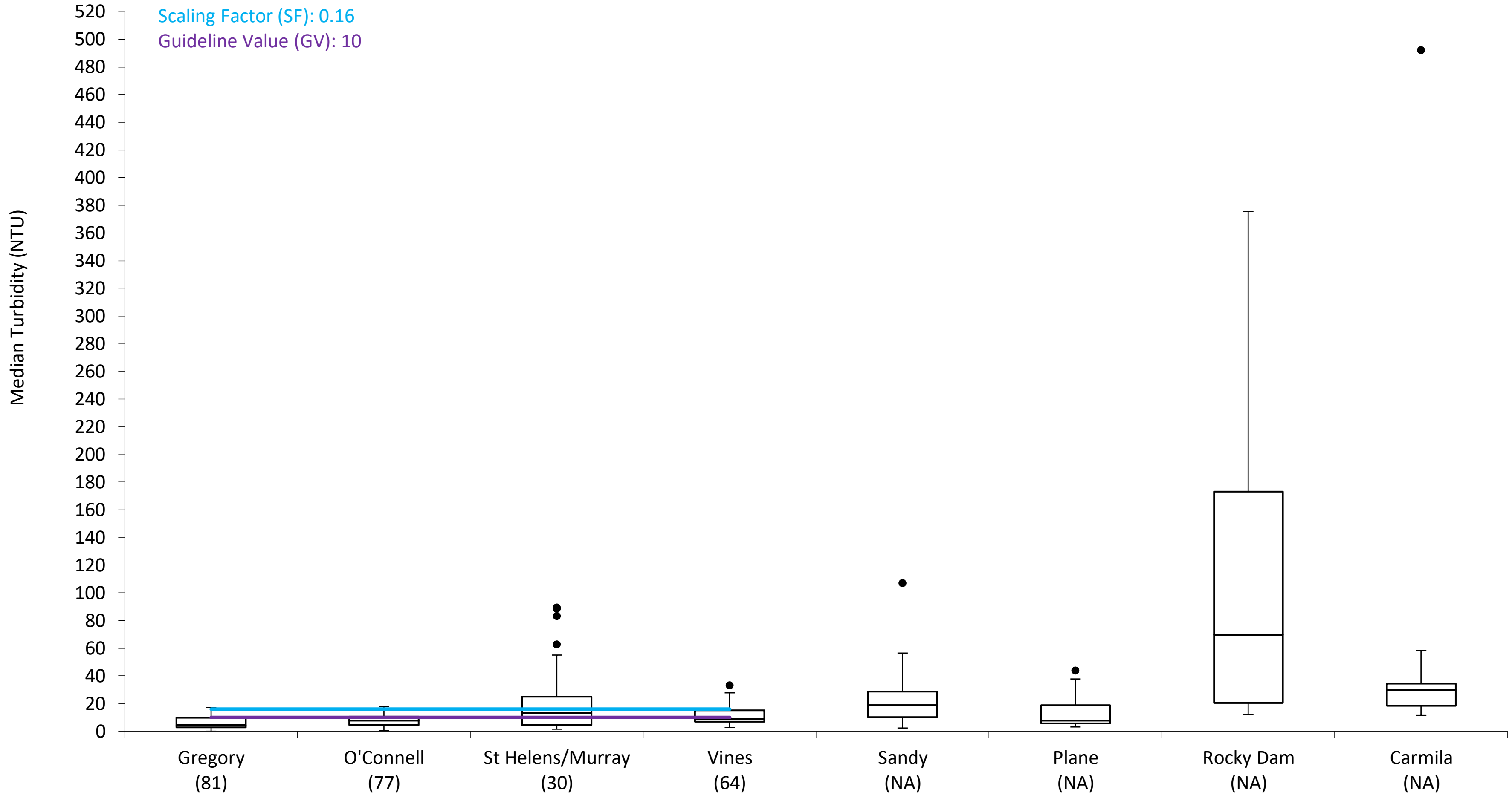



**Figure AB 14. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of turbidity levels in the Mackay-Whitsunday-Isaac estuaries for 2019-19. Scaling factors (SF) and guideline values (GV) are provided for each estuary, where information is available. Outliers are also pictured. Following estuary names are the calculated indicator scores.**

## Appendix B.3 – Revision to Riparian Extent and Mangrove/Saltmarsh Extent Scores, Estuaries

In the 2019 report card, scores for vegetation extent (riparian and mangrove/saltmarsh) were updated in the estuaries. Due to updates to the source mapping, such as fixing errors and re-mapping to a finer scale, data are not directly comparable to those previously reported, inhibiting interpretation of change observed between years. To rectify this, riparian and mangrove/saltmarsh extent scores were back-calculated for the 2013 assessment, using updated maps which depict condition in 2013. The results for back-calculated riparian extent scores are provided in Table AB 2, below.

**Table AB 2. Results for riparian and mangrove/saltmarsh extent loss since pre-development (%), hectares remaining and standardised riparian and mangrove & saltmarsh extent in estuaries in the 2019 report card (2016-2017 data). Hectares were rounded to the nearest whole number.**

| | 2019 report card | | | | 2019 report card | |
|---|---|---|---|---|---|---|
| | Mangrove/saltmarsh extent | | Riparian extent | | | |
| Estuary | Hectares lost since pre-development | (% loss since pre-development) | Hectares lost since pre-development | (% loss since pre-development) | Standardised mangrove/ saltmarsh extent | Standardised riparian extent |
| Gregory | 96.2 | 3.2 | 9.4 | 4.9 | 87 | 81 |
| O'Connell | 108.9 | 4.0 | 40.5 | 57.2 | 84 | 17 |
| St Helens/Murray | -6.5* | -0.2* | 54.2 | 17.1 | 100 | 58 |
| Vines | 114.0 | 15.6 | 8.6 | 18.1 | 60 | 56 |
| Sandy | 408.2 | 14.0 | 70.0 | 38.3 | 63 | 32 |
| Plane | 26.1 | 2.2 | 23.0 | 17.0 | 91 | 58 |
| Rocky Dam | 432.2 | 7.1 | 11.9 | 4.7 | 76 | 82 |
| Carmila | 29 | 6.9 | 0 | 0.0 | 77 | 100 |

**Riparian and mangrove/saltmarsh extent (% loss):** ■ Very Poor = >50% | ■ Poor =>30 to 50% | ■ Moderate = >15 to 30% | ■ Good = >5 to 15% | ■ Very Good ≤5% | ■ No score/data gap

**Standardised riparian and mangrove/saltmarsh extent:** ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ Very Good = 81 to 100 | ■ No score/data gap

*negative values denote scenarios where there has been an increase in the total area of riparian or mangrove/saltmarsh extent, since pre-development.

The results of the riparian and mangrove/saltmarsh extent scores are discussed in detail in section 4.2.2.

# Appendix C: Marine Environment

The scores and graphs presented below are inshore zone site scores for the Mackay-Whitsunday-Isaac 2019 report card. Boxplots are presented for water quality indicators and summary statistics are tabulated for individual sites.

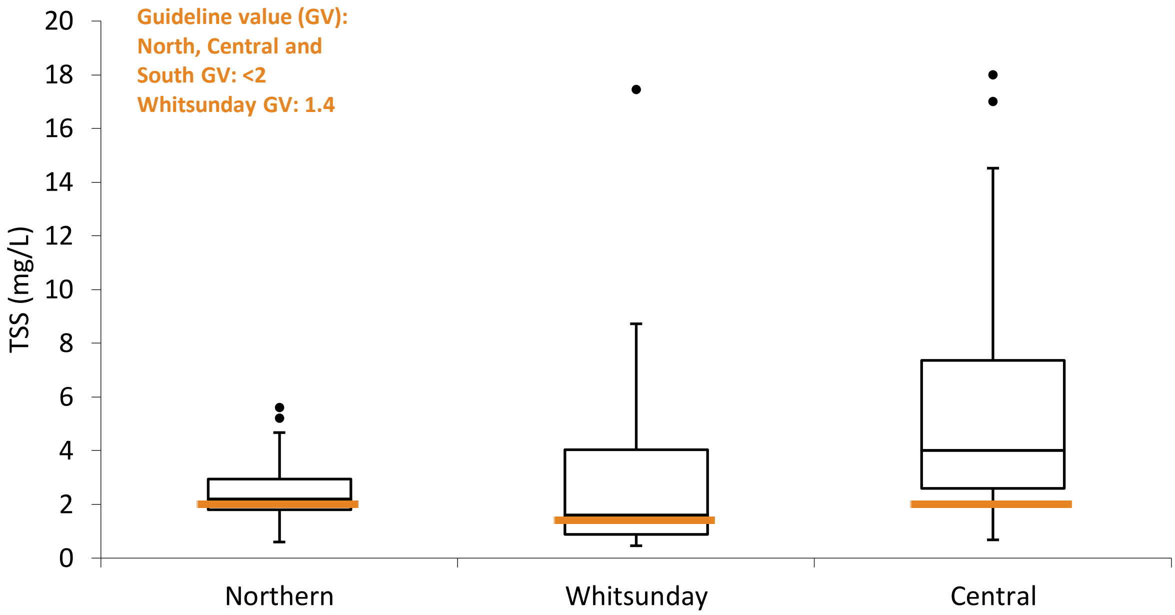



**Figure AC 1. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range [IQR]) for all total suspended solids (TSS) samples taken from relevant inshore zones in the Mackay-Whitsunday-Isaac Region for 2018-19. Where relevant outliers (>1.5x IQR) are also pictured, the Central inshore marine zone had two additional outliers not pictured (24mg/L and 47mg/L). Guideline values (GV) for each zone are pictured, where multiple guideline values are scheduled within a zone, the most conservative level was adopted for the purpose of graphical presentation.**

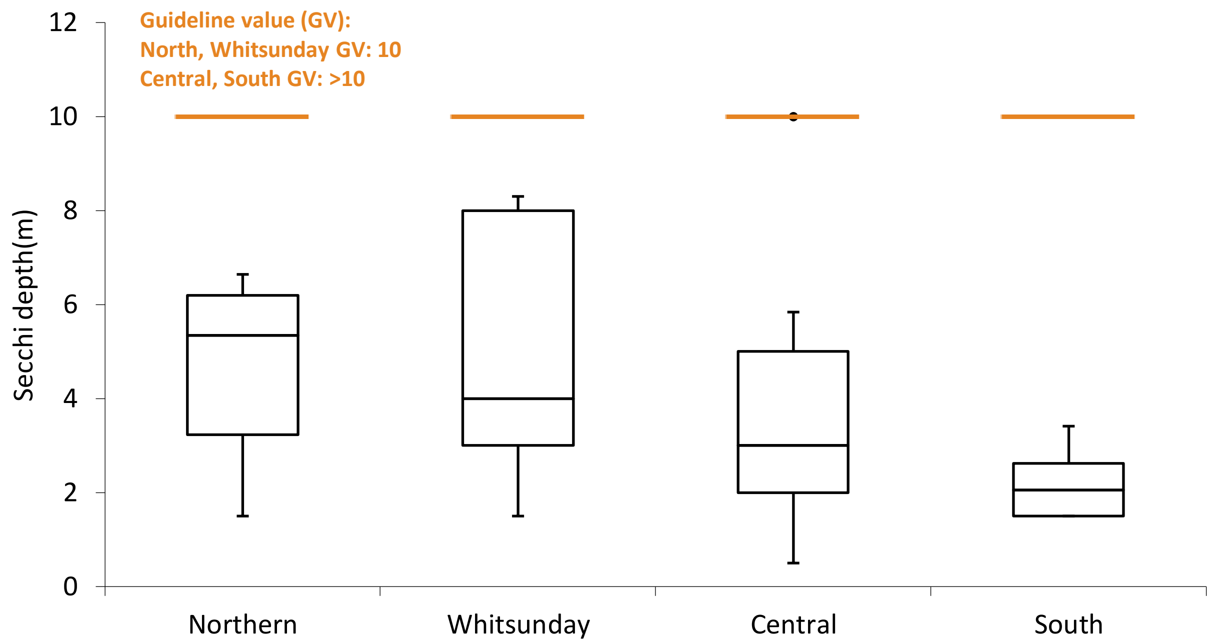



**Figure AC 2. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range [IQR]) for all secchi depth samples taken from relevant inshore zones in the Mackay-Whitsunday-Isaac Region for 2018-19. Outliers (>1.5x IQR) are also pictured. Guideline values (GV) for each zone are pictured. Higher secchi depth values relate to higher water clarity.**

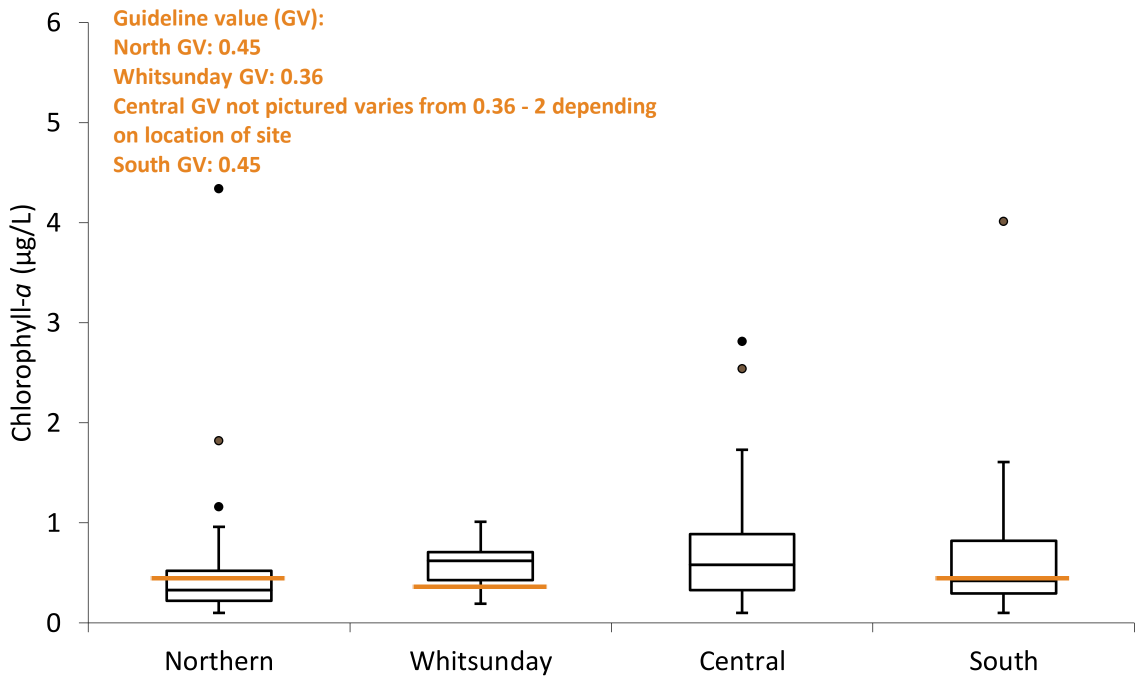



**Figure AC 3. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range [IQR]) for all chlorophyll-*a* samples taken from relevant inshore zones in the Mackay-Whitsunday-Isaac Region for 2018-19. Where relevant outliers (>1.5x IQR) are also pictured, the Central inshore marine zone had two additional outliers not pictured (10µg/L and 24µg/L Outliers (>1.5x IQR) are also pictured. Guideline values (GV) for each zone are pictured for Northern and Central inshore marine zones; Central GV not pictured as it varies from 0.36-2 µg/L depending on site location.**

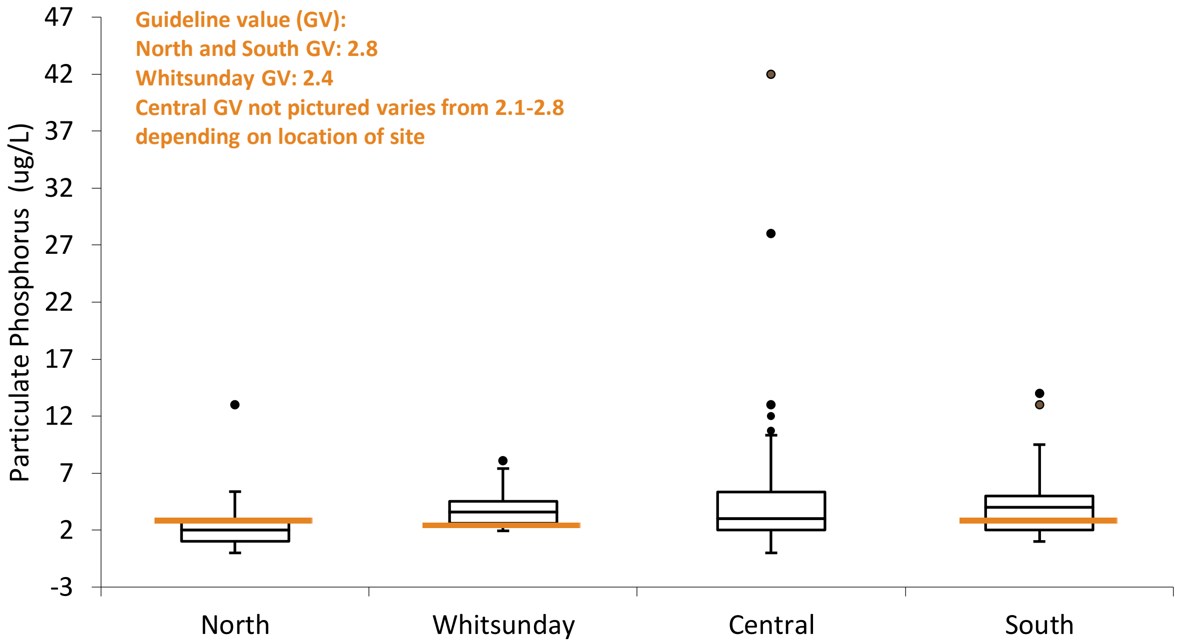



**Figure AC 4. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range [IQR]) for all particulate phosphorus samples taken from relevant inshore zones in the Mackay-Whitsunday-Isaac Region for 2018-19. Where relevant outliers (>1.5x IQR) are also pictured. Guideline values (GV) for each Northern, Whitsunday and Southern zone are pictured; Central GV not pictured as it varies from 2.1-2.8 µg/L depending on site location.**

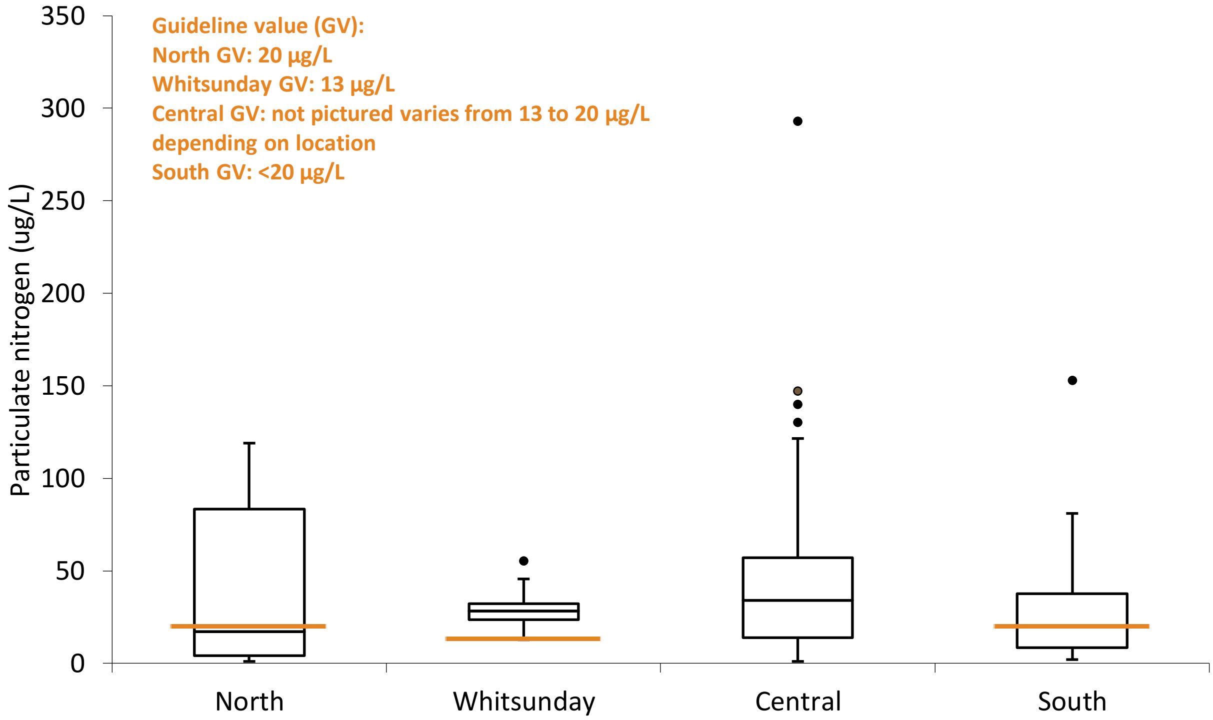



**Figure AC 5. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range [IQR]) for all particulate nitrogen samples taken from relevant inshore zones in the Mackay-Whitsunday-Isaac Region for 2018-19. Where relevant outliers (>1.5x IQR) are also pictured (Central inshore marine zone has one additional outlier of 633 µg/L that is not pictured). Guideline values (GV) for Northern, Whitsunday and Southern zone; Central GV not pictured as it varies from 13-20 µg/L depending on site location.**

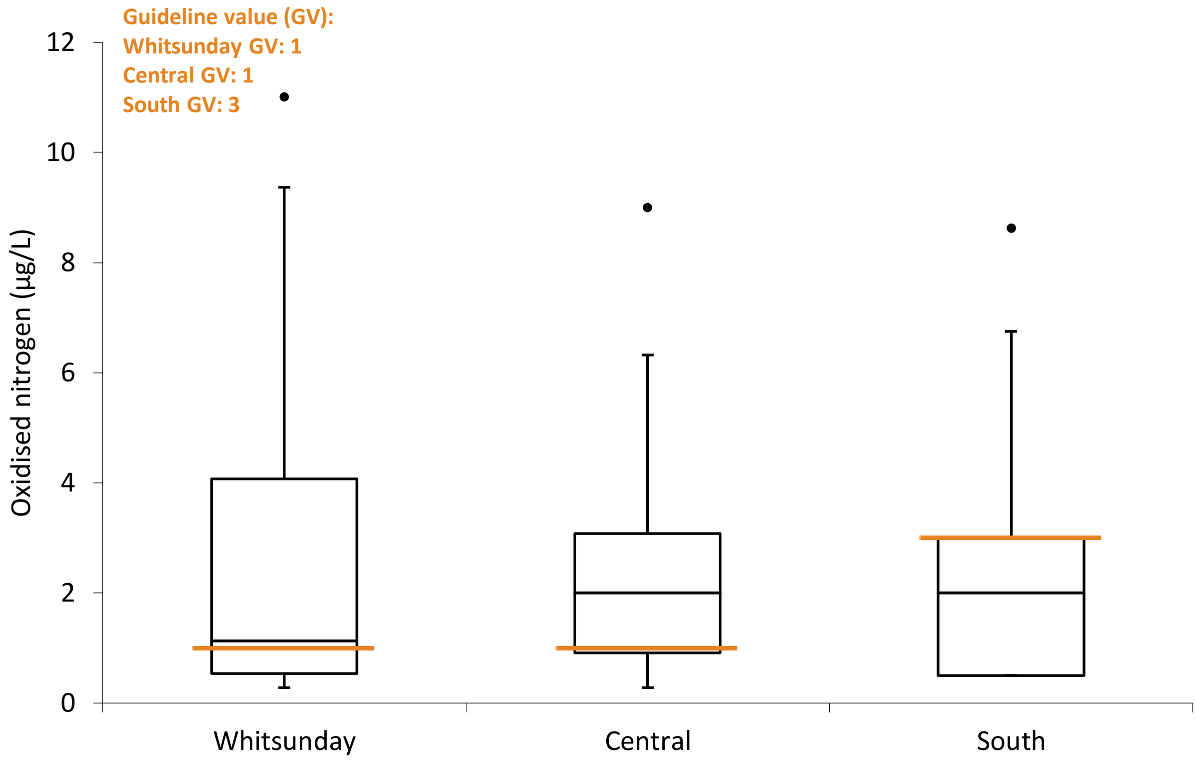



Figure AC 6. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range [IQR]) for all oxidised nitrogen samples taken from relevant inshore zones in the Mackay-Whitsunday-Isaac Region for 22018-19. Outliers (>1.5x IQR) are also pictured. Guideline values (GV) for the assessed zones pictured; where multiple guideline values are scheduled within a zone, the most conservative level was adopted for the purpose of graphical presentation

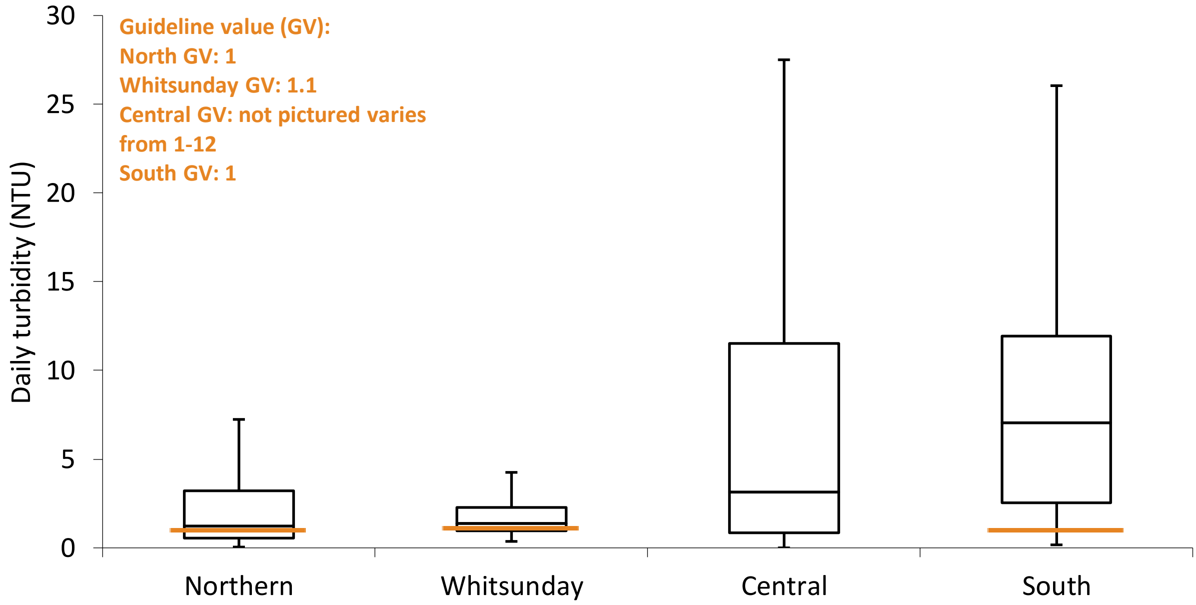



Figure AC 7. Box and whiskers plot (box 25th, 50th and 75th percentiles, whiskers 1.5x interquartile range) for daily turbidity taken from relevant inshore zones in the Mackay-Whitsunday-Isaac Region for 2018-19. Guideline values (GV) for the Northern, Whitsunday and Southern zone are pictured; Central GV vary from 1 – 12 NTU depending on site location and season (wet vs dry). NB outliers (>1.5x IQR) are not pictured due to excessive quantity (n=133 for Northern, n = 62 for Whitsunday, n = 257 for Central and n=0 for South).

**Table AC 1. 2018-19 indicator scores for Northern inshore marine sites (Abbot Point Program). * No samples collected for NOx.**

| Site | Nutrients | | | Chl-a | Water clarity | | |
|---|---|---|---|---|---|---|---|
| | PN | PP | NOx* | Chl-a | TSS | Turbidity | Secchi |
| Amb1 | -1.00 | 0.75 | | -0.18 | -0.93 | 0.31 | -1.00 |
| Amb 2 | -0.60 | 0.90 | | 0.58 | -0.66 | -0.91 | -1.00 |
| Amb 3 | -1.00 | -0.74 | | -0.40 | -0.26 | -0.01 | -1.00 |
| Amb 4a | -1.00 | 0.90 | | -1.00 | 0.07 | -0.22 | -1.00 |
| Amb 5 | -0.21 | 0.49 | | 0.66 | 0.51 | 0.47 | -0.45 |

Scoring range: ■ Very Poor = <-0.66 to -1 | ■ Poor = <-0.33 to -0.66 | ■ Moderate = <0 to -0.33 | ■ Good = 0 to 0.5 | ■ Very Good = >0.5 to 1 | ■ No score/data gap

**Table AC 2. 2018-19 indicator category scores for Northern inshore marine sites (Abbot Point Program) compared to indicator category scores for the Northern inshore marine zone in 2018, 2017, 2016, 2015 and 2014 report cards.**

| Site | Nutrients | Chl-a | Water clarity |
|---|---|---|---|
| Amb1 | -0.13 | -0.18 | -0.54 |
| Amb 2 | 0.15 | 0.58 | -0.86 |
| Amb 3 | -0.87 | -0.40 | -0.42 |
| Amb 4a | -0.05 | -1.00 | -0.38 |
| Amb 5 | 0.14 | 0.66 | 0.18 |
| **Northern 2019** | -0.15 | -0.07 | -0.41 |
| **Northern 2018** | 0.69 | 0.01 | -0.71 |
| **Northern 2017** | | 0.72 | -0.18 |
| **Northern 2016** | | 0.74* | -0.35* |
| **Northern 2015** | | | |
| **Northern 2014** | -0.96^ | -0.95 | -0.11 |

*Scores for chl-a and TSS are based on only one sample (taken in May 2016).

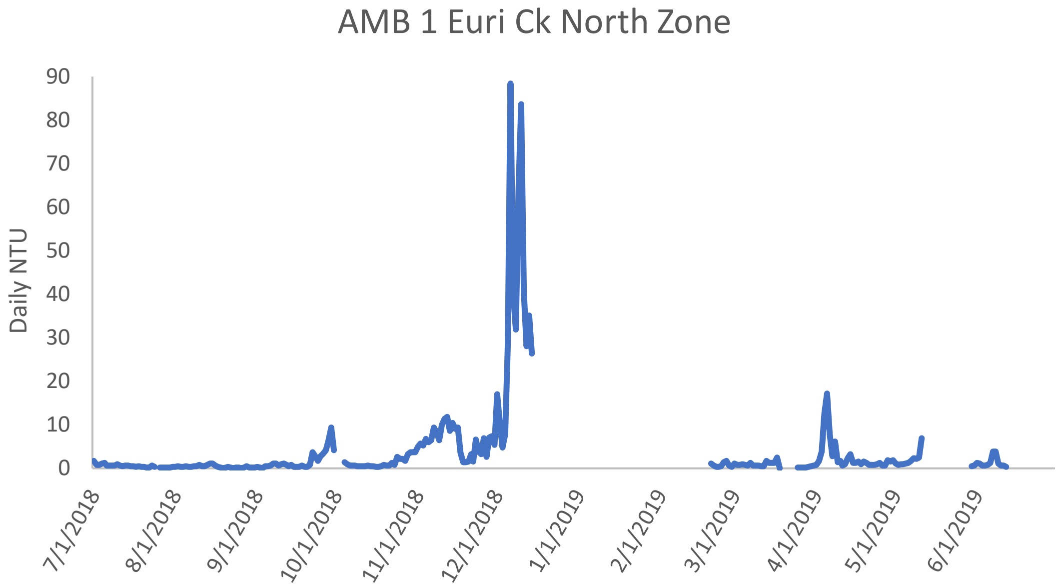
^For the 2014 pilot report card only, the indicator score for NOx was used on its own for the nutrients score.

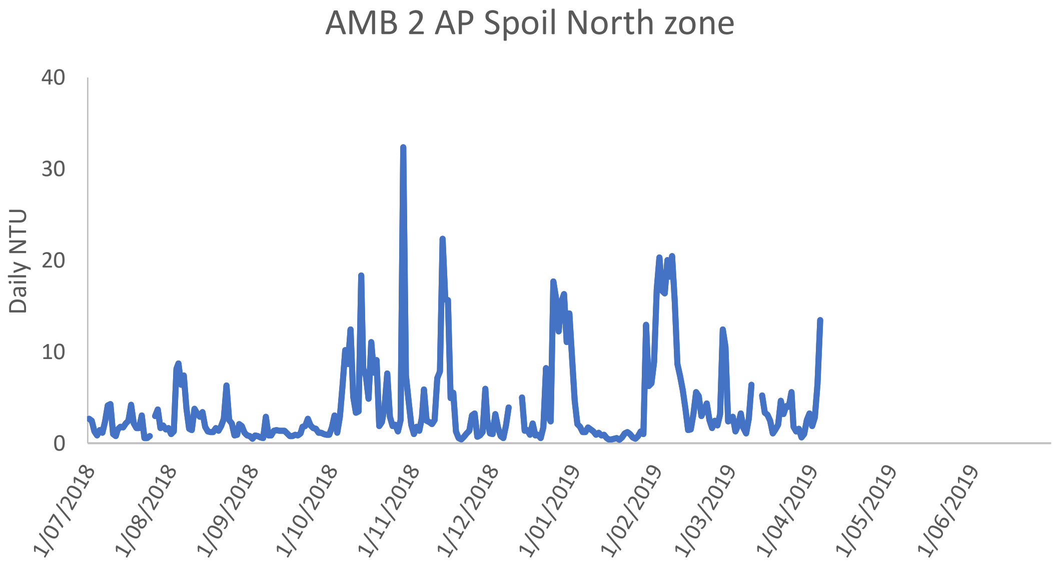
Scoring range: ■ Very Poor = <-0.66 to -1 | ■ Poor = <-0.33 to -0.66 | ■ Moderate = <0 to -0.33 | ■ Good = 0 to 0.5 | ■ Very Good = >0.5 to 1 | ■ No score/data gap

**Table AC 3. Summary statistics for water quality indicators in the Northern inshore marine sites from July 2018 to June 2019. Presented alongside statistics that were compared to guideline values. For all indicators except secchi, to meet the guideline the relevant statistic must be lower compared to the guideline (secchi must be higher than the guideline).**

| Site | Indicator | n | Mean | Minimum | 25th %tile | Median | 75th %tile | Maximum | Guidelines Comparison | Guideline value |
|---|---|---|---|---|---|---|---|---|---|---|
| Amb1 | NOx (µg/L) | | | | | | | | mean | 3 |
| | PN (µg/L) | 6 | 51.2 | 1.00 | 11.3 | 49.0 | 86.0 | 111 | mean | 20 |
| | PP (µg/L) | 6 | 1.67 | 0.00 | 1.00 | 1.00 | 2.50 | 4.00 | mean | 2.8 |
| | Chl-*a* (µg/L) | 6 | 0.51 | 0.10 | 0.34 | 0.44 | 0.57 | 1.16 | mean | 0.45 |
| | TSS (mg/L) | 3 | 3.80 | 2.20 | 2.90 | 3.60 | 4.60 | 5.60 | mean | 2 |
| | Secchi (m) | 6 | 4.78 | 1.50 | 3.63 | 5.75 | 6.00 | 6.70 | mean | 10 |
| | Turb (NTU) | 270* | 3.60 | 0.04 | 0.04 | 0.81 | 2.40 | 88.4 | median | 1 |
| Amb2 | NOx (µg/L) | | | | | | | | mean | 3 |
| | PN (µg/L) | 6 | 30.3 | 2.00 | 2.75 | 6.00 | 63.3 | 84.0 | mean | 20 |
| | PP (µg/L) | 6 | 1.50 | 1.00 | 1.00 | 1.50 | 2.00 | 2.00 | mean | 2.8 |
| | Chl-*a* (µg/L) | 6 | 0.30 | 0.10 | 0.10 | 0.17 | 0.43 | 0.78 | mean | 0.45 |
| | TSS (mg/L) | 3 | 3.17 | 1.90 | 2.15 | 2.40 | 3.80 | 5.20 | mean | 2 |
| | Secchi (m) | 6 | 4.60 | 1.80 | 3.15 | 4.80 | 6.38 | 6.70 | mean | 10 |
| | Turb (NTU) | 326* | 3.72 | 0.37 | 1.19 | 1.88 | 3.79 | 32.4 | median | 1 |
| Amb3 | NOx (µg/L) | | | | | | | | mean | 3 |
| | PN (µg/L) | 6 | 46.2 | 4.00 | 13.00 | 25.50 | 77.0 | 119 | mean | 20 |
| | PP (µg/L) | 6 | 4.67 | 1.00 | 2.25 | 3.50 | 4.75 | 13.0 | mean | 2.8 |
| | Chl-*a* (µg/L) | 6 | 0.60 | 0.10 | 0.24 | 0.36 | 0.65 | 1.82 | mean | 0.45 |
| | TSS (mg/L) | 3 | 2.40 | 1.30 | 1.95 | 2.60 | 2.95 | 3.30 | mean | 2 |
| | Secchi (m) | 6 | 4.02 | 2.00 | 2.75 | 3.50 | 5.45 | 6.50 | mean | 10 |
| | Turb (NTU) | 228* | 2.69 | 0.07 | 0.39 | 1.01 | 3.39 | 21.8 | median | 1 |
| Amb4 | NOx (µg/L) | | | | | | | | mean | 3 |
| | PN (µg/L) | 6 | 49.2 | 2.00 | 7.50 | 43.0 | 85.3 | 112 | mean | 20 |
| | PP (µg/L) | 6 | 1.50 | 1.00 | 1.00 | 1.00 | 1.75 | 3.00 | mean | 2.8 |
| | Chl-*a* (µg/L) | 6 | 1.04 | 0.23 | 0.25 | 0.30 | 0.68 | 4.34 | mean | 0.45 |
| | TSS (mg/L) | 3 | 1.90 | 1.50 | 1.65 | 1.80 | 2.10 | 2.40 | mean | 2 |
| | Secchi (m) | 5 | 4.36 | 2.50 | 3.30 | 5.00 | 5.20 | 5.80 | mean | 10 |
| | Turb (NTU) | 298* | 4.13 | 0.12 | 0.59 | 1.16 | 3.55 | 61.4 | median | 1 |
| Amb5 | NOx (µg/L) | | | | | | | | mean | 3 |
| | PN (µg/L) | 6 | 23.2 | 4.00 | 4.25 | 6.50 | 22.3 | 91.0 | mean | 20 |
| | PP (µg/L) | 6 | 2.00 | 1.00 | 1.25 | 2.00 | 2.00 | 4.00 | mean | 2.8 |
| | Chl-*a* (µg/L) | 6 | 0.29 | 0.10 | 0.13 | 0.28 | 0.41 | 0.51 | mean | 0.45 |
| | TSS (mg/L) | 3 | 1.40 | 0.60 | 1.20 | 1.80 | 1.80 | 1.80 | mean | 2 |
| | Secchi (m) | 5 | 7.30 | 4.50 | 6.00 | 7.00 | 9.00 | 10.0 | mean | 10 |
| | Turb (NTU) | 262* | 2.07 | 0.06 | 0.36 | 0.72 | 2.78 | 33.4 | median | 1 |

*While turbidity loggers were deployed for the entire 2018/2019 reporting period (365 days), sample size is based on daily averages from *validated* data recovered from this period. Some data points maybe lost due to unforeseen device malfunction or damage.



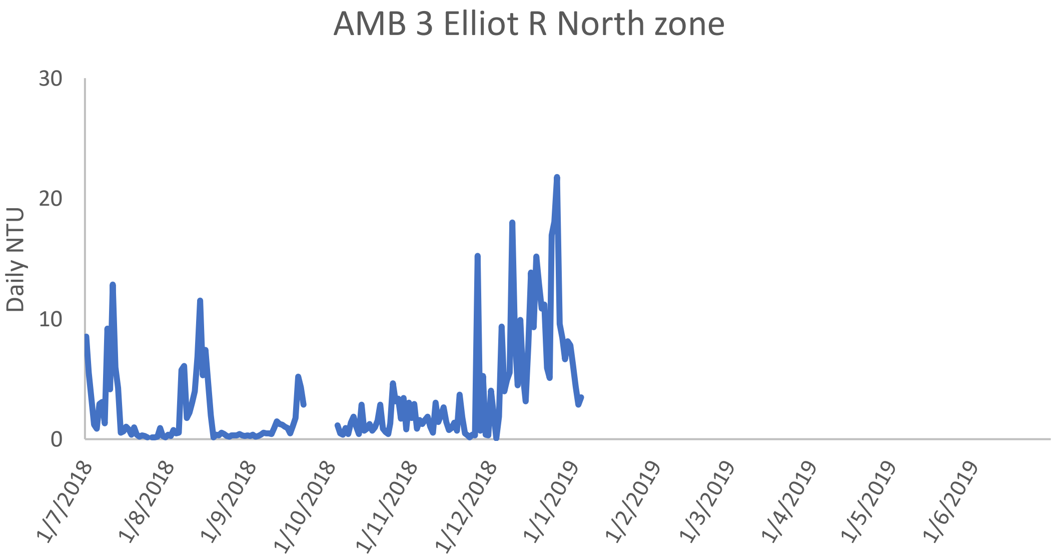
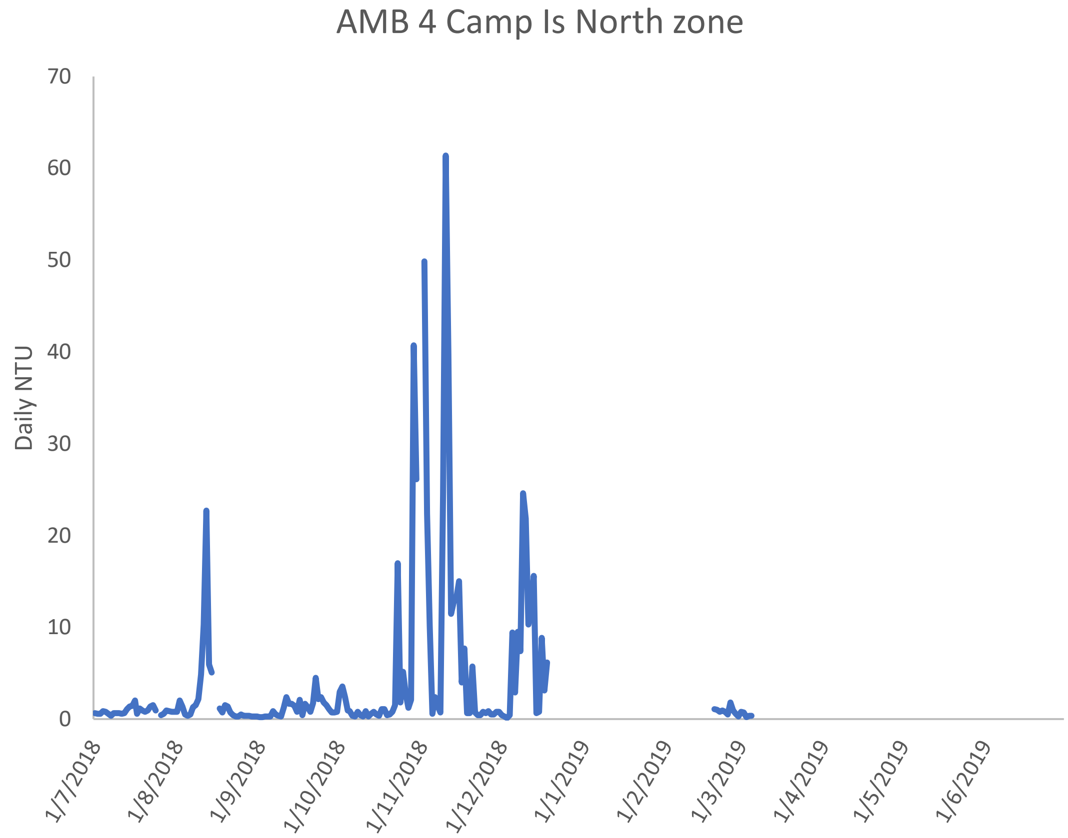




**Figure AC 8. Daily turbidity (NTU) from 2018-19 reporting year for Northern inshore marine (Abbot Point) loggers.**



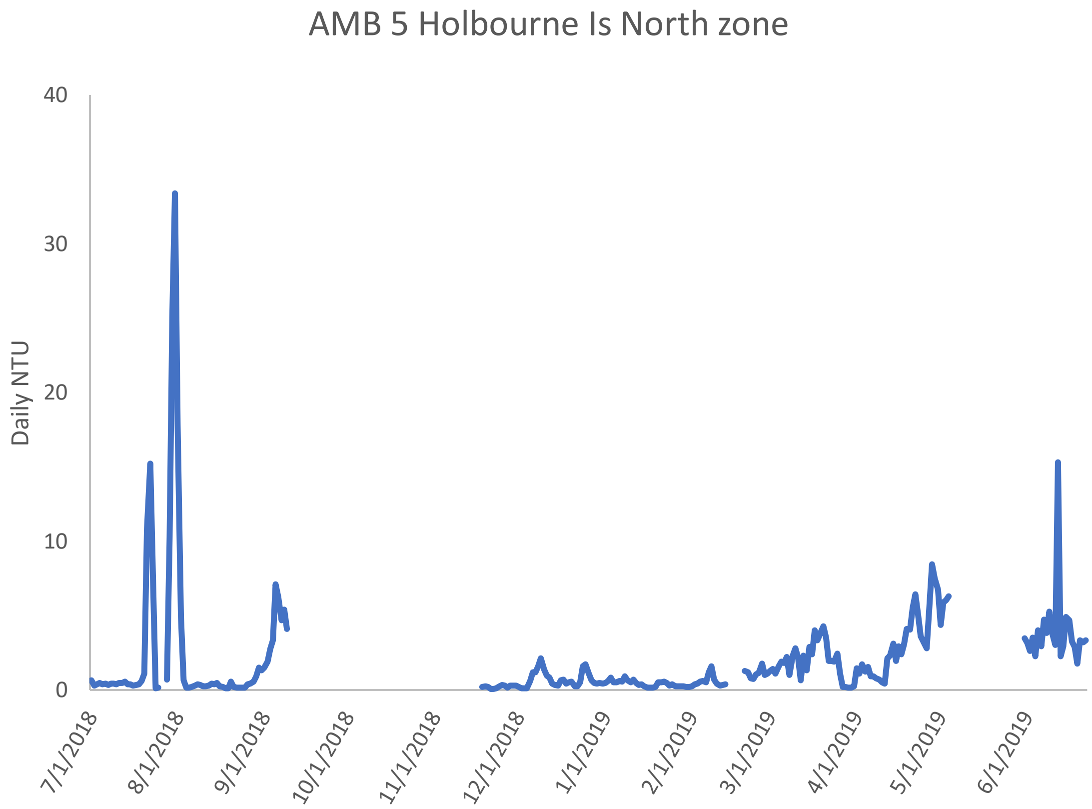




**Figure AC 9. Daily turbidity (NTU) for 2018-19 reporting year from Northern inshore marine (Abbot Point) loggers.**

**Table AC 4. 2018-19 indicator scores for Whitsunday inshore marine sites (Marine Monitoring Program).**

| Site | Nutrients | | | Chl-a | Water clarity | | |
|---|---|---|---|---|---|---|---|
| | NOx | PN | PP | Chl-a | TSS | Secchi | Turbidity |
| Double Cone Island | 1.00 | -1.00 | -0.52 | -0.78 | -0.18 | -0.76 | -0.08 |
| Pine Island | -1.00 | -0.88 | -1.00 | -0.74 | -1.00 | -1.00 | -0.69 |
| Seaforth Island | -0.13 | -1.00 | -0.87 | -0.92 | -1.00 | -1.00 | -0.31 |

**Scoring range:** Very Poor = <-0.66 to -1 | Poor = <-0.33 to -0.66 | Moderate = <0 to -0.33 | Good = 0 to 0.5 | Very Good = >0.5 to 1 | No score/data gap

**Table AC 5. 2018-19 indicator category scores for Whitsunday inshore marine sites (Marine Monitoring Program) compared to indicator category scores for the Whitsunday inshore marine zone in 2018, 2017, 2016, 2015 and 2014 report cards.**

| Site | Nutrients | Chl-a | Water clarity |
|---|---|---|---|
| Double Cone Island | -0.17 | -0.78 | -0.34 |
| Pine Island | -0.96 | -0.74 | -0.90 |
| Seaforth Island | -0.67 | -0.92 | -0.77 |
| Whitsunday 2019 | -0.60 | -0.81 | -0.67 |
| | | | |
| Whitsunday 2018 | -0.48 | -0.63 | -0.50 |
| Whitsunday 2017 | -0.99 | -0.99 | -0.66 |
| Whitsunday 2016 | -0.54 | -0.12 | -0.38 |
| Whitsunday 2015 | -0.48 | -0.20 | -0.23 |
| Whitsunday 2014 | -0.88 | -1.00 | -0.88 |

**Scoring range:** Very Poor = <-0.66 to -1 | Poor = <-0.33 to -0.66 | Moderate = <0 to -0.33 | Good = 0 to 0.5 | Very Good = >0.5 to 1 | No score/data gap

**Table AC 6. Summary statistics for water quality indicators in the Whitsunday inshore marine sites from July 2018 to June 2019. Presented alongside statistics are guideline values, including the statistic that was compared to the guideline (where three values are listed, the median is compared to the middle of the listed values). For all indicators except secchi, to meet the guideline the relevant statistic must be lower compared to the guideline (secchi must be higher than the guideline).**

| Site | Indicator | n | Mean | Minimum | 25th %ile | Median | 75th %ile | Maximum | Guidelines | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Comparison | Guideline value |
| Double Cone Island | NOx (µg/L) | 5 | 2.15 | 0.28 | 0.41 | 0.45 | 0.58 | 9.02 | median | 0-1-2 |
| | PN (µg/L) | 5 | 27.8 | 12.7 | 25.9 | 29.2 | 29.3 | 41.9 | median | 12-13-15 |
| | PP (µg/L) | 5 | 3.33 | 2.59 | 2.62 | 3.44 | 3.57 | 4.45 | median | 1.8-2.4-2.8 |
| | Chl-*a* (µg/L) | 5 | 0.56 | 0.19 | 0.49 | 0.62 | 0.68 | 0.79 | median | 0.25-0.36-0.54 |
| | TSS (mg/L) | 5 | 2.04 | 0.46 | 0.68 | 1.59 | 1.61 | 5.86 | median | 0.9-1.4-2.3 |
| | Secchi (m) | 5 | 5.90 | 3.00 | 4.00 | 4.50 | 8.00 | 10.0 | median | 10 |
| | Turb (NTU) | 347 | 1.64 | 0.36 | 0.83 | 1.16 | 2.02 | 13.6 | median | 0.7-1.1-2.1 |
| Pine Island | NOx (µg/L) | 5 | 4.30 | 1.13 | 1.24 | 2.61 | 5.53 | 11.0 | median | 0-1-2 |
| | PN (µg/L) | 5 | 29.8 | 15.3 | 22.3 | 23.9 | 32.3 | 55.4 | median | 12-13-15 |
| | PP (µg/L) | 5 | 4.59 | 1.93 | 2.86 | 4.97 | 5.09 | 8.09 | median | 1.8-2.4-2.8 |
| | Chl-*a* (µg/L) | 5 | 0.58 | 0.25 | 0.41 | 0.60 | 0.70 | 0.93 | median | 0.25-0.36-0.54 |
| | TSS (mg/L) | 5 | 5.46 | 0.81 | 0.98 | 3.50 | 4.56 | 17.5 | median | 0.9-1.4-2.3 |
| | Secchi (m) | 5 | 4.70 | 1.50 | 2.00 | 3.50 | 8.00 | 8.50 | median | 10 |
| | Turb (NTU) | 241 | 2.58 | 0.45 | 1.02 | 1.78 | 3.39 | 12.2 | median | 0.7-1.1-2.1 |
| Seaforth Island | NOx (µg/L) | 5 | 2.06 | 0.50 | 0.87 | 1.09 | 2.13 | 5.69 | median | 0-1-2 |
| | PN (µg/L) | 5 | 30.0 | 23.1 | 23.9 | 28.3 | 32.4 | 42.2 | median | 12-13-15 |
| | PP (µg/L) | 5 | 3.60 | 2.14 | 2.42 | 4.39 | 4.45 | 4.59 | median | 1.8-2.4-2.8 |
| | Chl-*a* (µg/L) | 5 | 0.63 | 0.29 | 0.45 | 0.68 | 0.72 | 1.01 | median | 0.25-0.36-0.54 |
| | TSS (mg/L) | 5 | 2.93 | 0.69 | 1.28 | 2.85 | 2.87 | 6.96 | median | 0.9-1.4-2.3 |
| | Secchi (m) | 5 | 4.40 | 2.50 | 3.00 | 3.50 | 5.00 | 8.00 | median | 10 |
| | Turb (NTU) | 366 | 1.67 | 0.46 | 1.00 | 1.36 | 2.05 | 6.11 | median | 0.7-1.1-2.1 |

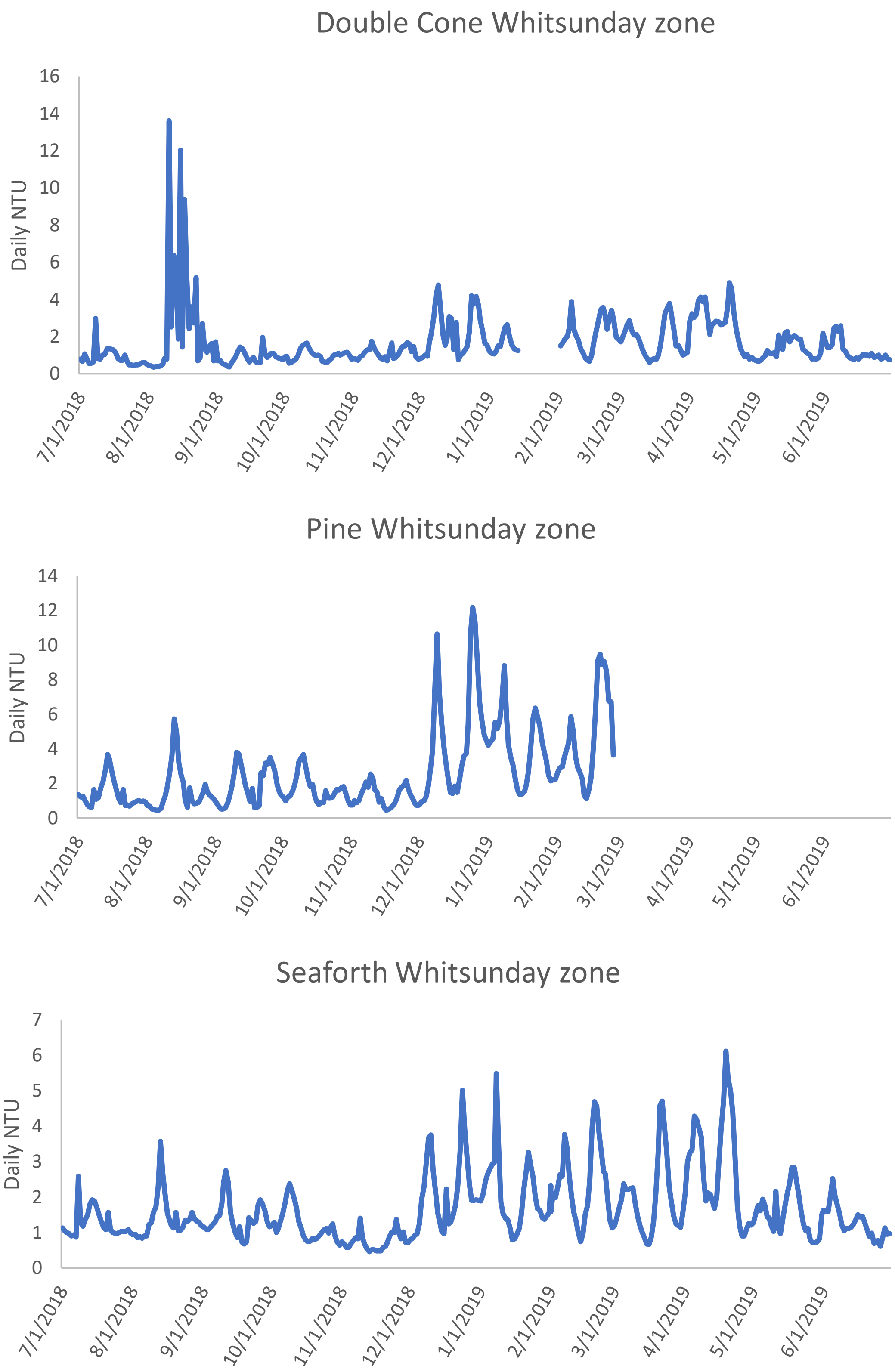



**Figure AC 10. Daily turbidity (NTU) for 2018-19 reporting year for Whitsunday inshore marine loggers.**

**Table AC 7. 2018-19 indicator scores for Central inshore marine sites (Hay Point Ports Program and Marine Monitoring Program). For two sites guideline values for turbidity were scored for the wet (Nov-Apr) and dry (May-Oct) season; the average of these scores is used for the turbidity score in the water clarity index.**

| | Nutrients | | | Chl-a | Water clarity | | | Turbidity | |
|---|---|---|---|---|---|---|---|---|---|
| **Site** | **NOx** | **PN** | **PP** | **Chl-a** | **TSS** | **Secchi** | **Turbidity** | **Dry** | **Wet** |
| O'Connell River mouth | 1.00 | | | 1.00 | | | | | |
| Repulse Islands dive mooring | 0.09 | -1.00 | -1.00 | -1.00 | -1.00 | -1.00 | -1.00 | | |
| AMB 1 | | -0.96 | -0.57 | -0.97 | -1.00 | -1.00 | -1.00 | | |
| AMB 2 | | -1.00 | 0.07 | -0.51 | -1.00 | -1.00 | 0.91 | 0.82 | 1.00 |
| AMB 3B | | -0.84 | -0.03 | -0.67 | -1.00 | -1.00 | 0.55 | | |
| AMB 5 | | -1.00 | -1.00 | -1.00 | -1.00 | -1.00 | 0.19 | 0.81 | -0.43 |
| AMB 6B | | -1.00 | -0.39 | -0.23 | -1.00 | -1.00 | | | |
| AMB 8 | | -1.00 | -0.58 | -1.00 | -0.77 | -1.00 | 0.87 | 1.00 | 0.74 |
| AMB 10 | | 0.19 | 0.49 | -1.00 | -1.00 | -1.00 | -1.00 | | |
| AMB 11 | | | | 1.00 | | 1.00 | | | |
| AMB 12 | -1.00 | -0.56 | -0.25 | -0.01 | -0.32 | -1.00 | 0.37 | | |

**Scoring range:** Very Poor = <-0.66 to -1 | Poor = <-0.33 to -0.66 | Moderate = <0 to -0.33 | Good = 0 to 0.5 | Very Good = >0.5 to 1 | No score/data gap

**Table AC 8. 2018-19 indicator category scores for Central inshore marine sites (Hay Point Ports Program and Marine Monitoring Program) compared to indicator category scores for the Central inshore marine zone in 2018, 2017, 2016, 2015 and 2014 report cards.**

| **Site** | **Nutrients** | **Chl-a** | **Water clarity** |
|---|---|---|---|
| O'Connell River mouth | | 1.00 | |
| Repulse Islands dive mooring | -0.64 | -1.00 | -1.00 |
| AMB 1 | -0.77 | -0.97 | -1.00 |
| AMB 2 | -0.46 | -0.51 | -0.36 |
| AMB 3B | -0.44 | -0.67 | -0.48 |
| AMB 5 | -1.00 | -1.00 | -0.60 |
| AMB 6B | -0.69 | -0.23 | -1.00 |
| AMB 8 | -0.79 | -1.00 | -0.30 |
| AMB 10 | 0.34 | -1.00 | -1.00 |
| AMB 11 | | 1.00 | |
| AMB 12 | -0.60 | -0.01 | -0.32 |
| Central 2019 | -0.56 | -0.40 | -0.67 |
| Central 2018 | 0.08 | -0.56 | -0.50 |
| Central 2017 | -0.10 | -0.53 | -0.59 |
| Central 2016 | -0.41 | -0.38 | -0.14 |
| Central 2015 | 0.10 | -0.15 | -0.47 |
| Central 2014 | | | |

**Scoring range:** Very Poor = <-0.66 to -1 | Poor = <-0.33 to -0.66 | Moderate = <0 to -0.33 | Good = 0 to 0.5 | Very Good = >0.5 to 1 | No score/data gap

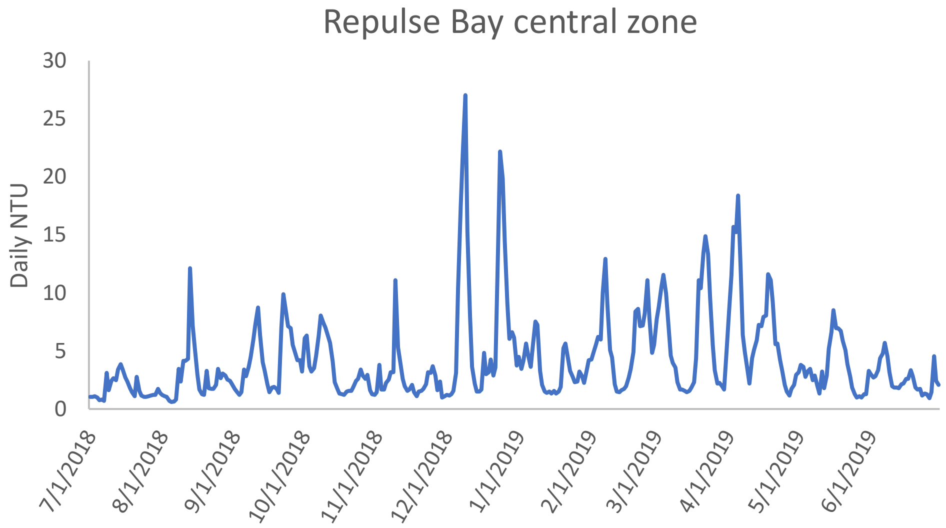
**Table AC 9. Summary statistics for water quality indicators in the Central inshore marine sites from July 2018 to June 2019. Presented alongside statistics are guideline values, including the statistic that was compared to the guideline (where three values are listed, the median is compared to the middle of the listed values). For all indicators except secchi, to meet the guideline the relevant statistic must be lower compared to the guideline (secchi must be higher than the guideline).**

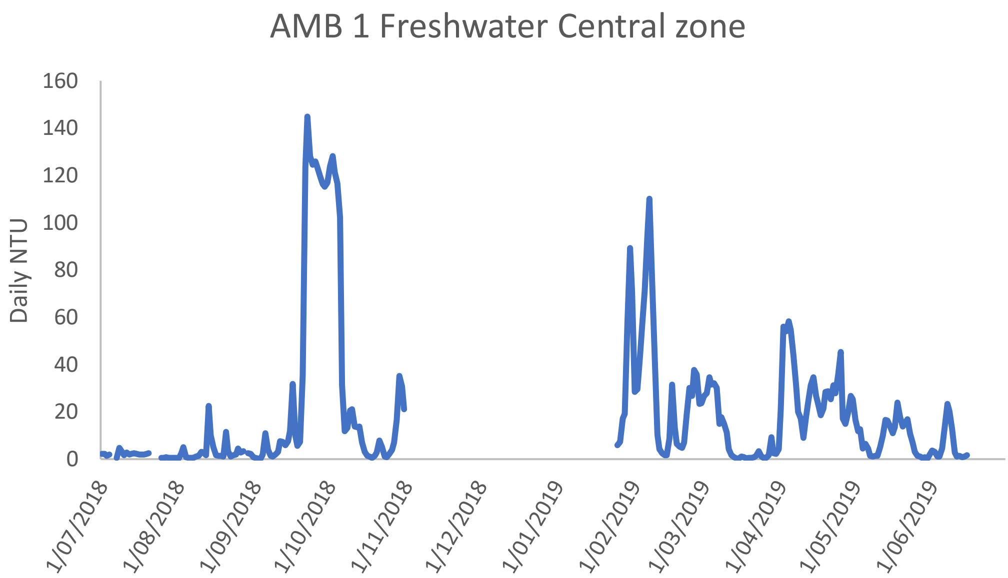
| | | | | | | | | | Guidelines | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Site** | **Indicator** | **n** | **Mean** | **Minimum** | **25th %ile** | **Median** | **75th %ile** | **Maximum** | **Comparison** | **Guideline value** |
| O'Connell River mouth | NOx (µg/L) | 5 | 12.8 | 0.28 | 0.53 | 1.25 | 3.08 | 59.1 | median | 2-4-10 |
| | PN (µg/L) | 5 | 58.2 | 30.3 | 36.4 | 51.2 | 75.2 | 97.7 | | |
| | PP (µg/L) | 5 | 5.82 | 3.21 | 4.43 | 5.33 | 7.90 | 8.20 | | |
| | Chl-*a* (µg/L) | 5 | 0.69 | 0.41 | 0.41 | 0.57 | 0.58 | 1.50 | median | 0.8-1.3-2 |
| | TSS (mg/L) | 5 | 7.45 | 0.68 | 2.30 | 2.35 | 7.87 | 24.0 | | |
| | Secchi (m) | 5 | 2.44 | 0.20 | 1.50 | 2.50 | 3.00 | 5.00 | | |
| | Turb (NTU) | | | | | | | | | |
| Repulse Islands dive mooring | NOx (µg/L) | 5 | 4.78 | 0.85 | 0.91 | 0.94 | 2.30 | 18.9 | median | 0-1-2 |
| | PN (µg/L) | 5 | 48.4 | 19.4 | 29.2 | 33.8 | 63.4 | 96.2 | median | 12-13-15 |
| | PP (µg/L) | 5 | 6.69 | 3.61 | 5.00 | 6.41 | 7.75 | 10.7 | median | 1.8-2.4-2.8 |
| | Chl-*a* (µg/L) | 5 | 0.75 | 0.41 | 0.42 | 0.74 | 1.01 | 1.19 | median | 0.25-0.36-0.54 |
| | TSS (mg/L) | 5 | 15.0 | 1.44 | 4.66 | 6.51 | 14.3 | 47.8 | median | 0.9-1.4-2.3 |
| | Secchi (m) | 5 | 2.50 | 1.00 | 1.50 | 2.00 | 3.00 | 5.00 | mean | 10 |
| | Turb (NTU) | 365 | 4.20 | 0.60 | 1.70 | 2.97 | 5.33 | 27.0 | median | 0.7-1.1-2.1 |
| AMB 1 | NOx (µg/L) | | | | | | | | | |
| | PN (µg/L) | 6 | 38.8 | 7.00 | 14.8 | 17.5 | 69.0 | 91.0 | mean | <20 |
| | PP (µg/L) | 6 | 4.17 | 0.00 | 1.25 | 3.00 | 4.75 | 13.0 | mean | <2.8 |
| | Chl-*a* (µg/L) | 6 | 0.88 | 0.10 | 0.14 | 0.64 | 1.01 | 2.81 | mean | <0.45 |
| | TSS (mg/L) | 3 | 12.8 | 3.40 | 10.2 | 17.0 | 17.5 | 18.0 | mean | <2.0 |
| | Secchi (m) | 6 | 2.98 | 1.00 | 1.45 | 2.75 | 4.50 | 5.30 | mean | >10 |
| | Turb (NTU) | 273 | 18.7 | 0.28 | 1.53 | 5.54 | 21.5 | 145 | median | <1 |
| AMB 2 | NOx (µg/L) | | | | | | | | | |
| | PN (µg/L) | 6 | 48.50 | 4.00 | 22.0 | 40.5 | 55.3 | 130 | mean | <20 |
| | PP (µg/L) | 6 | 2.67 | 0.00 | 1.25 | 2.50 | 3.00 | 7.00 | mean | <2.8 |
| | Chl-*a* (µg/L) | 5 | 0.72 | 0.26 | 0.55 | 0.78 | 0.86 | 1.16 | mean | <0.45 |
| | TSS (mg/L) | 3 | 5.83 | 2.70 | 2.75 | 2.80 | 7.40 | 12.0 | mean | <2.0 |
| | Secchi (m) | 6 | 3.28 | 0.50 | 1.63 | 2.44 | 5.03 | 6.00 | mean | >10 |
| | Turb (NTU) | 177 | 12.7 | 0.02 | 0.67 | 1.76 | 7.06 | 312 | median | D1-2-8<br>W5-12-33 |
| AMB 3B | NOx (µg/L) | | | | | | | | | |
| | PN (µg/L) | 7 | 35.86 | 1.00 | 4.50 | 24.0 | 62.0 | 93.0 | mean | <20 |
| | PP (µg/L) | 7 | 2.86 | 1.00 | 2.00 | 2.00 | 3.00 | 7.00 | mean | <2.8 |
| | Chl-*a* (µg/L) | 7 | 0.72 | 0.10 | 0.30 | 0.42 | 0.69 | 2.54 | mean | <0.45 |
| | TSS (mg/L) | 3 | 5.90 | 2.60 | 4.10 | 5.60 | 7.55 | 9.50 | mean | <2.0 |

| | | | | | | | | | Guidelines | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Site** | **Indicator** | **n** | **Mean** | **Minimum** | **25th %ile** | **Median** | **75th %ile** | **Maximum** | **Comparison** | **Guideline value** |
| | Secchi (m) | 6 | 3.52 | 1.00 | 1.75 | 2.75 | 5.25 | 7.10 | mean | >10 |
| | Turb (NTU) | 157.00* | 3.80 | 0.00 | 0.23 | 0.68 | 3.66 | 37.9 | median | <1 |
| AMB 5 | NOx (µg/L) | | | | | | | | | |
| | PN (µg/L) | 6 | 154 | 18.0 | 37.5 | 44.0 | 123 | 633 | mean | <20 |
| | PP (µg/L) | 6 | 14.0 | 1.00 | 3.25 | 5.00 | 22.5 | 42.0 | mean | <2.8 |
| | Chl-*a* (µg/L) | 6 | 4.73 | 0.36 | 0.66 | 0.96 | 1.04 | 24.5 | mean | <0.45 |
| | TSS (mg/L) | 3 | 4.87 | 3.10 | 3.70 | 4.30 | 5.75 | 7.20 | mean | <2.0 |
| | Secchi (m) | 6 | 5.02 | 2.50 | 2.90 | 4.55 | 5.75 | 10.0 | mean | >10 |
| | Turb (NTU) | 192* | 21.8 | 0.00 | 0.62 | 5.04 | 20.3 | 654 | median | D1-2-8<br>W5-12-33 |
| AMB 6B | NOx (µg/L) | | | | | | | | | |
| | PN (µg/L) | 6 | 42.3 | 5.00 | 13.3 | 37.0 | 51.0 | 114 | mean | <20 |
| | PP (µg/L) | 6 | 3.67 | 1.00 | 1.50 | 4.00 | 5.75 | 6.00 | mean | <2.8 |
| | Chl-*a* (µg/L) | 6 | 0.53 | 0.26 | 0.27 | 0.46 | 0.75 | 0.91 | mean | <0.45 |
| | TSS (mg/L) | 3 | 4.27 | 3.00 | 3.50 | 4.00 | 4.90 | 5.80 | mean | <2.0 |
| | Secchi (m) | 4 | 2.43 | 1.00 | 1.75 | 2.50 | 3.18 | 3.70 | mean | >10 |
| | Turb (NTU) | | | | | | | | | |
| AMB 8 | NOx (µg/L) | | | | | | | | | |
| | PN (µg/L) | 5 | 80.8 | 3.00 | 6.00 | 46.0 | 56.0 | 293 | mean | <20 |
| | PP (µg/L) | 5 | 4.20 | 1.00 | 1.00 | 2.00 | 5.00 | 12.0 | mean | <2.8 |
| | Chl-*a* (µg/L) | 5 | 2.49 | 0.33 | 0.33 | 0.42 | 0.91 | 10.5 | mean | <0.45 |
| | TSS (mg/L) | 2 | 3.40 | 2.20 | 2.80 | 3.40 | 4.00 | 4.60 | mean | <2.0 |
| | Secchi (m) | 5 | 4.22 | 1.50 | 3.00 | 5.00 | 5.60 | 6.00 | mean | >10 |
| | Turb (NTU) | 211* | 20.5 | 0.07 | 0.51 | 2.38 | 11.5 | 230 | median | D1-2-8<br>W5-12-33 |
| AMB 10 | NOx (µg/L) | | | | | | | | | |
| | PN (µg/L) | 7 | 17.6 | 1.00 | 6.50 | 12.0 | 23.5 | 50.0 | mean | <20 |
| | PP (µg/L) | 7 | 2.00 | 0.00 | 0.50 | 2.00 | 3.50 | 4.00 | mean | <2.8 |
| | Chl-*a* (µg/L) | 7 | 0.98 | 0.23 | 0.48 | 0.65 | 1.09 | 2.87 | mean | <0.45 |
| | TSS (mg/L) | 4 | 6.63 | 2.60 | 3.28 | 4.95 | 8.30 | 14.0 | mean | <2.0 |
| | Secchi (m) | 5 | 2.90 | 1.00 | 1.00 | 2.50 | 4.50 | 5.50 | mean | >10 |
| | Turb (NTU) | 259* | 41.1 | 0.00 | 1.94 | 2.65 | 50.6 | 338 | median | <1 |
| AMB 11 | NOx (µg/L) | | | | | | | | median | <10 |
| | PN (µg/L) | 6 | 49.3 | 1.00 | 18.0 | 2.00 | 72.3 | 140 | | |
| | PP (µg/L) | 6 | 3.33 | 1.00 | 2.25 | 3.00 | 3.75 | 7.00 | | |
| | Chl-*a* (µg/L) | 6 | 0.81 | 0.49 | 0.55 | 0.70 | 0.83 | 1.63 | median | <2.0 |
| | TSS (mg/L) | 2 | 3.80 | 3.60 | 3.70 | 3.80 | 3.90 | 4.00 | | |
| | Secchi (m) | 5 | 2.26 | 1.00 | 1.30 | 2.00 | 2.00 | 5.00 | median | >1 |

| Site | Indicator | n | Mean | Minimum | 25th %ile | Median | 75th %ile | Maximum | Guidelines | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Comparison | Guideline value |
| | Turb (NTU) | | | | | | | | | |
| AMB 12 | NOx (µg/L) | 3 | 4.33 | 2.00 | 2.00 | 2.00 | 5.50 | 9.00 | median | 0-0-1 |
| | PN (µg/L) | 6 | 26.5 | 1.00 | 7.75 | 26.5 | 43.0 | 55.0 | median | 14-18-24 |
| | PP (µg/L) | 6 | 2.50 | 0.00 | 1.25 | 2.50 | 3.00 | 6.00 | median | 1.6-2.1-3 |
| | Chl-*a* (µg/L) | 6 | 0.45 | 0.23 | 0.31 | 0.51 | 0.56 | 0.65 | mean | ≤0.45 |
| | TSS (mg/L) | 3 | 1.87 | 1.50 | 1.75 | 2.00 | 2.05 | 2.10 | median | 1.1-1.6-2.4 |
| | Secchi (m) | 6 | 4.83 | 3.00 | 4.50 | 4.75 | 5.75 | 6.00 | mean | 10 |
| | Turb (NTU) | 280* | 17.4 | 0.01 | 0.27 | 0.77 | 3.69 | 335 | median | <1 |

*While turbidity loggers were deployed for the entire 2018/2019 reporting period (365 days), sample size is based on daily averages from *validated* data recovered from this period. Some data points maybe lost due to unforeseen device malfunction or damage. Turbidity data is not collected at sites AMB6 and AMB11.



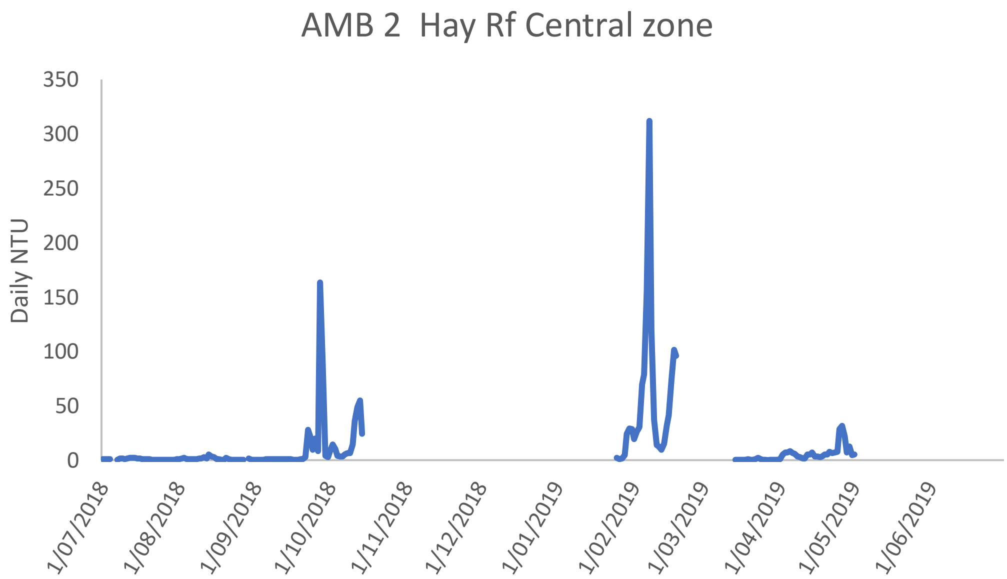




**Figure AC 11. Daily turbidity (NTU) for 2018-19 reporting year for three Central inshore marine loggers.**

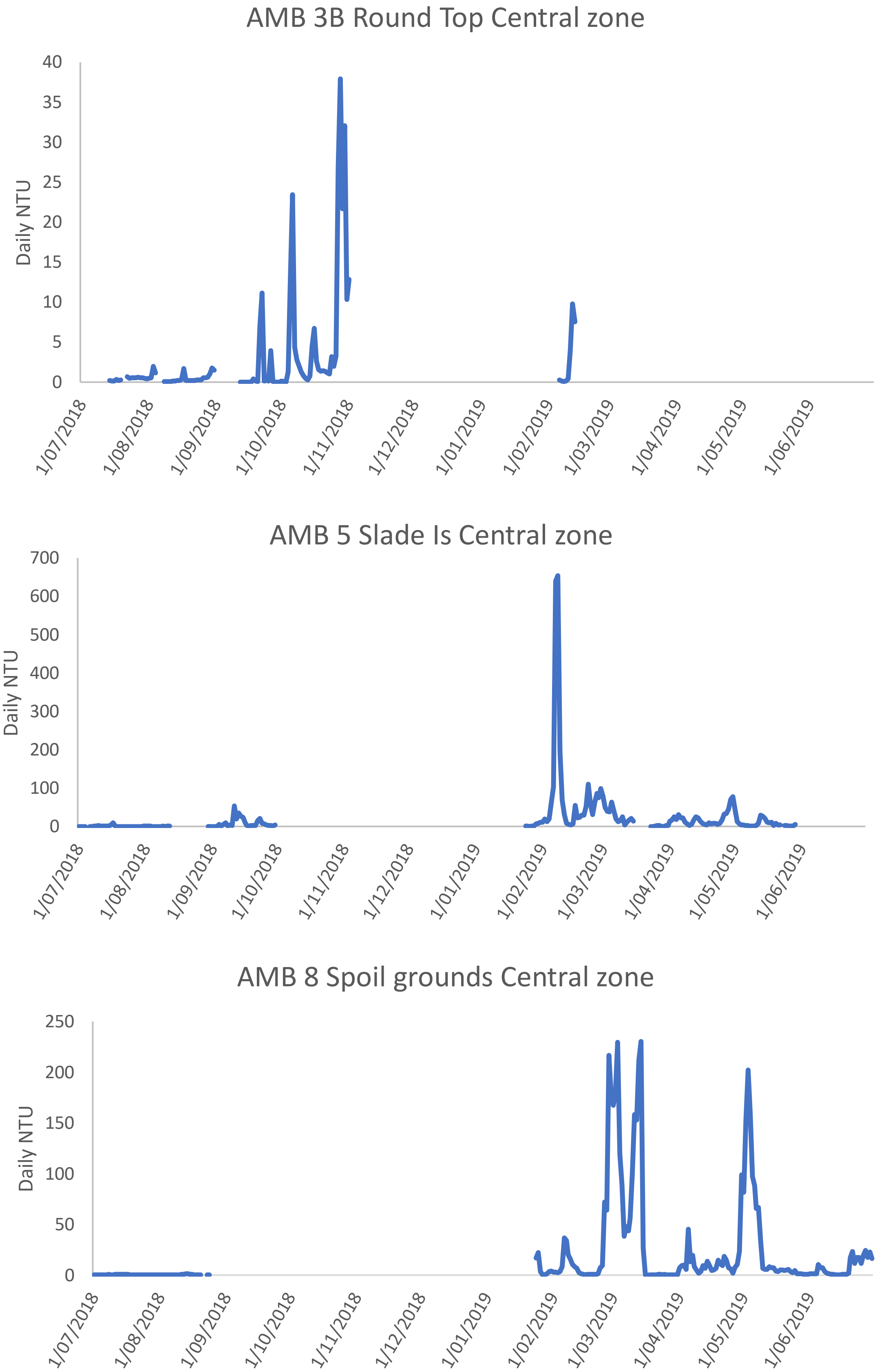
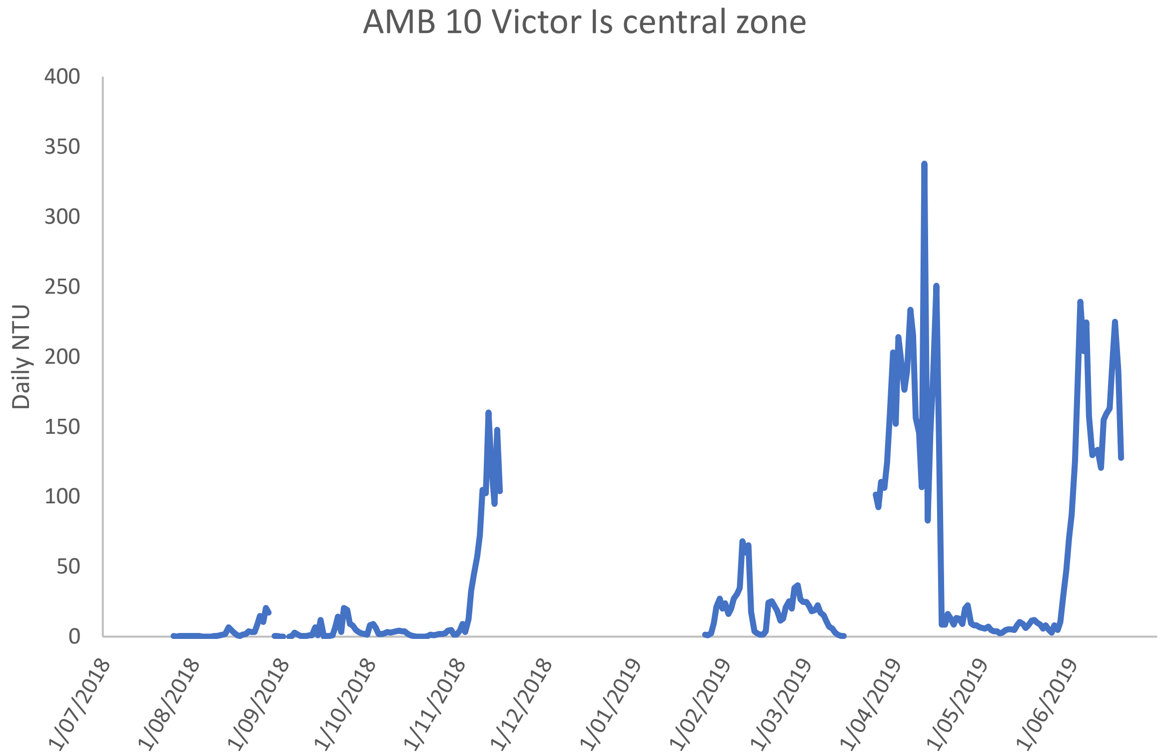



**Figure AC 12. Daily turbidity (NTU) for 2018-19 reporting year from three Central inshore marine loggers.**



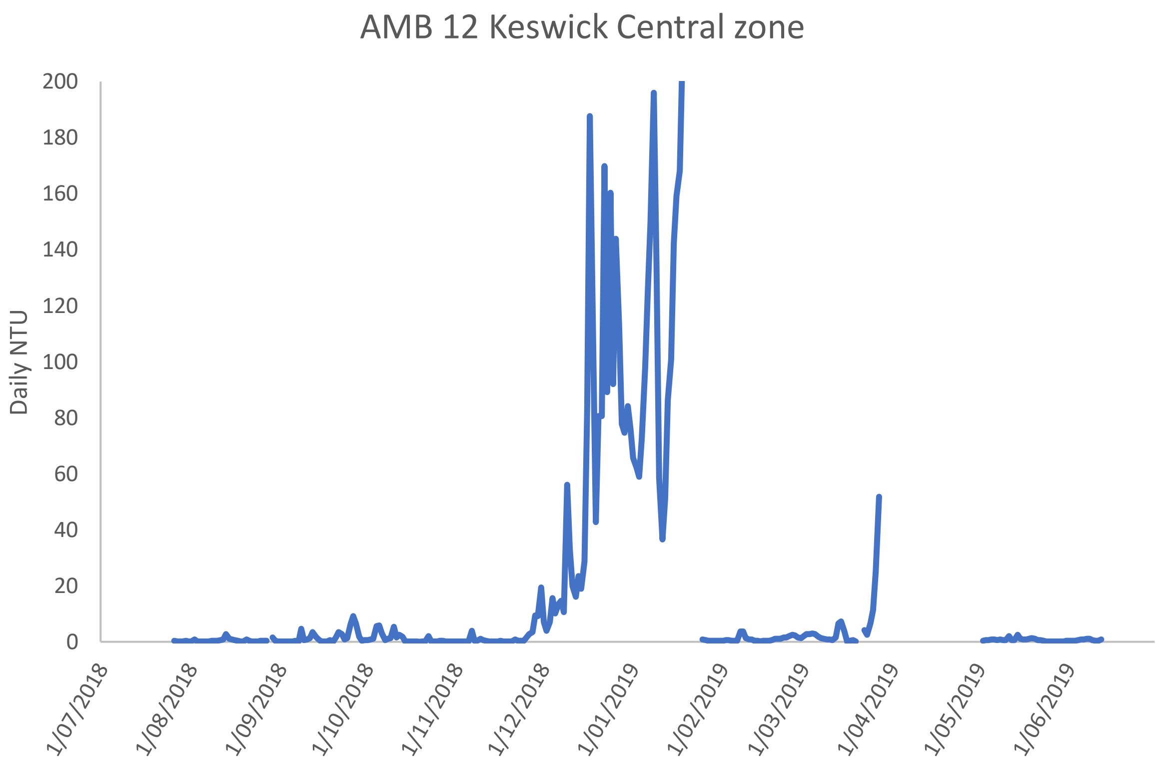




**Figure AC 13. Daily turbidity (NTU) for 2018-19 reporting year from two Central inshore marine loggers.**

**Table AC 10. Southern inshore water quality indicator scores for the 2018-19 report card.**

| Site | Nutrients | | | Chl-a | Water clarity | | |
|---|---|---|---|---|---|---|---|
| | NOx | PN | PP | Chl-a | TSS | Secchi | Turbidity |
| Mky_Cam 1 | 1.00 | 0.51 | -0.36 | -0.47 | | -1.00 | -1.00 |
| Mky_Cam 2 | 0.58 | -0.18 | -0.36 | 0.17 | | -1.00 | |
| Mky_Cam 3 | 0.26 | -1.00 | -1.00 | -1.00 | | -1.00 | |

**Table AC 11. Southern inshore water quality indices for the 2018-19 report card**

| Site | Nutrients | Chl-a | Water clarity |
|---|---|---|---|
| Mky_Cam 1 | 0.38 | -0.47 | -1.00 |
| Mky_Cam 2 | 0.02 | 0.17 | |
| Mky_Cam 3 | -0.58 | -1.00 | |
| Southern 2019 | -0.06 | -0.43 | -1.00 |

| | | | |
|---|---|---|---|
| Southern 2018 | -0.19 | -0.70 | -1.00 |

**Scoring range:** Very Poor = <-0.66 to -1 | Poor = <-0.33 to -0.66 | Moderate = <0 to -0.33 | Good = 0 to 0.5 | Very Good = >0.5 to 1 | No score/data gap

**Table AC 12. Summary statistics for water quality indicators in the Southern zone for marine sites from July 2018 to June 2019. Presented alongside statistics are guideline values, including the statistic that was compared to the guideline (where three values are listed, the median is compared to the middle of the listed values). For all indicators except secchi, to meet the guideline the relevant statistic must be lower compared to the guideline (secchi must be higher than the guideline).**

| | | | | | | | | | Guidelines | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Site** | **Indicator** | **n** | **Mean** | **Minimum** | **25th %ile** | **Median** | **75th %ile** | **Maximum** | **Comparison** | **Guideline value** |
| Mackay Cam 1 | NOx (µg/L) | 5 | 1.30 | 0.50 | 0.5 | 0.52 | 2 | 3.00 | median | 3.0 |
| | PN (µg/L) | 5 | 14.0 | 8.00 | 9 | 13.0 | 17 | 23.0 | | <20 |
| | PP (µg/L) | 5 | 3.60 | 2.00 | 2 | 4.00 | 5 | 5.00 | | <2.8 |
| | Chl-*a* (µg/L) | 5 | 0.62 | 0.33 | 0.46 | 0.46 | 0.91 | 0.95 | median | <0.45 |
| | TSS (mg/L) | | | | | | | | | 2.0 |
| | Secchi (m) | 4 | 2.15 | 1.50 | 2.1 | 2.05 | 2.33 | 3.00 | | >10 |
| | Turb (NTU) | 338* | 15.6 | 0.11 | 4.55 | 10.3 | 19.3 | 73.5 | | <1 |
| Mackay Cam 2 | NOx (µg/L) | 5 | 2.06 | 0.50 | 0.5 | 2.00 | 3 | 4.32 | median | 3.0 |
| | PN (µg/L) | 5 | 22.6 | 2.00 | 8 | 28.0 | 36 | 39.0 | median | <20 |
| | PP (µg/L) | 5 | 3.60 | 1.00 | 3 | 4.00 | 5 | 5.00 | median | <2.8 |
| | Chl-*a* (µg/L) | 5 | 0.40 | 0.10 | 0.33 | 0.42 | 0.42 | 0.73 | median | <0.45 |
| | TSS (mg/L) | | | | | | | | median | 2.0 |
| | Secchi (m) | 3 | 2.60 | 1.80 | 2.15 | 2.50 | 3 | 3.50 | mean | >10 |
| | Turb (NTU) | | | | | | | | median | <1 |
| Mackay Cam 3 | NOx (µg/L) | 5 | 3.43 | 0.50 | 2 | 2.51 | 3.51 | 8.63 | | 3.0 |
| | PN (µg/L) | 5 | 53.6 | 2.00 | 20 | 3.51 | 47 | 153 | mean | <20 |
| | PP (µg/L) | 5 | 6.20 | 1.00 | 1 | 2.00 | 13 | 14.0 | mean | <2.8 |
| | Chl-*a* (µg/L) | 5 | 3.22 | 0.10 | 0.23 | 0.26 | 4.01 | 11.5 | mean | <0.45 |
| | TSS (mg/L) | | | | | | | | mean | 2.0 |
| | Secchi (m) | 5 | 2.18 | 1.50 | 1.5 | 1.50 | 2.4 | 4.00 | mean | >10 |
| | Turb (NTU) | | | | | | | | median | <1 |

*While turbidity loggers were deployed for the entire 2018/2019 reporting period (365 days), sample size is based on daily averages from *validated* data recovered from this period. Some data points maybe lost due to unforeseen device malfunction or damage. Due to the recent development of the monitoring program within the Southern Inshore Zone, a turbidity logger has only been established at Mackay Cam 1 site, 'Aquilla'.

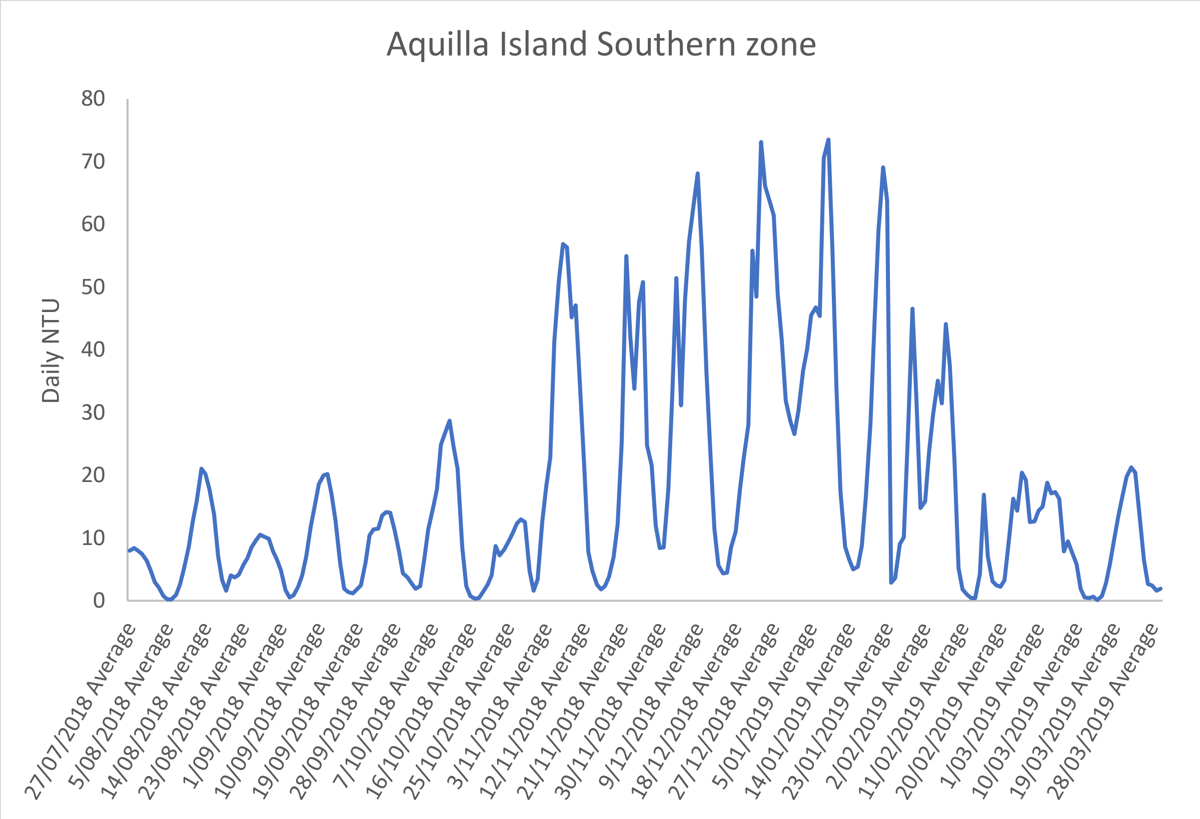



**Figure AC 14. Daily turbidity (NTU) for 2018-19 reporting year from Southern inshore zone marine logger.**

**Table AC 13. Coral indicator scores for 2019 in the Northern inshore marine sites (Abbot Point coral monitoring program). Coral change was reported on for the first time.**

| Zone | Reef ID | Depth | Cover | Macroalgae | Juvenile | Change* | Composition | Coral index |
|---|---|---|---|---|---|---|---|---|
| Northern | Camp East | 2 | 0.15 | 0.00 | 0.08 | 0.15 | | **0.09** |
| | Camp West | 2 | 0.38 | 0.00 | 0.20 | 0.44 | | **0.25** |
| | Holboune East | 2 | 0.04 | 1.00 | 0.05 | 0.37 | | **0.36** |
| | Holbourne East | 5 | 0.16 | 0.95 | 0.03 | 0.37 | | **0.38** |
| | Holbourne West | 2 | 0.02 | 0.76 | 0.04 | 0.46 | | **0.32** |
| | Holbourne West | 5 | 0.11 | 1.00 | 0.10 | 0.00 | | **0.30** |
| **2019 Report card score: Poor** | | | **0.14** | **0.62** | **0.08** | **0.30** | | **0.29** |
| | | | | | | | | |
| **2018 Report card score: Poor** | | | **0.12** | **0.61** | **0.07** | **0.20** | | **0.25** |
| 2017 Report card score: Moderate | | | 0.14 | 0.67 | 0.12 | | | **0.31** |
| 2016 Report card score: Moderate | | | 0.40 | 0.67 | 0.29 | | | **0.45** |
| 2015 Report card score: no data | | | | | | | | |
| 2014 Report card score: no data | | | | | | | | |

**Scoring range:** Very Poor = 0 to <0.21 | Poor = 0.21 to <0.41 | Moderate = 0.41 to <0.61 | Good = 0.61 to <0.81 | Very Good = 0.81 – 1 | No score/data gap

Table AC 14. Coral indicator scores for 2019 in the Whitsunday inshore marine sites (MMP coral monitoring program).

| Zone | Reef ID | Reef | Depth | Cover | Macroalgae | Juvenile | Change | Composition | Coral index |
|---|---|---|---|---|---|---|---|---|---|
| Whitsunday | W1 | Border | 5 | 0.47 | 1.00 | 0.33 | 0.47 | 0.00 | 0.45 |
| | W2 | Daydream | 2 | 0.01 | 0.00 | 0.20 | 0.43 | 0.00 | 0.13 |
| | W3 | | 5 | 0.04 | 0.19 | 0.19 | 0.39 | 0.00 | 0.16 |
| | W4 | Dent | 2 | 0.35 | 1.00 | 0.16 | 0.00 | 0.00 | 0.30 |
| | W5 | | 5 | 0.40 | 1.00 | 0.16 | 0.00 | 0.00 | 0.31 |
| | W6 | Double Cone | 2 | 0.02 | 0.00 | 0.07 | 0.40 | 0.00 | 0.10 |
| | W7 | | 5 | 0.24 | 0.00 | 0.14 | 0.16 | 0.00 | 0.11 |
| | W8 | Hayman | 5 | 0.13 | 1.00 | 0.22 | 0.20 | 0.00 | 0.31 |
| | W9 | Hook | 2 | 0.09 | 0.93 | 0.08 | 0.28 | 0.00 | 0.28 |
| | W10 | | 5 | 0.30 | 0.81 | 0.14 | 0.13 | 0.50 | 0.38 |
| | W11 | Langford | 5 | 0.20 | 1.00 | 0.28 | 0.00 | 0.00 | 0.30 |
| | W12 | Pine | 2 | 0.12 | 0.00 | 0.14 | 0.00 | 0.50 | 0.15 |
| | W13 | | 5 | 0.18 | 0.03 | 0.20 | 0.00 | 0.00 | 0.08 |
| | W14 | Seaforth | 2 | 0.24 | 0.00 | 0.22 | 0.25 | 1.00 | 0.34 |
| | W15 | | 5 | 0.19 | 0.00 | 0.45 | 0.10 | 1.00 | 0.35 |
| | W16 | Shute Harbour | 2 | 0.59 | 1.00 | 0.31 | 0.85 | 1.00 | 0.75 |
| | W17 | | 5 | 0.25 | 0.79 | 0.40 | 0.46 | 1.00 | 0.58 |
| **2019 Report card score: Poor** | | | | **0.22** | **0.51** | **0.22** | **0.24** | **0.29** | **0.30** |

| | Cover | Macroalgae | Juvenile | Change | Composition | Coral index |
|---|---|---|---|---|---|---|
| **2018 Report card score: Moderate** | **0.32** | **0.60** | **0.32** | **0.37** | **0.47** | **0.42** |
| 2017 Report card score: Moderate | 0.37 | 0.93 | 0.34 | 0.43 | 0.53 | **0.52** |
| 2016 Report card score: Good | 0.68 | 0.76 | 0.62 | 0.40 | 0.59 | **0.61** |
| 2015 Report card score: Moderate | 0.64 | 0.74 | 0.60 | 0.40 | 0.53 | **0.58** |
| 2014 Report card score: Moderate | 0.61 | 0.74 | 0.61 | 0.39 | 0.44 | **0.56** |

**Scoring range:** ■ Very Poor = 0 to <0.21 | ■ Poor = 0.21 to <0.41 | ■ Moderate = 0.41 to <0.61 | ■ Good = 0.61 to <0.81 | ■ Very Good = 0.81 – 1 | ■ No score/data gap

Table AC 15. Coral indicator scores for 2019 in the Central inshore marine sites (Hay Point coral monitoring program).

| Zone | Reef ID | Cover | Macroalgae | Juvenile | Change | Composition | Coral index |
|---|---|---|---|---|---|---|---|
| Central | Keswick | 0.52 | 0.00 | 0.04 | 0.36 | | **0.23** |
| | Round | 0.42 | 0.00 | 0.28 | 0.47 | | **0.29** |
| | Slade | 0.31 | 0.00 | 0.13 | 0.38 | | **0.21** |
| | Victor | 0.28 | 0.00 | 0.07 | 0.33 | | **0.17** |
| **2018 Report card score: Poor** | | **0.38** | **0.00** | **0.13** | **0.39** | | **0.23** |

| | Cover | Macroalgae | Juvenile | Change | Composition | Coral index |
|---|---|---|---|---|---|---|
| **2018 Report card score: Poor** | **0.36** | **0.00** | **0.16** | **0.39** | | **0.23** |
| 2017 Report card score: Poor | 0.35 | 0.01 | 0.18 | 0.40 | | **0.23** |
| 2016 Report card score: Poor | 0.44 | 0.00 | 0.15 | 0.64 | | **0.31** |
| 2015 Report card score: no score | 0.42 | | 0.39 | | | |
| 2014 Report card score: no data | | | | | | |

**Scoring range:** ■ Very Poor = 0 to <0.21 | ■ Poor = 0.21 to <0.41 | ■ Moderate = 0.41 to <0.61 | ■ Good = 0.61 to <0.81 | ■ Very Good = 0.81 – 1 | ■ No score/data gap

Table AC 16. Coral indicator scores for 2019 in the Southern inshore marine sites (Southern inshore program).

| Zone | Reef ID | Cover | Macroalgae | Juvenile | Change | Composition | Coral index | Zone |
|---|---|---|---|---|---|---|---|---|
| Southern | Pine Peak | 2 | 0.14 | 0.00 | 0.02 | | | 0.05 |
| | Pine Peak | 5 | 0.32 | 0.00 | 0.03 | | | 0.12 |
| | Pine Islets | 2 | 0.05 | 0.00 | 0.07 | | | 0.04 |
| | Pine Islets | 5 | 0.25 | 0.00 | 0.10 | | | 0.12 |
| | Henderson Island | 2 | 1.00 | 0.00 | 0.22 | | | 0.41 |
| | Henderson Island | 5 | 0.91 | 0.00 | 0.17 | | | 0.36 |
| | Connor Island | 2 | 0.48 | 0.00 | 0.15 | | | 0.21 |
| | Connor Island | 5 | 0.58 | 0.00 | 0.15 | | | 0.24 |
| | Temple Island | 1 | 0.70 | 0.00 | 0.25 | | | 0.32 |
| | Aquila Island | 1 | 0.42 | 0.00 | 0.14 | | | 0.19 |
| **2019 Report card score: Very Poor** | | | **0.49** | **0.00** | **0.13** | | | **0.20** |

**Scoring range:** Very Poor = 0 to <0.21 | Poor = 0.21 to <0.41 | Moderate = 0.41 to <0.61 | Good = 0.61 to <0.81 | Very Good = 0.81 – 1 | No score/data gap

**Table AC 16. Results for seagrass indicators, based on 2018-19 data. Indicators are based on data collected from the Marine Monitoring Program (MMP) or the Queensland Ports Seagrass Monitoring Program (QPSMP) and black cells indicate an indicator does not contribute to a reporting zone. Seagrass Watch sites that contribute to the MMP are indicated (SW). NB site scores for QPSMP are determined from the lowest indicator score. If species comp drives the overall score, it is given a 50% weighting; for MMP site scores are an average of indicators.**

| Zone | Habitat | Depth | Location/Meadow | Meadow/site | MMP | MMP | MMP | Ports | Ports | Ports | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Abundance | Reproductive effort | Nutrient status | Biomass | Area | Sp. Composition | Overall location/meadow score | Overall zone score |
| Inshore Marine Northern | coastal | inshore | Abbot Pt. | API3 | | | | 71 | 85 | 57 | 64 | 52 |
| | | | | API5 | | | | 92 | 85 | 69 | 77 | |
| | | | | API7 | | | | 67 | 86 | 92 | 67 | |
| | | | | API8 | | | | 0 | 0 | 0 | 0 | |
| | | | | API9 | | | | 55 | 45 | 94 | 45 | |
| | | subtidal | | APD1 | | | | 48 | | 0 | 24 | |
| | | | | APD2 | | | | 77 | | 100 | 77 | |
| | | | | APD3 | | | | 64 | | 100 | 64 | |
| | | | | APD4 | | | | 50 | | 92 | 50 | |
| Inshore Marine Whitsunday | reef | intertidal | Hydeaway Bay | HB1 and 2* | 81 | | | | | | 81 | 27 |
| | | | Hamilton Is. 1 | HM1 | 0 | 0 | 4 | | | | 1 | |
| | | | Hamilton Is. 2 | HM2 | 0 | 0 | 0 | | | | 0 | |
| | | subtidal | Tongue Bay | TO1 and 2^ | 13 | | | | | | 13 | |
| | | | Lindeman Island | LN1 and 2 | 38 | 38 | 36 | | | | 37 | |
| | coastal | intertidal | Pioneer Bay | PI2 and 3* | 31 | | | | | | 31 | |
| Inshore Marine Central | coastal | intertidal | Midge Point | MP2 and 3 | 69 | 0 | 53 | | | | 41 | 52 |
| | | | St Helens Beach | SH1*# | 25 | | | | | | 25 | |
| | | subtidal | Newry Bay | NB1 and 2^ | 75 | | | | | | 75 | |
| | estuarine | intertidal | Sarina Inlet | SI1 and 2 | 0 | 0 | 23 | | | | 8 | |
| | coastal | intertidal/subtidal | Dudgeon Pt | DP1 | | | | 56 | 94 | 94 | 56 | |
| | | subtidal | St Bees Island | SB10 | | | | 92 | 92 | 85 | 89 | |
| | | | Keswick Island | KW14 | | | | 77 | 89 | 89 | 77 | |
| | | | Hay Point | HPD1 | | | | 47 | 65 | 100 | 47 | |
| Inshore Marine Southern | coastal | intertidal | Clairview | CV1 and 2* | 19 | | | | | | 19 | not used |

**Scoring range:** Very Poor = 0 to <21 | Poor = 21 to <41 | Moderate = 41 to <61 | Good = 61 to <81 | Very Good = 81 to 100 | No score/data gap | Not applicable

## Appendix D: Agricultural stewardship

**Table AD 1. Management practice adoption of key practices for the sugarcane industry for the Proserpine, O'Connell, Pioneer and Plane basins for the 2019 report card, compared to the 2018.**

| Management system | Key management practice | Proserpine | | O'Connell | | Pioneer | | Plane | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 |
| Nutrient Management | Nitrogen Surplus | 12% | 20% | 15% | 17% | 9% | 9% | 10% | 11% |
| | Phosphorus Surplus | 6% | 6% | 26% | 26% | 25% | 25% | 22% | 22% |
| | Mud Rate | 30% | 30% | 42% | 42% | 35% | 35% | 43% | 43% |
| Pesticide management | Pesticide Application in Plant Cane | 1% | 1% | 2% | 3% | 9% | 10% | 9% | 10% |
| | Pesticide Application in Ratoons | 1% | 1% | 8% | 8% | 9% | 9% | 12% | 12% |
| | Use of Residuals | 11% | 11% | 20% | 22% | 2% | 4% | 7% | 8% |
| | Pesticide Selection | 53% | 53% | 53% | 53% | 22% | 22% | 53% | 53% |
| | Cane Grub Pesticides | 1% | 1% | 1% | 1% | 1% | 1% | 13% | 13% |
| Soil management | Trash Blanket | 100% | 100% | 100% | 100% | 100% | 100% | 98% | 98% |
| | Machinery Traffic | 4% | 4% | 4% | 5% | 5% | 7% | 20% | 20% |
| | Fallow Management | 10% | 15% | 25% | 28% | 17% | 18% | 16% | 17% |
| | Planting | 10% | 12% | 5% | 7% | 10% | 12% | 5% | 6% |
| Irrigation management | Irrigation Scheduling | 26% | 26% | 4% | 4% | 0% | 0% | 8% | 8% |
| | Irrigation volume | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| | Irrigation runoff | 28% | 28% | 5% | 5% | 0% | 0% | 7% | 7% |

## Appendix E: Interpreting pesticide risk values and risk categories

The pesticide risk metric is reported as the '% of species' protected from mixtures of pesticides detected in an ecosystem over the wet season (the period when pesticides most commonly occur in catchments and are present at their highest concentrations). How that percentage of species protected in the ecosystem is estimated is described in the Methods document (Mackay-Whitsunday-Isaac 2020) and elsewhere (Warne et al. In prep). But in summary, ecotoxicity experiments provide an indication of how organisms in the ecosystem might respond when they are exposed to different concentrations of pesticides. By collating these (published) experimental data for multiple species, it is possible to derive (i.e. using species sensitivity distributions) the relationship between the concentration of a pesticide and the percent of species it is likely to affect. Pesticide concentrations detected in an ecosystem can then be compared against the species sensitivity distribution to estimate the per cent of species being affected in the ecosystem. By expanding this process to account for the cumulative impact of multiple pesticides over the wet season, the risk of pesticides can be estimated (i.e. the pesticide risk metric). The Pesticide Risk Metric can estimate the effect of mixtures of up to 22 pesticides frequently detected in waters discharging to the Great Barrier Reef, and from this, the percentage of species that should be protected from the concentration of the 22 pesticides is estimated.

For example, a pesticide risk value of 95% species protection, means that 95% of aquatic species in an ecosystem should not experience harmful non-lethal or lethal effects (such as reduced growth or reproduction) resulting from exposure to pesticides present in that waterbody. It also means that the most sensitive 5% of aquatic species would be expected to experience some harmful non-lethal effects. The types of organisms that are most sensitive depends on the type of pesticides that they are exposed to, as pesticides are designed to affect specific types of organisms. For example, herbicides are designed to kill plants and therefore algae and aquatic plants (including seagrass and coral) are generally the most sensitive aquatic species to herbicides. Insecticides are designed to kill insects and therefore aquatic insects and crustaceans (e.g. crabs, lobsters, prawns and copepods), which are closely related to insects, are the most sensitive aquatic species. As pesticide concentrations increase:

- more species will experience harmful effects;
- the harmful effects will change from non-lethal to lethal; and
- what is affected will increase from individuals, to populations, to whole communities or ecosystems

Fish are relatively insensitive to herbicides and insecticides as they do not have the biochemical pathways that these pesticides affect. Therefore, based on the types and concentrations of pesticides currently being detected in the lower reaches of Great Barrier Reef catchments and the inshore marine ecosystems, it is unlikely that fish mortality or population decline would occur as a direct result of exposure to those pesticides. Rather sublethal and/or indirect effects could occur. For example, Kroon et al. (2013) found that barramundi and coral trout collected along the east coast of Queensland exhibited signs of endocrine disruption (a non-lethal effect) and the extent of this was related to the concentrations of a number of pesticides in the water where the fish were collected. In contrast, the effects on aquatic plants (such as algae and sea grasses) in lower reaches of Great Barrier Reef catchments and the inshore marine ecosystems are expected to be greater, because they are more sensitive to herbicides, and herbicides are the main kinds of pesticides found in these waterways. This has been shown by Wood et al. (2018) who found that as herbicide concentrations increased the number of sensitive algal species present in waterways decreased for at least the duration of the wet season. While concentrations of pesticides may not be sufficiently high to kill fish, they could be indirectly affected by pesticides through declines in their food (e.g. fish that eat plants or insects), and/or habitats (e.g. aquatic plants and sea grasses). Such indirect effects could decrease the amount of food and shelter available for organisms, including fish, further up food webs. Instability in a food web can lead to increased vulnerability of an ecosystem to other stressors (e.g. disease) and decrease ecosystem resilience.

The estimates of species protected were divided into five categories ranging from very low to very high risk (Table 1) that were aligned to the ecosystem protection levels used in the Australian and New Zealand Water Quality Guidelines (ANZG, 2018). The alignment of the percentage of species protected, pesticide risk categories and the ecosystem protection levels is shown in Table 1.

**Table AE 1. The alignment of the percentage of protected species, risk category and ecosystem protection levels**

| Pesticide risk value<br><br>(% species protection) | Risk category | Ecosystem condition (ANZG, 2018) |
|---|---|---|
| ≥ **99%** | Very Low | high conservation or ecological value systems |
| <99 to **95%** | Low | slightly to moderately disturbed systems |
| <95 to **90%** | Moderate | highly disturbed systems |
| <90 to **80%** | High | |
| <80% | Very High | |

**References**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## Appendix F: Long-term annual rainfall totals (1912 to 2019) for basin areas of the Mackay-Whitsunday-Isaac region

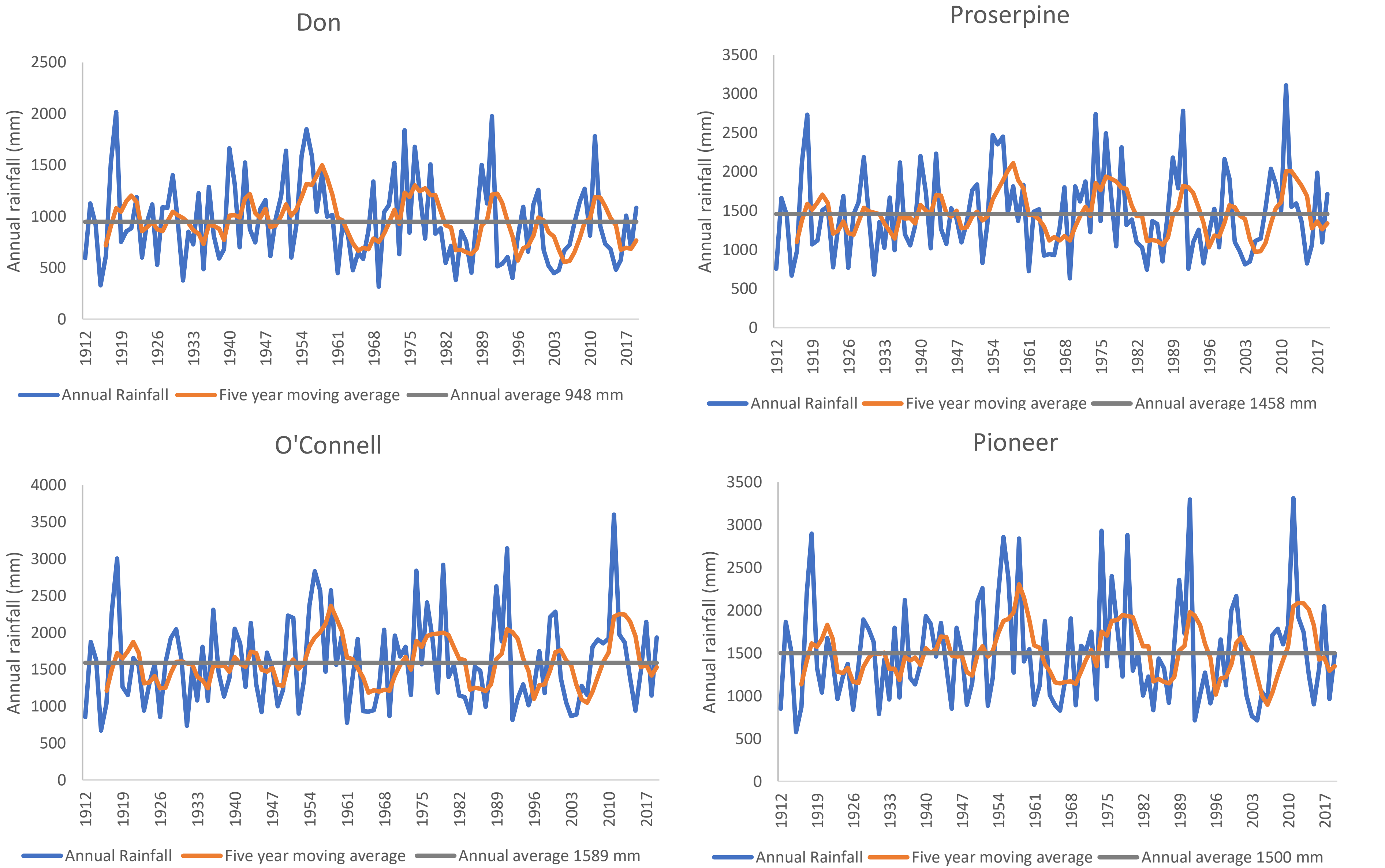


**Figure AF 1. Annual rainfall totals, five year moving average of totals and long-term annual rainfall average (1912-2019) for the Don, Proserpine, O'Connell and Pioneer basins in the Mackay-Whitsunday-Isaac region. Long-term annual rainfall data sourced from the Bureau of Meteorology and calculated using results from 1912-2019, inclusive.**

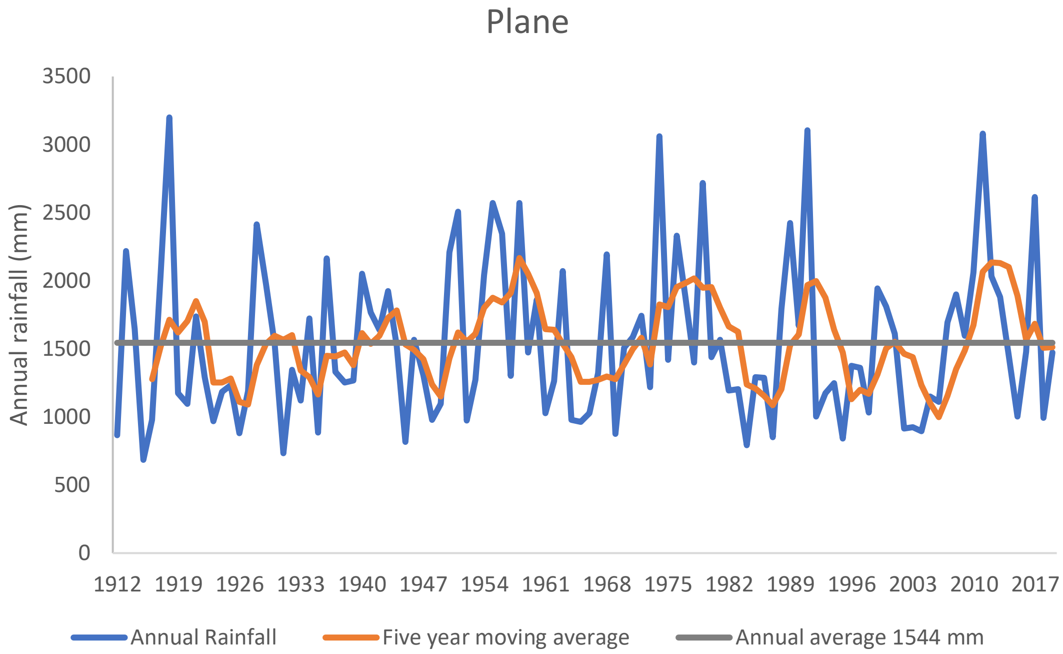


**Figure AF 2. Annual rainfall totals, five year moving average of totals and long-term annual rainfall average (1912-2019) for the Plane basin in the Mackay-Whitsunday-Isaac region. Long-term annual rainfall data sourced from the Bureau of Meteorology and calculated using results from 1912-2019, inclusive.**