Mackay-Whitsunday-Isaac 2021 Report Card Results

Technical Report
Mackay-Whitsunday-Isaac Healthy Rivers to Reef Partnership
July 2022

Authorship Statement

The Mackay-Whitsunday-Isaac (MWI) Healthy Rivers to Reef Partnership (the Partnership) 'Mackay-Whitsunday-Isaac 2021 Report Card Results' technical report was compiled by the Partnership's Technical Officers, Talen Rimmer, Brie Sherow, and Michelle Perez.

Substantial input was received from the Regional Report Card's Technical Working Group (TWG) members. Some content was also drawn from technical reports from earlier MWI Report Cards.

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The Partnership acknowledges the Traditional Owners from the Land and Sea Country of (or within) the region, including the Yuwibara, Koinmerburra, Barada, Widi, Ngaro, Gia and Juru Peoples, and pays respect to the ancestors, the Elders both past and present, and to the people.

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Contents

Terms and Acronyms

AIMS	Australian Institute of Marine Science
AMDI	Australian Marine Debris Initiative
Average	A calculated central value of a set of numbers measured by adding up all values and dividing by the number of values included.
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 that can be expected to result in a moderate–low risk to water quality.
Biodiversity	The variability among living organisms from all sources. It includes diversity within species and between species and the diversity of ecosystems.
Biomass	The total quantity or weight of organisms over a given area or volume.
BoM	Bureau of Meteorology
Chl-*a*	Chlorophyll-*a*: A measure of overall phytoplankton biomass. It is widely considered a useful proxy for measuring nutrient availability and the productivity of a system.
CTF	Cease-to-flow
CV	Coefficient of variation
DDL	Declared Downstream Limit
DEHP	Department of Environment and Heritage Protection, Queensland. Now part of DES.
DES	Department of Environment and Science, Queensland
DHW	Degree Heating Weeks (DHW) are an accumulated measurement of sea surface temperature (SST) that assesses the instantaneous bleaching heat stress during the prior 12-week period. Significant coral bleaching usually occurs when the DHW value reaches 4 °C-weeks. By the time the DHW value reaches 8 °C-weeks, severe, widespread bleaching and significant mortality are likely. Source: Coral Reef Watch, National Oceanic and Atmospheric Administration (CRW, NOAA)[1]
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.

[1] https://coralreefwatch.noaa.gov/product/50km/index.php

Ecosystem health	"An ecological system is healthy and free from 'distress syndrome' if it is stable and sustainable—that is, if it is active and maintains its organization and autonomy over time and is resilient to stress. Ecosystem health is thus closely linked to the idea of sustainability, which is seen to be a comprehensive, multiscale, dynamic measure of system resilience, organization, and vigour." (Costanza, 1992)
EC	An enclosed coastal (EC) water body includes shallow, enclosed waters near an estuary mouth and extends seaward towards deeper, more oceanic waters further out. The seaward cut-off off an EC water body is defined by the Great Barrier Reef Marine Park Authority (GBRMPA, 2010).
Estuary	The aquatic environment at the interface between freshwater and marine ecosystems.
Fish (as an index)	The fish community index, measured by two indicators (the number of indigenous and non-indigenous fish, respectively), is evaluated and included in the ecosystem health assessment (coasters) for basins. Inclusion in the Report Card will contribute to an understanding of the local fish communities.
Fish Barriers (as an indicator)	Fish barriers relate to any man-made barriers that prevent or delay connectivity between key habitats that have the potential to impact migratory fish populations, decrease the diversity of freshwater fish communities, and reduce the condition of aquatic ecosystems (Moore, 2016).
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
GBRCLMP	Great Barrier Reef Catchment Loads Monitoring Program
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—Limits that are defined by experts in their respective fields used to gauge the condition of an indicator/site. If grades/scores do not meet guideline values, this signifies that changes impacting ecosystem health have occurred at a level beyond naturally occurring processes.
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 is an index made up of nutrients, water clarity, chlorophyll-*a*, and pesticides indicator categories).
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-Isaac 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.
IQQM	Integrated water quantity and quality simulation model—used to model pre-development flow for the flow tool score calculations.
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
LTMP	Long-Term Monitoring Program
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 & McCook, 2008).
Mean	The average or 'central' value of a set of numbers.
Measure	A measured value that contributes to an indicator score for indicators that consist of multiple measures (e.g., flow, estuary fish barriers).
Median	The middle value out of a defined list of values.
MMP	Great Barrier Reef Marine Monitoring Program. This provides water quality, coral, and seagrass data for the Central and Whitsunday inshore zones in the Report Card.
MoA	The mode of action is used to classify pesticides according to how they exert their effect on the target organism. The mode of action will be defined by its biochemical effects.
MWI	Mackay-Whitsunday-Isaac
MWQ	Marine water quality (MWQ) dashboard and data—Bureau of Meteorology.

NO_x	Oxidised nitrogen (nitrate and nitrite)
NQBP	North Queensland Bulk Ports Corporation Ltd
Offshore Zone	Offshore is a reporting zone in the Mackay-Whitsunday-Isaac Report Card that includes mid-shelf and offshore water bodies.
Offshore (water body)	Offshore water bodies begin 60 km from the enclosed coastal boundary and extend to 280 km in the Mackay-Whitsunday-Isaac Region (GBRMPA, 2010).
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 eight hectares. Examples of palustrine wetlands include billabongs, swamps, bogs, springs, etc.
Pesticides (as an indicator)	Incorporating up to 22 herbicides and insecticides with different modes of action. A list of the relevant chemical components is provided in the Methods Report.
Pesticide Risk Metric (PRM)	Refers to the methodology for estimation of ecological risk associated with pesticide pollution.
Phys–chem	The physical–chemical indicator category that includes the indicators dissolved oxygen (DO) and turbidity.
PN	Particulate nitrogen
PONSE	Proportion of native (fish) species expected
Ports	NQBP Port Authority
PP	Particulate phosphorus
Pre-clearing	Pre-clearing vegetation is defined as the vegetation or regional ecosystem present before clearing. This generally equates to terms such as ‘pre-1750’ or ‘pre-European’ used elsewhere (Nelder et al., 2019).
Pre-development Flow	The pattern of waterflows during the simulation period, using the IQQM computer program as if there were no dams or other water infrastructure in the plan area and no water was taken under authorisations in the plan area[2].
PSII herbicides	Herbicides that inhibit Photosystem II, an essential component of a plant’s ability to absorb and transfer light energy. These include ametryn, atrazine, diuron, hexazinone, tebuthiuron, bromacil, fluometuron, metribuzin, prometryn, propazine, simazine, terbuthylazine, and 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.

[2] Queensland Government 2016. Water Plan (Wet Tropics) 2013. Water Act 2000. https://www.legislation.qld.gov.au/view/pdf/2016-12-06/sl-2013-0282

Queensland Government	The Queensland Government includes several departments that provide data sources and support for the report card. Key departments for the report card are the Department of Environment and Sciences (includes management of the GBRCLMP); the Department of Regional Development, Manufacturing and Water (includes management of water monitoring); and the Department of Resources (includes management of Queensland Spatial).
QPSMP	Queensland Ports Seagrass Monitoring Program
RCA	Reef Check Australia
RE	Regional ecosystem
REMP	Receiving End Monitoring Program
Resilience (as an indicator)	A multivariate metric developed by the MMP to measure the capacity of seagrass to cope with disturbances (Collier et al., 2021). The resilience metric better accommodates differences in recovery strategies between species in comparison to previous indicators.
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)—a measure of water clarity determined as the depth at which an opaque disc lowered into a water column is no longer visible.
SF	Scaling factor—A value used to set scoring range limits for indicators.
SST	Sea surface temperature
Standardised condition score	The transformation of indicator scores into the MWI Report Card scoring range of 0 to 100.
TC	Tropical Cyclone
TSS	Total suspended solids
TWG	Technical Working Group
Waterway	All freshwater, estuarine, and marine bodies of water, including reefs, and storm drains, channels, and other human-made structures in the MWI Region.
Water quality guideline	For the purposes of waterway assessment, the term water quality guideline refers to values for the condition assessment of water quality drawn from a range of sources, including water quality objectives scheduled under the Environmental Protection (Water) Policy 2009 and water quality guideline values obtained from the Queensland Water Quality Guidelines (DEHP, 2009), the GBRMPA Guidelines (GBRMPA, 2010), and the (ANZG, 2018).

Water quality objective (WQO)	Water quality objective refers to values for the condition assessment of water quality scheduled under the Environmental Protection (Water) Policy 2009.

Executive Summary

The Mackay-Whitsunday-Isaac (MWI) 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 our region's waterways.

The 2021 Report Card, reporting on the 2020–2021 financial year, is the Partnership's eighth Report Card, demonstrating the MWI community's commitment to understanding and caring for the local environment. This commitment is matched outside of regional reporting boundaries, as this is one of five regional report cards released annually in the Great Barrier Reef (GBR) World Heritage Area.

The purpose of this document is to provide the detailed results of the 2021 MWI Report Card and discuss these findings in relation to guideline values, regional climate, and human activities. It contains data from a variety of condition assessments of our local waterways including freshwater, estuarine, and inshore and offshore marine environments. For each of these waterway types, a series of environmental *indicators* are reported, which are aggregated into *indicator categories* and then into *indices*. As the Report Card integrates data from many sources with evolving maturity and comprehensiveness, confidence levels are published following results as are historic scores for comparison where appropriate.

i. Regional Climate

Annual rainfall was lower than the long-term mean throughout the MWI region (BoM (Bureau of Meteorology), 2021). Rainfall was varied and patchy across space and time, with less intensity of events recorded during 2020–2021. Overall, rainfall was average in the Don, Proserpine, and O'Connell Basins, and below average in Pioneer and Plane Basins. In the northern part of the region, the months leading up to the wet season were particularly dry. Rainfall in the Proserpine basin was less than the 30th percentile in both October and November, while conditions in the Don in November were in the lowest 1% of recorded rainfall since 1911 (Figure 7). The onset of wet season led to rainfall recorded above the 70th percentile for all basins in December and continued into January for the Proserpine and O'Connell basins (Figure 7). Regional rainfall is often a key driver of the Report Card scores, as reductions or increases in runoff throughout the region lead to reductions or increases of inputs into aquatic systems.

Extreme events can have long-lasting impacts on aquatic ecosystems. In recent history, the impact of the 2020 marine heat wave and bleaching event are still widespread in parts of the GBR. This event extended much further south than the 2016 and 2017 mass bleaching events. In the MWI Region the bleaching appeared to be mostly non-lethal, however continued recovery depends on a prolonged period of favourable conditions. With lingering impacts of Tropical Cyclone (TC) Debbie on coral communities across the region, bleaching events such as this are likely to further hinder coral reef recovery.

Under current climate change projections, marine heatwaves as recorded in 2020 are going to become more widespread, frequent, and intense. Climate scientists also predict more extremely hot days and a higher intensity of short-duration heavy rainfall events. Cyclones are expected to decline in frequency but increase in intensity. For these reasons, climate change remains the most significant threat affecting the health of the GBR (Folkers et al., 2014).

ii. Freshwater Basins

For freshwater basin condition assessments, water quality, flow scores, and freshwater fish were updated for this reporting period. The majority of the habitat and hydrology index were based on repeated data (following three or four-year reporting cycles). (Section 2.Freshwater Basin Results)

Freshwater basins key findings:

Overall grades for freshwater basins ranged from 'moderate' to 'good' with the only grade change reported being the O'Connell Basin ('good' (63) to 'moderate' (60); Table I).

MWI **basin water quality index grades were similar** to the previous monitoring period with the exception of the Plane Basin, which declined from 'moderate' (42) in 2019–20 to 'poor' (38) in 2020–21 (Table I). **Sediment scores did not meet guideline values** in the MWI Region, with 'moderate' to 'very poor' grades observed across the Don, O'Connell, and Plane basins for five or more consecutive years. Most basins received the **same grade for the Nutrients indicator category** as the previous year. The Plane Basin reported the only grade change, with a decline from 'moderate' to 'poor', due to increased concentration of both FRP and DIN in Sandy Creek. **Pesticide risk remained the poorest scoring indicator** for basin water quality in the MWI region, with most of the region's basins recording either 'poor' or 'very poor' grades. As with previous years, applications of imidacloprid and diuron due to intensive land use were the key contributors to pesticide risk across most of the MWI region.

Only the **flow indicator** category data were updated in the **habitat and hydrology index** in this year's Report Card. The Plane Basin recorded a grade improvement for the second consecutive year, shifting from 'moderate' condition in 2020 to 'good' in the 2021 Report Card. The **freshwater fish index** was updated for the 2021 Report Card, with all basins receiving 'good' or 'very good' grades. The Don Basin was assessed for the first time, receiving the highest score of any basin in the region (88; Table I).

Table I. Condition grades and scores of freshwater basins for the 2021 Report Card compared to 2014–2020 Report Cards.

Freshwater Basin	2021 Report Card					2020	2019	2018	*2017	^2016	^2015	^2014
	Water Quality	Habitat and Hydrology	Fish	Basin Score and Grade		Basin Score						
Don	58	75	88	**74**	**B**	**62**	71	56	47	48	48	54
Proserpine		50	80	**65**	**B**	**65**	65	66	53	53	53	52
O'Connell	53	43	83	**60**	**C**	**63**	63	66	54**	58	57	52
Pioneer	48	33	75	**52**	**C**	**53**	56	54	40	41	41	34
Plane	38	39	73	**50**	**C**	**53**	51	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 that have been back-calculated to incorporate updates to freshwater pesticides made in the 2018 Report Card.

**2017–2014 scores do not incorporate additional sites included for the first time in the 2018 Report Card.

^ 2016–2014 Report Card scores do not include back-calculated pesticide updates established for the 2018 Report Card.

iii. Estuaries

Estuarine water quality scores were updated for this reporting period while condition assessments were based on repeated data for the habitat and hydrology index (following three- or four-year reporting cycles).

Estuaries key findings:

Overall estuary grades ranged from 'moderate' to 'very good', with the only grade change reported in the Vines Creek estuary (declined from 'good' (68) in 2019–20 to 'moderate' (60) in 2020–21) (Table II).

MWI **estuarine water quality index grades** (combining nutrients, chlorophyll-*a* (chl-*a*), phys–chem, and pesticide risk scores) saw a **decline in the Vines Creek Estuary** ('good' in 2019–20 to 'moderate' in 2020–21). Change was predominantly due to a decline in DIN grades, with increased ammonia recorded in the estuary during the 2020–21 monitoring period in comparison to the previous year. The greatest change in the **Chl-*a* indicator** was a decline in the Rocky Dam Estuary from 'good' in the 2019–20 monitoring period to 'poor' in 2020-21. This is the lowest grade recorded in the Rocky Dam Estuary since the Report Card's inception. **For pesticides, the Rocky Dam Estuary had the largest score change** of all monitored estuaries in the 2020–21 monitoring period, improving two grade categories from the previous year ('poor' to 'good'). This is primarily due to a decrease in risk for atrazine, diuron, imidacloprid, and imazipic. Conversely, the Vines Estuary declined from 'good' to 'moderate' in comparison to the previous monitoring period due to an increased risk for imidacloprid, diuron, and metsulfuron-methyl.

Table II. Condition grades and scores of estuaries for the 2021 Report Card compared to 2015–2020 Report Cards.

Estuary	2021 Report Card					2020	2019	2018**	2017*	2016*	2015*^
	Water Quality	Habitat and Hydrology	Fish	Estuary Score and Grade		Estuary Score					
Gregory River	79	83		**81**	**A**	81	80	82	79	80	79
O'Connell River	56	57		**56**	**C**	56	56	51	61	54	57
St Helens/Murray Creek	63	69		**66**	**B**	67	64	57	61	61	63
Vines Creek	56	65		**60**	**C**	68	57	68	64	72	73
Sandy Creek	53	45		**49**	**C**	51	51	58	52	50	52
Plane Creek	81	56		**68**	**B**	64	63	68	67	59	61
Rocky Dam Creek	65	73		**69**	**B**	67	66	76	70	73	70
Carmila Creek	70	92		**81**	**A**	82	78	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

*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.

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

^Data from 2015 Report Card are repeated from the 2014 Report Card.

iv. Inshore and Offshore Marine

All indicators of inshore marine condition, and offshore marine corals are updated annually. Offshore water quality is not currently reported as new data sources are being investigated. In the 2021 Report Card litter is reported at the site-level and is not included in overall zone scores.

Inshore and offshore marine key findings:

Water quality in the Whitsunday Zone improved for the third consecutive year[3] with a current score of 'moderate', driven largely by improvements in Chl-*a.* The Central Zone water quality grade improved from 'poor' to 'moderate', largely driven by reduced concentrations of nutrients. The pesticide risk grade in the Central Zone improved for the fourth consecutive year with a current score of 'very good'.

Coral scores reflect pressures from poor water quality and extreme weather events. For the five years since TC Debbie, coral cover and juvenile density in the Whitsunday and Northern Zones have remained 'poor' or 'very poor', demonstrating limited recovery of these coral communities. Improvements in the Central Zone were driven by increased juvenile recruitment and decreased macroalgae coverage, while the Southern Zone continued to experience decline driven by a heat wave in February 2020.

Seagrass index grades did not change in Northern or Whitsunday Zones. Both Central and Southern Zones saw a decline from 'good' to 'moderate' driven by reduced meadow area, likely related to poor water quality and suspended sediments.

Table III. Condition grades and scores of inshore and offshore marine zones for the 2021 Report Card compared to 2017–2020 Report Cards. Note that data are not directly comparable due to changes in methods for several indicators.

	2021 Report Card						2020^^	2019^	2018	2017*
	Water Quality	Coral	Seagrass	Fish	Total Score and Grade		Total Score			
Northern	53	32	70		51	C	50	43	35	44
Whitsunday	42	31	29		34	D	32	25	27	27
Central	54	43	58		52	C	44	36	37	31
Southern	52	16	60		42	C	43	34	22	
Offshore		59					77	77	77	76

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

^^2020 scores adjusted to refer to back-calculated results due to changes in water quality and seagrass methods applied in the 2021 Report Card.

^2019 scores adjusted to refer to back-calculated results due to changes in seagrass methods applied in the 2021 Report Card.

*2017 scores adjusted to refer to back-calculated results due to changes in pesticide and seagrass methods applied in the 2018 Report Card.

[3] These improvements make reference to the back-calculated scores, where water quality improved from 'very poor' in the 2019 Report Card to 'poor' in the 2020 Report Card in the Whitsunday Zone.

1. Introduction

1.1. Purpose of this document

The purpose of this document is to provide detailed results to support the 2021 Mackay-Whitsunday-Isaac (MWI) Report Card on waterway health. The results provided in this document relate to the condition of environmental indicators.

This document presents scores and grades based on data collected between July 1st 2020 and June 30th 2021 (refer to the Mackay-Whitsunday-Isaac 2021 Report Card Methods[4] (hereafter referred to as the Methods Report) for indicators that are updated on three and four-year cycles). The 2021 condition assessments (scores) for environmental indicators in their original scale, and standardised scores that (where relevant) were used for aggregation are presented alongside confidence levels associated with results.

The 2021 Report Card results were compared to 2020–2014 results where applicable. Where this is not the case, previous results back-calculated using alternate methods are presented for reference. Additional information associated with 2021 Report Card results are contained in appendices.

1.2. Background

The MWI 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 (Figure 1). The 2021 Report Card includes condition assessments of the freshwater, estuarine, and marine ecosystems in the reporting region.

For each index, a series of indicators broken into different indicator categories is used to provide a holistic assessment of these environmental, social, cultural, and economic factors. In contrast to last year, this report does not include human dimension reporting for agricultural stewardship due to the current review of agricultural management practice targets[5].

The 2017–2022 Program Design[6] outlines the guiding framework for the development and scope of the 2021 Report Card. Since the publication of the Program Design in 2018, changes to the scope of assessment (monitoring sites and methods) have occurred and are highlighted where relevant throughout this document. For more detail on the methods used to produce the MWI 2021 Report Card, refer to the Methods Report[3] and the Mackay-Whitsunday Report Card Program Design 2017 to 2022[5].

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[4] https://healthyriverstoreef.org.au/report-card/report-card-download/
[5] https://alluviumgroup.mysocialpinpoint.com.au/apa-review
[6] https://healthyriverstoreef.org.au/wp-content/uploads/2018/12/mackay-whitsunday-report-card-program-design-2017-2022.pdf

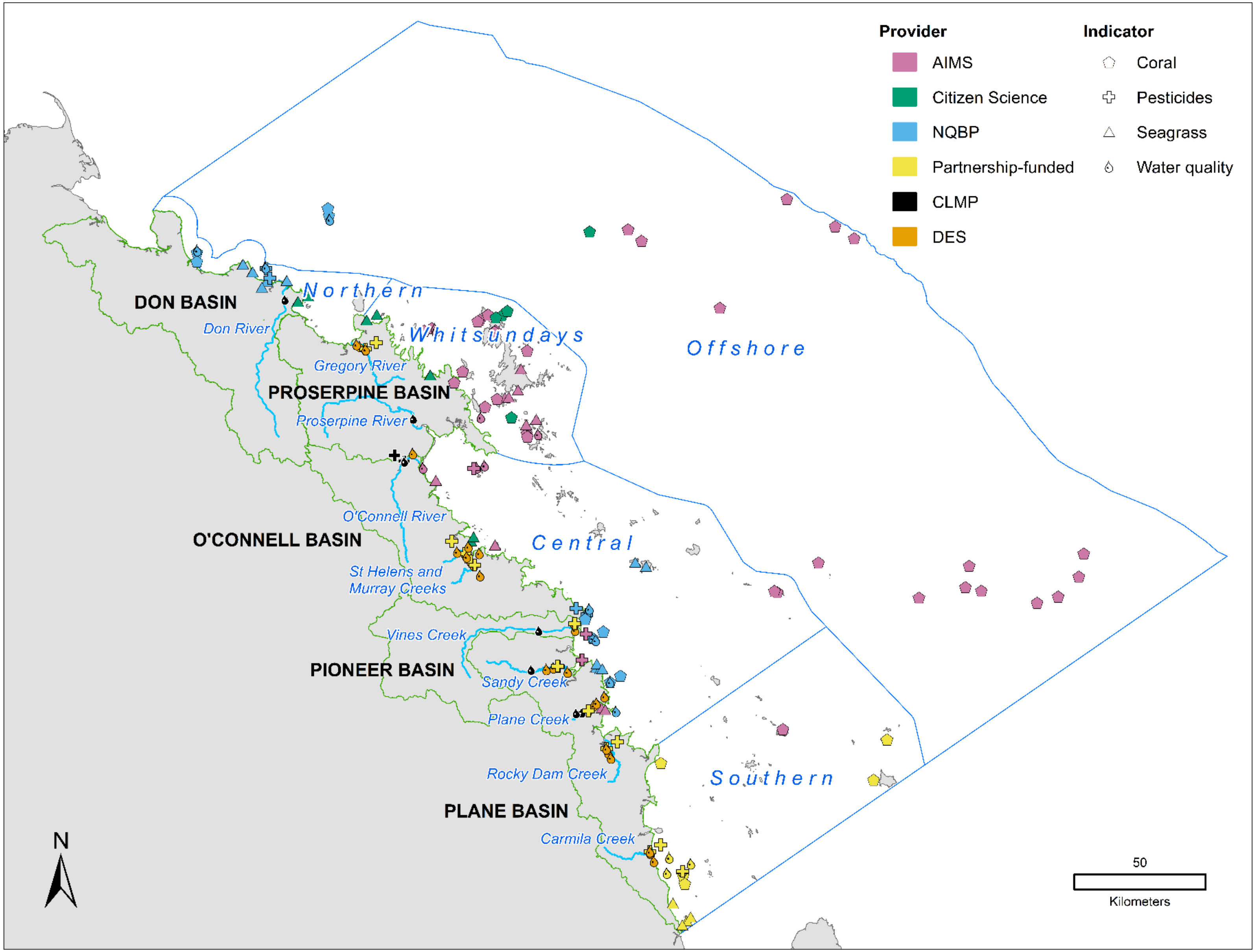

Figure 1. Mackay-Whitsunday-Isaac reporting region showing sampling sites within freshwater basins, inshore (designated by the local or state jurisdictional boundary), and offshore marine zones (designated by the commonwealth boundary).

1.3. Terminology

The Report Card assesses different ecosystem health (environmental) indicators to report on the overall condition of MWI waterways. Scores for indicators are aggregated depending on the aspect of the environment they are assessing and typically follow three key themes: water quality, habitat, and fish.

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

An **indicator** is a measured value (e.g., particulate nitrogen concentration).

Indicator categories (e.g., nutrients) are generated by one or more indicators.

Index/indices (e.g., water quality) are generated by the aggregation of indicator categories.

Grades are generated by the aggregation of indices or by a single index score.

Figure 2. Terminology used for defining the level of aggregation of indicators and how they are displayed in coasters in the Report Card.

In the Report Card, overall scores and grades for indices are represented in the format of a coaster (Figure 2). Presentation of the coasters can be with or without the outer ring (i.e., indicators).

Ordinal categories are used to describe the scores for condition of indicators, indicator categories and the overall score. This follows a five-point grading system from 'very good' (A) to 'very poor' (E) (Table 1). Indicators have specific scoring ranges and bandwidths, which are listed below the relevant results tables. Results for indicators that have divergent scoring ranges and bandwidths are required to be translated into a common scoring range before aggregation (based on that used by the GBR Water Quality Report Card (Table 1).

Table 1. Overall range of scores and grades within the Report Card.

Scoring Range	Condition Grade and Colour Code
81 to 100	A = Very Good
61 to <81	B = Good
41 to <61	C = Moderate
21 to <41	D = Poor
0 to <21	E = Very Poor

1.4. Regional Setting

1.4.1. Drivers of Condition Assessments During 2020–2021

Climate, population, and the economy are the key external forces that influence the condition of waterways in the MWI Region, either directly or by driving activities that put pressure on local waterways[7] (Figure 3). The MWI Partnership reporting region includes the Don, Proserpine, O'Connell, Pioneer, and Plane basins and is made up of 33 sub-catchments that flow into eight receiving waters, from the Don River in the north to the Carmila coast in the south. Land use in the region is dominated by agricultural activities, including sugarcane, grazing and horticulture, and other activities, such as mining and urban development. These terrestrial activities can put pressure on local freshwater and estuarine waterways due to the mobilisation of sediments, nutrients, pesticides, 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 waters (Figure 3). Additional pressures that can impact the region's marine ecosystems include ports and marinas, shipping, fishing, tourism, and recreational activities (Figure 3).

Figure 3. Conceptual diagram of the key drivers, pressures, and ecosystems in the MWI Region. Source: J. Prange, GBRMPA.

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

Weather events are a key driver likely to affect scores of many environmental indicators. Recent events within Mackay-Whitsunday-Isaac include below average rainfall between 2019–2021, a marine heat wave in 2020, a monsoon trough that impacted the northern extent of the region during the 2018–19 wet season, and the residual impacts of Tropical Cyclone (TC) Debbie in March 2017.

1.4.2. Regional Climate

Geographically, the MWI region is situated in North Queensland, north of the Tropic of Capricorn and typified by a tropical to subtropical climate. Regionally, the climate is characterised by two distinct seasons: a wet (November to April) and a dry (May to October) season. During the wet season, the MWI area may experience elevated rainfall, tropical lows, and cyclones. Upon making landfall, cyclones may generate considerable rainfall and flooding in addition to increased sediment resuspension in the marine environment. In the northern extent of the region (i.e., Don Basin), predominant trade winds create a similar but smaller-scale effect; dry season south easterly trade winds result in increased wave action on nearshore benthos leading to larger volumes of sediment resuspension.

Annual shifts in weather patterns 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.

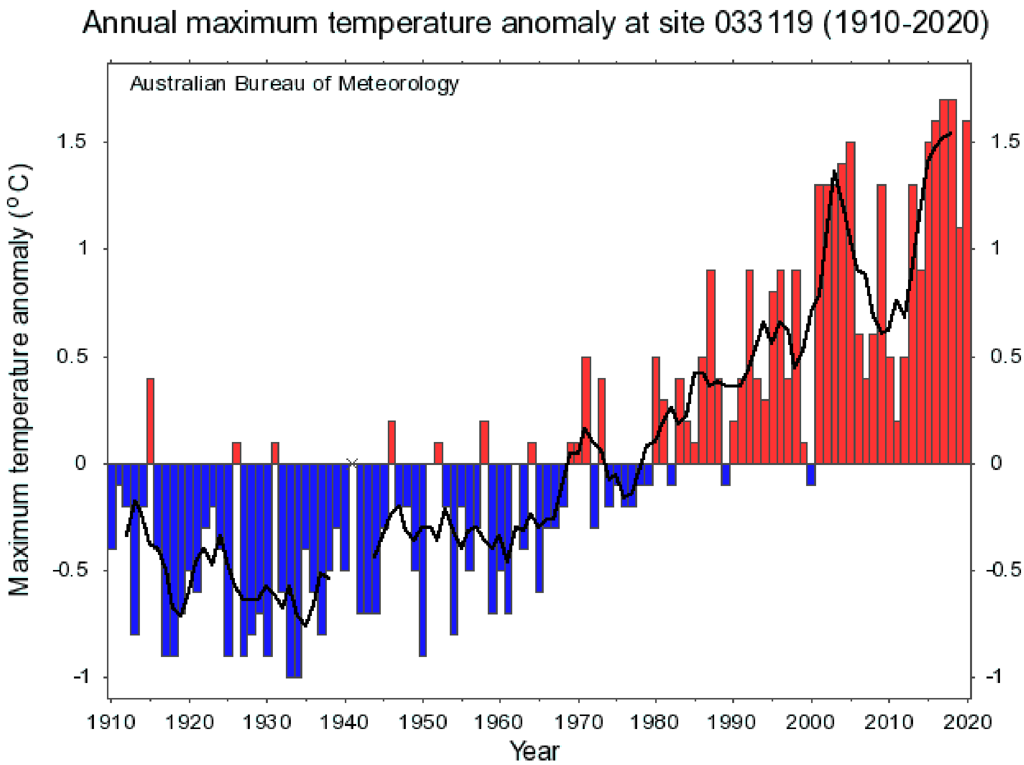

Figure 4. Annual maximum temperature (˚C) anomaly at Mackay (site 033119) from 1910 to 2022. A rolling five-year average is shown by the black line. Source: Bureau of Meteorology, Australia climate change site data (http://www.bom.gov.au/climate/change/hqsites/).

1.4.3. Climate Change

Since records began in 1910, Australia's climate has warmed by 1.44°C (±0.24°C)[8]. The majority of this warming has occurred since 1950, with every decade since being warmer than the one before. 'Very high' monthly maximum temperatures now occur six times as often as they did in 1960[7]. This is reflected locally, with the Mackay weather station recording annual maximum temperature (°C) anomalies that have been above zero (unusually warm) almost every year since the 1980s—a stark change to the 70 years prior (Figure 4).

Rainfall variability has increased such that while wet season rainfall has increased in northern Australia since the 1970s, annual rainfall totals are below average across much of this region. The intensity of rainfall events has increased, causing a higher risk of flash flooding that can impact agricultural and urban communities and natural ecosystems[7].

In Australian waters, the average sea surface temperature (SST) has risen by more than 1° C since 1900. Eight of the ten warmest years on record have occurred since 2010[9]. Marine heatwaves have consequently increased in frequency and duration (defined by temperatures in the upper range of historical baseline conditions for 5+ days). This is of concern as marine heatwaves can cause permanent damage to marine ecosystems, including the depletion of seagrass meadows, higher occurrences of disease and wide-spread coral bleaching, and a reduction in coral resilience[8].

In addition to these impacts, rising atmospheric CO_2 levels are causing oceans to increase their CO_2 uptake, causing a decline in ocean pH. This process of ocean acidification reduces the calcification rate in species that produce shells or have calcium carbonate skeletons, such as corals. Since the 1880s, the average pH of Australia's surface waters has decreased by 0.12—a 30% increase in acidity[8].

Climate change is the most significant threat affecting the health of the Great Barrier Reef (GBR), impacting this ecosystem through several cumulative impacts (GBRMPA, 2019). Perhaps the greatest threat among these is the increase in atmospheric temperature, with more extremely hot days and fewer extremely cold days. There will likely be an increased frequency of high intensity, short-duration rainfall events, impacting stream flow and erosion[10]. Cyclones are predicted to decline in frequency but increase in intensity, which is likely to have major consequences for coastal communities and ecosystems when combined with sea level rise. Marine heatwaves will become more frequent and intense, becoming larger in their spatial and temporal scales. Ocean acidification is also predicted to worsen with rising CO_2 levels[7], putting increased pressure on coral populations that are already under significant stress.

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[8] http://www.bom.gov.au/state-of-the-climate/australias-changing-climate.shtml

[9] http://www.bom.gov.au/state-of-the-climate/oceans.shtml

[10] http://www.bom.gov.au/state-of-the-climate/future-climate.shtml

1.4.4. Rainfall

Australian rainfall for the 2020–21 period was 10% above the 1961–90 climatological averaging period, a departure from the preceding three drier-than-average periods (2017–18, 2018–19, and 2019–20, respectively). A weak La Niña contributed to the third-wettest December on record and wettest northern wet season since 2016–17 for the country[11]. However, in the MWI Region rainfall was below average for the 2020–21 reporting year, ranging between 68 and 89% of the long-term mean (Figure 5; Table 2), and rainfall events were of a lower intensity. The Don Basin has consistently been the driest of the MWI basins since 1911, with a long-term mean of 942 mm compared to between 1,453 and 1,584 mm for the other basins (Table 2). In the last ten years, the Don Basin has recorded eight years with rainfall below this mean, including the 2020–21 reporting year (Appendix A), at just 78% of the long-term mean (Table 2). Both the Plane and Pioneer basins have had annual rainfall totals below the long-term mean for the last four years, and seven of the last eight years (Appendix A). All basins had lower annual rainfall in 2020–21 than the long-term mean, with lower annual rainfall in the O'Connell, Pioneer, and Plane Basins during the 2020–21 reporting year compared to the 2019–20 reporting year (Figure 6).

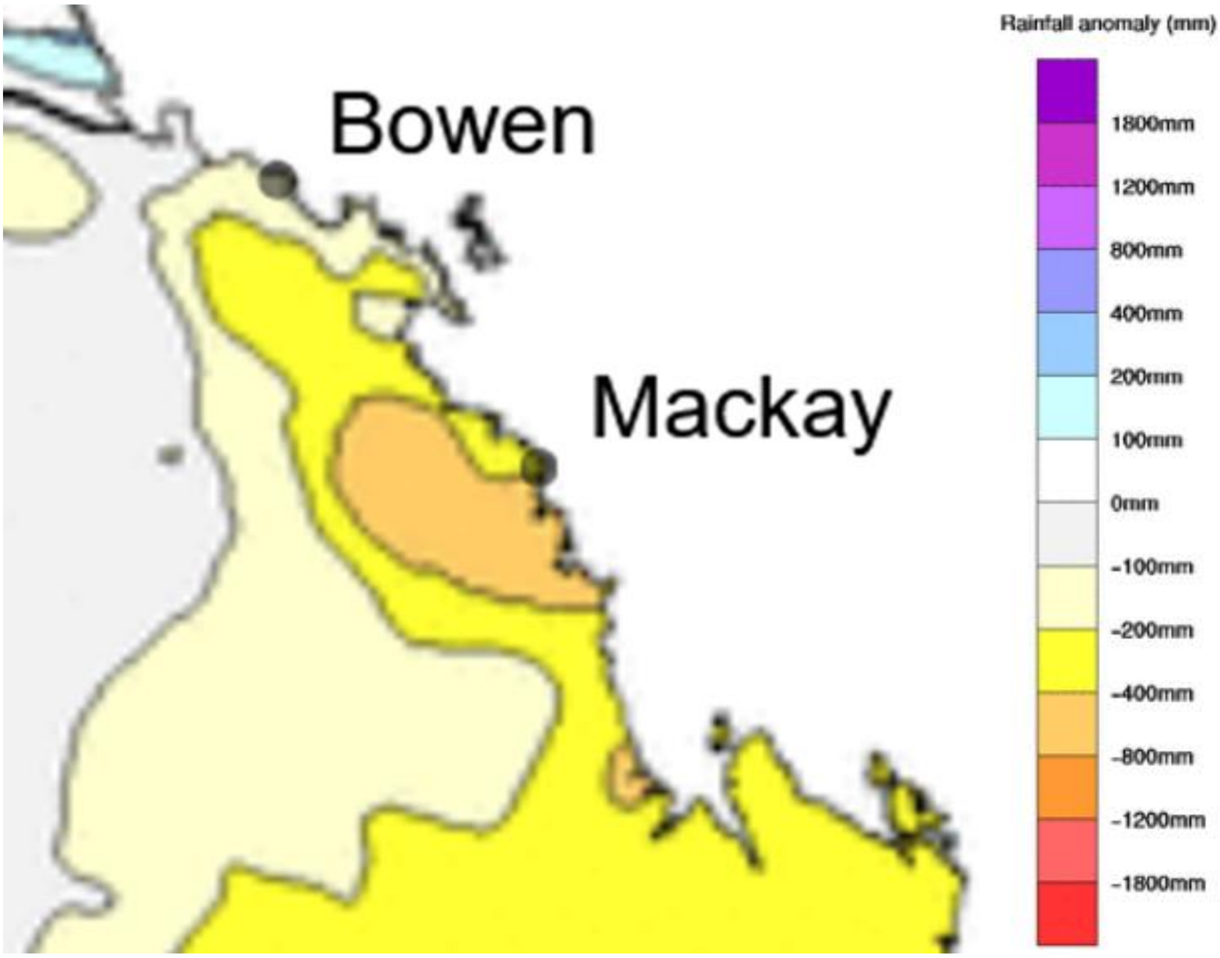

Figure 5. Difference of annual rainfall (2020–21) from long-term mean annual rainfall for the Mackay-Whitsunday-Isaac Region. The long-term mean is represented as a 'difference from mean rainfall' of 100% and was based upon historical rainfall records from 1912 to 2021. Data source: Bureau of Meteorology Regional Water Information Portal (http://www.bom.gov.au/water/rwi/#ra_pa/048/2019).

[11] http://www.bom.gov.au/climate/updates/articles/a039.shtml

Table 2. Annual rainfall statistics for basins in the MWI Region for 2020–21.

Basin	Total (mm)	Long-term mean (mm)	Percentile	Anomaly (mm) (+/- long-term mean	Percentage (%) of long-term mean
Don	733	942	4–7	−209	78
Proserpine	1294	1453	4–7	−158	89
O'Connell	1294	1584	4–7	−290	82
Pioneer	1016	1494	2–3	−477	68
Plane	1086	1539	2–3	−453	89

Percentile category: 1: very much below average, 2–3: below average, 4–7: average, 8–9: above average, 10: very much above average.

Annual rainfall patterns obscure the variation in rainfall observed throughout the year, with some months recording above average rainfall and others being very much below average (Figure 7). July and December 2020 reported 'above average' rainfall across all MWI basins, with 'above average' or 'very much above average' in much of the western and northern regions of Queensland[12]. February and May 2021 were relatively dry months, with all basins except the Don reporting 'below average' in February and all basins reporting 'below average' in May, except the Plane Basin, which was 'very much below average'. This pattern was seen across other regions of Queensland, with most of the state receiving little to no rain in May, in particular[11].

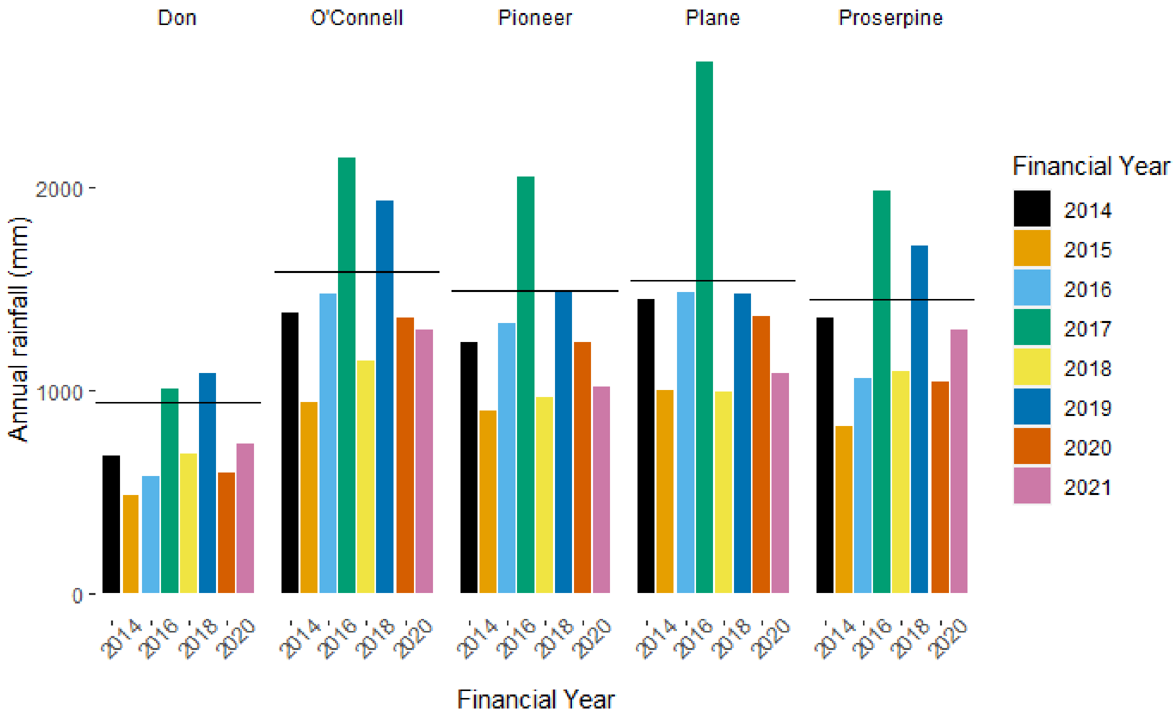

Figure 6. Annual rainfall across the Mackay-Whitsunday-Isaac Region basins for the 2020–21 reporting period compared to previous reporting periods and the long-term mean (1912–2021) represented by a horizontal black line. Data source: Bureau of Meteorology Regional Water Information (http://www.bom.gov.au/water/rwi/#ra_pa/048/2019).

[12] http://www.bom.gov.au/climate/current/annual/qld/summary.shtml

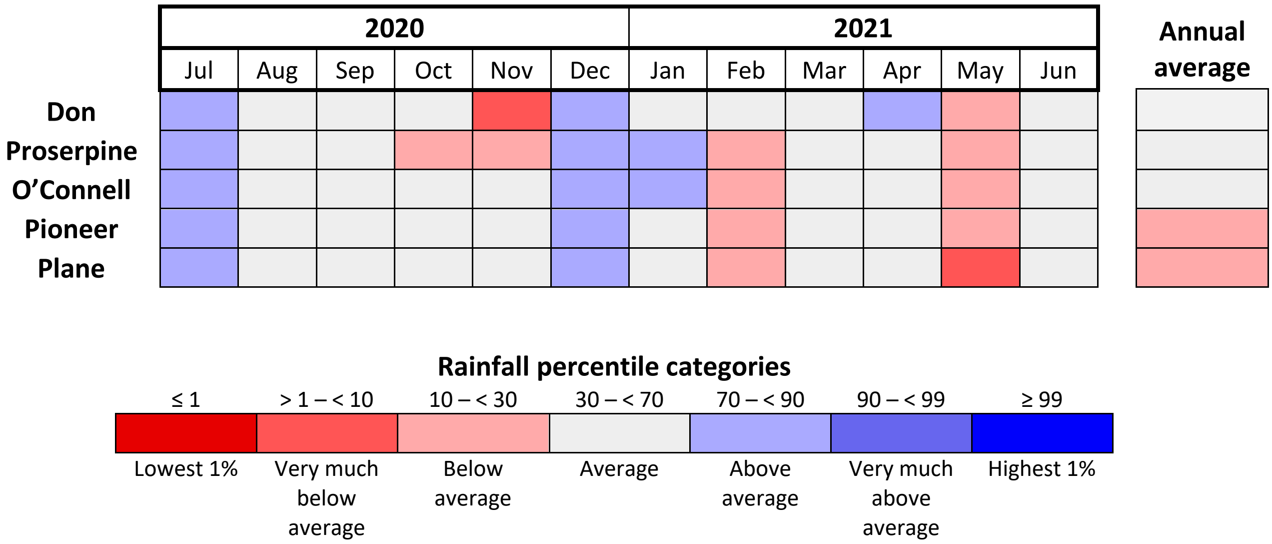

Figure 7. Monthly rainfall percentiles and annual average percentile for basin areas for the Mackay-Whitsunday-Isaac Region for 2020–21. Data source: Bureau of Meteorology Regional Water Information (http://www.bom.gov.au/water/rwi/#ra_pa/048/2019).

Due to the low rainfall across the MWI region for 2020–21, discharges measured at gauging stations across the region were generally much lower than the long-term mean annual discharge[13] (Figure 8). This impacted ecosystem condition scores across freshwater, estuarine, and marine MWI zones. Due to the impacts of climate change, declines in annual streamflow are being seen across the country, with many of Australia's largest basins (e.g., the Murray–Darling Basin) showing declining trends since 1975[7].

1.4.4.1. Agricultural Context

Late wet season conditions in 2020 (Figure 7) caused cane planting to be delayed until July or afterwards, which in turn increased fertiliser applications and herbicide spray during October – December 2020. An extended dry period that extended into October/November 2020 (Figure 7) meant that weed growth was suppressed and conditions were unsuitable for spraying across unirrigated farms (P. Trendell, pers. comm. 05/04/22). This was reflected in pesticide scores across the MWI basins, with most zones remaining similar to last year (Sections 2.1.3 (Basins).

A large proportion of spraying was done in mid-December 2020 once growers completed their crush, and increased rain in December and January 2021 meant that growers applied herbicides and insecticides during breaks in the weather. Runoff events began in late December 2020, and many chemicals had a peak of detections above ecosystem guidelines until mid-January (P. Trendell, pers. comm. 05/04/22).

A second peak in chemical detection in mid to late March suggests the application of herbicides and insecticides after the run-off events in late January. Variable rain across the district meant that ratoon blocks were still having fertiliser, herbicides, and insecticides applications in February 2021 (P. Trendell, pers. comm. 05/04/22).

[12] http://www.bom.gov.au/climate/current/annual/qld/su

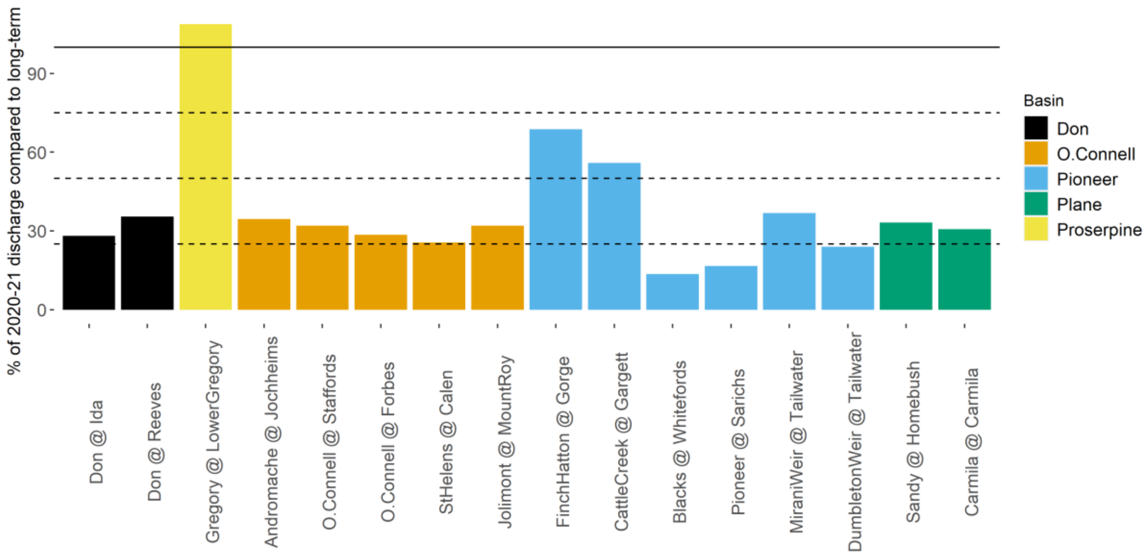

Figure 8. Proportion of 2020–21 discharge recorded from gauging stations at major river channels in Mackay-Whitsunday-Isaac Region compared to the long-term mean. The long-term mean is represented by a solid black horizontal line, while dashed lines represent 25%, 50%, and 75% of long-term mean. Long-term mean annual discharge is based on historical gauging station records until present; the time frame varies according to station. Source: Queensland Government (water-monitoring.information.qld.gov.au).

1.4.5. Coral Bleaching

Heat stress in coral is a measure of the duration of time in which the temperature exceeds the long-term mean maximum, with four Degree Heating Weeks (DHW) likely to cause significant coral bleaching[14]. The marine heatwave of 2020, where SSTs on the Great Barrier Reef during February were the warmest on record, caused significant coral bleaching events, including in areas that had experienced little to no bleaching in previous heat waves[15]. The event was attributed to climate change, a strong positive Indian Ocean Dipole, and local weather patterns[16]. Despite the severity of the 2020 heatwave, much of the bleached coral remained alive with the potential for recovery[17]. In the MWI region, 2021 had fewer DHW than 2020, with no parts of the inshore reef reaching four DHW (Figure 9). Despite being warmer than average, the conditions were relatively milder in 2021 and there were no prolonged high temperatures or major cyclone events[18].

While MWI reefs were directly impacted by the heatwave of 2020, there was evidence of recovery across the region[19] (discussed further in Section 4.2 Coral). Full recovery and future health of coral depends on continued lack of disturbances, and it is important to continue monitoring these habitats. While heat stress is particularly damaging for corals, it can also have major impacts on seagrass meadows and other organisms on the GBR.

[14] https://coralreefwatch.noaa.gov/satellite/education/tutorial/crw24_dhw_product.php
[15] https://www.gbrmpa.gov.au/news-room/latest-news/latest-news/coral-bleaching/2020/statement-coral-bleaching-on-the-great-barrier-reef
[16] http://www.bom.gov.au/environment/doc/2020-GBR-marine-heatwave-factsheet.pdf
[17] https://www.gbrmpa.gov.au/news-room/latest-news/latest-news/coral-bleaching/2020/statement-aerial-surveys-on-the-great-barrier-reef
[18] https://www.gbrmpa.gov.au/news-room/latest-news/latest-news/corporate/2021/relief-for-the-great-barrier-reef-this-summer
[19] https://www.gbrmpa.gov.au/news-room/latest-news/latest-news/corporate/2021/statement-long-term-monitoring-program-annual-summary-report

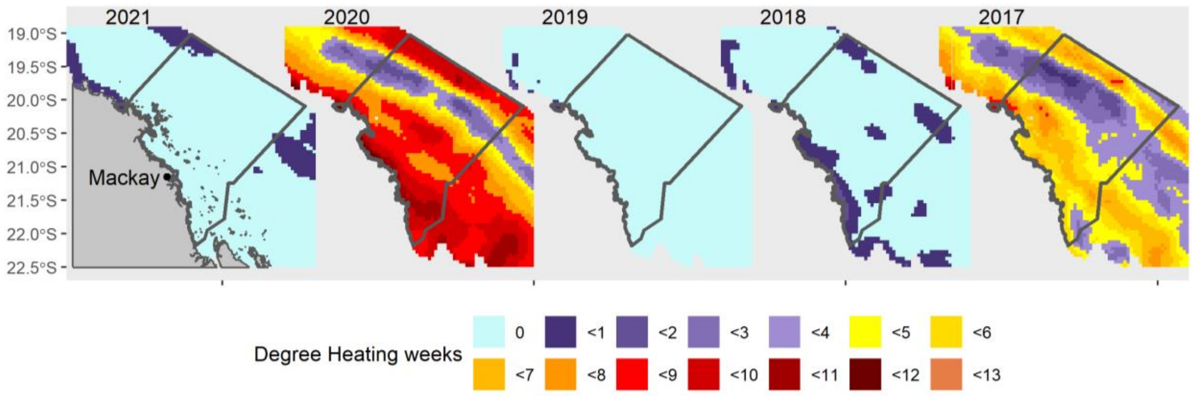

Figure 9. Degree heating weeks for the MWI Region from 2017 to 2021. This is a measure of heat stress accumulation over the past 12 weeks by summing SSTs exceeding 1°C above the long-term mean maximum temperature. Source: NOAA coral reef watch.

1.4.6. Tropical Cyclones

Tropical cyclone (TC) systems in the region develop from tropical lows, typically between November and April. The cyclone season across Queensland was below average and there were no significant storm events recorded in the Mackay-Whitsunday-Isaac region during 2020–2021[20]. This is in line with current climate trends, showing a decline in the number of TCs across Australia since 1982[5]. It has, however, been predicted that the intensity of cyclones will increase[7].

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[21]. Flow-on effects arising from TC Debbie in 2017 continue to impact some ecosystems, particularly evident in coral and seagrass condition scores in the inshore marine environment.

[20] http://www.bom.gov.au/cyclone/tropical-cyclone-knowledge-centre/history/past-tropical-cyclones/
[21] http://www.bom.gov.au/cyclone/history/debbie17.shtml

2. Freshwater Basin Results

The overall freshwater basin grades were derived from three indices: water quality, habitat and hydrology, and fish; each made up of a series of indicator categories and indicators (Figure 10). Water quality indicators and the flow indicator category were updated in the 2021 Report Card while the remainder refer to repeat data as per approved sampling timelines and methodologies. The designated reporting frequency reflects a combination of the gradual nature of change associated with these indicators and the logistical feasibility of assessing them. For more information on reporting frequencies and metrics for each indicator, refer to the Methods Report[2].

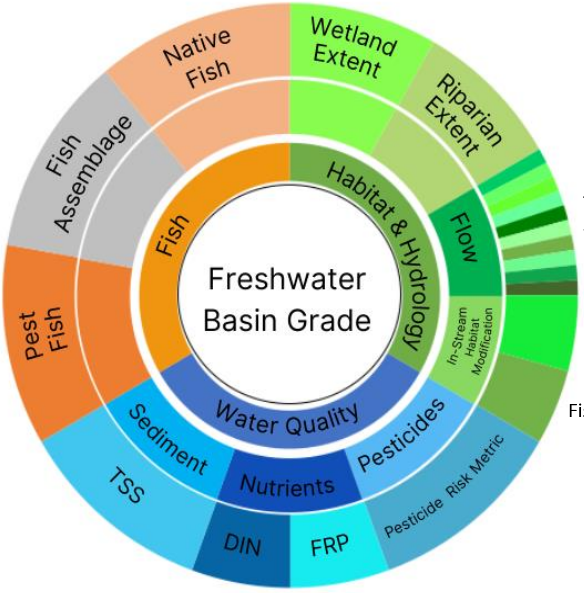

Figure 10. Indicators (outer ring), indicator categories (middle ring) and indices (inner ring) that contribute to overall freshwater basin scores.

2.1. Water Quality in Freshwater Basins

Water quality condition scores for the 2021 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 sites: one in each of the Don and Pioneer Basins and two in the O'Connell and Plane Basins (Figure 11).

Where multiple monitoring sites exist within a reporting zone, a weighted average of site-level scores was used to determine the relevant indicator score (Appendix B.3.). In each case, weightings are based upon the catchment area draining into the waterway upstream of the gauging station. Further information on site and sampling methodology is provided in the Methods Report[3].

Water quality samples in MWI basins are collected using two methods: manual grab sampling and automated grab sampling using refrigerated pump samplers. Intensive automated sampling (daily or every few hours) occurred during high flow events, and monthly sampling during low or base-flow (ambient) conditions. Where sites are tidally influenced, samples were collected on the outgoing low tide[22].

Water quality criteria for assessment was derived from the Queensland Water Quality Guidelines (DES, 2009) for all MWI basins except for the Don. Criteria assessments for the Don Basin were based on the ‘Draft environmental values and water quality guidelines: Don and Haughton River basins, Mackay-Whitsunday-Isaac 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 Report[3].

Notes on data interpretation for 2021 Report Card results:

Tidal Influence in Proserpine River: While water quality data were collected from the Proserpine River end of the catchment loads monitoring site at Glen Isla, the site is located in the estuary. Therefore, concentrations of nutrients and sediments at this site are influenced by tidal movements and are not suitable for reporting the ambient state (concentration) of nutrients and sediments in the freshwater ecosystem. As a result, and consistent with previous reporting since 2018, nutrient and sediment indicator category results for the Proserpine Basin are not reported in the 2021 Report Card. The dilutive potential of the tidal inflow of seawater is not anticipated to decrease the magnitude of the Pesticide Risk Metric (PRM) score substantially (see Methods Report[3] for further detail), and pesticides are still reported for the Proserpine Basin. Work is currently being undertaken to find a suitable freshwater sampling site in the Proserpine River.

Low flow in Don River: Due to a lack of surface flow in the Don River for much of the 2020–21 monitoring period water quality monitoring in this basin was restricted to periods of substantial rainfall in the area, specifically from January–April 2021. Despite the condensed sampling period, scores for total suspended solids (TSS) and nutrients in the Don Basin were allocated as if water quality monitoring data encompassed both ambient (low flow) conditions and event (high flow) conditions, in line with other MWI basins. Therefore, grades for the Don Basin should not be directly compared to previous Report Card grades that were calculated using data from uninterrupted sampling and should be considered in light of wet season representation.

[22] Catchment pollutant loads monitoring methods, Great Barrier Reef Report Card 2016, Reef Water Quality Protection Plan, Queensland Government.

2.1.1. Sediments

Sediment scores are based on the reported concentrations of TSS. This indicator category is particularly vulnerable to changes in rainfall, wherein periods of high flow can suspend large amounts of sediment in a basin.

Results (Table 3)**:**

Key Messages:

1) Sediment scores indicated three of the four graded basins within the MWI region failed to meet the guideline values, with 'moderate' to 'very poor' grades observed for five or more consecutive years in the Don, O'Connell, and Plane Basins.

2) In the 2021 Report Card sediment grades were similar or improved compared to the previous year (Table 3). The improved grade in the Don Basin is likely due to changes in sample size during the 2020–21 year compared to the previous monitoring period, as monitoring is only possible during wet season periods.

There was average rainfall across most of the region during the 2020–21 wet season, with the Don, Pioneer, and O'Connell (Caravan Park) Basins receiving their maximum median sediment concentrations in late December 2020 to early January 2021. In the case of the Don, an exceptionally dry November coupled with an above average rainfall in late December (Figure 7) likely contributed to the high median sediment concentration for the basin in January, which exceeded the respective guideline value for the indicator by more than an order of magnitude.

Table 3. Results for the sediment indicator category (based on a measure of TSS) for water quality in freshwater basins for the 2021 Report Card (2020–21 data) in comparison to 2015–2020 scores. Scores from 2018 onwards include combined additional sites in the O'Connell and Plane Basins.

Freshwater Basin	2021 Sediment Score	2020	2019	2018	2017	2016	2015
		Sediment					
Don (Don River)	49	18	58	60	29		
Proserpine							
O'Connell (O'Connell River)*	58	59	59	53	57	55	58
Pioneer (Pioneer River)	72	61	63	54	60	59	59
Plane (Sandy and Plane Creeks)*	60	59	55	55	55	54	61

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 were obtained from additional monitoring sites in the O'Connell and Plane Basins. Consequently, these scores are not directly comparable to the values reported in 2015–2017.

^ Proserpine data were found to be tidal confounded and therefore excluded from these scores. Further information on monitoring in the Proserpine Basin is provided in the Methods Report[2].

2.1.2. Nutrients

The nutrients indicator category contains dissolved inorganic nitrogen (DIN) and filterable reactive phosphorus (FRP) indicators.

Results (Table 4)**:**

Key Message:

1) Nutrient grades were the same in three basins (Don, Pioneer, and O'Connell) in 2020–21 compared to the previous reporting period. The only grade change came from the Plane Basin, which declined from 'moderate' (47) in 2019–20 to 'poor' (37) in 2020–21. This was due to associated score declines in both DIN and FRP exclusively at the Sandy Creek monitoring site (see below).

2.1.2.1. Dissolved Inorganic Nitrogen (DIN)

Results (Table 4)**:**

DIN remains an indicator of concern for the MWI Region. Three of the four basins in the region (Don, Pioneer, and Plane) were graded 'moderate' or 'poor' in the 2020–21 reporting period. This indicates that none of the annual medians for DIN in those basins met the relevant guidelines for the protection of environmental values in the 2020–21 reporting period.

DIN in Pioneer: For the second consecutive year, an improvement in the score for DIN was evident in the Pioneer Basin, increasing from 41 in the 2019–20 year (not shown here) to 52 (Table 4). The 2021 Report Card DIN score (52) is the highest yet recorded in the Pioneer, and the first time the basin has consecutively improved in score over two report cards. Monthly median concentrations in the basin exceeded guideline values for most of the year (November–June); however, exceedances during the wet season for this indicator were not as high as in previous years.

DIN in O'Connell: The O'Connell Basin recorded its highest DIN score since the Report Card's inception (67) and marks the first time any basin in the region has received a 'good' DIN grade. This is due to corresponding score improvements in both the Stafford's Crossing and Caravan Park monitoring sites. The dominant guideline value exceedances were in December 2020 and January 2021, with all months outside of the wet season (i.e., April–November 2021), meeting the relevant guidelines for the protection of environmental values.

DIN in Plane: There was a score decline for the second consecutive year in the Plane Basin (38 to 26), which did not result in a grade change. This decline was due solely to a decline in the DIN grade at the Sandy Creek site, which declined from 'poor' (32) to 'very poor' (17). Separate from any other basin site in the MWI Region, DIN guideline value exceedances for Sandy Creek in the 2020–21 year occurred in every month, and the second-highest monthly median concentration of DIN occurred during the dry season (July 2020). The pattern of Sandy Creek receiving a lower DIN grade than the nearby Plane Creek over multiple years (see Appendix B.4. Site-level Scores for Additional Freshwater Basin Sites, Table B10) reflects a higher proportion of intensive land use practices in the Sandy Creek catchment.

2.1.2.2. Filterable Reactive Phosphorus (FRP)

Results (Table 4)**:**

FRP scores were similar when compared to the previous reporting period, and all basins maintained the same grades.

FRP in Plane: The only FRP score that recorded a grade change was the Plane Basin, which declined from 56 to 49. This was due to a decline in the Sandy Creek site from 55 to 45. The current score remains higher than previous years (i.e., before the 2020 Report Card). Monthly medians for FRP at this site failed to meet the guideline value for eleven months in the 2020–21 reporting period, compared to five months in 2019–20. Similar to sediment results above (2.1.2.1), the lower FRP grade in Sandy Creek compared to the neighbouring Plane Creek is likely reflective of relevant land use differences within these catchments.

Table 4. Results for DIN and FRP indicators and overall nutrients indicator category scores for water quality in freshwater basins for the 2021 Report Card (2020–21 data) in comparison to 2015–2020 Report Card scores. Scores from 2018 onwards 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	2021 Report Card			2020	2019	2018	2017	2016	2015
	DIN	FRP	Nutrients	Nutrients					
Don	47	40	44	46	66	62	33		
Proserpine									
O'Connell	67	65	66	61	57	59	60	60	90
Pioneer	52	57	54	51	46	53	45	52	53
Plane	26	49	37	47	37	24	24	39	27

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 were 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.

2.1.4. Pesticides

The pesticide indicator scores were developed using the Pesticide Risk Metric (PRM) approach. This approach quantifies the ecological risk associated with exposure to a mixture of pesticides. Measured concentrations of up to 22 different pesticides in each 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. For further information on the methodology adopted for the calculation of the PRM, refer to the Methods Report[3].

The PRM can be expressed as either the percent species affected or as the inverse percent species protected. The PRM can also be used in two ways. It can be used to estimate the risk to aquatic ecosystem, and for this it is expressed as the percentage of species protected (Table 5), but it can also be used to estimate the proportional contribution of individual pesticides (Figure 11).

<u>Results</u> <u>(Table 5)</u>**<u>:</u>**

Key Messages:

1) Pesticide risk scores were similar or declined compared to the previous reporting period, with all basins except for the Don reporting a ‘poor’ or ‘very poor’ grade. The only grade change was recorded in the O’Connell Basin, which declined from ‘moderate’ (45) in 2019–20 to ‘poor’ (34) in 2020–21. This is the fifth consecutive year that the Proserpine and Plane Basins have received a ‘very poor’ grade for this indicator.

2) Imidacloprid and diuron were the key contributors to the overall pesticide risk in the Proserpine, O’Connell, and Pioneer Basins, as well as Sandy Creek (Table 5). In contrast, a high proportion of the pesticide risk was attributed to reported metolachlor concentrations in the Don Basin and metsulfuron-methyl in Plane Creek (Figure 11). This variation in the pesticide risk profile across the region is similar to previous reporting periods, and reflects relevant land-use applications; specifically, the Don Basin is dominated by horticultural crops as opposed to intensive sugarcane farming in the other basins.

3) Overall, pesticides remained the poorest scoring indicator for basin water quality in the MWI region in the 2020–21 reporting year, indicating a high risk of adverse effects to the region’s aquatic species due to pesticide exposure.

The **Don Basin** maintained a ‘very good’ grade for the second consecutive year. This is likely associated with reduced surface flow in the basin during the 2020–21 and 2019–20 wet seasons relative to previous years.

One of the two pesticide sampling sites used for the **O’Connell Basin** (Stafford’s Creek location) was discontinued in 2020, meaning that pesticide grades for this basin in the 2020–21 period were derived solely from the Caravan Park location. As a result, while the O’Connell declined in grade in the 2020–21 reporting period (‘moderate’ (45) grade in 2019–20 to a ‘poor’ grade (34) in 2020–21), it is likely that this shift is at least partly due to the change in sampling regime as the Caravan Park location received similar site-level grades in the previous monitoring period.

The spring of 2020 had very low rainfall, and with minimal weed growth and reduced crop vigour, conditions were not suitable to apply inputs on unirrigated farms. Weed growth following December rains coincided with growers completing their crush and increasing applications of herbicides. Increased weed pressure in some paddocks led to herbicide selection targeted at PSII products (P. Trendell, pers. comm. 05/04/2022). Variable rainfall and drier conditions throughout much of the region in February and March 2021 (Figure 7) meant that some herbicides and insecticides were often applied in February due to access and timing (P. Trendell, pers. comm. 05/04/2022).

Table 5. Results for the Pesticide Risk Metric (PRM) indicator accounting for 22 pesticides, reporting aquatic species protected (%) and overall standardised pesticide score for freshwater basins for the 2021 Report Card compared to 2017–2020.

Pesticides	2021 Report Card		2020	2019	2018	*2017
Freshwater Basin	PRM (% species Protected)	Standardised Pesticide Score	Pesticide Score			
Don	99	81	82	76	70	75
Proserpine	74	19	19	17	18	19
O'Connell**	87	34	45	49	48	36
Pioneer	77	20	20	31	19	26
Plane	66	17	19	19	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.

**O'Connell Basin grades were only represented by data from one monitoring site in the 2020–21 monitoring season (Caravan Park), whereas previous years have incorporated data from a downstream site, Stafford's Creek.

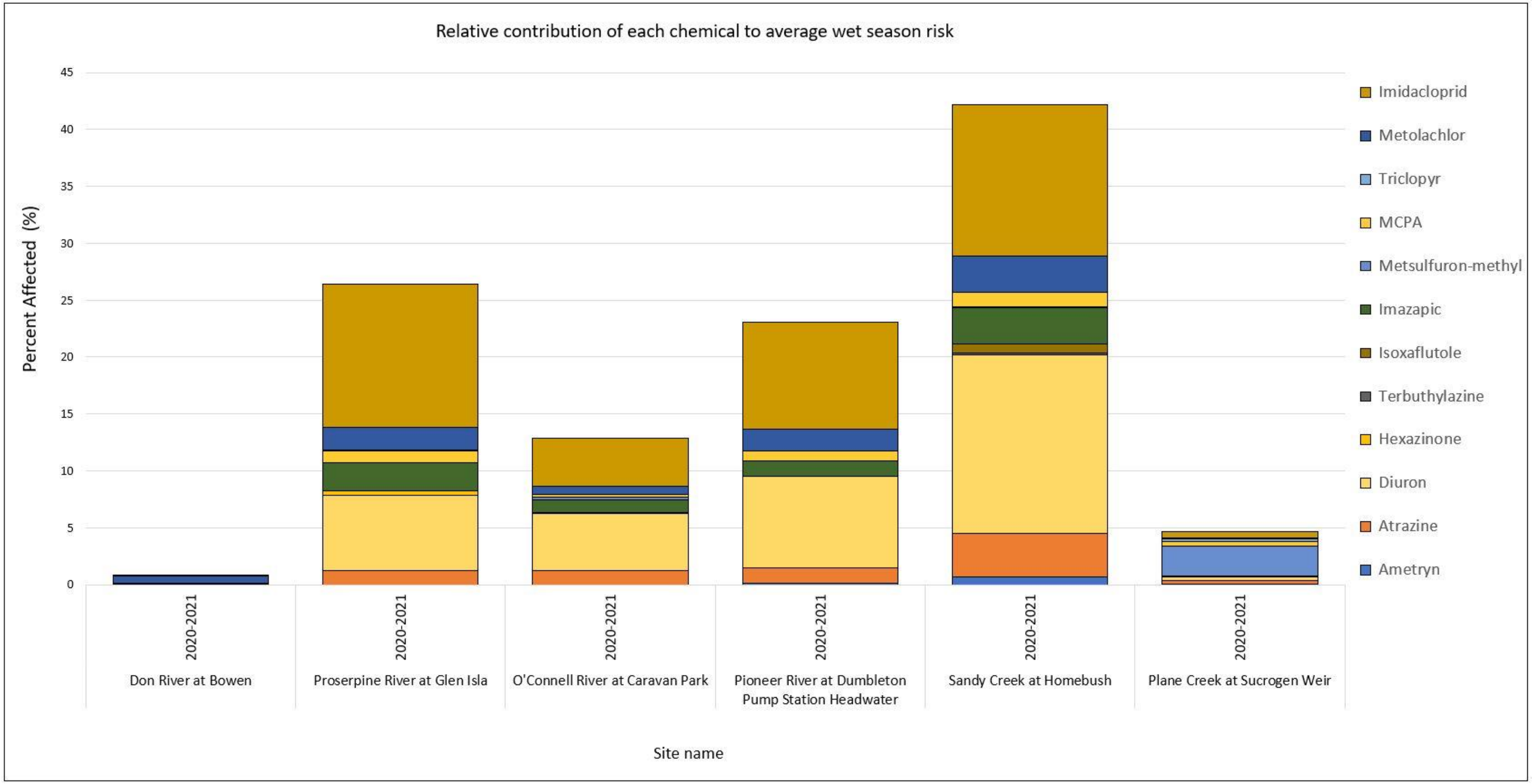

Figure 11. The proportional contribution of each chemical to the final Pesticide Risk Metric (PRM) score, for the 2020–21 reporting year. In this instance, the PRM is expressed as the % species affected fraction. Source: QLD Government, GBR CLMP

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2.1.5. Water Quality Index Scores

Results (Table 6)**:**

Key Messages:

1) In the 2021 Report Card, most regional basins received the same water quality grade as in the previous monitoring period, with the exception of the Plane Basin, which declined from 'moderate' (42) in 2019–20 to 'poor' (38) in 2020–21. This is the fifth consecutive year that scores for water quality have not met the desired criteria in the O'Connell Basin, and the eighth year in the Pioneer and Plane basins.
2) Score decline in the Plane Basin was driven primarily by an increased concentration of DIN and FRP in Sandy Creek that caused a grade change from 'moderate' to 'poor'.

The **Don Basin** recorded an improvement in scores compared to the previous reporting period (49 to 58); yet remained 'moderate'. Improvement was driven by reduced concentration of TSS in the basin (from 'very poor' in 2019–20 to 'moderate' in 2020–21), which was likely influenced by improved temporal representation in the 2020–21 year compared to the previous reporting period. Water quality grades for the Don should be interpreted with caution, as a lack of surface flow in the basin prevented sampling outside of periods of relatively high flow (January–April 2021).

Based on the rules for the minimum proportion of information required to generate overall scores, a final water quality score could not be calculated for the **Proserpine Basin** (see Section 2.1 for details).

Table 6. Results for water quality indicator categories and final water quality index scores in freshwater basins for the 2021 Report Card (2020–21 data) in comparison to 2015–2020 Report Cards.

Freshwater Basin	2021 Report Card				2020	2019	2018	*2017	^2016	^2015
	Sediment	Nutrients	Pesticides	Water Quality Index	Water Quality Index					
Don	49	44	81	**58**	49	66	64	46		
Proserpine			19							
O'Connell	58	66	34	**53**	55	55	53	51	63	63
Pioneer	72	54	20	**48**	44	46	42	44	48	48
Plane	60	37	17	**38**	42	37	32	31	37	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

*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.

2.1.5.1. Confidence

The Report Card scores were rated in terms of the confidence and uncertainty based on methods and data used in the development of each score. A detailed summary of confidence methods and scoring is provided in the Methods Report[2].

Confidence in water quality scores for MWI basins varied depending on the indicator category and basin (Table 7). Most basins were given a moderate rank of confidence, primarily due to the low spatial representativeness of the monitoring program. However, this was changed to 'low' for pesticide monitoring due to decreased 'directness' and 'maturity of the methodology'. In addition, the Don Basin was given a 'low' rank for water quality monitoring in the 2019–20 and 2020–21 monitoring periods due to a lack of surface flow over much of the year, which decreased annual temporal representativeness. 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 7. Confidence associated with water quality index results in freshwater basins in the 2021 Report Card. Confidence criteria are scored 1–3 and then weighted by the value identified in parentheses. Final scores (4.5–13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1 to 5 (very low–very high), which indicates the final confidence level. Where confidence in results for the Don Basin differ from the other basins, the relevant confidence score for the Don is presented in square parentheses. 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 [0.5]	3	2	8.8 [7.8]	3 [2]
Nutrients	3	3	1 [0.5]	3	2	8.8 [7.8]	3 [2]
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.

2.2. Habitat and Hydrology in Freshwater Basins

The habitat and hydrology index comprises four indicator categories. Flow, which is updated annually, and three indicator categories (in-stream habitat modification, riparian extent, and wetland extent) which are updated every three to four years.

2.2.1. In-stream Habitat Modification

The in-stream habitat modification indicator category comprises two sub-categories: fish barriers and impoundment, which are updated every four years. The results here for fish barriers and impoundment data were last updated in the 2019 and 2018 Report Cards, respectively. The most recent assessment on fish barriers (Power et al., 2022) will be incorporated into the 2022 Report Card.

2.2.1.1. Fish Barriers

Results (2018–19 data, Table 8):

Key Message:

1) The Don and O'Connell Basins recorded higher fish barrier grades ('good' and 'moderate', respectively) compared to the Proserpine Basin and southern freshwater basins of the Plane and Pioneer, which graded 'moderate' and 'poor', respectively.
2) The Proserpine, Pioneer, and Plane freshwater basins are home to large population centres in the region (Proserpine, Mackay, and Sarina, respectively), and land use activities include 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) have been required, creating barriers to fish passage.

Weirs: Many of the low passability barriers are weirs. The impacts of these structures are particularly pronounced in the Pioneer Basin, which was graded 'very poor' for the 'proportion of stream length to the first low/no passability barrier' indicator (T. Power, pers. Comms., 29/04/2020). These factors also contributed to the declined barrier condition grades in the Proserpine, Pioneer, and Plane freshwater basins (Moore, 2016).

Fish barrier field validation: As a component of the 2019 assessment, field validation works were undertaken in the Don and Proserpine Basins to investigate potential fish barriers identified through a desktop review process. Based on the field validation, several potential fish barriers were reclassified, as it was determined they did not impede fish passage. In the **Don Basin**, this review resulted in an improved fish barrier score. These findings are encouraging, as the freshwater streams of the Don Basin are ephemeral in nature; they are typified by episodic flow, channels with sandy substrates, and characterised by few permanent freshwater habitats. Therefore, the unimpeded connection between limited permanent waterholes is important to prevent fragmentation of fish populations and for sustaining aquatic ecosystem health (Moore, 2016). In the **Proserpine Basin**, although there were some barrier reclassifications that were improved, the overall grade declined from 'good' to 'moderate', as field validation works identified a large low passability barrier close to the estuarine interface. This barrier blocks connectivity to a large proportion (>60%) of the Proserpine River. This dam has been created to impound water for irrigation.

Table 8. Results for fish barrier indicators in freshwater basins in the 2021 Report Card (2018–19 data) compared to the 2018 Report Card (2014–15 data). Indicators were assessed on Stream Orders (SO) ≥3 or ≥4 as indicated.

Freshwater Basin	2021 Report Card								2018
	Barrier Density		Stream to the 1st Barrier		Stream to the 1st Low "Passability" Barrier		Fish Barriers		Fish Barriers
	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***

Refer to Table 9 for an explanation of relevant scoring ranges.
*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 ('moderate') for '% of stream length to the first low passability barrier'. Instead, the Plane Basin recorded a score of 4 ('good') for this indicator. This discrepancy has been rectified here.

Table 9. Scoring ranges and corresponding grades for specific metrics within the fish barriers indicator.

	Very Poor	Poor	Moderate	Good	Very Good	No score/data
Barrier Density (km)	1 = 0 to 2km	2 = >2 to 4km	3 = >4 to 8km	4 = >8 to 16km	5 = >16km	
% of Stream Before 1st Barrier	1 = 0 to <10%	2 = 10 to <30%	3 = 30 to <50%	4 = 50 to <100%	5 = 100%	
% of Stream to 1st Low "Passability" Barrier	1 = 0 to 50%	2 = >50 to 60%	3 = >60 to 70%	4 = >70 to 95%	5 = >95%	
Total Score	3 to 4	5 to 7	8 to 10	11 to 13	14 to 15	
Fish Barriers (standardised)	0 to <21	21 to <41	41 to <61	61 to <81	81 to 100	

2.2.1.2. Impoundment Length

<u>**Impoundment Length Results** (2017–18 data, Table 10):</u>

Key Message:

1) All basins except the Proserpine remained at a similar condition for the 2018 assessment, indicating there has been little change in the net proportion of ponded channel habitat within each basin since the previous assessment conducted in 2015.

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 an extended inundation of riparian vegetation, contributing to potential increased erosion if submerged vegetation dies. This impoundment may also affect the efficacy of the fishway, 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 structures.

There were no impoundments on streams (of order three or higher) in the **Don Basin**, giving it a condition grade of 'very good'.

Table 10. Results for the impounded stream indicator in freshwater basins in the 2021 Report Card (2017–18 data).

Freshwater 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

In-stream Habitat Modification Results (2017–18 data, Table 11)**:**

Key Messages:

1) There were no changes to the in-stream habitat modification grades for the O'Connell, Pioneer, and Plane, which were graded as 'good', 'poor', and 'moderate', respectively.
2) The in-stream habitat modification grade changed from 'good' to 'very good' in the Don Basin between 2017–18 and 2018–19, owing to improvements in the condition of the fish barrier indicator, which shifted from a 'moderate' to 'good' grade in the most recent assessment.
3) Conversely, there was a decline observed in the aggregated score for the Proserpine Basin, owing to reductions in the condition of the fish barrier indicator.

In-stream habitat modification: The impoundment and fish barrier indicator sub-categories are aggregated to form the in-stream habitat modification indicator category. As highlighted above, impoundment and fish barrier scores for the 2021 Report Card are based on repeat data (2017–18 and 2018–19 data, respectively).

Table 11. Results for the in-stream habitat modification indicator category in freshwater basins in the 2021 Report Card (2018–19 data), compared to 2018 (2017–18 data).

Freshwater Basin	2021 Report Card			2018
	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

2.2.2. Riparian and Wetland Extent

2.2.2.1. Riparian Extent

Results (2013 data, Table 12)**:**

Key Messages:

1) Overall, the percent loss of riparian extent since pre-clearing ranged from 20–30% within the basins assessed. As a result, all basins were graded moderate for the condition of riparian extent.

2) This assessment is based on the oldest dataset from any indicator in the 2021 Report Card (2013–14 data), which should be noted when interpreting these results.

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 (DES). 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, to improve the resolution and accuracy of vegetation mapping. The updated mapping is scheduled to be released after the development of the 2021 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 that they are suitable for reporting here. It is anticipated that this information will be available in future report cards.

2.2.2.2. Wetland Extent

Updated datasets and scores based on new wetland mapping methodology (Queensland Regional Ecosystem Version 5.1 Wetland Mapping), including the most recent assessment scores, supersede all previously reported results of wetland extent. Consequently, scores from the previous assessment (2013) have been back-calculated using the new maps to evaluate any change in wetland extent over time (Appendix B.5.).

Results (2017 data, Table 12)**:**

Key Messages:

1) Wetland extent grades ranged from 'very good' in the Don Basin[23], to 'very poor' in the O'Connell and Plane Basins.

2) Although no natural or modified wetlands have been lost since the previous assessment, 'poor' and 'very poor' scores reflect the significant historical loss estimated in regional wetlands. It is estimated that there has been a 44% reduction in wetland extent in the region as a result of development. Declines at the basin level are particularly pronounced for the O'Connell and Pioneer Basins, where palustrine wetlands have lost 66% and 71% of their pre-clearing 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. For example,

[23] This is a somewhat false representation masking the losses of converted estuarine wetlands and significant losses of freshwater wetlands in other locations.

the historical loss of 1,109 hectares of freshwater wetland in the Don catchment is masked by a gain of 1,184 hectares due to conversion from estuarine to freshwater wetland[24]. In this instance, decreases in wetlands extent driven by land modification and filling were moderated by increases associated with anthropogenically driven changes in hydrology. Whilst the ecological value of new or expanded modified wetlands is acknowledged, 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.

Table 12. Results showing % of riparian and wetland extent loss compared to pre-clearing conditions for the 2021 Report Card. Scores are repeated from the 2019 Report Card, in which scores were back-calculated from updated methodology, as assessed using 2013/14 (riparian extent) and 2017/18 (wetland extent) data. The wetland assessment pertains to palustrine wetlands only.

Freshwater Basin	2021 Report Card				2021 Report Card	
	Wetland extent		Riparian extent			
	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 an increase in area since pre-development. In this instance, however, this is a somewhat false representation masking the losses of converted estuarine wetlands and significant losses of freshwater wetlands in other locations (Section 2.2.2).

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

2.2.3. Flow

Flow scores are only reported for Pioneer and Plane Basins due to concerns that results did not accurately reflect on-ground flow observations in the O'Connell Basin. In the O'Connell Basin this was primarily connected to unusually prolonged periods of low or no flow relating to the dry climate conditions and effects of water extractions that occurred during this period. The resulting low to no flows interrupted important processes that support a healthy river ecosystem. This includes deterioration of important riffle habitats, decline of water quality in water holes (e.g., low dissolved oxygen and high water temperatures) and a reduced capacity for fish migration (B. Cockayne, pers. comms., 22/04/2020).

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. Work is currently being undertaken to fill these data gaps and is currently progressing in collaboration with the TWG and BoM. Information on the methods employed for the flow indicator are available in the Methods Report[3].

Notes on data interpretation for 2021 Report Card results

Data sources*:* Some differences can occur between climate type (based on rainfall) produced by the flow indicator tool and the BoM climate reporting. This is due to differences in spatial coverage and the analysis applied to assess rainfall in the flow indicator tool. The data source will be specified in each instance to minimise confusion.

Climate impact on Flow measurement: While rainfall does affect freshwater flows, the flow indicator tool has been designed to take this natural variability into account and produce scores that reflect anthropogenic impacts on flow (measured against the pre-development period).

Results (Table 13, Appendix B.2.: Table B2, Figure B4):

Key Messages:

1) The flow indicator category grade improved to 'good' (61) in the Plane Basin, improving from 'moderate' (43) in 2019–2020.
2) The Pioneer Basin improved to 'good' (66) from 'moderate' (49). The grade change was driven by improvement at the Dumbleton Weir site from 'very poor' to 'moderate', potentially influenced by agricultural water use and updates to the site's rating table, where changes observed in the streambed lead to changes in hydrograph interpretation. (Appendix B.2.: Figure B4, Table B2; also see Figure 8).

Monitoring sites: Both the Pioneer and Plane basins received a 'good' grade for the 2021 Report Card, with scores of 66 and 61, respectively. While the Pioneer Basin flow score was assessed from four stream gauging stations (with individual stations grading 'moderate' to 'good') flow in the Plane Basin was based on one monitoring location which received a 'good' grade (61) (Appendix B.2.: Table B2).

Climate: The climate type for 2020–2021 was classed as drought for both the Plane and Pioneer Basins using the flow indicator tool (Table 13). Conditions were particularly dry in both basins during both February and May of 2021, with 'below' or 'very much below' average rainfalls during this period (BoM data, Figure 7). Both basins however, had 'above average' rainfall in December 2020, yet still the annual average was classed as ‘below’ the long-term average annual rainfall for those basins, as calculated by both the flow indicator tool and BoM (Table 13; Figure 7).

Table 13. Results for the flow indicator for freshwater basins for the 2021 Report Card and the climate type based on average rainfall, as compared to the 2018–2020 Report Cards.

Freshwater Basin	2021 Report Card		2020		2019		2018	
	Climate Type	Flow Indicator	Climate Type	Flow Indicator	Climate Type	Flow Indicator	Climate Type	Flow Indicator
Don^								
Proserpine^								
O'Connell*							Dry	78
Pioneer	Drought	66	Dry	49	Average	72	Drought	66
Plane	Drought	61	Average	43	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
^ No pre-development reference data are available.
*The O’Connell Basin was omitted from reporting due to anomalous scores.

2.2.4. Habitat and Hydrology Index Scores

The overall habitat and hydrology index grades for basins in the 2021 Report Card ranged from ‘poor’ to ‘good’ across the MWI Region, the same as in the previous two reporting periods (Table 14).

Notably, the only habitat and hydrology indicator category that was updated in the last two Report Cards was flow (in the Pioneer and Plane basins), and thus, scores in the other basins remain unchanged since the 2019 Report Card.

Results (Table 14):

As data for the habitat and hydrology index includes repeat data (e.g., riparian extent from 2013–14, wetland extent and in-stream habitat modification from 2018–19), these scores do not fully capture changes in conditions associated with major weather events, including TC Debbie or potential anthropogenic impacts to riparian extent, which may have occurred between 2014 and 2021. Updates to the riparian extent indicator are scheduled for future report cards, as described in Section 2.2.2.

Table 14. Results for habitat and hydrology indicator categories and the aggregated index in freshwater basins in the 2021 Report Card compared to the 2017–2020 Report Cards. Aside from an updated flow indicator, all other indicator categories use repeated data from 2020, 2019, 2018, and 2014 Report Cards.

Freshwater Basin	2021 Report Card: In-stream habitat modification	Flow	Riparian Extent	Wetland Extent	Habitat and Hydrology Index	2020	2019	2018*	*2017
						Habitat and Hydrology Index			
Don	85		41	100	**75**	75	75	73	73
Proserpine	40		50	59	**50**	50	50	51	52
O'Connell	65		51	14	**43**	43	43	52	43
Pioneer	21	66	54	12	**38**	34	40	38	29
Plane	50	61	41	23	**44**	39	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 in 2019.

2.2.4.1. Confidence

Overall confidence for the habitat and hydrology indicator category was 'moderate' (Table 15).

Table 15. Confidence associated with habitat and hydrology index results in freshwater basins for the 2021 Report Card. Confidence criteria are scored 1–3 and then weighted by the value identified in parentheses. Final scores (4.5–13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1 to 5 (very low–very high), which indicates the final confidence level. Where confidence in results for the Don Basin differ from the other basins, the relevant confidence score for the Don is presented in square parentheses. 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
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]
In-stream Habitat Modification*						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**

*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.

2.3. Fish in Freshwater Basins

Notes on data interpretation for 2021 Report Card results

Baseline: Species richness of sites within the MWI region was assessed using a regression line describing the relationship between the species richness of the 10% most specious samples in relation to the variables describing the natural variation of species richness across the region (D. Moffatt, pers. comm. 19/04/2022). As a pre-development baseline is not available, the results here are relative to this derived baseline to track changes over time (see Methods[3]).

Results (2018 data; Table 16):

Key Messages:

1) Overall, the fish index recorded the same grade as in the previous assessment for three of the region's basins (Proserpine, O'Connell, and Plane Basins). The Pioneer Basin recorded a grade decline, shifting from 'very good' (83) in the previous assessment to 'good' (75).
2) The Don Basin was included in the fish index assessment for the first time and received the highest grade of any basin in the region ('very good' (88)).
3) The proportion of alien (pest) fish in catches (samples) were graded as 'very good' across all the basins assessed for the second assessment in a row. This means that the median proportion of catches for pest fish comprised less than 3% of fish recorded during the assessment.
4) Native fish species richness reported between 'moderate' to 'good' grades for all basins in the region with three basins (Proserpine, Pioneer, and Plane) reporting the same grade as in the previous assessment. The O'Connell declined from a 'very good' (84) grade to a 'good' (69) grade.

Reporting lag: When interpreting the results from this index, please note that the most recent assessment (published in the 2021 Report Card) took place in September–October 2020, while the previous assessment took place in 2017.

Species richness vs. health: At face value, the 'good' to 'very good' fish grades appear to be inconsistent with the grades for freshwater pesticides, which are 'very poor' in three of the five basins (Figure 11, Table 5). However, it is important to note that the fish and pesticide grades for the region represent two quite different measures and should not be compared. For example, fish grades strictly represent the *species richness*, rather than the *abundance* or *health* of fish within each waterway.[25]

Individual site conditions: Due to the nature of how the fish indicator is calculated, there was variation for these indicators (mainly for POISE) both within sites and across the MWI Region (Figure 12 and Figure 13). For example, there were sites in each basin for the POISE indicator that fell into the 'poor' grading range. As we calculate our grades based on the median of site-level scores, the overall fish index grades do not necessarily reflect the condition of individual sites.

[25] https://healthyriverstoreef.org.au/news/answering-your-questions-on-freshwater-fish-pesticides-and-waterway-health/

Interpreting grades: We report against reference condition guideline values for each indicator (see Methods document[3]) with discrete ranges, allowing us to capture broad indicator condition trends over time. However, this also means that the scoring difference between a site being assigned a certain grade (e.g., 'good' versus 'moderate') can be minimal. In the 2020 fish assessment, this should be noted when interpreting the indicator grades for some basins that have medians close to the border of a grade range, such as the Pioneer and Plane Basins for the POISE indicator (see Figure 12 and Figure 13).

Table 16. Results for fish indicators in freshwater basins in the 2021 Report Card (2020–21 data) compared to the 2020 Report Card (2017–18 data) and the 2017 Report Card (2014–15 data).

2021 Report Card				2020*	2017*
Basin	Proportion of Indigenous Fish Richness (POISE)	Proportion of Non-Indigenous Fish	Fish Index	Fish Index	Fish Index
Don	76	100	**88**		
Proserpine	74	86	**80**	79	
O'Connell	69	98	**83**	**92**	**65**
Pioneer	64	87	**75**	**82**	**48**
Plane	60	86	**73**	**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
*Scores are based on a superseded methodology.

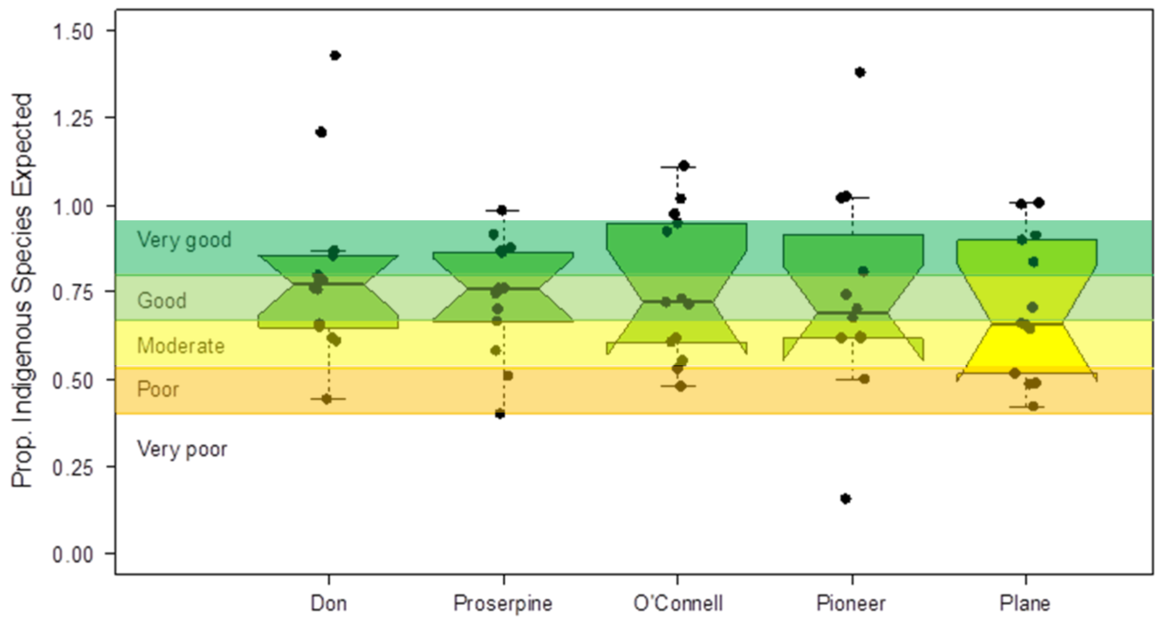

Figure 12. Distribution of the median proportion of indigenous species expected (POISE) for freshwater fish, showing the variability amongst sites within each basin of the MWI region. Coloured bands indicate the range of values that fall within each grade zone. The median value is represented by a horizontal black line, upper and lower whiskers are 1.5 * IQR (inter-quartile range), and notches represent ~95% of median value. Non-overlapping notches suggest significant differences. Folded corners indicate uncertainty of the true median value.

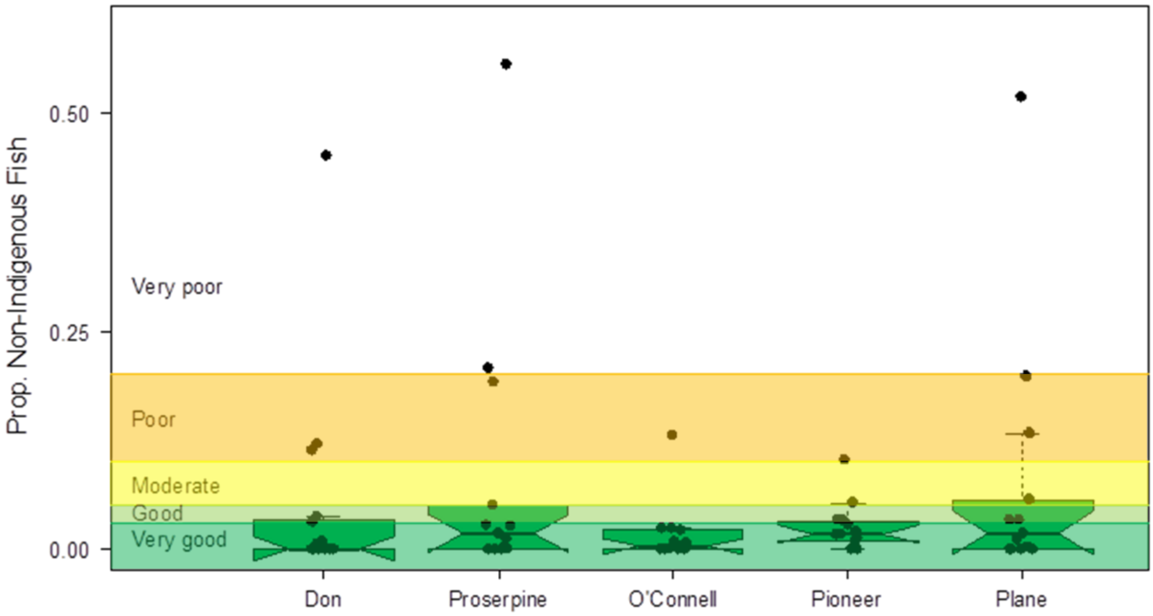

Figure 13. Distribution of the median proportion of non-indigenous (PONI) freshwater fish species, showing the variability amongst sites within each basin of the MWI region. Coloured bands indicate the range of values that fall within each grade zone. The median value is represented by a horizontal black line, upper and lower whiskers are 1.5 * IQR (inter-quartile range), and notches represent ~95% of median value. Non-overlapping notches suggest significant differences. Folded corners indicate uncertainty of the true median value.

2.3.1. Confidence

Confidence associated with freshwater fish results was 'moderate' (Table 17).

Table 17. Confidence associated with fish index results in freshwater basins for the 2021 Report Card. Confidence criteria are scored 1–3 and then weighted by the value identified in parentheses. Final scores (4.5–13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1 to 5 (very low–very high), which indicates the final confidence level. Unless otherwise specified, confidence in results is the same across basins.

Index	Maturity of Methodology (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured Error (x0.71)	Final	Rank
Proportion of Indigenous Fish Richness (POISE)	1	2	2	3	1	9.0	3
Proportion of Non-Indigenous Fish	1	2	2	3	1	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.

2.4. Overall Basin Condition

Notes on data interpretation for 2021 Report Card results

Results drivers: As scores for the majority of the habitat and hydrology index are based on repeat data, any changes to the overall basin scores in the 2021 Report Card are driven by score changes for the water quality and fish indices and the flow indicator category.

Results (Table 18):

Key Messages:

1) The overall freshwater basin scores ranged from 'moderate' to 'good'. The only grade change was due to a decreased score in the O'Connell Basin from 'good' (63) to 'moderate' (60).

2) Similar to the previous year, the northern basins (Don and Proserpine) generally scored higher across water quality indicators than the southern Pioneer and Plane Basins, potentially indicating differences in land use intensity across the region.

3) The Don Basin improved from 62 to 74 ('good') due to the incorporation of fish index grades for the first time, as well as an improvement in the TSS indicator score relative to the previous reporting period.

Table 18. Condition grades and scores of freshwater basins for the 2021 Report Card compared to 2014–2020 Report Cards.

Freshwater Basin	2021 Report Card					2020	2019	2018	*2017	^2016	^2015	^2014
	Water Quality	Habitat and Hydrology	Fish	Basin Score and Grade		Basin Score						
Don	58	75	88	**74**	**B**	62	71	56	47	48	48	54
Proserpine		50	80	**65**	**B**	65	65	66	53	53	53	52
O'Connell	53	43	83	**60**	**C**	63	63	66	54**	58	57	52
Pioneer	48	33	75	**52**	**C**	53	56	54	40	41	41	34
Plane	38	44	73	**52**	**C**	53	51	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 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. Estuary Results

The overall estuary grade is derived from the habitat and hydrology and water quality indices, each comprising a series of indicator categories and indicators (Figure 14). There is no established methodology for the assessment of estuarine fish, therefore no score is reported for this index at this stage (Figure 14). Following their four-year reporting cycles, habitat and hydrology indicators were not updated in 2020–21 and scores presented here represent repeat data from previous report cards. Due to minimal data availability, flow is currently not reported for estuaries.

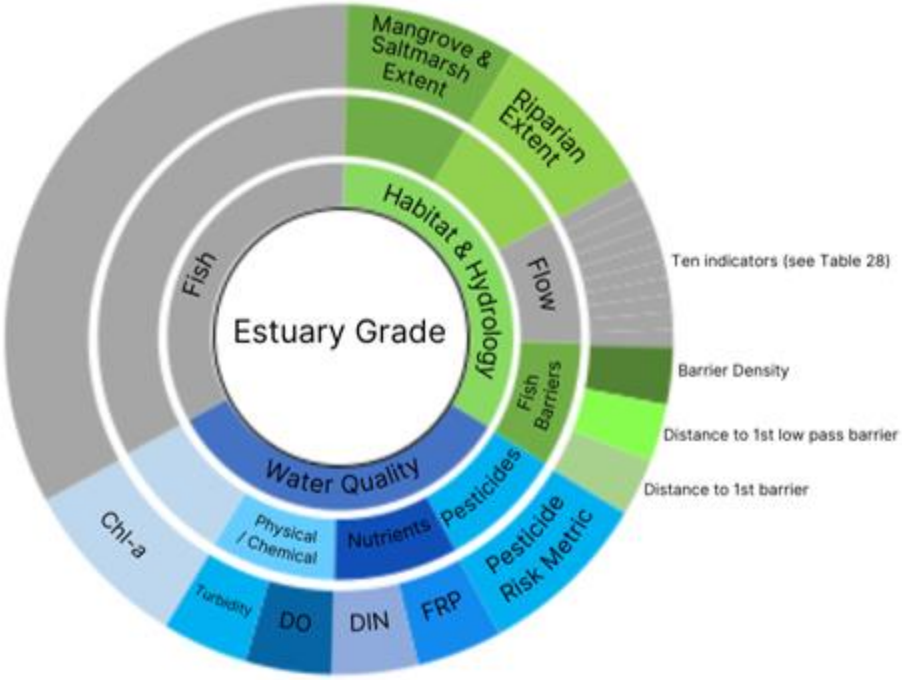

Figure 14. Indicators (outer ring), indicator categories (middle ring) and indices (inner ring) that contribute to overall estuary scores. In the 2021 Report Card, only indicators shaded blue were updated.

Notes on data interpretation for 2021 Report Card results

Impact of reporting cycle variability: When comparing overall scores and grades between reporting years, it is important to note that there were no habitat and hydrology indicators updated in the 2020–21 monitoring period. Any differences in scores are exclusively due to changes in water quality.

Impact of drought: In the 2020–21 reporting year there were drier than usual conditions across the Southern MWI Region, particularly the Pioneer and Plane basins (Figure 5). This is a potential driver behind some water quality grade changes in the 2021 Report Card as reduced runoff is generally associated with reductions in nutrients, sediment, and pesticides in the waterways. Due to climatic influences and the natural variability of basin systems in the MWI Region, grade changes in the 2020–21 monitoring period are not necessarily indicative of long-term trends in waterway health.

Rocky Dam Site Access: In the 2020–21 monitoring period, Rocky Dam was inaccessible for sampling during some peak rainfall periods in the wet season due to flooding. As such, grade improvements for this estuary in the 2021 Report Card should be interpreted with caution.

3.1. Water Quality in Estuaries

Scores and grades for estuaries reported in the MWI Region are based on monitoring conducted in the following tidal waterways: Gregory River, O'Connell River, St Helens Creek, Murray Creek, Vines Creek, Sandy Creek, Plane Creek, Rocky Dam Creek, and Carmila Creek (Figure 1). Indicators used to report on the water quality index in estuaries include DIN, FRP, turbidity, dissolved oxygen (DO), chlorophyll-*a* (chl-*a*), and pesticides (which are reported using the PRM). The results for DIN and FRP are aggregated to form the nutrients indicator category while turbidity and DO are aggregated to form the physical–chemical (phys–chem) indicator category (Figure 14). For details on water quality monitoring and grading please refer to the Methods Report[3].

Notes on data interpretation for 2021 Report Card results

Sampling regime and climatic variability: When interpreting estuarine water quality grades it should be noted that all estuarine water quality samples in this Report Card are collected via ambient grab sampling at a regular interval (i.e., one sample per month for most indicators). As such, scores in this section may be influenced disproportionately by the timing of meteorological events (e.g., rainfall) relative to the sampling schedule.

3.1.1. Nutrients

Nutrient scores were based upon the reported concentrations of DIN (Oxidised nitrogen [NO_2 + NO_3] + ammonia [NH_3]) and FRP.

Results (Table 19 and Appendix C.2.)**:**

Key Messages:

1) Five out of eight estuaries retained the same nutrients grade as in the previous monitoring period, ranging from 'moderate' to 'very good'. The sole grade improvement was recorded in the Gregory Estuary due to reduced concentrations of DIN with respect to the previous year. The two declines were recorded in the Vines and Sandy Creek Estuaries (63 to 52 and 61 to 43, respectively) due to increased concentration of DIN in both.
2) Scores were similar to the previous year for the FRP indicator, with no grade changes and all estuaries recording measurements within their respective annual median guideline value.

Gregory Estuary improved from a 'good' grade in the previous year to 'very good' in 2021. This was due to a decrease in monthly median exceedances of the recommended guideline value during the wet season, with the only exceedances taking place in December 2020 and April 2021.

Vines Creek reported a DIN score that was almost half of the year before (14 in 2021 from 37 in 2020). The recommended ecosystem guideline value for DIN in the Vines Estuary was exceeded every month in the 2020–21 monitoring season, indicating a high risk to local aquatic species. An investigation of monthly median concentrations indicated that this was due to an increase in ammonia across the 2020–21 monitoring period, with the cause of the increase under investigation (A. Moss, pers. comm. 24/03/22).

Sandy Creek declined from 'moderate' (48) in 2020 to 'poor' (21) in 2021. Contrary to the above estuaries, this decline was largely due to monthly median exceedances in DIN concentration during the dry season, with Sandy Estuary recording the highest mean DIN concentration of any MWI estuary from July–November 2020. A preliminary investigation of the data suggested that at least part of the DIN increase may have been due to monthly sampling aligning with a large rainfall event in July 2020 (A. Moss, pers. comm. 24/03/21). Future report cards will help determine if this grade decline is representative of a change in the system such as climate or management practice, or an artefact of sample variability.

Table 19. Results for DIN and FRP indicators and nutrient indicator category in estuaries for the 2021 Report Card in comparison to 2015 to 2020 Report Card nutrient scores.

	2021 Report Card			2020	2019	2018	2017	2016	2015*
Estuary	DIN	FRP	Nutrients	Nutrients					
Gregory River	90	90	**90**	77	90	74	78	78	90
O'Connell River^	61	90	**75**	73	72	73	74	75	78
St Helens/Murray Creek	51	79	**65**	65	60	56	54	60	62
Vines Creek	14	90	**52**	63	50	67	50	61	64
Sandy Creek	21	65	**43**	61	53	54	49	46	41
Plane Creek	67	90	**78**	78	76	74	75	74	74
Rocky Dam Creek	54	90	**72**	71	69	68	66	66	66
Carmila Creek	57	90	**73**	75	71	74	69	63	65

DIN and FRP scoring range: ■ 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 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

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

* Data from the 2015 Report Card are repeated from the 2014 Report Card.

3.1.2. Chlorophyll-*a*

Results (Table 20 and Appendix C.2.):

Key Messages:

1) Chl-*a* indicator grades in the 2020–21 monitoring period declined in four MWI estuaries (the Gregory, Vines, Rocky Dam, and Carmila Estuaries) when compared to the previous year. The only monitored estuary that improved in the 2020–21 reporting cycle was the O'Connell, which shifted from 'moderate' (49) in 2020 to 'good' (61) in 2021.
2) The greatest change in chl-*a* scores in the 2020–21 monitoring period came from the Rocky Dam Estuary, which saw a decline from 'good' (61) to 'poor' (35). This is the lowest grade recorded in the Rocky Dam Estuary since the Report Card's inception. Further investigation is required to determine the cause of this decline.
3) The Gregory, St.Helens/Murray, and Vines Creeks also recorded their lowest Chl-*a* scores (62, 47, and 44, respectively) since the Report Card's inception.

Table 20. Chlorophyll-*a* (chl-*a*) indicator scores within estuaries for the 2021 Report Card, compared to the 2015 to 2020 Report Cards.

	2021 Report Card	2020	2019	2018	2017	2016	2015
Estuary	Chl-*a*	Chl-*a*					
Gregory River	62	90	73	90	90	90	90
O'Connell River^	61	49	53	58	63	33	
St Helens/Murray Creek	47	56	58	52	58	54	62
Vines Creek	44	63	60	62	55	74	90
Sandy Creek	72	64	68	66	51	60	63
Plane Creek	75	69	62	77	75	69	69
Rocky Dam Creek	35	62	62	76	65	58	90
Carmila Creek	48	68	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 River 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.

3.1.3. Phys–chem

Notes on data interpretation for 2021 Report Card results

Phys-chem scores: The phys–chem indicator category scores were generated by the aggregation of the turbidity and upper and low DO indicators. In accordance with the guideline values, the reported DO indicator scores are based upon the percent saturation of DO. To avoid over-representation of the DO indicator in the final score, the most conservative result of the two (upper and lower DO) is adopted for aggregation.

Lack of guideline values: A turbidity score was not calculated for the four estuaries south of Mackay (Sandy, Plane, Rocky Dam, and Carmila Creek Estuaries), as the draft guidelines for MWI estuaries characterised turbidity as too variable to derive a suitable guideline (Newham et al., 2017).

Results (Table 21 and Appendix C.2.):

Key Message:

1) Overall, phys–chem grades were the same as the previous monitoring period for all estuaries in the region except for the Plane Creek, which improved from 'good' (71) to 'very good' (90). The improvement in Plane Creek is due to a corresponding improvement in the Upper DO grade ('good' in 2020 to 'very good' in 2021) for the 2020–21 monitoring period.

Turbidity grades were the same as the previous year, with the only score change being St Helens/Murray Creek, a decline in score from 70 in 2020 to 65 in 2021.

Lower DO scores were similar to those of the previous year except in the Vines Creek Estuary, which declined from a grade of ('very good' to 'good' (90 to 74)).

Upper DO scores were similar or improved with respect to the previous monitoring year, with the only grade change being an improvement in Plane Creek from 'good' (71) in 2020 to 'very good' (90) in 2021. The O'Connell also improved in score, however remained in 'very poor' condition. This is likely due to the nature of the monitoring site for the O'Connell River Estuary, which has been reported as characteristically lacustrine with periods of limited mixing (A. Moss, pers. comm 29/03/21).

Table 21. Results for turbidity, DO, and aggregated phys–chem indicator category within estuaries for the 2021 Report Card in comparison to 2015–2020 Report Card scores for phys–chem. The aggregated phys–chem score is calculated by averaging the poorer DO score with the turbidity score. In the absence of a suitable turbidity score, phys–chem results will be based upon the condition of DO.

Estuary	2021 Report Card				2020	2019	2018	2017	2016	2015*
	Turbidity	Lower DO	Upper DO	Phys–chem	Phys–chem					
Gregory River	90	78	90	**84**	81	85	79	84	84	85
O'Connell River^	90	90	19	**54**	50	52	2	63	18	53
St Helens/Murray Creek	65	90	90	**77**	80	60	49	60	52	81
Vines Creek	90	74	90	**82**	90	64	77	64	90	84
Sandy Creek		80	90	**80**	79	90	78	90	77	90
Plane Creek		90	90	**90**	71	67	90	90	68	67
Rocky Dam Creek		90	90	**90**	90	90	90	90	90	90
Carmila Creek		90	70	**70**	66	62	0	0	90	65

Scoring range ■ Very Poor = 0 to <21 | ■ Poor = 21 to <41 | ■ Moderate = 41 to <61 | ■ Good = 61 to <81 | ■ No score/data gap
DO and turbidity ■ Very Good = assigned 90 | **Phys–chem** ■ Very Good = 81 to 100
*Data from the 2015 report card is repeated data from the 2014 report card.
^ Data used to evaluate the O'Connell River estuary are taken from an end-of-catchment monitoring site within the O'Connell River, which is also used to monitor nutrients within freshwater basins.

3.1.4. Pesticides

Reporting of pesticides in the MWI estuaries follow similar methods to those adopted for freshwater basins in which measured concentrations of up to 22 different pesticides in each sample are converted to a PRM that expresses risk as the percentage of aquatic species that may be adversely affected/protected by a mixture of pesticides. Further information on the method for assessing pesticide condition is presented in the Methods Report[3].

Notes on data interpretation for 2021 Report Card results

Chemical use: Metsulfuron-methyl is not registered for use in sugarcane and applications are likely not agricultural in origin. This is particularly relevant in the Vines Creek region, where the land use is primarily urban.

Results (Table 22, Figure 15 and Appendix C.1.)**:**

Key Messages:

1) Most PRM estuarine grades changed in the 2020–21 monitoring period with respect to the previous year. Estuaries that improved in grade included the Gregory ('good' (70) to 'very good' (81)), St. Helens/Murray ('moderate' (59) to 'good' (62)), and Rocky Dam ('poor' (24) to 'good' (63)), while estuaries that declined in grade included the O'Connell ('moderate' (50) to 'poor' (35) and Vines ('good' (71) to 'moderate' (48)).
2) Imidacloprid and diuron were the key contributors to the overall PRM in all the estuaries assessed, with the exception of the Vines and Plane Creek Estuaries, where metsulfuron-methyl was the key contributor (Figure 15). Notably, atrazine contributed less of the total PRM across the region than in the previous year.
3) Of the eight estuaries assessed, five were reported to have met the desired low risk category (i.e., protective of at least 95% of species, with less than 5% of species are affected). However, the Sandy Creek, O'Connell River, and Vines Creek estuarine waters experienced 'very high', 'high', and 'moderate' pesticide risks, respectively. These results highlight that estuarine species are at moderate to high risk of experiencing toxic effects due to high pesticide concentrations in three monitored MWI waterways, particularly in the Mackay region. There is a strong need to adopt management measures in the catchments where the pesticides are applied to mitigate impacts to aquatic biota.

The Rocky Dam Estuary had the largest score change of all monitored estuaries in the 2020–21 monitoring period, improving two grade categories from the previous year ('poor' (24) to 'good' (63)). This is primarily due to a decrease in risk for atrazine, diuron, imidacloprid, and imazapic, which are chemicals associated with agricultural practice in the Region.

The PRM score for **Vines Estuary** declined by 23 points (71 to 48) in comparison to the previous monitoring period. This score change was primarily due to an increase in risk for the chemicals imidacloprid, diuron, and metsulfuron-methyl.

Table 22. Results for the Pesticide Risk Metric (PRM) indicator accounting for 22 pesticides, expressed as aquatic species protected (%) and associated standardised pesticide score, for eight estuaries in the MWI Region in the 2021 Report Card compared to 2017–2020 Report Cards.

Estuary	2021 Report Card		2020	2019	2018	2017*
	PRM (% species protected)	Standardised Pesticide Score	Standardised Pesticide Score			
Gregory River	99.00	**81**	70	59		39
O'Connell River^	87.10	**35**	50	48		36
St Helens/Murray Creek	95.30	**62**	59	58		62
Vines Creek	92.00	**48**	71	26		64
Sandy Creek	70.90	**18**	19	18		18
Plane Creek	98.90	**80**	75	74		73
Rocky Dam Creek	95.60	**63**	24	22		40
Carmila Creek	99.50	**90**	82	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 grade 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

Risk level: ■ Very high risk | ■ High risk | ■ Moderate risk | ■ Low risk | ■ Very low risk

* 2017 pesticides scores have been back-calculated to incorporate changes in pesticide methods 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.

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

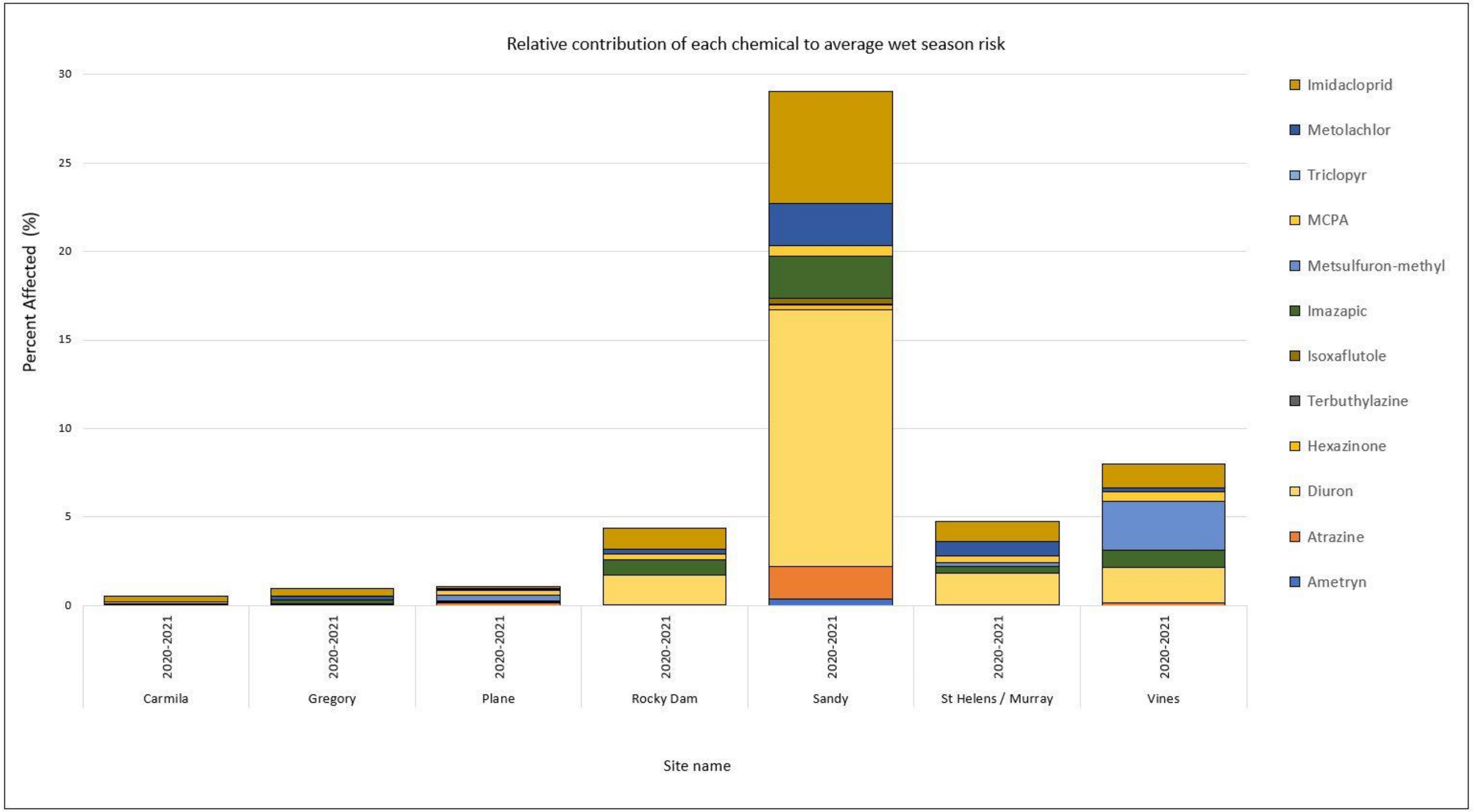

Figure 15. Proportional contribution of each pesticide to as the total percentage of species affected (PAF) as calculated using the Pesticide Risk Metric (PRM) for the 2020–21 reporting year in the MWI estuaries. Source: QLD Government, GBR CLMP.

3.1.5. Water Quality Index Scores

Notes on data interpretation for the 2021 Report Card

O'Connell data source: Data used to derive the O'Connell River Estuary water quality index are taken from an end-of-catchment monitoring site on the O'Connell River which is also used to monitor water quality within freshwater basins.

Results (Table 23 and Appendix C)**:**

Key Messages:

1) Water quality grades ranged from 'moderate' to 'good' in the current assessment period, where five of the eight estuaries met the water quality objective for the monitoring period.
2) An improvement in the Plane ('good' (73) to 'very good' (81)) was primarily due to a corresponding indicator category improvement in phys–chem. This is the first time the Plane Estuary has recorded a 'very good' grade since the inception of the Report Card.
3) The decline in the Vines Estuary ('good' (72) to 'moderate' (56)) was due primarily to corresponding increase in pesticide risk and DIN concentration in the estuary.

Table 23. Results for water quality indicator categories and final water quality index scores in estuaries for the 2021 Report Card (2020–21 data) in comparison to the 2015 to 2020 Report Card scores.

	2021 Report Card					2020	2019	2018	2017	2016	2015*
Estuary	Phys–chem	Nutrients	Pesticides	Chl-*a*	Water Quality Index	Water Quality Index					
Gregory River	84	90	81	62	**79**	**79**	77	81	75	76	75
O'Connell River^	54	75	35	61	**56**	**55**	56	44	65	50	57
St Helens/Murray Creek	77	65	62	47	**63**	**65**	59	53	62	61	66
Vines Creek	82	52	48	44	**56**	**72**	50	69	61	75	79
Sandy Creek	80	43	18	72	**53**	**59**	57	66	54	51	53
Plane Creek	90	78	80	75	**81**	**73**	70	80	78	62	66
Rocky Dam Creek	90	72	63	35	**65**	**62**	60	78	65	71	66
Carmila Creek	70	73	90	48	**70**	**73**	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

* Data from the 2015 Report Card are repeated from the 2014 Report Card.

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

3.1.5.1. Confidence

Confidence in water quality index scores in estuaries is shown in Table 24 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 are collected at either two or three monitoring sites, resulting in scores that are more spatially representative.

Table 24. Confidence associated with water quality index results in estuaries for the 2021 Report Card. Confidence criteria are scored 1–3 and then weighted by the value identified in parentheses. Final scores (4.5–13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1 to 5 (very low–very high), which indicates the final confidence level. Where confidence in results for the O'Connell River and Vines Creek and Carmila Creek Estuaries differ from the other estuaries, the relevant confidence scores for these estuaries are presented in square parentheses. 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
Phys–chem	3	3	1.5 [0.5]	3	1	9.1 [7.1]	3 [2]
Nutrients	3	3	1.5	3	1	9.1 [7.1]	3 [2]
Chl-*a*	3	3	1.5	3	1	9.1 [7.1]	3 [2]
Pesticides	3	3	1	3	2	8.8	3
					Water Quality Index	**10.1 [8.1]**	**3 [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.

3.2. 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, riparian and mangrove/saltmarsh extent, and flow. Impoundments are not assessed as a component of the estuaries. To assess vegetation condition in the estuaries, the same broad principles of assessment are applied within the target area, which begins at the estuary mouth and continues upstream to the tidal limit. Reporting cycles for the habitat and hydrology indicators are detailed in each section below, noting that these were not updated for the 2021 Report Card (Table 25).

3.2.1. Fish Barriers

Similar to freshwater basins, estuary fish barrier indicators are updated every four years and were last updated for the 2019 Report Card. The most recent assessment on fish barriers (Power et al., 2022) will be incorporated into the 2022 Report Card.

<u>**Results** (Table 25, 2018–19 data)</u>:

Key Messages:

1) Since the previous assessment, there has been no change to the overall fish barrier grade in any of the estuaries assessed. There was an improvement in the 'barrier density' indicator in the St Helens/Murray Creek Estuary reporting area, which shifted from a 'poor' to 'moderate' grade. 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 Estuary reporting area determined that these structures were not barriers to fish passage and were subsequently removed from the assessment.
2) The Vines Creek, O'Connell, and Gregory River Estuary assessment areas all received fish 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).

Plane Creek Estuary recorded the lowest fish barrier grade of 'poor'. The Plane Creek catchment is largely grazing and forestry, with some sugarcane production. The creek also flows through Sarina, a population centre of 5,500 residents where a sugar mill is 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.

The **Carmila Creek Estuary** assessment area reported no barriers to fish passage, scoring a grade of 'very good'. Fish barriers in Carmila Creek Estuary are located in the middle and upper river reaches, falling outside the estuary extent (18.5 m above the declared downstream limit (DDL)).

Table 25. Results for fish barrier indicators in estuaries in the 2021 Report Card (2018–19 data) compared to the 2018 Report Card (2014–15 data). Indicators assessed on Stream Order (SO) ≥3 or ≥4 as indicated. NB: no barriers. NLPB: no low "passability" barriers.

	2021 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 SO ≥3	Score	% of stream before first barrier on SO ≥3	Score	% of stream before 1st low pass barrier on SO ≥4	Score	Total Score	Fish Barriers (standardised)	Fish Barriers (standardised)
Gregory River	35	5	96	4	97	4	13	80	80
O'Connell River	5	3	85	4	NLPB	5	12	70	70
St Helens/Murray Creek	4	3	67	3	83	3	9	50	41
Vines Creek	13	4	96	4	NLPB	5	13	80	80
Sandy Creek	3	2	44	2	90	4	8	41	41
Plane Creek	2	1	48	2	76	2	5	21	21
Rocky Dam Creek	5	3	74	3	NLPB	5	11	61	61
Carmila Creek	NB	5	NB	5	NLPB	5	15	100	100

Refer to Table 9 for explanations of the relevant scoring ranges.

3.2.2. 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 saltmarsh environments also provide a variety 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 & Wolanski, 2001). To understand continuing threats to estuarine riparian vegetation extent and mangrove/saltmarsh extent, indicators are assessed every four years and were last updated in the 2019 Report Card (Table 26). Notably, these scores represent repeat data (indicated below) and changes only in the extent of vegetation since pre-clearing, not changes in the condition of the vegetation assessed.

<u>**Results** (2018–19 data, Table 26):</u>

Key Messages:

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

2) The mangrove/saltmarsh extent grades ranged from 'moderate' in the Vines Creek Estuary to 'very good' in the Gregory River and O'Connell, St Helens/Murray, and Plane Creek Estuaries.

Overall, the mangrove/saltmarsh extent grades ranged from 'moderate' in the Vines Creek Estuary to 'very good' in the Gregory River and O'Connell, St Helens/Murray, and Plane Creek Estuaries. The remaining estuaries were reported to be in 'good' condition for mangrove/saltmarsh extent.

The extent of riparian vegetation in the **Carmila Creek Estuary** in 2017 was equal to the pre-clearing extent. Overall, there was no change in the extent of riparian vegetation observed between the 2013 and 2017 assessments. To evaluate any change in extent between assessment years, back-calculated values were developed for 2013 (Appendix C.3.).

In the **Sandy Creek Estuary**, approximately 2.9 ha of mangrove and saltmarsh vegetation have been lost since the 2013 assessment (Appendix C.3.). This included approximately 2.58 ha of Regional Ecosystem (RE) 8.1.3 (*Sporobolus virginicus* tussock grassland on marine sediments) and 0.27 ha of RE 8.1.2 (Samphire open forbland on saltpans and plains adjacent to mangroves). Both REs are listed with a biodiversity status 'Of concern' and are valued, in part, for the habitat they provide to endangered and significant species, respectively. Agricultural encroachment and changes to hydrology in Sandy Creek Estuary may have caused this reduction (Chamberlain et al., 2020).

There was a net increase in the areal extent of mangrove/saltmarsh vegetation in the **St Helens/Murray Creek Estuary** since pre-clearing. Such changes may occur as a result of extensive sediment deposition in nearshore environments. 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/Murray Creek (Duke & Wolanski, 2001). 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 & Wolanski, 2001).

Table 26. Results for riparian and mangrove/saltmarsh extent loss since pre-clearing (%), hectares remaining, and standardised riparian and mangrove/saltmarsh extent in estuaries in the 2021 Report Card (2017 data). Hectares were rounded to the nearest whole number.

Estuary	2021 Report Card					
	Mangrove/Saltmarsh Extent		Riparian Extent		Standardised Mangrove/ Saltmarsh Extent	Standardised Riparian Extent
	Hectares lost since pre-clearing	% loss since pre-clearing	Hectares lost since pre-clearing	% loss since pre-clearing		
Gregory River	96.2	3.2	9.4	4.9	87	81
O'Connell River	108.9	4.0	40.5	57.2	84	17
St Helens/Murray Creek	-6.5*	-0.2*	54.2	17.1	100	58
Vines Creek	114.0	15.6	8.6	18.1	60	56
Sandy Creek	411.0	14.0	70.0	38.3	63	32
Plane Creek	26.1	2.2	23.0	17.0	91	58
Rocky Dam Creek	432.2	7.1	11.9	4.7	76	82
Carmila Creek	29.0	6.9	0.0	0.0	77	100

Riparian and mangrove/saltmarsh extent (% loss) scoring range: ■ 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 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

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

3.2.3. Flow

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 2021 Report Card.

Considerable work has been undertaken to fill data gaps and is currently progressing in collaboration with the TWG and BoM. A review of the flow tool to identify further refinements and updates is expected for future report cards. In addition, the Partnership has submitted a recommendation to BoM on priority sites for flow gauging stations to be implemented in MWI estuaries in the future.

3.2.4. Habitat and Hydrology Index Scores

As no habitat and hydrology indicators were updated in the 2021 Report Card, scores for this index are repeated from the 2019 Report Card. In accordance with the approximate four-year reporting frequency for these indicators, scores for riparian extent, mangrove/saltmarsh extent, and fish barriers were all last updated in the 2019 Report Card. Scores have been back-calculated using new methodologies to facilitate comparison between datasets over time.

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 historical impacts and ultimately drive an improvement in condition grades.

Results (Table 27 and Appendix C):

Key Messages:

1) The overall habitat and hydrology index grades for estuaries in the 2021 Report Card ranged from 'moderate' to 'very good' across the MWI Region.
2) 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 ('good'), there was an 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.

Table 27. Results for habitat and hydrology indicator categories and index in estuaries for the 2021 Report Card (2018–19 data) compared to the 2018 Report Card (2014–15 data).

	2021 Report Card						2018*
Estuary	**Mangrove/ Saltmarsh Extent**	**Riparian Extent**	**Fish Barriers**	**Flow**	**Habitat and Hydrology Index**		**Habitat and Hydrology Index**
Gregory River	87	81	80		**83**		83
O'Connell River	84	17	70		**57**		57
St Helens/Murray Creek	100	58	50		**69**		66
Vines Creek	60	56	80		**65**		66
Sandy Creek	63	32	41		**45**		45
Plane Creek	91	58	21		**56**		56
Rocky Dam Creek	76	82	61		**73**		77
Carmila Creek	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 updated to incorporate changes associated with refinements to the source mapping used to assess vegetation (riparian and mangrove/saltmarsh) extent.

3.2.4.1. Confidence

Overall confidence for the habitat and hydrology indicator category was 'moderate' (Table 28).

Table 28. Confidence associated with habitat and hydrology index results in estuaries for the 2021 Report Card. Confidence criteria are scored 1–3 and then weighted by the value identified in parentheses. Final scores (4.5–13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1 to 5 (very low–very high), which indicates the 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.

3.3. Fish in Estuaries

There is no score for the 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.

3.4. Overall Estuary Condition

Results (Table 29 and Appendix C.2.):

Key Message:

1) Overall estuary grades in the 2020–21 monitoring period were similar to the previous year, with the exception of the Vines Estuary, which declined from 'good' (68) to 'moderate' (60). This shift was due largely to declines in the chl-*a*, pesticide risk, and DIN grades for the estuary.
2) For the Gregory and Carmila Estuaries, this marks the second consecutive year in which these estuaries have recorded 'very good' overall grades.
3) Due to varied reporting frequency of some data, no indicators from the 'Habitat and Hydrology' index were updated in the 2021 Report Card.

Table 29. Overall condition scores and grades of estuaries for the 2021 Report Card in comparison to 2015–2020 Report Card scores.

Estuary	2021 Report Card					2020	2019	2018**	2017*	2016*	2015*#
	Water Quality	Habitat and Hydrology	Fish	Estuary Score and Grade		Estuary Score					
Gregory River	79	83		**81**	**A**	81	80	82	79	80	79
O'Connell River^	56	57		**56**	**C**	56	56	51	61	54	57
St Helens/Murray Creek	63	69		**66**	**B**	67	64	57	61	61	63
Vines Creek	56	65		**60**	**C**	68	57	68	64	72	73
Sandy Creek	53	45		**49**	**C**	50	51	58	52	50	52
Plane Creek	81	56		**68**	**B**	64	63	68	67	59	61
Rocky Dam Creek	65	73		**69**	**B**	67	66	76	70	73	70
Carmila Creek	70	92		**81**	**A**	82	78	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

*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.

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

Data from 2015 Report Card are repeated from the 2014 Report Card.

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

4. Inshore and Offshore Marine Results

The inshore marine region is divided into four zones: The Northern, Whitsunday, Central, and Southern Inshore Marine Zones (hereafter referred to as the Northern, Whitsunday, Central, and Southern Zones, respectively). The offshore region is represented by the Offshore Marine Zone (hereafter referred to as the Offshore Zone) (Figure 1). Scores for each zone are calculated from a series of indices that consist of indicators under relevant indicator categories (Figure 16). Litter scores are reported in inshore zones and urban areas for the second time in the 2021 Report Card. These scores do not contribute to the overall inshore marine grade as they are site-specific and recorded on a different scale (4.4.4. Litter).

The North Queensland Bulk Ports Corporation Ltd (NQBP) Marine Monitoring Programs and the GBR Marine Monitoring Program (MMP) are significant contributors to the inshore marine dataset used to calculate scores. Monitoring reports for NQBP Monitoring Programs can be found on the NQBP website[26], while the MMP annual reports can be found in the GBRMPA e-library[27]. Identifying a data gap in Southern Zone monitoring, the Partnership initiated and funded the Southern Inshore Program (SIP) in 2017[28]. Data used to calculate offshore coral scores is sourced from the Long-term Monitoring Program (LTMP), and reports can be found on the AIMS website[29]. Water quality data for the Offshore Zone is currently not reported following the decommissioning BoM's marine water quality dashboard, and new data sources are being investigated.

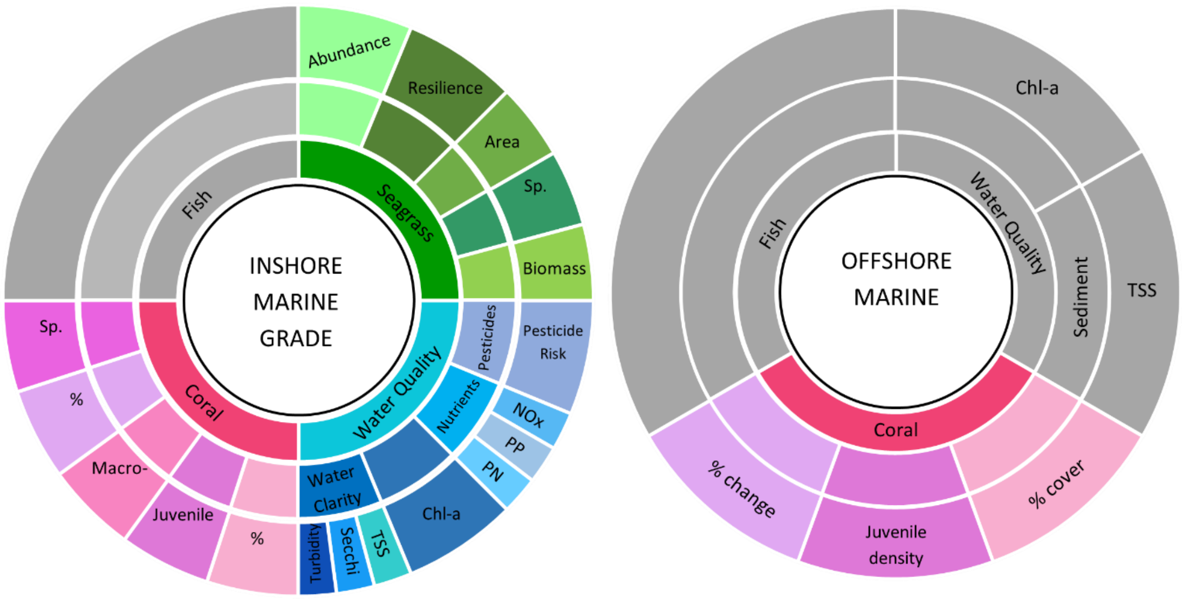

Figure 16. Indicators (outer ring), indicator categories (middle ring) and indices (inner ring) that contribute to overall inshore (A) and offshore (B) marine grades. Where no indicator category is listed, this represents that the indicator/s (e.g. juvenile density) does not fit into any category below the index level (e.g. coral). Grey shading represents no data. Note: NOx = nitrogen oxides, PP = particulate phosphorus, PN = particulate nitrogen, TSS = total suspended solids, chl-*a* = chlorophyll-*a* concentration, and sp. comp = species composition.

[26] https://nqbp.com.au/sustainability/research-and-reports
[27] https://elibrary.gbrmpa.gov.au/jspui/browse?type=series&value=Marine+Monitoring+Program
[28] https://healthyriverstoreef.org.au/southern-inshore-monitoring-project/
[29] https://www.aims.gov.au/reef-monitoring/gbr-condition-summary-2020-2021

4.1. Water Quality in Marine Zones

Inshore marine water quality in the MWI Region is influenced by six major river basins: the Don, Proserpine, O'Connell, Pioneer, and Plane Basins in the MWI Region and the Fitzroy Basin. More specifically, the Pioneer and Fitzroy Rivers appear to have the greatest influence on the Whitsunday region. Under strong discharge conditions, the Pioneer River dominates waters inshore of the Whitsunday Islands, while the offshore area of this region is influenced by the Fitzroy River (Baird et al., 2019). The Whitsunday 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).

4.1.1. Inshore Marine Zones

4.1.1.1. Nutrients, Chlorophyll-*a*, and Water Clarity

Nutrient scores for inshore zones 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[30] for each indicator at each site within a zone. Preliminary scores are aggregated across sites and indicators to produce the final nutrients, chl-*a*, and water clarity indicator category scores within a zone (see Methods Report[3]).

<u>Notes on data interpretation for 2021 Report Card results</u>

Water Clarity: Water clarity indicators (TSS, secchi depth, and turbidity) are related but not completely comparable. 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. The former is considered the most damaging to seagrass and coral growth (Bainbridge et al., 2018; Storlazzi et al., 2015).

Decommissioned Sites: Several of the NQBP water quality monitoring sites were decommissioned during the 2020–2021 reporting season (see Methods[3]). These sites were decommissioned either due to repeated instrument loss and/or lack of variance in data between adjacent site locations. To facilitate effective temporal comparison, see supplementary materials Appendix D.1.3. Marine water quality back-calculationsAll comparisons in the current results refer to the back-calculated scores for the 2019–2020 period.

Depth-Weighted Average Samples: The 2021 Report Card uses depth-weighted average (DWA) sample data from MMP rather than previous years which used only surface sample data. This change was made to align with reporting at AIMS and throughout Regional Report Card networks. Differences observed in these scores are likely due to stratification from different physical pressures between different water depths. DWA samples are commonly used to account for this variability within the water column and provide a representation of what the substrate and associated sensitive receptors

[30] The Northern Zone does not yet have localised GVs and instead uses values defined by GBRMPA or central QLD-wide. While these GVs are current, they don't account for ambient conditions or representative transitions between water type boundaries. This is relevant as many other sites within the region use site-specific GVs. See page 70 of Methods for a table showing all GVs and their sources.

experience. See supplementary materials Appendix D.1.3. Marine water quality back-calculationsAll comparisons in the current results refer to the back-calculated scores for the 2019–2020 period.

Water quality grades in the freshwater basins and estuaries are often better than those in the receiving inshore marine zone due to differences in guideline values and the cumulative impacts of multiple riverine sources converging.

Results (Table 30 and Appendix D.1.1.)**:**

Key Messages:

1) Site-level declines, particularly in the Whitsunday Zone, were driven largely by increased levels of NOx. Many sites within the Central Zone do not record NOx as there is no guideline value for comparison.
2) Chl-*a* scores in the Whitsunday Zone were 'good' for the first time, with all sites improving from either 'poor' or 'moderate' in the previous year. Despite site-specific NOx declines, the Whitsunday Zone recorded an improvement for the third year in a row, largely driven by reduced concentrations of chl-*a*.
3) Improvements in the Central Zone scores were driven largely by reductions in PN concentration (and to a lesser extent PP and Chl-*a*).
4) The Southern Zone recorded a zero grade in Water Clarity every year since monitoring began in 2018, however at many other sites throughout the region there was a trend in improved TSS scores accompanied by a decline in Turbidity scores. This may be a result of sampling, where Turbidity is influenced by wave action and resuspension across a broader temporal scale, while TSS measurements capture suspended particulate matter at a point in time.

In the 2021 Report Card, nutrients, chl-*a* and water clarity grades ranged from 'good' to 'very poor' across the MWI inshore zones (Table 30). Appendix D.1.1. presents boxplots along with site-level and historic (2016 to 2020) scores for individual indicators.

Nutrients

At the zone-level, Nutrients scores in 2020–2021 remained similar to the previous year, with Northern remaining 'moderate' (50 to 55), Whitsunday remaining 'poor' (33 to 21), and Southern remaining 'good' (69 to 78). In the Central Zone the Nutrients score increased 28 points from 'poor' (36) to 'good' (63), largely driven by reductions in PN (and to a lesser extent PP) at the NQBP sites Slade, Victor, and Round Top Islands. These improvements were not detected at the MMP site at Repulse Bay.

In the **Northern Zone**, Euri Creek remained 'good', however PN scores declined from 'good' to 'poor'. Camp Island PP scores improved from 'very poor' to 'good', improving the overall site score from 'very poor' to 'poor'.

The declining score in the **Whitsunday Zone** was largely driven by increased levels of NOx at all sites, and all sites recorded the lowest possible score. This difference was most notable at Double Cone ('very good' to 'very poor'), and to a lesser extent Seaforth ('poor' to 'very poor'), as Pine Island retained its 'very poor' score from the previous year.

Most **Central Zone** sites showed improvements in PN scores in the 2020–2021 reporting cycle. During the previous year, all Central Zone sites scored ‘very poor’ for PN, whereas in the current year, the NQBP sites ranged from ‘moderate’ (Slade Island) to ‘good’ (Victor and Round Top Island). The MMP site at Repulse Bay remained ‘very poor’, with the lowest possible score recorded for all nutrients indicators. All NQBP sites remained ‘good’ (Slade and Victor Island) or improved to ‘very good’ (Round Top Island) for PP, while Repulse Bay remained ‘very poor’. Overall decline at Repulse Bay was driven by increased levels of NOx (‘good’ to ‘very poor’), which is not measured at NQBP sites due to lack of guideline values.

Nutrients scores improved at all three sites in the **Southern Zone** and the overall grade remained ‘good’ continuing improvements each year since commencement of monitoring in 2018. The most noticeable improvements related to PN, as Aquila improved from ‘very poor’ to ‘moderate’, and the two Carmila sites improved from ‘moderate’ to ‘very good’. PP scores differed spatially, with declines recorded at Aquila and CAM3, and an improvement at CAM2. All NOx scores remained ‘very good’.

Chlorophyll-*a*

Two of the four zones improved, with Whitsunday Zone score increasing to ‘good’ (68) from ‘moderate’ (43) and Central Zone increasing from ‘poor’ (24) to ‘moderate’ (42). Conversely, in the Northern Zone Chl-*a* declined to ‘moderate’ from ‘good’ (76). In the Southern Zone Chl-*a* remained ‘poor’ (30 to 31).

All sites in the **Northern Zone** experienced declined in Chl-*a* scores. Decline was most notable at the more inshore sites of Euri Creek (‘very good’ to ‘moderate’) and Camp Island (‘moderate’ to ‘very poor’).

Chl-*a* scores improved at all sites in the **Whitsunday Zone**. Both Double Cone and Pine Islands improved from 'poor’ to ‘good’, whereas Seaforth Island improved from ‘moderate’ to ‘good’.

In the **Central Zone**, chl-*a* varied at the site-level. Both Round Top Island and O’Connell River mouth improved (‘very poor’ to ‘good’ and ‘good’ to ‘very good’ respectively). Slade Island and Repulse Island dive mooring did not change (‘very poor’ and ‘poor’ respectively), whereas Victor Island declined from ‘poor’ to ‘very poor’.

The **Southern Zone** results varied across sites for chl-*a*. Aquila Island declined from ‘poor’ to ‘very poor’, Carmila-2 improved from ‘moderate’ to ‘good’, while Carmila-3 remained ‘very poor’.

Water Clarity

Overall Water Clarity improved from ‘moderate’ (50) to ‘good’ (63) in the Northern Zone and remained ‘poor’ in both the Whitsunday (33 to 38) and Central Zones (21 to 26). The Southern Zone remained ‘very poor’, recording a zero score consistently since monitoring began.

Scores in the **Northern Zone** did not change at either Camp or Holbourne Island ('moderate' and 'good' respectively), whereas it improved from 'poor' to 'moderate' at Euri Creek. Improvements at Euri Creek were driven by improved TSS ('poor' to 'good') despite a decline in Turbidity from 'good' to 'moderate'.

In the **Whitsunday Zone**, site level grades remained the same at Double Cone ('moderate') and Seaforth ('poor') whereas they improved at Pine Island ('very poor' to 'poor'). Improvements at Pine Island were driven by TSS scores ('very poor' to 'good'), although Turbidity at Pine Island declined from 'poor' to 'very poor'.

Central Zone sites generally remained 'very poor' with exceptions at Round Top and Slade Islands where water clarity scores improved from 'moderate' to 'good'. These improvements were driven in part by improvements in TSS (from 'very poor' to 'moderate' at Slade and 'good' at Round Top) despite declines in Turbidity scores.

In the **Southern Zone**, scores remained 'very poor' for the fourth year in a row. This pattern has likely been driven by the geophysical differences in this zone, where the proximity to silt-laden shallows and the large tidal range accompanied by strong currents often causes sediment to become resuspended in the water column.

Table 30. Results for inshore water quality indicator categories for the 2021 Report Card (2020–21 data) compared to 2017 through 2020 Report Cards.

	2021 Report Card			2020*			2019			2018			2017		
	Nutrients	*Chl-a*	Water Clarity	Nutrients	*Chl-a*	Water Clarity	Nutrients	*Chl-a*	Water Clarity	Nutrients	*Chl-a*	Water Clarity	Nutrients	*Chl-a*	Water Clarity
Northern	55	41	63	50	76	50	52	57	36	88	61	17		89	50
Whitsunday	21	68	38	33	43	33	24	11	20	32	22	30	1	0	21
Central	63	42	26	36	24	21	27	37	20	63	27	30	55	29	25
Southern	78	31	0	69	30	0	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

*2020 scores are back-calculated to take into consideration decommissioned sites and depth-weighted average sampling

4.1.1.2. Pesticides

Pesticides in the Inshore Zones are reported using the PRM (Table 31). This approach considers pesticides with multiple Modes of Action (MoA) that exert their toxicity by different means. As a result, the impacts to the marine environment through land-based run-off are assessed for a greater number of chemicals than when previously using the PSll-HEq (PSll Herbicide Equivalent Concentration) method (2017 and prior).

In the 2021 Report Card, 14 pesticides were measured in the North, 19 in the Central Zone, and 16 in the Southern Zone. It is expected that additional pesticides will be included in future Report Cards to align with Reef 2050 Water Quality Improvement Plan (WQIP) pesticide targets. Due to the additive nature of the PRM calculations, this may result in pesticide scores declining in future years as more pesticides are assessed.

Notes on data interpretation for 2021 Report Card results

Sampling methods: Pesticides data were collected using passive polar samples with up to five deployments at each site throughout the wet season. The specific pesticides included in the analysis have changed since previous years, with this year's samples excluding both Chlorpyrifos and Pendimethalin, most notably, both of which were previously detected in the Central and Southern Zones.

Reporting: Passive sampler deployments record a time-averaged estimate of pesticide concentrations and the highest (poorest) score is used to report risk. For the purposes of reporting, the percentage species protected (the inverse of percentage species affected) is reported alongside the final PRM score.

Whitsunday Zone data gap: Pesticides are not monitored in the Whitsunday Zone as previous investigations by MMP have determined that, with no major creeks or rivers flowing into this Zone, pesticide risk is very low. With risk being low, we have established that it would be poor value for the Partnership to contract a field team to undertake this work.

Results (Table 31 and Appendix D.1.2.)**:**

Key Message:

1) In the 2021 Report Card the Central and Southern Zones pesticides grade improved from 'good' to 'very good'. (Table 31). Low rainfall in the MWI region reduced freshwater discharge into the marine environment (Figure 8). This is likely to have driven improvements in pesticide grades.

Pesticides in the **Northern Zone** were monitored with Passive Polar samplers instead of grab samples for the first time, an improvement in methodology due to the ability to record concentration over an increased temporal scale. Scores for the 2021 Report Card are included for reference only as the first deployment (Nov. to 15th Dec.) was removed before the first flush onset of the wet season[31] and a second deployment was lost in the field.

[31] This deployment was within the 1st November to 30th April target period, yet removed before the first flush of the wet season rains.

In the **Central Zone**, site level improvements in the PRM (i.e., percentage of species protected) at MMP sites and the inclusion of NQBP sites were the key drivers for the improved pesticides score. At MMP sites, Repulse Bay remained 'very low risk' (99% species protected), and both Flat Top Island and Sandy Creek improved from 'low risk' (97% species protected) to 'very low risk' (99% species protected). The NQBP monitoring site at Slade Island was included in the report card for the first time and was graded as 'very low risk' (100% of species protected).

In the **Southern Zone**, risk improved from 'low' (98% of species protected) to 'very low' (100% of species protected).

Despite current scores showing 'low' or 'very low' risks from pesticides in inshore zones it is important to note that long term trends in the region suggest that concentrations of PSII herbicides are increasing at monitoring sites within the Great Barrier Reef Marine Park (Taucare et al., 2022). Pesticide management and load reduction plans may reduce the flow of pesticides into the marine environment at a site level, however there may be accumulation of PSII herbicides as they have long half lives in the marine environment (Taucare et al., 2022).

Table 31. Standardised pesticide scores for the 2021 Report Card, compared to the 2017 to 2020 Report Cards. Scores are calculated from the Pesticide Risk Metric (PRM) (up to 22 pesticides) reporting on the percentage of aquatic species protected (%) for inshore zones. NQBP = North Queensland Bulk Ports, MMP = Marine Monitoring Program, SIP = Southern Inshore Monitoring Program.

	2021 Report Card^			2020	2019	2018	2017
	Sample Type	**Program**	**Pesticide Score**	**Pesticide Score**			
Northern	Passive Polar	NQBP	100*	100**	99**		
Whitsunday							
Central	Passive Polar	MMP	85	74	60	54	50
	Passive Polar	NQBP	100	100**	99**		
Southern	Passive Polar	SIP	100	75	100		

Pesticide scoring range: ■ Very Poor = 0 to 20 | ■ Poor = >20 to 40 | ■ Moderate = >40 to 60 | ■ Good = >60 to 80 | ■ Very Good = >80 | ■ No score/data gap

*Passive Polar samples used as reference but not incorporated into Water Quality scores due to lack of temporal representativeness during wet season

**Grab samples used as reference but not incorporated into Water Quality scores.

^2021 scores are not directly comparable to previous years due to changes in sampling methodologies that may not measure the same analytes within the PRM.

4.1.2. Offshore Marine Zone

Offshore marine water quality scores were previously sourced from the BoM MWQ dashboard. During 2019–20 there were limitations in the technical support for maintaining the MWQ processing scripts and satellite data streams. Consequently, in early 2021, the BoM advised that the MWQ dashboard had been decommissioned and that the underlying data would be discontinued during the year. Alternative data sources are currently being identified for reporting offshore water quality for the 2021–22 reporting year. See Appendix D.1.4. for a historic record of Offshore water quality results.

4.1.3. Overall Marine Water Quality Index

Results (Table 32)**:**

Key Messages:

1) Similar to the previous year, below average rainfall across the region likely influenced grades, as lower freshwater inputs correspond with less nutrients, sediments, and pollutants transported from agricultural and urban areas.
2) Water clarity remains a key issue in the Whitsundays, with the local tourism industry, researchers, and recreational users reporting significant amounts of silt and other sediments still in the system.

All inshore zones were graded as 'moderate', and both Whitsunday and Central Zones recorded change and improved from 'poor'.

In the Whitsunday Zone, overall improvement was driven by Chl-*a,* while the Central Zone saw improvement in both Chl-*a* ('poor' to 'moderate') and Nutrients ('poor' to 'good').

Although overall score in the Northern Zone remained similar to the previous reporting cycle, a decline in Chl-*a* ('good' to 'moderate') balanced an improvement in Water Clarity ('moderate' to 'good').

Table 32. Water quality scores and grades for the 2021 Report Card for inshore zones, including previous water quality scores for the 2015–2020 Report Cards. Scores from the 2015 Report Card have been back-calculated to exclude pesticide scores in the Whitsunday Zone so that they are directly comparable to 2016 and 2017 scores.

	2021 Report Card*					2020*	2019	2018	2017	2016	2015
	Nutrients	Chl-*a*	Water Clarity	Pesticides	Water Quality Index	Water Quality Index					
Northern	55	41	63	100^	**53**	59	48	55			
Whitsunday	21	68	38		**42**	36	18	28	7	40	42
Central	63	42	34	85	**56**	39	36	44	40	44	54
Southern	78	31	0	100	**52**	43	48	22			

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

*Due to decommissioned sites and depth-weighted average sampling, grades from 2020 onwards cannot be directly compared to previous scores

^*Passive Polar samples used as reference due to lack of temporal representativeness during wet season

4.1.3.1. Confidence

Confidence in water quality index scores in the inshore zones is 'moderate', ranging from 'moderate' to 'low' for different indicators (Table 33). Improvements to quality assurance and control of turbidity data are continuing as part of the 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 33. Confidence associated with water quality index results in marine zones for the 2021 Report Card. Confidence criteria are scored 1–3 and then weighted by the value identified in the parentheses. Final scores (4.5–13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1 to 5 (very low–very high), which indicates the final confidence level.

Zone	Indicator Category	Maturity of Methodology (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured Error (x0.71)	Final	Rank
Northern	Nutrients	3	3	1.5	3	3	10.5	4
	Chl-*a*	3	3	1.5	3	3	10.5	4
	Water Clarity	3	3	1	3	2	8.8	3
	Pesticides	2	2	0.5	2	1	5.3	1
Whitsundays	Nutrients	3	3	1	3	3	9.5	3
	Chl-*a*	3	3	1	3	3	9.5	3
	Water Clarity	3	3	1.5	3	3	10.5	4
	Pesticides							
Central	Nutrients	3	3	2	3	3	11.5	4
	Chl-*a*	3	3	2	3	3	11.5	4
	Water Clarity	3	3	2	3	2	10.8	4
	Pesticides	2	2	2	2	1	8.3	3
Southern	Nutrients	3	3	1.5	3	3	10.5	4
	Chl-*a*	3	3	1.5	3	3	10.5	4
	Water Clarity	3	3	1	3	3	9.5	3
	Pesticides	2	2	1	2	1	6.3	1
						Inshore Water Quality Index	**9.6**	**3**

Rank based on final score: 1 (very low): 4.5–6.3; 2 (low): >6.35–8.1; 3 (moderate): >8.1–9.9; 4 (high): >9.9–11.7; 5 (very high): >11.7–13.5.

4.2. Coral Index

Coral reef assessments are undertaken with the general understanding that healthy and resilient coral communities exist in a dynamic equilibrium between acute disturbances and reef recovery. Disturbance events may include cyclones, thermal bleaching, and outbreaks of crown-of-thorns starfish (COTS) (Thompson et al., 2018).

This year, for the second time, citizen science coral cover data collected by Reef Check Australia (RCA) volunteers are included in score calculations for the Whitsunday and Offshore Zones (Cook et al., 2020).

4.2.1. Inshore Marine Zones

Results (Table 34 and Appendix D.2.)**:**

Key Messages:

1) Although coral scores remained 'poor' across the Whitsunday Zone, there was an improvement in grade since 2020 (28 to 31) (Table D12). This is the first improvement since the continuous decline in grades following TC Debbie in 2017 and demonstrates potential for recovery after severe impacts provided conditions remain favourable (Thompson et al., 2022).
2) Recovery since TC Debbie is likely to have been influenced by poor water quality, as demonstrated by 'poor' or 'very poor' scores in recent years (4.1.1.1 Inshore Water Quality). High turbidity is a continued cause for concern to coral communities in the Whitsundays. Coral species tolerant of turbid conditions tend to be slower growing, and poor water quality favours macroalgae that make it difficult for juvenile corals to establish themselves, both factors that lead to slow recovery at highly impacted reefs (Thompson et al., 2022).
3) Despite the lack of significant disturbances in 2020–2021, inshore coral communities in the Southern Zone continue to experience cumulative impacts from the 2020 marine heat wave (Davidson et al., 2021) (1.4.5 Coral bleaching).

Overall scores in the **Northern Zone** remained 'poor' (from 28 in the previous year to 32 in 2020–2021). At Camp Island reef, the Cover Change indicator declined from 'poor' (29) to 'very poor' (12), whereas Juvenile recruitment improved from 'very poor' (12) to 'poor' (28). At Holbourne Island, shallow sites (2 m) were decommissioned in favour of alternative 5 m sites that better aligned with the objectives of the monitoring program (see Methods Report[3]). Consequently, they are not directly comparable to previous years. Coral Cover scores at Holbourne increased from 'very poor' (7) to 'poor' (32), due to the changes in sampling design, and total score improved from 'poor' (35) to 'moderate' (51).

The most notable improvements in the **Whitsunday Zone** were at Hook Island, Hayman Island, and Shute Harbour at 5 m. At Hook Island, improvement was driven by the high score for Cover Change (100), where cover of genus *Porites* has increased. Improved grades at Hayman Island were driven by Juvenile scores raising from 'poor' (22) to 'very good' (89) due predominately to increases in genus *Acropora,* a group that can lead to rapid increase in coral cover. At Shute Harbour, improvements were driven by reduction of macroalgae cover resulting in the Macroalgae score raising from 'poor' (28) to 'very good' (89) (Thompson et al., 2022).

Overall scores improved from 'poor' (28) to 'moderate' (43) in the **Central Zone** for the first time since monitoring began. The overall improvement at Round Top Island from 'poor' to 'good' (35 to 65) was largely driven by increased Juvenile recruitment ('poor' 28 to 'very good' 100) and reduced Macroalgae coverage ('poor' 26 to 'very good' 100). At Slade Island, overall scores improved from 'poor' to 'moderate', driven by improvements in Macroalgae scores from 'poor' to 'very good' (23 to 83). Warmer waters in 2020 may have reduced macroalgal cover, allowing recruitment of coral communities that had relatively low mortality despite observations of bleaching (Chartrand et al., 2021).

Coral scores in the **Southern Zone** declined from 'poor' (21) to 'very poor' (16). Scores were driven largely by a decrease in Cover at Henderson Island, a residual impact from the marine heat wave in 2020 that caused widespread bleaching, with over 50 % of hard coral cover lost from the 2 m depth and ~10 % of hard coral at the 5 m depth. Although genus *Acropora* populations were hardest hit, approximately 25 % of soft coral cover was also lost between 2019 and 2021 (Davidson et al., 2021). Consequently, at the 2 m depth Cover declined from 'very good' (85) to 'moderate' (51), and at the 5 m depth from 'very good' (88) to 'good' (78).

4.2.2. Offshore Marine Zone

The Offshore Zone felt some impacts of TC Debbie in 2017 and has shown some recovery since the event. Some impacts on these reefs are attributed to COTS, although this is often balanced by recovery of coral cover.

Results (Table 34 and Appendix D.2.5.)**:**

Key Messages:

1) Coral scores in the Offshore Zone remained 'moderate', improving from the previous year (57 to 59).
2) Overall scores were driven by on-going 'very good' grades for juvenile coral densities (95), contrasting 'poor' but improving coral cover.

Offshore Zone reef-level scores in 2020–2021 ranged from 'poor' (min 36) to 'good' (max 77) (Appendix D.2.5.).

Juvenile coral density was 'very good' at every site in the Offshore Zone except Penrith Island ('poor'). Coral recruitment is potentially limited by supply of larvae, or poor water quality that impacts the settlement or survival of these larvae (A. Thompson, pers. comm. 07/04/22). This score suggests that recent environmental conditions have not imposed substantive limitations to hard coral recruitment, reassuring ongoing resilience of coral communities in this zone.

The low juvenile coral density score of 28 'poor' for **Penrith Island** is potentially due to either the spatial remoteness of this island or relatively poor water quality. This is the most inshore of the offshore sites (see the Methods Report[3]) and may be isolated from the relevant brood stock (A. Thompson, pers. comm. 14/04/21).

Coral cover and cover change: Increases in coral Cover occurred at most reefs surveyed in 2021, the clear exception was Reef 20-104 where the 2021 cover represented the first survey of this reef since it was impacted by TC Debbie in 2017. Conversely, the Cover Change score remained 'moderate' (47 to 43), suggesting recovery of coral cover since the 2020 bleaching event was slightly suppressed. During March 2020 surveys, RCA reported 15% of Hardy Reef coral colonies were bleached, which was the highest level since surveys began at that site in 2002.

Table 34. Final 2020–21 coral scores for MWI inshore and offshore zones compared to previous Report Cards (2015–2020).

	2021 Report Card						2020	2019	2018	2017	2016	2015
	Cover	Macroalgae	Juvenile	Cover Change	Composition	Coral Index	Coral Index					
Northern	23	50	24	19		**32^**	25^^	29	25	31	45	
Whitsunday	27	38	40	27	24	**31**	28	30	42	52	61	58
Central	27	61	63	23		**43**	28	23	23	23	30	
Southern	37	0	10			**16**	21	20				
Offshore	39		95	43		**59**	57**	55	56	60	57*	57*

Coral index scoring range: ■ Very Poor = 0 to 20 | ■ Poor = >20 to 40 | ■ Moderate = >40 to 60 | ■ Good = >60 to 80 | ■ Very Good = >80 | ■ No score/data gap
^Scores in the Northern Zone are not comparable to previous years due to changes in sampling design.
^^Northern Zone scores in 2020 have been back-calculated to aggregate by island/reef-level rather than by site-level. This is to match current methods used in 2021, and all other zones in 2020. This resulted in a score change from 28 to 25.
*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.
**Offshore Cover Change scores, calculated by considering the change in coral cover during periods where reefs lack acute disturbance, have been amended due to updates in the disturbance categorisation at AIMS. This resulted in a score change from 55 to 57.

4.2.3. Confidence

Confidence in scores for coral indicators is 'high' (Table 35).

Table 35. Confidence associated with coral index results in marine zones for the 2020 Report Card. Confidence criteria are scored 1–3 and then weighted by the value identified in parentheses. Final scores (4.5–13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1 to 5 (very low–very high), which indicates the final confidence level. Unless otherwise specified, confidence in results is the same across marine zones where relevant.

	Indicator	Maturity of Methodology (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured Error (x0.71)	Final Score	Rank
Inshore	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**
Offshore	Cover	3	3	1	3	2	8.8	4
	Change	3	3	1	3	2	8.8	4
	Juvenile	3	3	1	3	2	8.8	4
						Offshore Coral Index	**8.8**	**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.

4.3. Seagrass Index

Seagrass data for the 2021 Report Card were sourced from either the MMP, the Queensland Ports Seagrass Monitoring Program (QPSMP), or the Partnership-funded Southern Inshore Program (SIP). The MMP measures abundance (percent cover) and resilience, while the QPSMP and SIP condition indicators are area, biomass, and species composition. Following a period of baseline data collection, the 2021 Report Card is the first to report on seagrass condition in the Southern Zone

Seagrass meadows across the region have been in a period of recovery since the devastating impacts of TC Debbie in March 2017. During TC Debbie, meadows sustained high rainfall, flood plumes, increased wave height, and strong winds, which severely impacted seagrass in the region. Compared to the previous year, in 2020–2021 overall condition grades remained 'good' in the Northern Zone, 'poor' in the Whitsunday Zone, and declined from 'good' to 'moderate' in the Central and Southern Zones. Conditions in 2020–2021 were favourable for seagrass growth as the wet season was mild and there were no extreme weather events.

Notes on data interpretation for 2021 Report Card results

Seagrass Resilience Metric: The MMP program has removed the nutrient status indicator and replaced the reproductive effort indicator with a resilience metric (Collier et al., 2021). This is due to the negative bias of the reproductive effort indicator in its failure to take into account differing life histories among seagrass species (see Methods[3]). Previous years' results have been back-calculated to offer comparison (Appendix D.3., Table D18–D19). All comparisons to previous years in the following section refer to these back-calculated scores.

Site Representation: In the 2021 report card, Abbot Point sites (APD1–4) were combined for meadow-scale monitoring instead of recording biomass and species composition as four separate blocks. This change has been referenced in the scores for the Area indicator and can more easily account for change in large-scale meadows that can be highly variable spatially from year to year, particularly in offshore habitats (McKenna et al., 2021). Refer to this year's scores and grades (Appendix D.3. Seagrass Index) and back-calculated results (Table D18–D19).

Results (Table 36 and Appendix D.3.)**:**

Key Messages:

1) Following several years of recovery after impacts from TC Debbie in 2017, 2020–2021 seagrass scores were similar to the previous year, yet variable across the region. Reduced freshwater discharge from local rivers in 2020–2021 (Figure 8) likely had a positive impact on seagrass meadows across MWI.
2) The Northern Zone continued to show improvement after seagrass loss from TC Debbie, moving from 'poor' (25) in 2017–18 to 'moderate' (52) in 2018–19 to a current score of 'good' (63 in 2019–2020 to 70 in 2020–2021).
3) Seagrass in the Whitsunday Zone has been poor for three consecutive years.
4) The shift in Central Zone scores from 'good' (65) to 'moderate' (58) were driven by a decline in Area at both Dudgeon Point and Hay Point and decline in Abundance at Newry Bay.

5) Seagrass condition is reported in the Southern Zone for the first time with a ‘moderate’ (60) score.

Northern Zone: Scores improved slightly but remained ‘good’. Improvements occurred primarily in Biomass, but also in Area at Abbot Point sites. Species composition ranged from ‘moderate’ (56) to ‘very good’ (93).

Whitsunday Zone: Overall meadow scores declined in the Whitsunday Zone, the exception being improved Abundance in the subtidal site at Tongue Bay (25 from 12). A new intertidal site at Lindeman Island (LN3) scored relatively high for Whitsundays (40) whereas the subtidal site at Lindeman (LN1 and LN2) declined; both Lindeman Island sites were ‘poor’. Abundance scores declined at Hydeaway Bay for the third year (from ‘very good’ to ‘good’ to ‘moderate’). Seagrass Resilience was either ‘poor’ or ‘very poor’ at all sites in the Whitsunday Zone.

Central Zone: There was an overall decline from ‘good’ to ‘moderate’ across the Central Zone and scores were variable between sites. Abundance scores at St. Helens improved for the third year in a row (from ‘poor’ to ‘moderate’ to ‘very good’), however declined at subtidal Newry Bay (from ‘good’ to ‘very poor’). Declines in scores at Dudgeon Point and Hay Point were driven by reduced Area, potentially due to degraded water quality and resuspension of sediments due to increased wave height (York & Rasheed, 2021).

Southern Zone: Overall condition in this zone has declined consistently, from ‘very good’ in 2018–2019, to ‘good’ in 2019–2020, to ‘moderate’ in 2020–2021. Individual sites scored ‘very good’ for Species Composition and varied from ‘moderate’ to ‘very good’ for Biomass. The overall Zone score of ‘moderate’ was driven by a ‘very poor’ score for Area at Flock Pigeon Island (site CVH2), a decline from ‘very good’ in the previous year, despite the coastal Clairview sites scoring ‘very good’ for Area. The Flock Pigeon Island meadow is characterised by isolated patches of seagrass rather than continuous coverage at the two coastal sites and it remains to be seen whether these changes in area are part of the normal variation of this site (Van De Wetering et al., 2021).

Table 36. Results for seagrass indicators for inshore zones for the 2020–21 reporting year, compared to previous Report Cards (2016–2020). Indicators are based on data collected from the Marine Monitoring Program (MMP) or North Queensland Bulk Port's (NQBP) Queensland Ports Seagrass Monitoring Program (QPSMP). Scores reported without a colour grade indicate back-calculations that have not been incorporated into overall scores. The seagrass index is derived via calculation rather than average of *site/meadow* scores, which can be found in Appendix D.3.

	2021 Report Card						2020	2019	2018*	2017*
	MMP		NQBP			Seagrass Index^	Seagrass Index			
	Abundance	Resilience	Biomass	Area	Species Comp.					
Northern	54		80	77	78	**70**	**63**	52	25	58
Whitsunday	26	25				**29**	**33**	27	13	24
Central	56	52	81	61	96	**58**	**65**	56	45	30
Southern			71	63	92	**60**	**64**	**82**		

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

*2017–2018 scores have not been back-calculated with the MMP Resilience metric and are therefore not directly comparable to current scores.

^Refer to Appendix D.3 for individual site scores used to calculate the seagrass index. Each meadow/site score is defined as the lowest grade/score of the three indicators within that meadow where this is driven by biomass or area. Where species composition is the lowest score, it contributed 50% of the overall meadow score, with the next lowest indicator (area or biomass) contributed the remaining 50%.

4.3.1. Confidence

Confidence ranks for seagrass condition indicators associated with both the MMP and QPSMP were equal, resulting in 'moderate' confidence in the overall seagrass index (Table 37).

Table 37. Confidence associated with seagrass index results in inshore zones for the 2020 Report Card. Confidence criteria are scored 1–3 and then weighted by the value identified in parentheses. Final scores (4.5–13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1 to 5 (very low–very high), which indicates the final confidence level.

Indicator	Maturity of Methodology (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured Error (x0.71)	Final Score	Rank
Abundance	3	3	1	3	2	8.8	3
Resilience	2	3	1	3	2	8.4	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	**8.7**	**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

4.4. Litter

A formal grade is given for litter for the second time in the 2021 Report Card. Data were sourced from the Australian Marine Debris Initiative (AMDI) Database. Scores were calculated based on a comparison of the data to a four-year baseline period from 2014–15 to 2017–18, representing the time before the Queensland Government state-wide management strategies were put in place. These strategies included the plastic bag ban that began 1st July 2018 and the container refund scheme that began 1st November 2018. For further details on data filtering and statistical methods, see Methods Report (sections 2.3.4., 3.2.5., and Appendix B).

Notes on data interpretation for 2021 Report Card results

Site-level scores: Scores are provided at the site level due to inconsistencies in sample sizes and sampling location across zones and years, and our 'very low' confidence in the results.

Standardised vs community events: ReefClean events, conducted quarterly at set locations, collect standardised litter data at beach sites. These data provide more reliable trends of change in litter type and abundance compared to volunteer beach clean-up data which are non-standardised. At community litter events, individual volunteer effort cannot be accounted for, and sites may not have standardised sampling methods.

Scoring scale: Litter score cut-off points are based on annual data distribution and refer to a scale of 'very high pressure' to 'slight pressure'.

Site-level differences: Coastal, island, and urban sites were cleaned in 2020–21; each with different potential sources of litter and frequency of clean-ups. Urban areas, for example, may be cleaned more regularly by the council and community.

Gross pollutant traps: Gross pollutant traps (GPTs) installed throughout Mackay are expected to reduce the amount of litter reaching the coastal and marine environment. These traps will impact results and it is not recommended to compare litter abundance in this zone with other zones that do not have GPTs installed.

Results (Table 38):

Key Messages:

1) Georges Point, a rural beach on Cape Gloucester, was the poorest scoring site in the MWI region. The site remained 'high pressure' and declined from 28 to 23 since 2019–20.

2) 75% of sites surveyed in 2020–21 scored either 'low' or 'slight' pressure.

Both Saba Bay on Hook Island (Whitsunday Zone) and Half Tide Beach at Hay Point (Central Zone) shifted from 'high pressure' to 'moderate pressure' since 2019–20, with scores of 49 and 43 respectively.

Fewer sites scored ‘high pressure’ than in the previous year, however it is important to note that some urban sites that scored ‘high pressure’ in previous reporting cycles have not been assessed this year.

All sites in the Southern Zone scored as 'slight pressure'.

Table 38. Site-level litter scores across the MWI Region for the 2021 Report Card.

Zone	Site-type	Site	2021 Report Card Score	2020 Report Card Score
Northern	Inshore	Queens Beach, Bowen*	**99**	99
		Gloucester Island, Eastern side	**63**	
		Don River Mouth, Bowen*	**99**	95
Central	Urban	Mackay City Centre		80
		Mackay Industrial Precinct		98
		Sarina Townsite		51
		Pioneer River, Glenella Connection Rd*	**84**	76
	Inshore	Town Beach, Mackay*	**73**	56
		Conway Beach*	**85**	96
		Dinghy Bay West, Brampton Island	**58**	
		Cape Conway	**77**	
		Far Beach, Mackay	**99**	
		Hay Point	**88**	
		Harbour Beach, Mackay*	**93**	99
		Half Tide Beach, Hay Point*	**43**	33
		Lamberts Beach, Mackay		94
		Wilson Beach, Conway*	**99**	100
		Midgeton Beach*	**97**	
		Louisa Creek Beach, Hay Point*	**88**	98
		Penrith Island*	**99**	
		Cattle Bay*	**99**	
		Goldsmith Island	**96**	
		South Bay*	**97**	
		St Helens Beach*	**92**	
		Sarina Beach	**98**	
		Armstrong Beach*		81
Whitsunday	Urban	Proserpine Town*		47
	Inshore	Turtle Bay, Whitsunday Island*	79	80
		Saba Bay, Hook Island*	49	25
		South East Bay, Long Island*	83	87
		Border Island	93	86
		Grimstone Point, Airlie Beach	42	
		East Beach*	89	
		Coral Beach, Airlie Beach*	85	66

Zone	Site-type	Site	2021 Report Card Score	2020 Report Card Score
		Mackerel Bay, Hook Island*	55	70
		Pigs Head Bay*	65	
		Neck Bay, Shaw Island	94	
		Billbob Bay, Shaw Island	91	
		White Bay*	74	
		Blue Pearl Bay, Hayman Island	96	
		South End of Runway, Hamilton Island		59
		Double Cone Island	96	
		Keyser Island*	98	
		South Bay*	99	
		Gap Beach*	99	
		Dalwood Point Bay*	98	
		Georges Point	23	28
		Eagle Bay, Shaw Island		71
		Solway Circuit, Whitsunday Island		76
		Pandanus Bay Long Island	62	
		Hook Island, East	60	53
		Bluff Point, Pioneer Bay*		20
		Pandanus Bay Long Island	62	
		Turtle Bay, South Molle Island*	**59**	52
		Luncheon Bay, Hook Island*	99	97
		Grimston Point East*	64	
		Southern Tip, Whitsunday Island*	52	35
		Dingo Beach*	99	84
Southern	Inshore	Avoid Island, The Percy Group	99	99
		South Beach*	99	
		Davidson Bay*	99	
		Treble Island*	99	
		North Beach*	99	
		Clairview Beach North*		99

Scoring range: ■ Very High Pressure = 0 to 5 | ■ High Pressure = >5 to 36 | ■ Moderate Pressure = >36 to 65 | ■ Low Pressure = >65 to 95 | ■ Slight Pressure = >95 | ■ No score/data gap (note, scoring range cut-offs are dependent on annual data distribution).
*ReefClean monitoring sites

4.4.1. Confidence

Data for the litter index are sourced from citizen scientists, introducing potential issues with data recording and input into the AMDI Database. Confidence for the litter index is therefore 'very low' (Table 39).

Table 39. Confidence associated with litter index results in inshore zones for the 2021 Report Card. Confidence criteria are scored 1–3 and then weighted by the value identified in parentheses. Final scores (4.5–13.5) are additive across weighted confidence criteria. Final scores correspond to a rank from 1 to 5 (very low–very high), which indicates the final confidence level. Unless otherwise specified, confidence in results is the same across inshore zones where relevant.

Indicator Category	Maturity of Methodology (x0.36)	Validation (x0.71)	Representativeness (x2)	Directness (x0.71)	Measured Error (x0.71)	Final Score	Rank
Litter	1	1	1	3	1	**5.9**	**1**
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.							

4.5. Fish Index

There is no score for marine fish condition for the 2021 Report Card. Identification of appropriate indicators and methodology development is currently underway for progressing fish assessment indicators in inshore and offshore zones. Development of this index using citizen science and/or engagement of recreational fishers is currently being investigated by the TWG, Wet Tropics, Dry Tropics, and MWI Partnerships.

4.6. Overall Marine Zone Condition

Results (Table 40)**:**

Key Messages:

1) Scores remained similar to the previous year and are likely tied to similar patterns of rainfall across the region.
2) In the Southern Zone, the inclusion of the seagrass indicator raised the overall grade to 'moderate' (42). Scores prior to the inclusion of seagrass measurements were typically 'poor'.

Overall, condition grades for inshore zones in the 2021 Report Card ranged from 'poor' (D) to 'moderate' (C). The Offshore Zone cannot be given an overall grade, as only the coral index was measured during the 2020–21 reporting cycle; however, coral scores remain for reference (Table 40).

While scores remained 'moderate' in the **Northern and Central Zones**, changes were driven by a decline in coral condition that balanced an improvement in seagrass condition. The **Whitsunday Zone** remained 'poor' for the fifth consecutive year.

The partnership-funded **Southern Inshore Program** is now well-established, with water quality (including pesticides) and coral indicators now assessed across multiple years. The addition of condition assessment for seagrass meadows in the current Report Card is particularly relevant for dugong protection in the region (Coles et al., 2002; Van De Wetering et al., 2021).

Table 40. Overall inshore and offshore marine scores for the 2020–21 reporting year, compared to 2016–2020 Report Cards. Scores incorporate back-calculations in the year prior to methods changes.

		2021 Report Card						2020^	2019	2018	2017*	2016
		Water Quality	Coral	Seagrass	Fish	Total Score and Grade		Total Score				
Inshore	Northern	53	32	70		49	C	50	43	35	44	43
Inshore	Whitsunday	42	31	29		34	D	32	25	27	27	47
Inshore	Central	54	43	58		48	C	44	38	37	31	41
Inshore	Southern	52	16	60		42	C	43	34	22		
Offshore			59					77	77	77	76	77**

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

^2020 scores have been adjusted to incorporate water-quality and seagrass methods changes applied in the 2021 Report Card and are not comparable to previous years.

*2017 scores have been adjusted to incorporate pesticide and seagrass methods changes applied in the 2018 Report Card and are not comparable to 2016.

**Offshore coral scores have been amended due to error in methods.

5. Human Dimensions Results

Unlike the other reporting groups in this document (i.e., freshwater, estuarine, and inshore and offshore marine), Human Dimensions indices comprise the human aspects of environmental management as opposed to a water type. As such, each of the indicators in this section have a modified grading scheme to the environmental indicators, which have been created out of necessity due to the unique nature of each index in this section (see corresponding Methods Report). Furthermore, as many of these indicators are either in their early stages of reporting and/or are still in methodological development, human dimensions indicators are not included in the 2021 Report Card.

5.1. Urban Water Stewardship Framework

Urban Water Stewardship Framework results are reported according to three indices: Developing Urban, Established Urban, and Point Source (Figure 17).

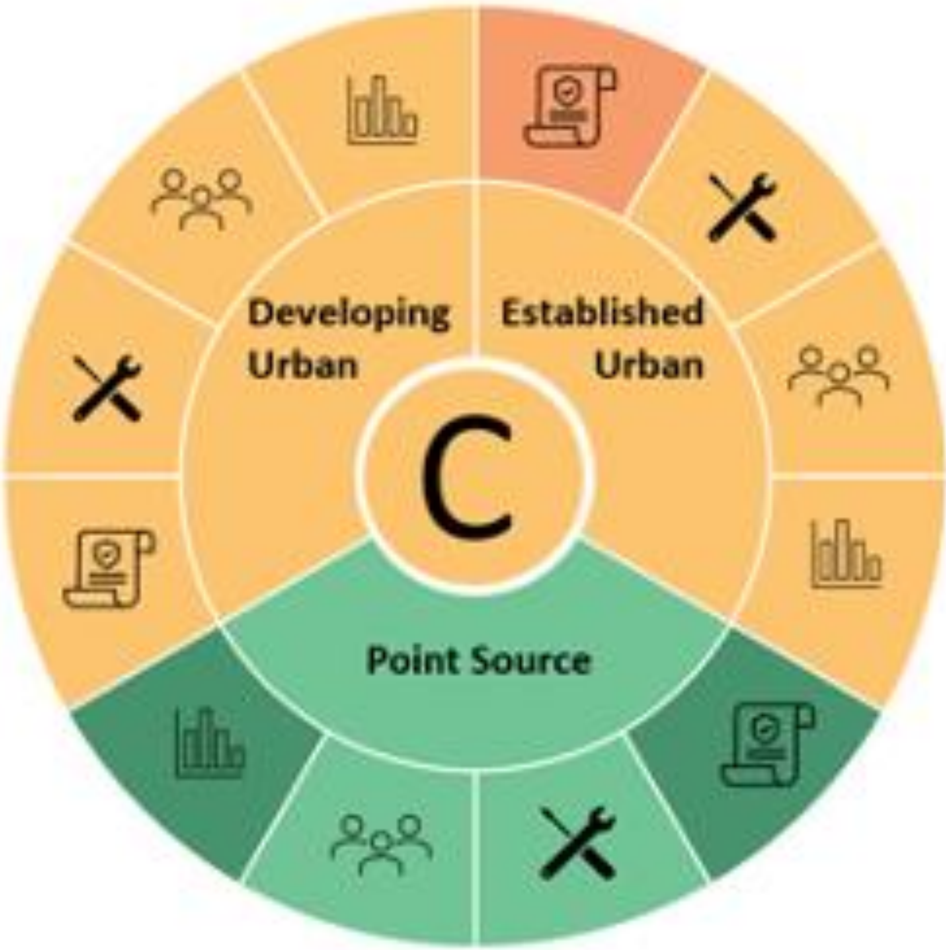

Figure 17. Indicator categories (outer ring), indicators (middle ring), and overall index grade (inner ring) that contribute to the overall UWSF score. The indicator categories (clockwise) for each indicator are 'policy, planning, and governance' symbolised by a scroll, 'infrastructure, management, and maintenance' symbolised by tools, 'social approaches' symbolised by people, and 'monitoring and evaluation' symbolised by a graph.

Results (Table 41–Table 43):

Key Messages:

1) The overall urban water management practice level for the MWI region was rated as C, which equates to a level of practice that meets minimum industry standards (i.e., general compliance with regulations and applying management practices that, whilst not best practice, are in line with those commonly used in Queensland). This also equates to a moderate level of risk to water quality, which implies either maintaining the status quo or a chance of slight deterioration in water quality.

2) The Developing Urban and Established Urban components of the framework received an overall rating of C, while the Point Source component received an overall rating of B. The latter represents management considered to be current industry best management practice. It means going above and beyond industry standards to protect or improve urban water quality.

3) For the Developing Urban and Established Urban components, elements received either a C or D grade. This means that the relevant water quality objective was not met for these

elements and suggests that all elements relating to pre- and post-development activities are at either a moderate or high risk of negatively influencing water quality.

4) Regionally, the poorest-scoring indicators related to policy, planning, and governance for the Developing and Established Urban categories, receiving either moderate or high-risk grades for all councils. This indicates that pre- and post-development plans currently lack the capability to deliver outcomes that meet stormwater and water quality objectives outlined in the urban water management processes. The results also indicate an opportunity for regional-level investment in building elements related to these categories to improve urban water outcomes.

5.1.1. Developing Urban

The Developing Urban component refers to urban areas under development for residential, commercial, or industrial purposes, which are frequently associated with the mobilisation of soils.

- One element of Policy, Planning, and Governing (site-based and ESC plans) was the poorest-scoring element in the Developing Urban component, with all LGAs receiving a 'high risk' grade (Table 41). This suggests a potential opportunity for more comprehensive erosion control planning across the MWI Region, including improved alignment with water sensitive urban design (WSUD) principles in the planning stage of developments in order to meet water quality objectives of the development approvals process.

- Regional grades for the Developing Urban indicator category (component) were either 'moderate' (C) or 'high risk' (D) for all indicators (elements).

Table 41. Scores and grades for Management Activity Groups for the Developing Urban indicator category. Regional Councils have been de-identified for privacy purposes. RC = Regional Council.

Management Activity Group (MAG)		Regional Council Score			Regional Mean Score
		RC 1	RC 2	RC 3	
DU 1	Policy, planning, and governance (Urban Stormwater Management & ESC policy)	10.00	9.75	10.00	9.92
DU 2	Policy, planning, and governance (development assessment and approvals)	7.00	8.75	8.75	8.17
DU 3	Policy, planning, and governance (Site-based and ESC plans)	0.00	2.00	9.50	3.83
DU 4	Infrastructure management & maintenance (Site-based USM and ESC)	3.00	5.00	11.00	6.33
DU 5	Social approaches (Collaboration, partnerships, capacity building, and learning)	6.00	15.50	7.50	9.67
DU 6	Monitoring, evaluation, reporting & improvement	6.00	12.75	9.43	9.39

Score Ranges: ■ Very Poor = 0 to <5 | ■ Poor = 5 to 12.5 | ■ Good = 12.5 to <17.5 | ■ Very Good = >17.5 | ■ No score/data gap

5.1.2. Established Urban

The Established Urban indicator category refers to contaminant loads from established residential, commercial, or industrial areas and is often associated with the mobilisation of soils.

- Similar to the Developing Urban category, all indicators scored as 'high risk' (D) or 'moderate risk' (C) for the Established Urban indicator category (**Error! Reference source not found.**). T his indicates regional room for improvement across various post-development activities, including the installation and maintenance of treatment devices within catchments, ecosystem-based sediment and nutrient pollution mitigation, managing and maintaining stormwater treatment assets, and urban water monitoring that integrates catchment-level considerations.

- Both of the policy, planning, and governance indicators (elements) graded as high risk (D) at the regional level. This indicates a gap in policy and planning for both urban stormwater systems (USS) and the incorporation of total water cycle management and catchment-based principles in informing decision-making urban water processes.

Table 42. Scores and grades for Management Activity Groups for the Established Urban indicator category. Regional Councils have been de-identified for privacy purposes. RC = Regional Council.

Management Activity Group (MAG)		Regional Council Score			Regional Mean Score
		RC 1	RC 2	RC 3	
EU 1	Policy, planning, and governance (Catchment Management)	10.00	4.00	0.00	4.67
EU 2	Policy, planning, and governance (Stormwater Management Plan)	7.00	1.00	0.00	2.67
EU 3	Infrastructure management and maintenance (Stormwater network)	7.00	9.00	3.33	6.44
EU 4	Social approaches (Collaboration, partnerships, capacity building, and learning)	7.50	14.25	1.00	7.58
EU 5	Monitoring, evaluation, reporting, and improvement	11.00	6.00	6.00	7.67

Score Ranges: ■ Very Poor = 0 to <5 | ■ Poor = 5 to 12.5 | ■ Good = 12.5 to <17.5 | ■ Very Good = >17.5 | ■ No score/data gap

5.1.3. Point Source

Point sources are considered to emanate from wastewater treatment facilities operated by councils, exclusive of industrial waste and privately-owned wastewater treatment facilities.

- Point Source components were all rated either as A- or B-level practice (**Error! Reference s ource not found.**). The highest scores were regarding management practices associated with activities in the policy, planning, and governance and monitoring and evaluation. Point Source elements are advanced and indicative of a high level of stewardship.

- The highest regional score for point source was attributed to management activities relating to monitoring, evaluation, reporting, and improvement, receiving a 'very good' grade. This is the highest-scoring element across any activity group, indicating above-and-beyond-level stewardship across the MWI Region.

Table 43. Scores and grades for Management Activity Groups for the Point Source indicator category. Regional Councils have been de-identified for privacy purposes. RC = Regional Council.

Management Activity Group (MAG)		Regional Council Score			Regional Mean Score
		RC 1	RC 2	RC 3	
PS 1	Policy, planning, and governance (sewage wastewater management)	18.75	13.75	20.00	17.50
PS 2	Infrastructure management and maintenance (Sewerage network)	13.50	15.00	20.00	16.17
PS 3	Infrastructure management and maintenance (new STP and upgrades)	17.50	15.00	15.00	15.83
PS 4	Social approaches (Collaboration, partnerships, capacity building, and learning)	17.00	14.50	19.00	16.83
PS 5	Monitoring, evaluation, reporting, and improvement	19.00	18.50	18.00	18.50

Score Ranges: ■ Very Poor = 0 to <5 | ■ Poor = 5 to 12.5 | ■ Good = 12.5 to <17.5 | ■ Very Good = >17.5 | ■ No score/data gap

5.1.4. Confidence

Overall confidence for the Urban Water Stewardship indicator was 'poor' (Table 44).

Table 44. Confidence associated with Urban Water Stewardship Results for the 2020–21 monitoring period. Confidence criteria are scored 1 to 3 and then weighted by the value identified in parentheses as per the UWSF implementation manual (DES, 2020). Final scores (6–18) are additive across weighted confidence criteria. Summary rationales are given below each criterion.

	Maturity of methodology (x0.4)	Validation (x0.7)	Representativeness (x4.0)	Directness (x0.7)	Measured error (x0.7)	Final	Rank
UWSF 2020–21	2	1	2	1	1	**11**	**2**
Rationale	UWSF ratings based on ISP-endorsed method	No reference to use of primary data for UWSF activity ratings (pre and during workshop)	Spatial (3): All 3 LGAs in RRC region included in assessment Temporal (1): This is the first year the finalised UWSF assessment method was done in the region (even though a pilot was done in the Whitsunday SC the year before)	The UWSF assessment process was applied at the LGA urban area urban footprint scale (i.e., not to particular areas within an LGA) and based on the most common scenario (i.e., not to a particular case).	No measure of error quantified		

5.2. Cultural Heritage

Cultural Heritage results are currently in review with the MWI Traditional Owner Reference Group (TORG).

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Appendix A—Annual Rainfall

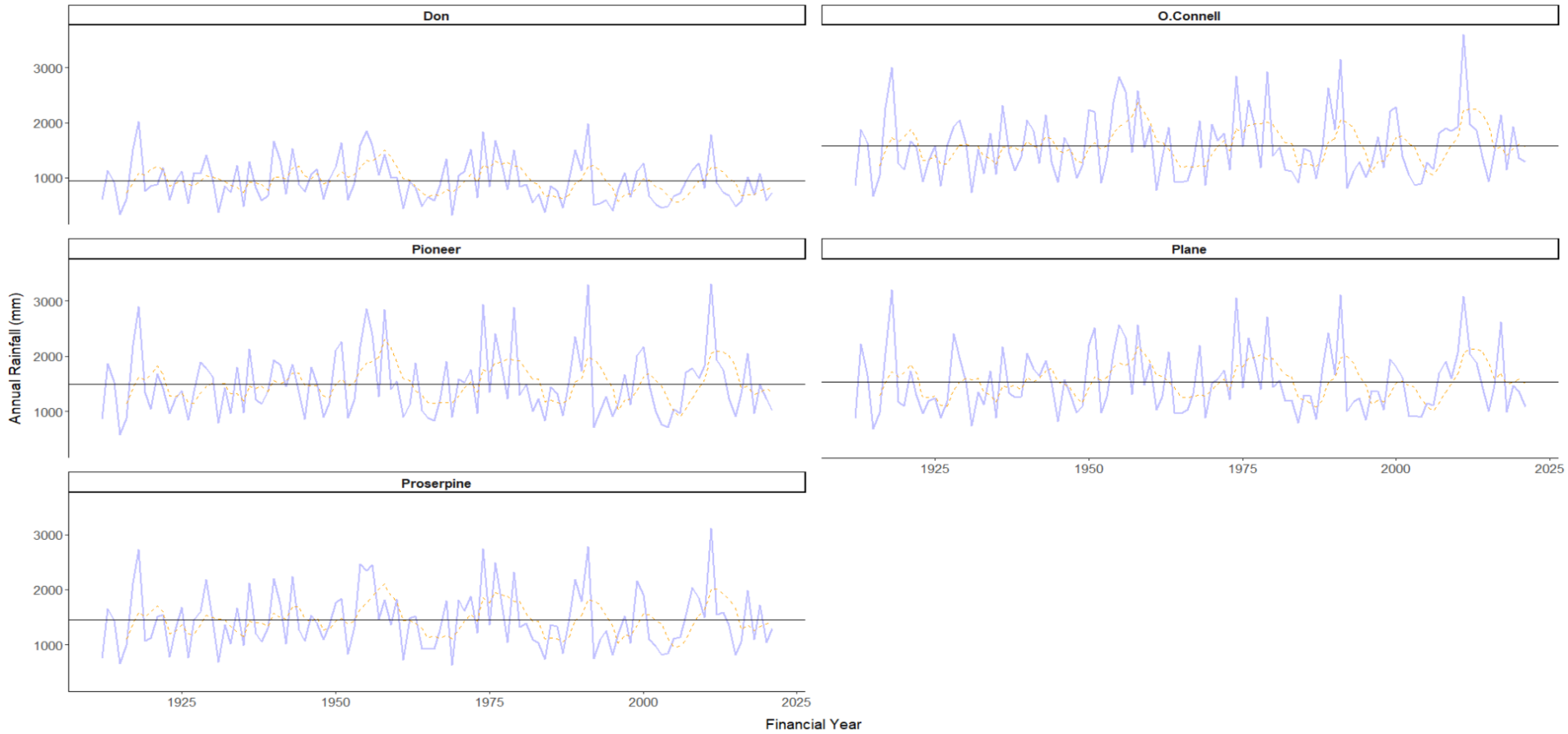

Figure A1. Annual rainfall totals for each MWI basin (Don, Proserpine, O'Connell, Plane, and Pioneer). Financial year represented by blue line, five-year moving average of totals represented by orange dashed line, and long-term annual rainfall average (1911–12 to 2019–20) represented by black horizontal line. Long-term annual rainfall data sourced from BoM and calculated using results from 1911–2020.

Appendix B.1. Basins—Summary Statistics and Boxplots

Site	Indicator	Sample Size	Mean	Min	25th percentile	Median	75th percentile	Max	Guideline Value
Don River at Bowen	TSS	38	224.37	0.5	10	133.5	293	1580	5
Proserpine River at Glen Isla	TSS	58	259.31	16	128	185	358.5	836	5
O'Connell at Caravan Park	TSS	65	33.14	2	10	23	46	178	2
O'Connell at Stafford's Crossing	TSS	56	76.5	0.5	9.25	21.5	80	897	2
Pioneer River at Dumbleton HW	TSS	61	9.53	0.5	2	4	8	88	5
Sandy Creek at Homebush	TSS	100	94.52	1	15.5	35	98.25	956	5
Plane Creek at Sucrogen Weir	TSS	49	31.71	1	5	13	32	285	3
Don River at Bowen	DIN	38	0.26	0.05	0.18	0.22	0.26	0.78	0.03
Proserpine River at Glen Isla	DIN	58	0.38	0.07	0.21	0.32	0.49	1.09	0.03
O'Connell at Caravan Park	DIN	66	0.59	0	0.04	0.1	0.72	5.27	0.03
O'Connell at Stafford's Crossing	DIN	55	0.13	0	0.03	0.09	0.2	0.48	0.03
Pioneer River at Dumbleton HW	DIN	60	0.31	0	0.11	0.28	0.42	0.97	0.008
Sandy Creek at Homebush	DIN	97	0.59	0.02	0.19	0.32	0.68	3.76	0.03
Plane Creek at Sucrogen Weir	DIN	49	0.13	0	0.02	0.14	0.19	0.37	0.008
Don River at Bowen	FRP	38	0.12	0.01	0.07	0.13	0.16	0.31	0.045
Proserpine River at Glen Isla	FRP	58	0.12	0.02	0.09	0.11	0.15	0.21	0.025
O'Connell at Caravan Park	FRP	66	0.09	0	0.01	0.02	0.05	1.18	0.006
O'Connell at Stafford's Crossing	FRP	55	0.02	0	0.01	0.02	0.03	0.04	0.006
Pioneer River at Dumbleton HW	FRP	61	0.05	0	0.02	0.04	0.07	0.11	0.005
Sandy Creek at Homebush	FRP	100	0.16	0	0.12	0.18	0.2	0.28	0.015
Plane Creek at Sucrogen Weir	FRP	49	0.11	0	0.02	0.1	0.17	0.37	0.008

Table B1. Summary statistics for monitored water quality in the MWI basin reporting areas, from July 2019 to June 2020. 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 50^{th} percentile (the median) concentration value should be compared against the applicable water quality guideline. Significant figures are shown to the same level as given in the relevant guideline value.

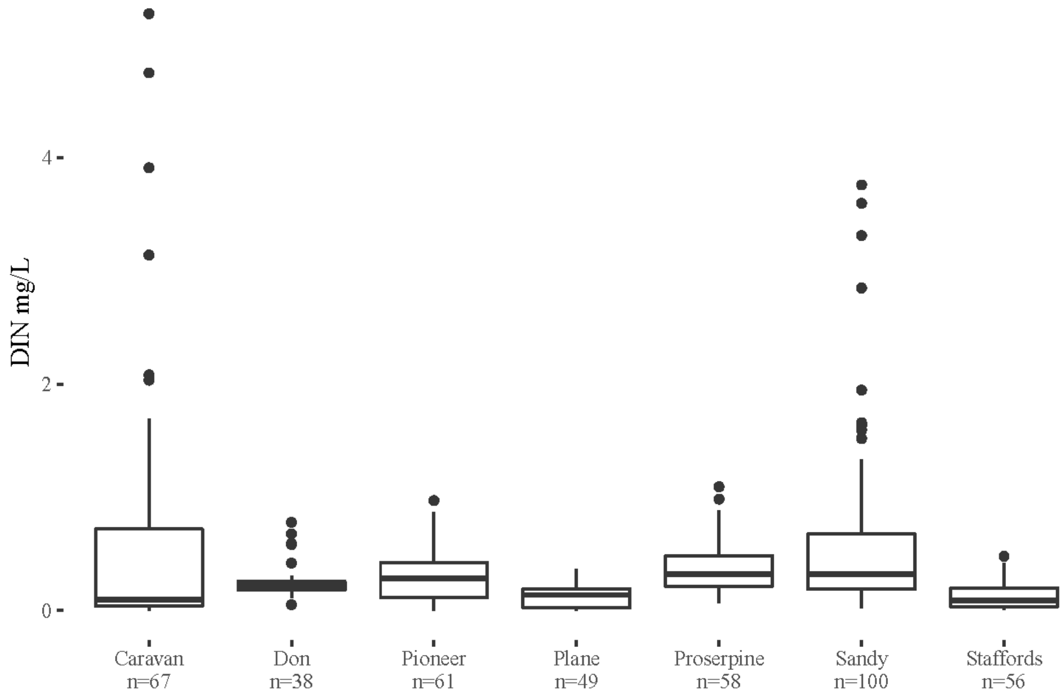

Figure B1. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x interquartile range [IQR]) of monthly median DIN concentrations in the MWI basins. Scaling factors (SF) and guideline values (GV) are provided for each basin, where information is available. Outliers (>1.5 x IQR) are also pictured.

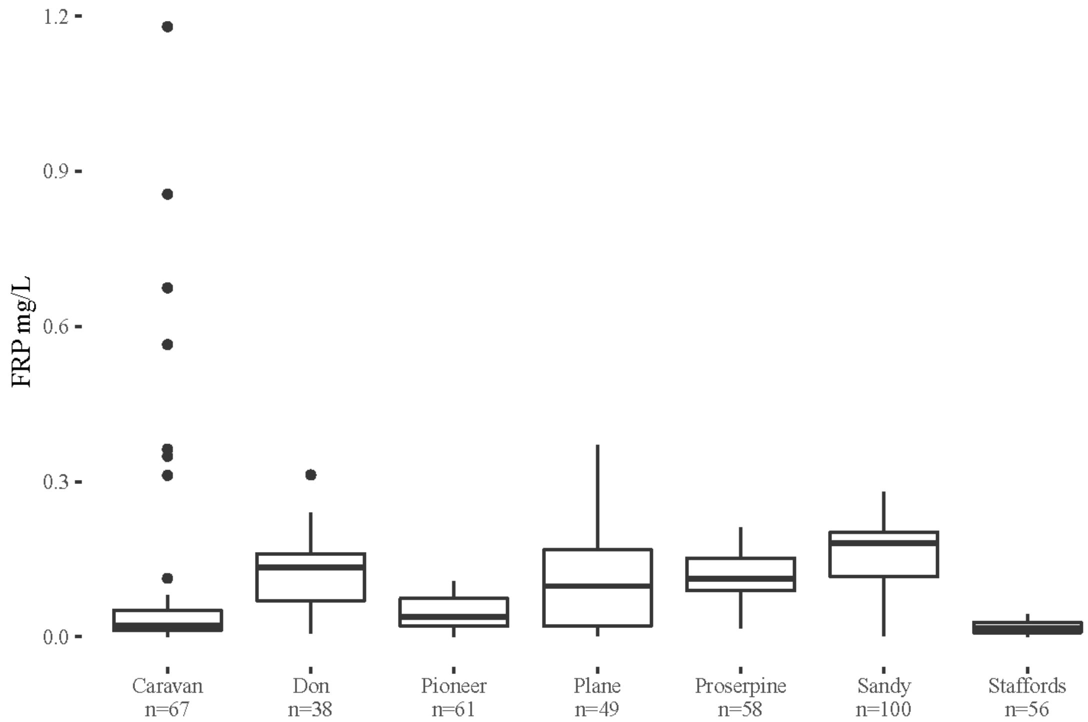

Figure B2. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of monthly median FRP concentrations in the MWI basins. Scaling factors (SF) and guideline values (GV) are provided for each basin, where information is available. Outliers (>1.5 x IQR) are also pictured.

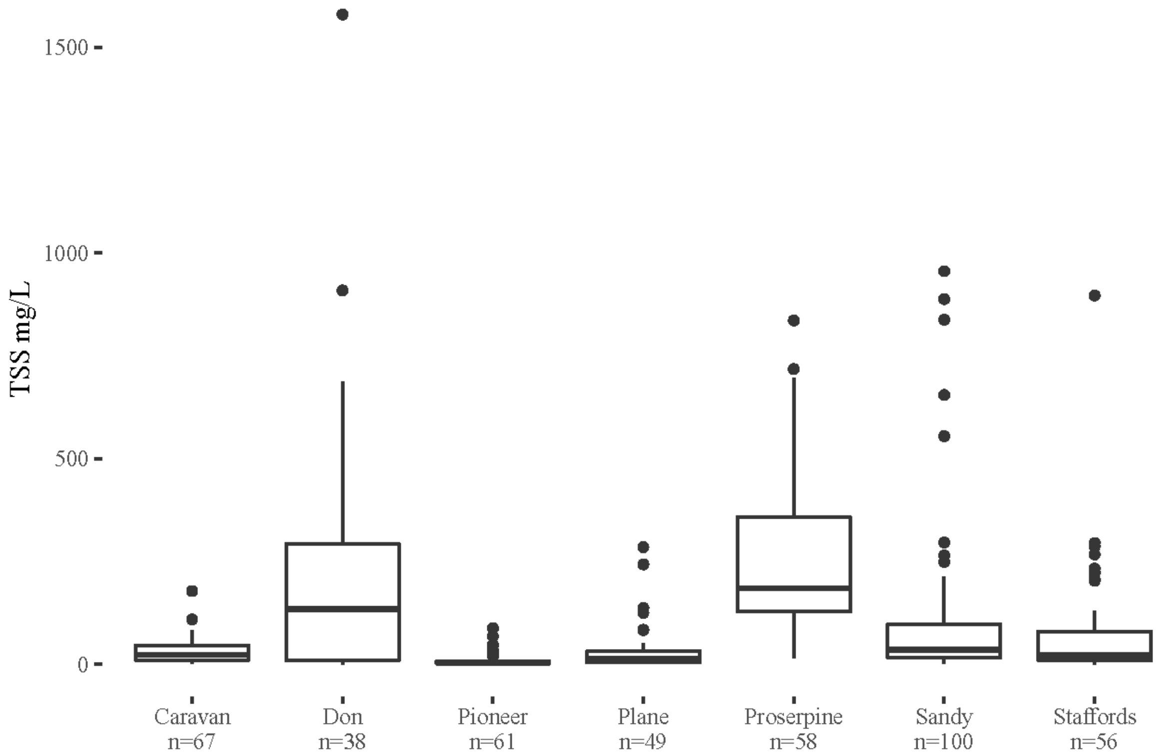

Figure B3. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of monthly median TSS concentrations in the MWI basins. Scaling factors (SF) and guideline values (GV) are provided for each basin, where information is available. Outliers (>1.5 x IQR) are also pictured.

Appendix B.2. Basins—Freshwater Flow Indicator Tool Scores and Hydrographs

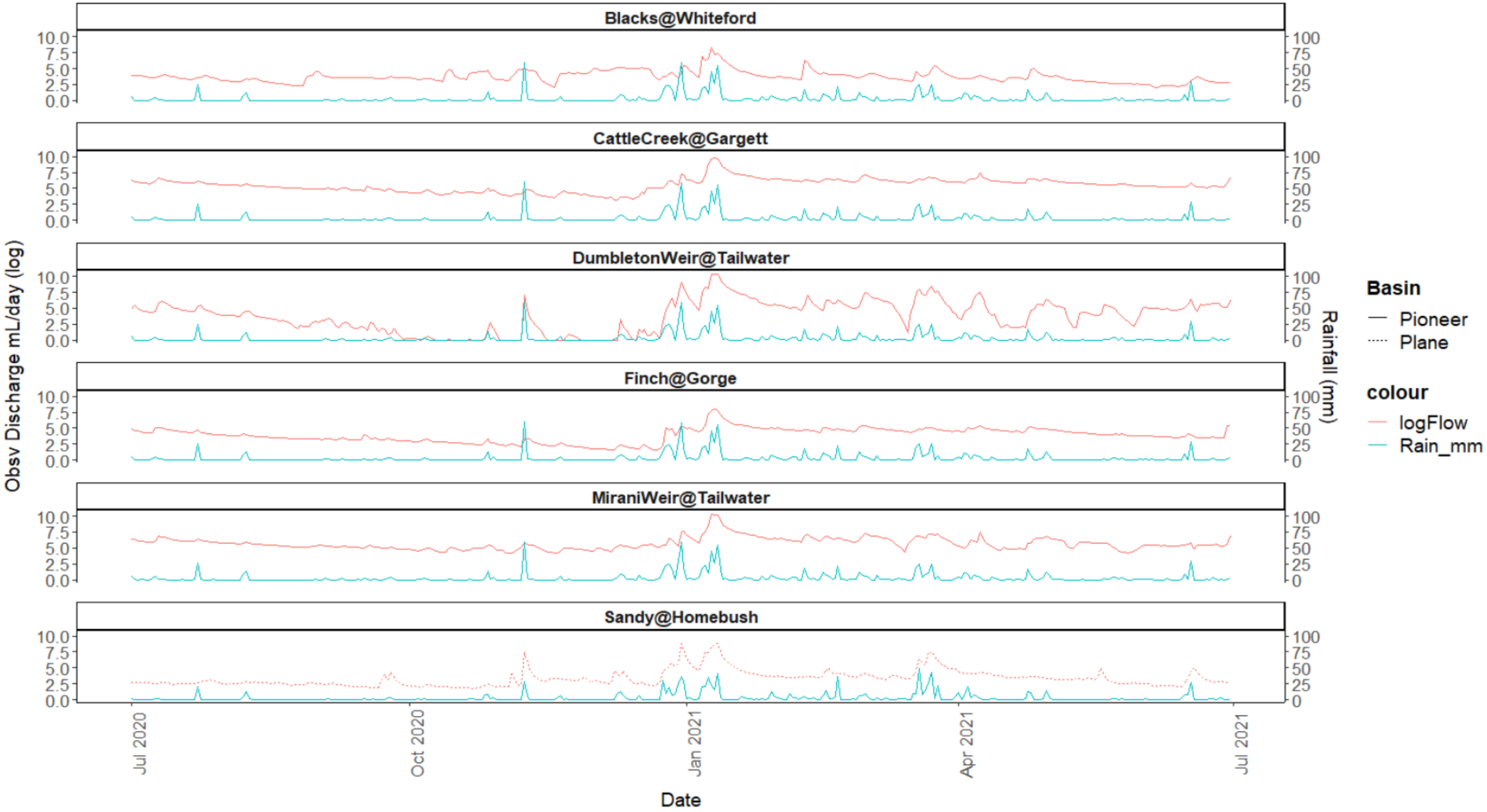

Figure B4. Hydrographs for gauging stations in the Pioneer and Plane basins. Observed discharge (ml/day) is plotted on a log scale against rainfall (mm) over the 2020–21 reporting year. Data gaps represent periods of no flow rather than missing data. Blacks Creek @ Whiteford has not been included in the 2021 Report Card due to discrepancies in the model output.

Table B2. Flow measure scores and summary scores for freshwater flow across the MWI Region, weighted by catchment area for the 2020–21 reporting year. Flow measures are scored between 1 to 5 and the 30th percentile is used as a summary score. Scores are then converted from a 1–5 scale to the standardised 0–100 for weighted aggregation. Climate type is based on annual rainfall across the basin.

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 Site Score	Gauge Catchment Area (km^2)	Adjusted Catchment Area (km^2)	Proportion (based on using gauged catchment area)	Standardised score x proportion	Aggregated Basin Score	Climate Type
Pioneer Basin																			66	Drought
CattleCk@Gargett	125004B	2.1	5	5	4	2	5	4	5	1	5	5	4	61	326	326	0.21	13.1		
FinchHattonCk@GorgeRd	125006A	2.7	4	4	5	5	5	4	5	1	1	5	4	61	35	35	0.02	1.4		
PioneerR@MiraniWeirTW	125007A	1.8	5	5	4	4	5	4	5	5	5	5	4.7	75	1211	885	0.58	43.6		
PioneerR@DumbletonWeirTW	125016A	1.4	1	1	4	4	5	1	5	5	4	5	3.1	43	1488	277	0.18	7.8		
Plane Basin																			61	Drought
SandyCreek@Homebush	126001A	1.5	4	4	5	4	5	1	5	5	5	4	4	61	326	326	1.00	61		

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

Appendix B.3. Assessing Multiple Freshwater Monitoring Sites & Individual Indicators

Assessing Multiple Freshwater Monitoring Sites:

Based on the recommendation provided by the TWG 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 MWI 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 B3–B6 below for DIN, FRP, TSS, and pesticides, respectively. For further information on assessing multiple freshwater monitoring sites, email technical@healthyriverstoreef.org.au. The scores for each site for the O'Connell and Plane basins in the 2020 Report Card are shown below.

Table B3. Calculation of proportional contribution to scores for multiple monitoring sites within the O'Connell Basin for the 2019 Report Card, based on the relative upstream catchment area. Where applicable, the adjusted area is calculated and represents the 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 Stafford's	342	342	0.41
Total area measured		**825**	

Table B4. Calculation of weighted site-level scores and total scores (sum of the weighted site-level scores) for DIN, FRP, and TSS indicators.

Site (O'Connell Basin)	DIN	FRP	TSS	Pesticides (PRM)
Caravan Park standard score	65.8	64.2	57.3	10.0
Caravan Park x weighting	**38.5**	**37.5**	**33.5**	**6.0**
Stafford's standard score	69.9	67.2	60.8	8.0
Stafford's x weighting	**28.9**	**27.8**	**25.2**	**3.2**
TOTAL (sum of weighted scores)	**67.5**	**65.4**	**58.8**	**9.2 (score = 45)**

Table B5. Calculation of proportional contribution to scores for multiple monitoring sites within the Plane Basin, based on the relative upstream catchment area. Where applicable, the adjusted area is calculated and represents the 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	0.22
Total area measured		**416**	

Table B6. 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	Pesticide risk (PRM)
Sandy Creek standard score	17.2	45.8	60.5	33.4
Sandy Creek x weighting	**13.4**	**35.8**	**47.4**	**26.2**
Plane Creek standard score	59.1	60.7	60.1	5.8
Plane Creek x weighting	**12.7**	**13.1**	**13.0**	**1.3**
TOTAL (sum of weighted scores)	**26.3**	**49.0**	**60.4**	**27.4 (score = 19)**

Individual Water Quality Indicator Tables:

Indicators are aggregated to form *indicator categories*, which are in turn used to create overall water quality grades for each waterway. For concision and consistency, some indicator scores and grades are not displayed next to relevant grades from previous years on their own, instead being aggregated first into an indicator category and then displayed. Those indicators have been listed in the tables below with previous years' grades for comparison.

Table B7. DIN indicator scores within freshwater basins for the 2021 Report Card, compared to 2016–2020 reporting years.

Basin	2021 Report Card DIN		2020	2019	2018 (DIN)	2017	2016
Don	47		52	58	55	42	
Proserpine*							
O'Connell	67		60	56	59	60	61

Table B7. DIN indicator scores within freshwater basins for the 2021 Report Card, compared to 2016–2020 reporting years.

Basin	2021 Report Card DIN		2020	2019	2018	2017	2016
			DIN				
Pioneer	52		41	33	46	35	46
Plane	26		38	41	23	30	44

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

Table B8. FRP indicator scores within freshwater basins for the 2021 Report Card, compared to 2016–2020 reporting years.

Basin	2021 Report Card FRP		2020	2019	2018	2017	2016
			FRP				
Don	40		40	74	69	24	
Proserpine*							
O'Connell	65		62	59	59	60	59
Pioneer	57		60	60	61	55	57
Plane	49		56	34	25	17	34

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

*Water quality data (excluding pesticides) was not available in the Proserpine Basin. See the 2020 Methods Report[2] for more information.

Appendix B.4. Site-level Scores for Additional Freshwater Basin Sites

An additional site in the Plane Basin was included into the MWI Report Card calculations for the third consecutive year. However, the O'Connell site at Stafford's Crossing was decommissioned, as the lower catchment site was deemed to be most important. Site-level scores are presented in Tables B9, B10, and B11 below.

Table B9. Results for the sediment indicator category (based on a measure of TSS) for sites in the O'Connell and Plane basins for the 2021 Report Card (2020–21 data), compared to 2018–2020.

Freshwater Basin	Sediment 2021	2020	2019	2018
O'Connell Basin				
O'Connell River (Caravan Park)	57	58	58	56
O'Connell River (Stafford's Crossing)	60	60	60	48
Plane Basin				
Plane (Sandy Creek)	60	59	55	54
Plane (Plane Creek)	60	59	56	58

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

Table B10. 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 2021 Report Card (2020–21 data) compared to 2018–20 scores.

Freshwater Basin	2021 Report Card		2020 Report Card		2019 Report Card		2018 Report Card	
	DIN	FRP	DIN	FRP	DIN	FRP	DIN	FRP
O'Connell Basin								
O'Connell River (Caravan Park)	65	64	60	62	55	58	59	59
O'Connell River (Stafford's Crossing)	69	67	62	62	56	60	59	59
Plane Basin								
Plane (Sandy Creek)	17	45	32	55	37	29	12	15
Plane (Plane Creek)	59	60	59	60	52	53	61	61

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

Table B11. Results for the pesticides indicator (based on a measure of 22 pesticides) for sites in the O'Connell and Plane Basins for water quality in freshwater basins for the 2021 Report Card compared to historic data. Note that the O'Connell Stafford's Crossing site was decommissioned in 2021, as the end-of-catchment monitoring was seen to be most important.

Freshwater Basin	2021 Report Card		2020	2019	2018
	% Species Protected	Standardised Pesticide Score	Standardised Pesticide Scores		
O'Connell Basin					
O'Connell River (Caravan Park)	87	35	50	50	59
O'Connell River (Stafford's Crossing)			23	48	59
Plane Basin					
Plane (Sandy Creek)	67	17	17	17	15
Plane (Plane Creek)	99	81	58	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 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

Appendix B.5. Basins—Revision to Wetland Extent Scores

Based on available refinements to the wetland mapping data (version 5), the scores for wetland extent were last updated for the 2019 Report Card. Due to updates to the source mapping, including refinements such as error correction 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 B12, below. Notably, the back-calculated scores for 2013 are the same as those for the most recent 2019 assessment.

Table B12. Results showing % of wetland extent loss compared to pre-development conditions, in 2013. This assessment pertains to palustrine wetlands only.

	2013		2013
	Wetland Extent		
Basin	**Hectares lost since pre-development**	**% loss since pre-development**	**Standardised Wetland 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 C—Estuarine Environment

Appendix C.1. Pesticide Study Sites in Detail

The number of samples used to derive the pesticide score has 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 2020–21 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. The location of monitoring sites is outlined in further detail, below.

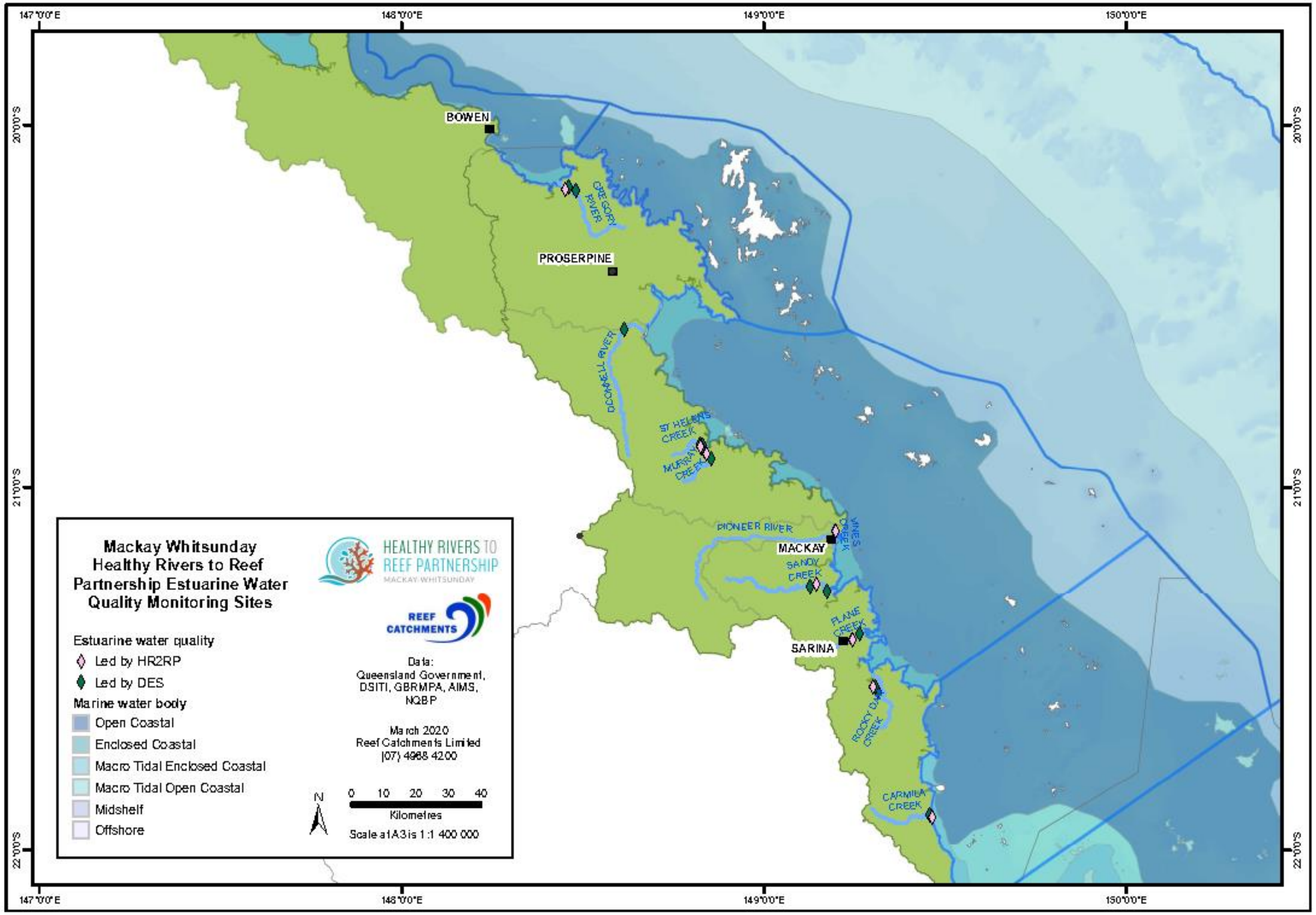

Figure C1. Locations of monitoring sites for estuarine water quality sampling, including DIN, FRP, turbidity, DO, chl-*a* and pesticides in the MWI Region. Black squares and circles indicate towns.

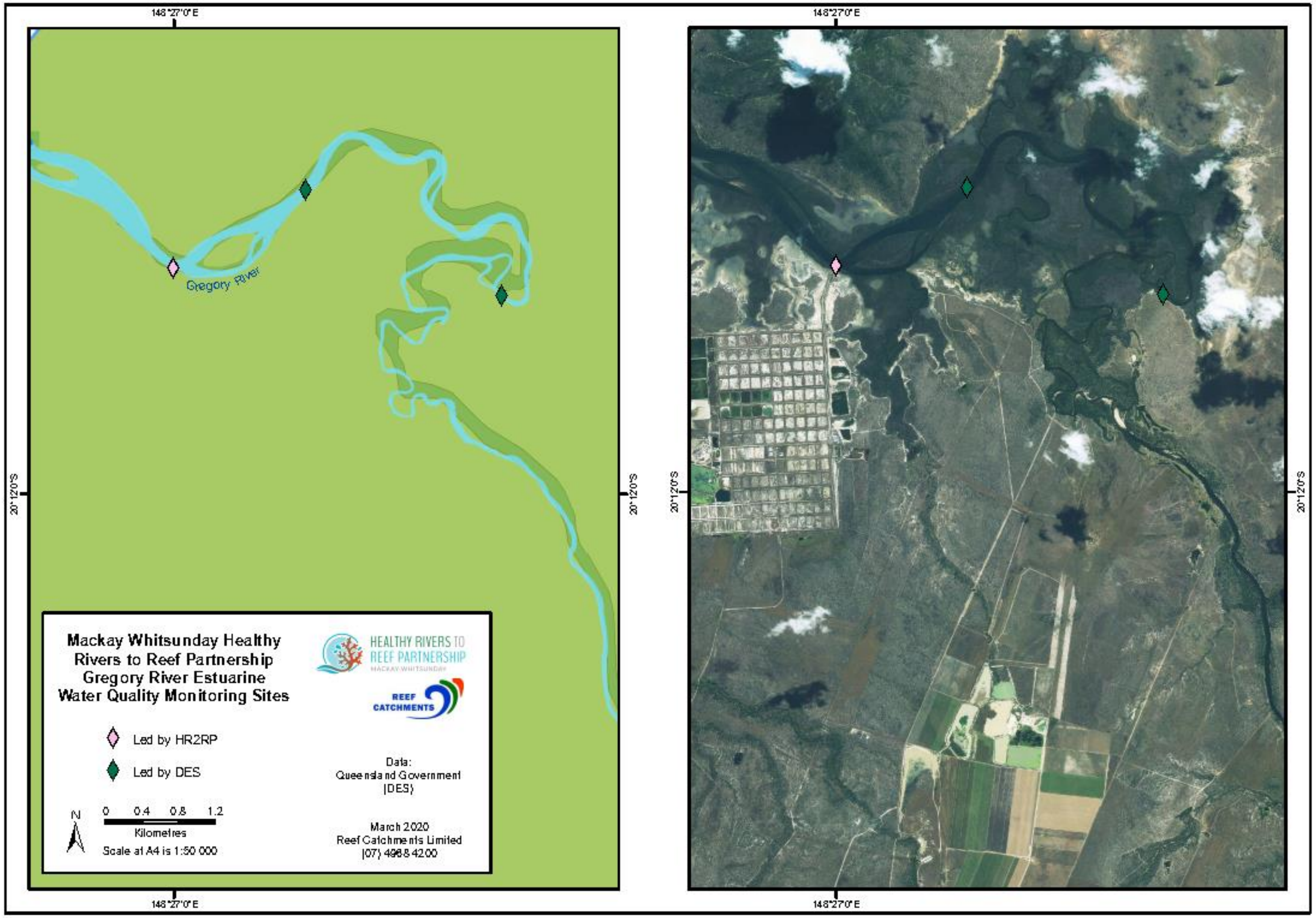

Figure C2. Locations of monitoring sites for estuarine sampling of pesticides in the Gregory River. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the northwest, beyond the boundary of the map.

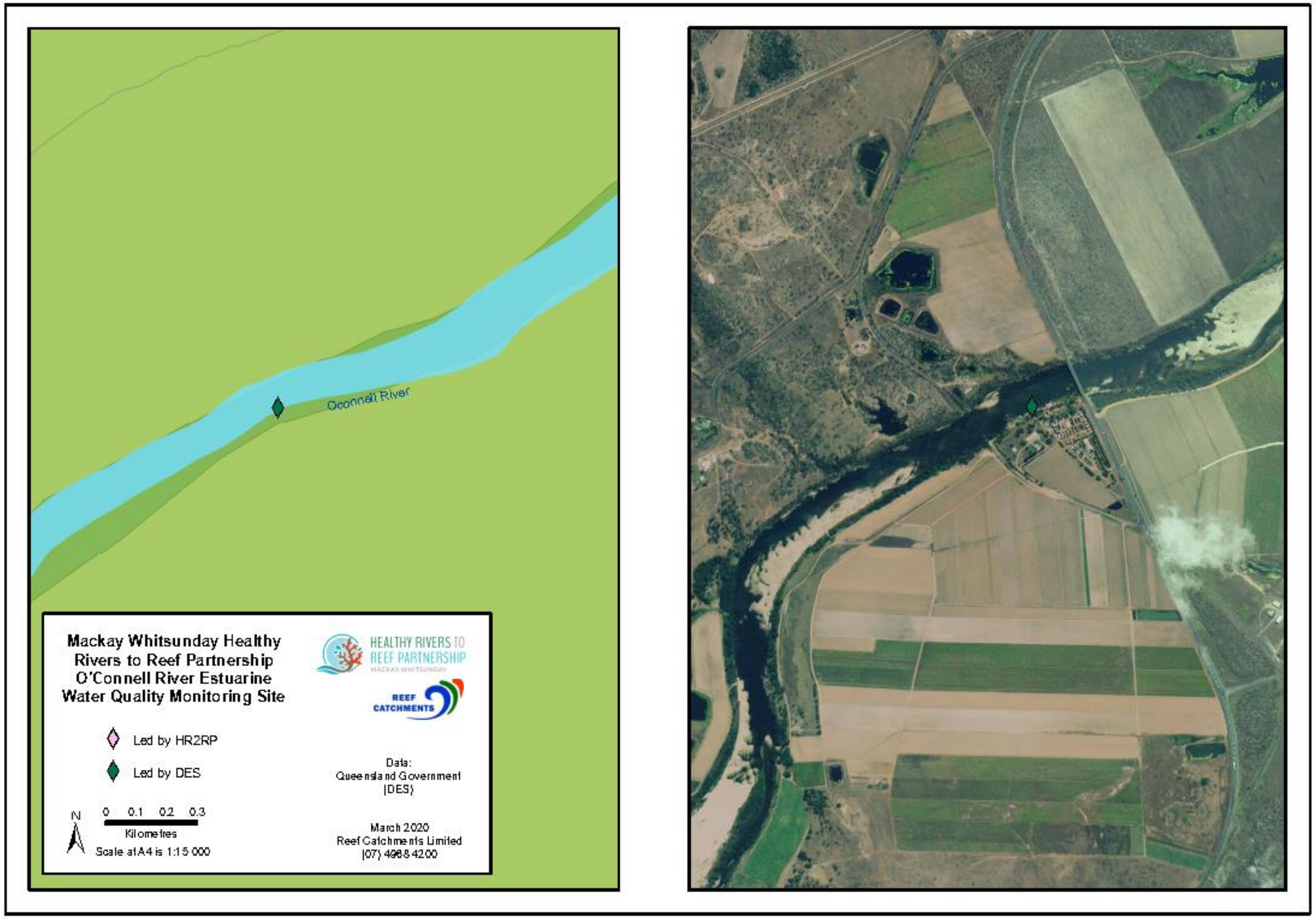

Figure C3. Locations of monitoring site(s) for estuarine sampling of pesticides in the O'Connell River. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located approximately to the northeast, beyond the boundary of the map.

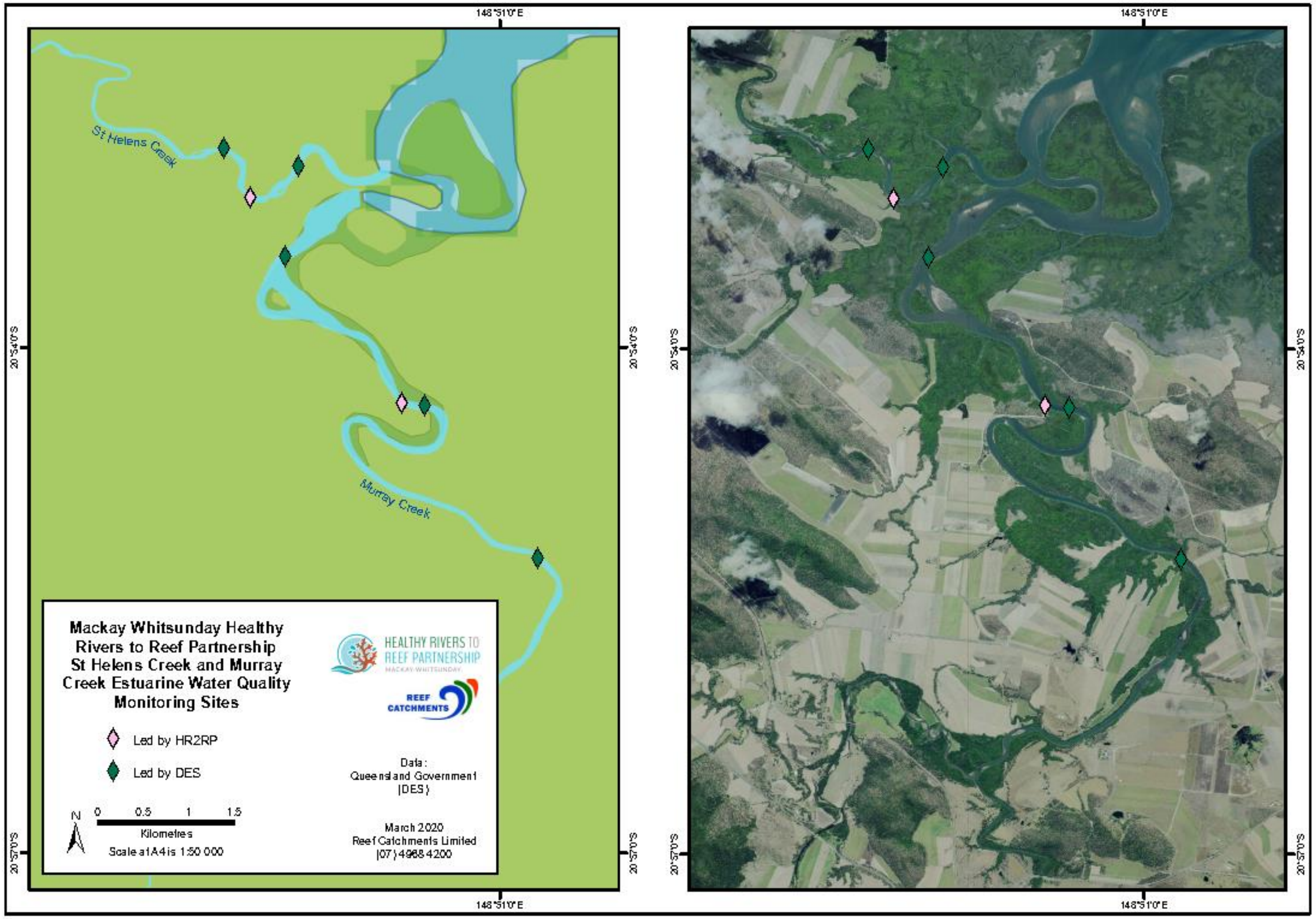

Figure C4. Locations of monitoring sites for estuarine sampling of pesticides in St Helens Creek/Murray Creek. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the north, beyond the boundary of the map.

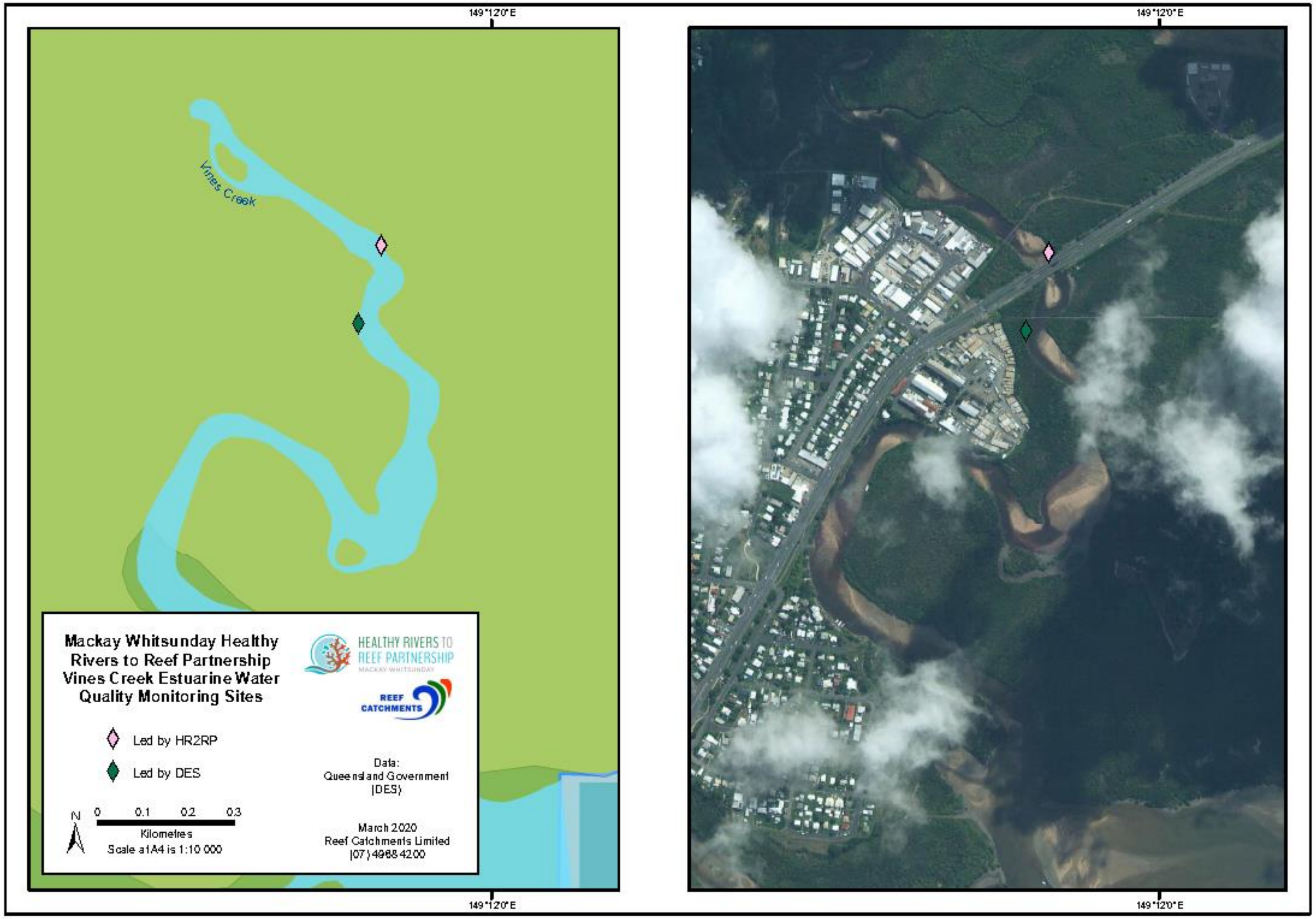

Figure C5. Locations of monitoring sites for estuarine sampling of pesticides in Vines Creek. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the south, beyond the boundary of the map.

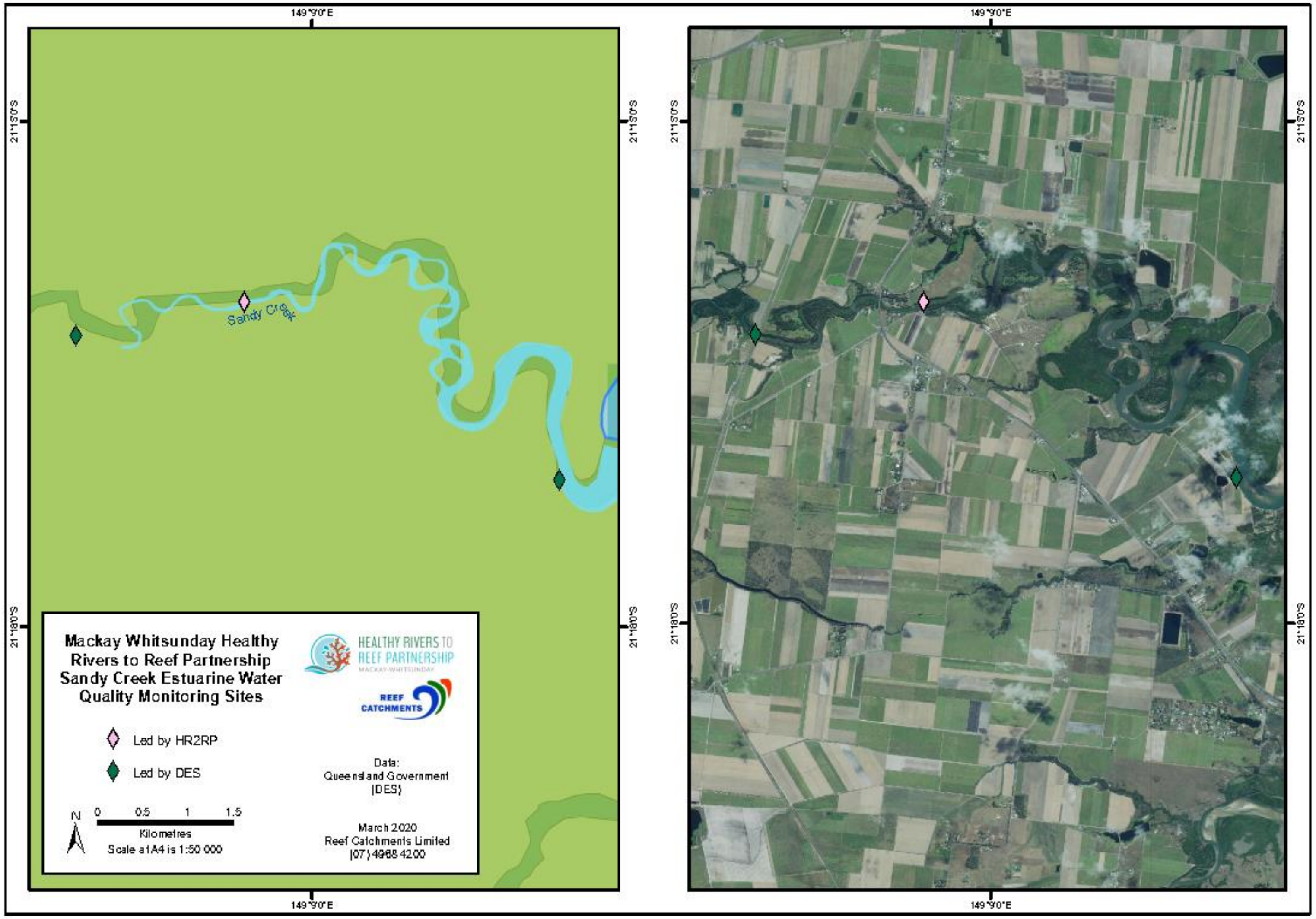

Figure C6. Locations of monitoring sites for estuarine sampling of pesticides in Sandy Creek. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the east, beyond the boundary of the map.

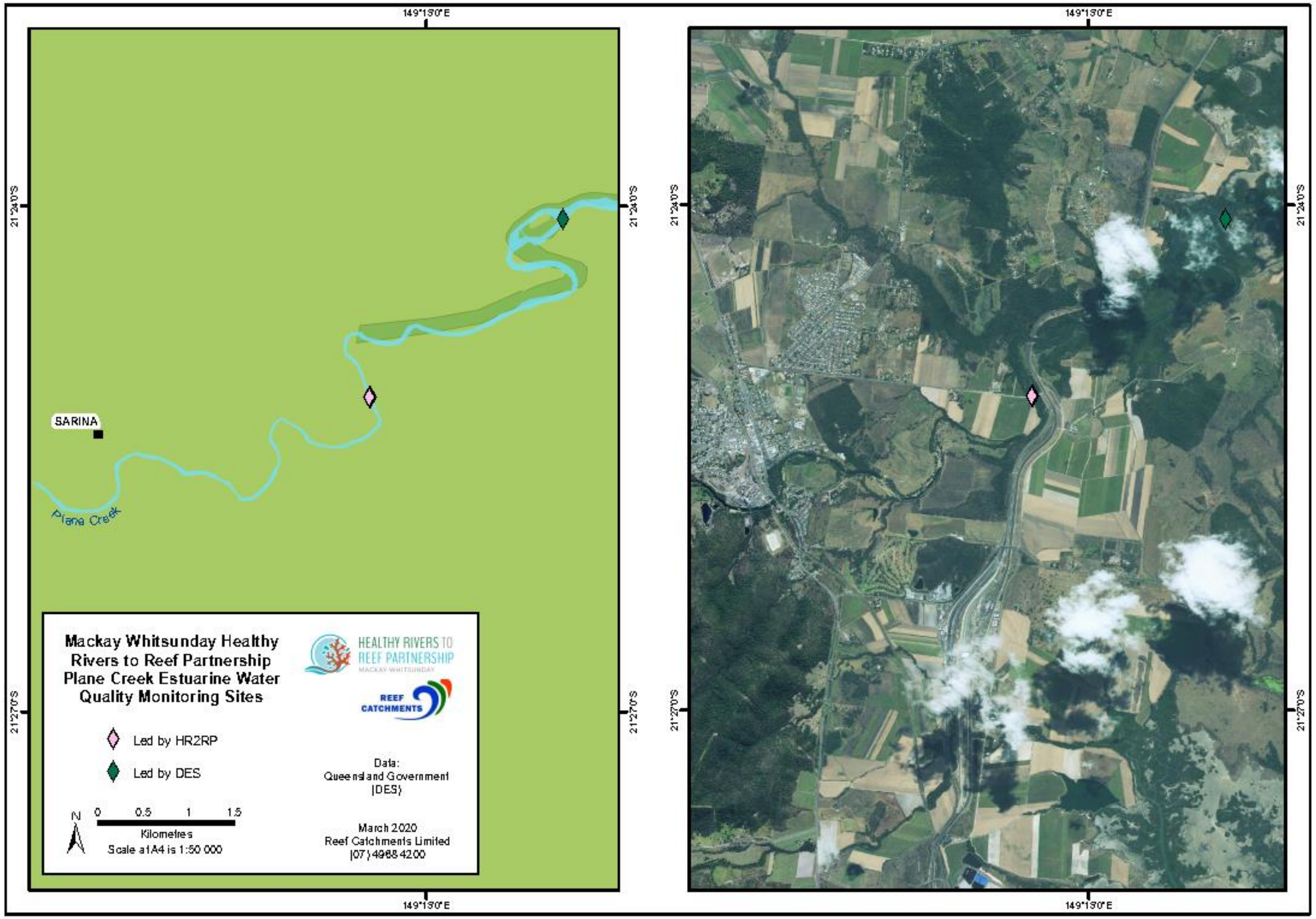

Figure C7. Locations of monitoring sites for estuarine sampling of pesticides in Plane Creek. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the northeast, beyond the boundary of the map.

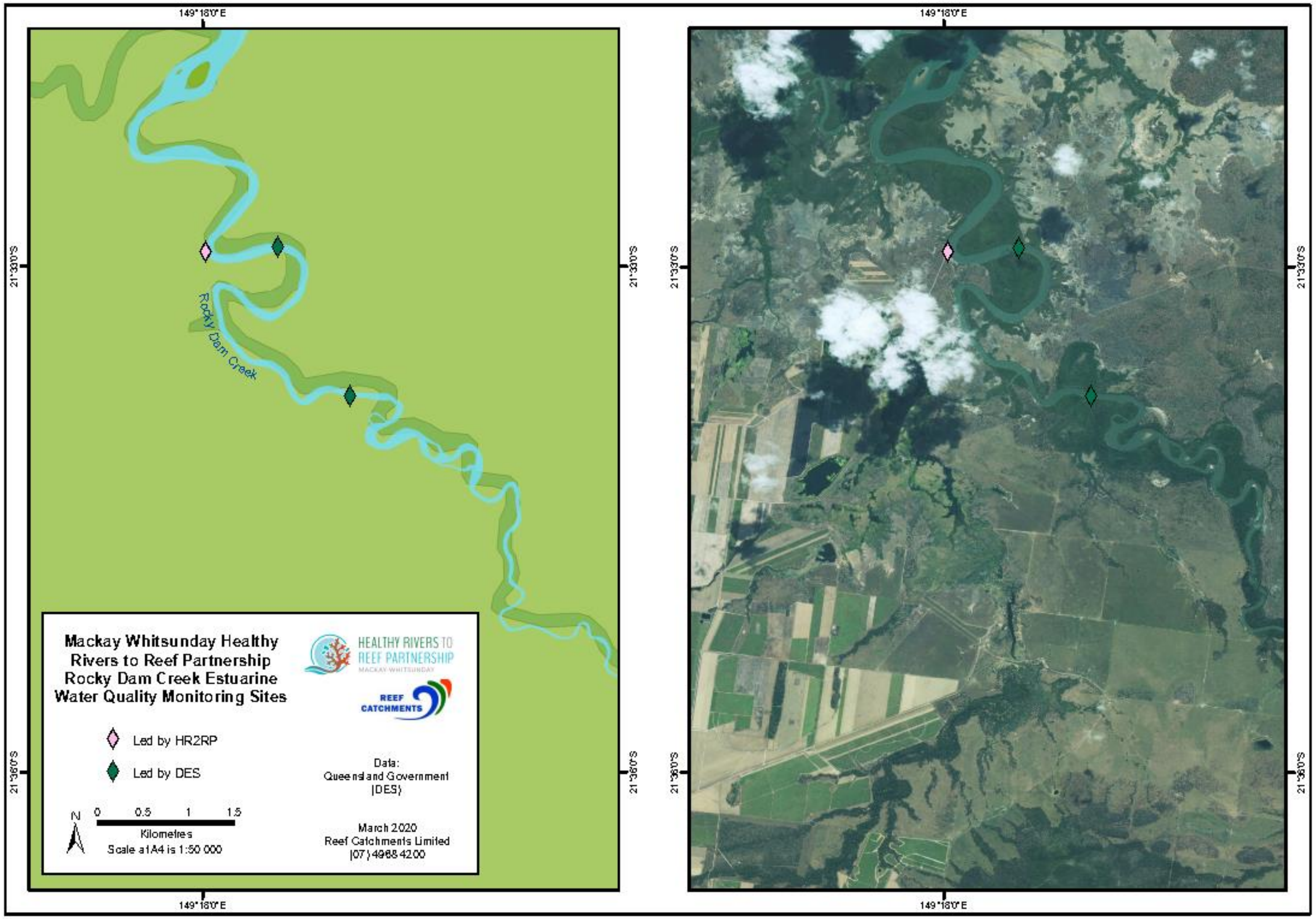

Figure C8. Locations of monitoring sites for estuarine sampling of pesticides in Rocky Dam Creek. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the northwest, beyond the boundary of the map.

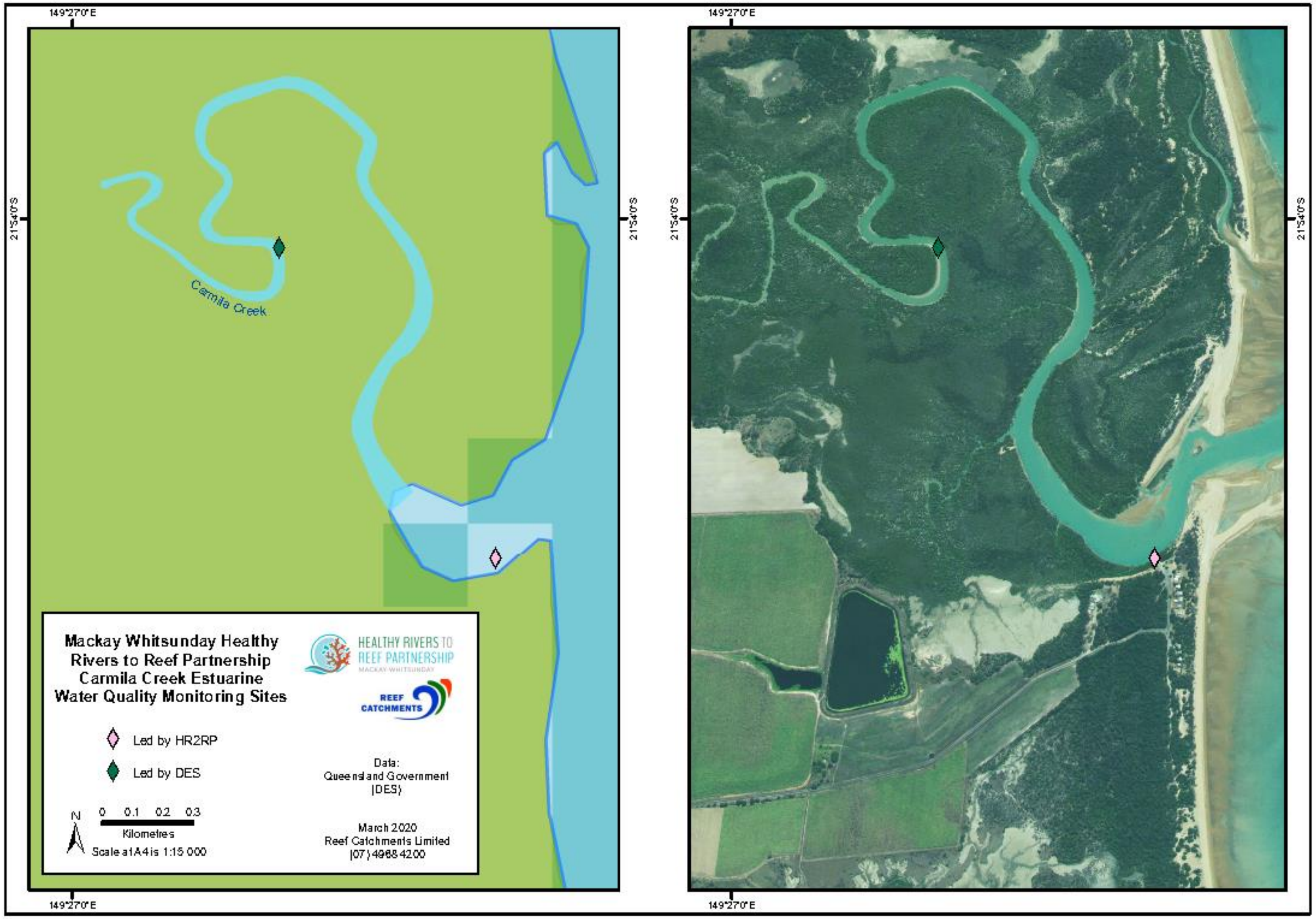

Figure C9. Locations of monitoring sites for estuarine sampling of pesticides in Carmila Creek. Sites are overlaid on a reference map and a satellite map, respectively. The estuary mouth is located to the east, as shown.

Appendix C.2. Estuaries—Summary Statistics, Boxplots, and Individual Indicator Tables

Table C1. Summary statistics for monitored water quality in the MWI estuary reporting areas, from July 2019 to June 2020. 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. Significant figures are shown to the same level as given in the relevant guideline value.

Name	Indicator	n	Mean	Minimum	25th percentile	Median	75th percentile	Maximum	Guideline Value
Gregory River 3.6km from mouth	Chl-a	13	2.56	0.9	1.2	1.7	3.1	7.1	2 µg/L
	DIN	13	0.02	0	0	0	0.01	0.19	0.018 mg/L
	DOSat	12	73.71	61.9	70.85	72.45	78.6	82	70-105%
	FRP	13	0.01	0	0	0	0.01	0.06	0.03 mg/L
	Turbidity	12	5.49	0.8	2.28	2.65	4.88	18.7	10 mg/L
Gregory River 8.4km from mouth	Chl-a	12	2.29	0.7	1.48	2.15	3.5	3.7	2 µg/L
	DIN	12	0.02	0	0	0.01	0.01	0.15	0.018 mg/L
	DOSat	12	78.33	59.7	72.27	79.75	85	95.3	70-105%
	FRP	12	0.02	0.01	0.01	0.01	0.01	0.06	0.03 mg/L
	Turbidity	12	5.08	1.1	3.48	4.65	4.82	13.1	10 mg/L
O Connell River 7.5km from mouth	Chl-a	12	3.01	0.2	1.38	1.95	2.88	12.5	2 µg/L
	DIN	12	0.11	0	0.01	0.02	0.05	0.64	0.018 mg/L
	DOSat	12	111.28	89	101.65	109.1	111.4	165	70-105%
	FRP	12	0.01	0	0	0	0.02	0.06	0.03 mg/L
	Turbidity	12	5.3	0.6	3.22	3.9	5.25	16.6	10 mg/L
St Helens Creek 7.5km from mouth	DOSat	12	85.16	71.2	82.35	86.85	90.48	95.6	70-105%
	Turbidity	12	8.57	4.2	5.47	6.4	7.3	27.2	10 mg/L
St Helens Creek 8.9km from mouth	Chl-a	12	4.31	1.6	1.98	2.9	5.28	10.4	2 µg/L
	DIN	12	0.08	0.04	0.04	0.07	0.09	0.21	0.018 mg/L
	DOSat	12	85.84	69.1	80.17	88.9	92.73	99.6	70-105%
	FRP	12	0.01	0	0.01	0.01	0.01	0.03	0.03 mg/L
	Turbidity	12	9.47	3.3	6.22	8.35	10.4	28.2	10 mg/L
Murray Creek 10.0km from mouth	DOSat	12	82.94	63.9	80.05	84.85	89.35	91.3	70-105%
	Turbidity	12	19.3	2.3	3.75	5	12.32	147.1	10 mg/L

Name	Indicator	n	Mean	Minimum	25th percentile	Median	75th percentile	Maximum	Guideline Value
Murray Creek 12.5km from mouth	Chl-a	12	4.05	1.4	2.43	3.35	4.8	8.4	2 µg/L
	DIN	12	0.13	0	0.06	0.13	0.17	0.31	0.018 mg/L
	DOSat	12	80.31	63	78.38	81.05	84	94.5	70-105%
	FRP	12	0.02	0.01	0.01	0.02	0.03	0.06	0.03 mg/L
	Turbidity	12	32.54	3.3	4.95	5.85	25.33	210.4	10 mg/L
Murray Creek 16.5km from mouth	Chl-a	12	3.68	0.8	1.68	4.05	5.05	6.8	2 µg/L
	DIN	12	0.19	0.01	0.13	0.16	0.24	0.59	0.018 mg/L
	DOSat	12	78.8	54.7	73.38	80.3	86.08	90.5	70-105%
	FRP	12	0.03	0.01	0.02	0.03	0.03	0.06	0.03 mg/L
	Turbidity	12	28.23	3.4	7.38	9.9	24.35	133.5	10 mg/L
Vines Creek 2.0km from mouth	Chl-a	12	4.35	1	2.05	3.65	6.72	9	2 µg/L
	DIN	12	0.51	0.21	0.36	0.5	0.61	0.95	0.018 mg/L
	DOSat	12	79.76	45.7	68.77	85.4	92.97	101	70-105%
	FRP	12	0.01	0	0	0.01	0.01	0.04	0.03 mg/L
	Turbidity	12	5.13	2.5	3.92	4.9	5.32	12	10 mg/L
Sandy Creek 4.5km from mouth	Chl-a	12	3.97	1.17	1.63	1.95	2.85	20.44	5 µg/L
	DIN	12	0.33	0	0.01	0.02	0.2	3.05	0.018 mg/L
	DOSat	12	89.03	77.1	83.35	88.25	92.3	110.2	70-105%
	FRP	12	0.05	0.01	0.02	0.03	0.05	0.2	0.06 mg/L
	Turbidity	12	8.63	1.3	5.12	7.25	8.1	23.2	NA
Sandy Creek 13.5km from mouth	Chl-a	12	7.58	1.95	2.34	3.43	6.48	46.89	5 µg/L
	DIN	12	0.88	0.1	0.71	0.9	1.11	1.55	0.018 mg/L
	DOSat	12	74.02	54	65.5	70.15	79.25	98.8	70-105%
	FRP	12	0.08	0.04	0.05	0.07	0.09	0.17	0.06 mg/L
	Turbidity	12	67.61	4	8.8	9.85	26.25	601.8	NA
Plane Creek 0.0km at mouth	Chl-a	12	2.42	0.4	0.68	1.53	3.26	7.86	5 µg/L
	DIN	12	0.01	0	0	0	0	0.02	0.018 mg/L
	DOSat	12	99.55	92.2	97.4	100.1	101.97	104.1	70-105%
	FRP	12	0	0	0	0	0	0.01	0.06 mg/L

Name	Indicator	n	Mean	Minimum	25th percentile	Median	75th percentile	Maximum	Guideline Value
	Turbidity	12	3.67	0.8	1.55	2.1	3	18	NA
Plane Creek 6.0km from mouth	Chl-a	12	4.41	0.94	2.64	4.31	6.25	7.36	5 µg/L
	DIN	12	0.01	0	0	0	0.01	0.08	0.018 mg/L
	DOSat	12	91.3	74.6	86.5	91.6	95.95	107.2	70-105%
	FRP	12	0.01	0	0	0.01	0.01	0.06	0.06 mg/L
	Turbidity	12	17.01	3.4	4.6	6.2	8.75	123.8	NA
Plane Creek 9.0km from mouth	Chl-a	12	2.68	0.25	1.16	1.97	3.32	7.87	5 µg/L
	DIN	12	0.06	0	0.02	0.06	0.09	0.12	0.018 mg/L
	DOSat	12	99.45	83.7	89.2	98	101.17	136.9	70-105%
	FRP	12	0.04	0.01	0.02	0.03	0.05	0.1	0.06 mg/L
	Turbidity	12	12.9	2.8	3.38	6.05	7.55	93	NA
Rocky Dam Creek 8.9km from mouth	Chl-a	11	7.35	2	4.27	6.24	7.7	23.15	5 µg/L
	DIN	11	0.08	0.01	0.03	0.08	0.11	0.18	0.018 mg/L
	DOSat	11	84.25	69.7	81.2	86.1	88.35	98.3	70-105%
	FRP	11	0.02	0.01	0.02	0.02	0.03	0.04	0.06 mg/L
	Turbidity	11	59.3	10.4	31.2	57.7	86.1	123.4	NA
Rocky Dam Creek 12.9km from mouth	Chl-a	11	7.51	2.38	4.44	6.81	10.02	16.99	5 µg/L
	DIN	11	0.1	0	0.05	0.09	0.15	0.2	0.018 mg/L
	DOSat	11	85.85	71.4	83	86.8	89.65	97.6	70-105%
	FRP	11	0.03	0.02	0.02	0.03	0.04	0.05	0.06 mg/L
	Turbidity	11	66.13	26.9	40.8	50.5	83.7	143.9	NA
Carmila Creek 0.9km from mouth	DOSat	12	96.67	79.3	87.65	97.9	104.62	117.3	70-105%
	Turbidity	12	33.27	6.4	8	11.9	16.7	246.1	NA
Carmila Creek 2.9km from mouth	Chl-a	12	7.24	2.4	4.65	5.6	8.72	19	5 µg/L
	DIN	12	0.06	0	0	0.05	0.09	0.19	0.018 mg/L
	DOSat	12	107.74	75.8	84.1	103.9	117.5	170.3	70-105%
	FRP	12	0.03	0.01	0.03	0.03	0.04	0.05	0.06 mg/L
	Turbidity	12	44.66	11.1	14.15	16.9	37.73	265.6	NA

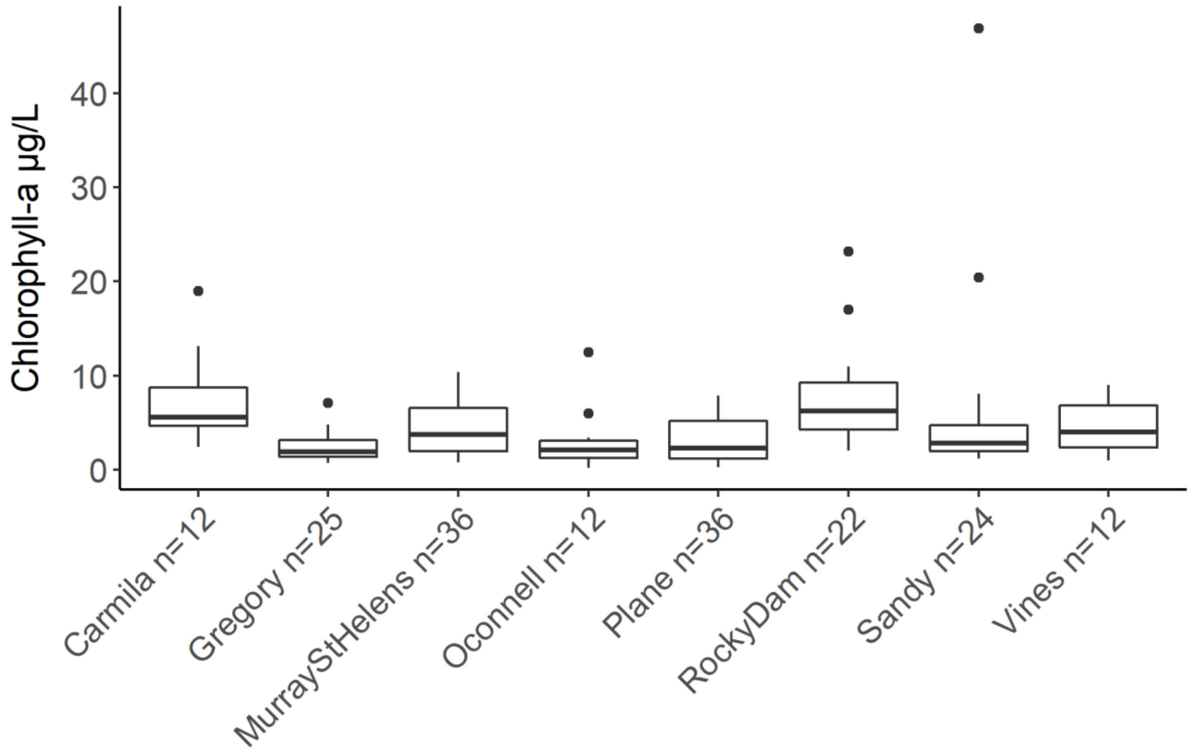

Figure C10. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of monthly chlorophyll-*a* concentrations in the MWI estuaries for 2020–21. Scaling factors is 8 and guideline values are 2 (Gregory, O'Connell, Murray/St Helens, Vines) and 5 (Sandy, Plane, Rocky Dam, and Carmila). Outliers are also pictured. Sample sizes are shown after the estuary names.

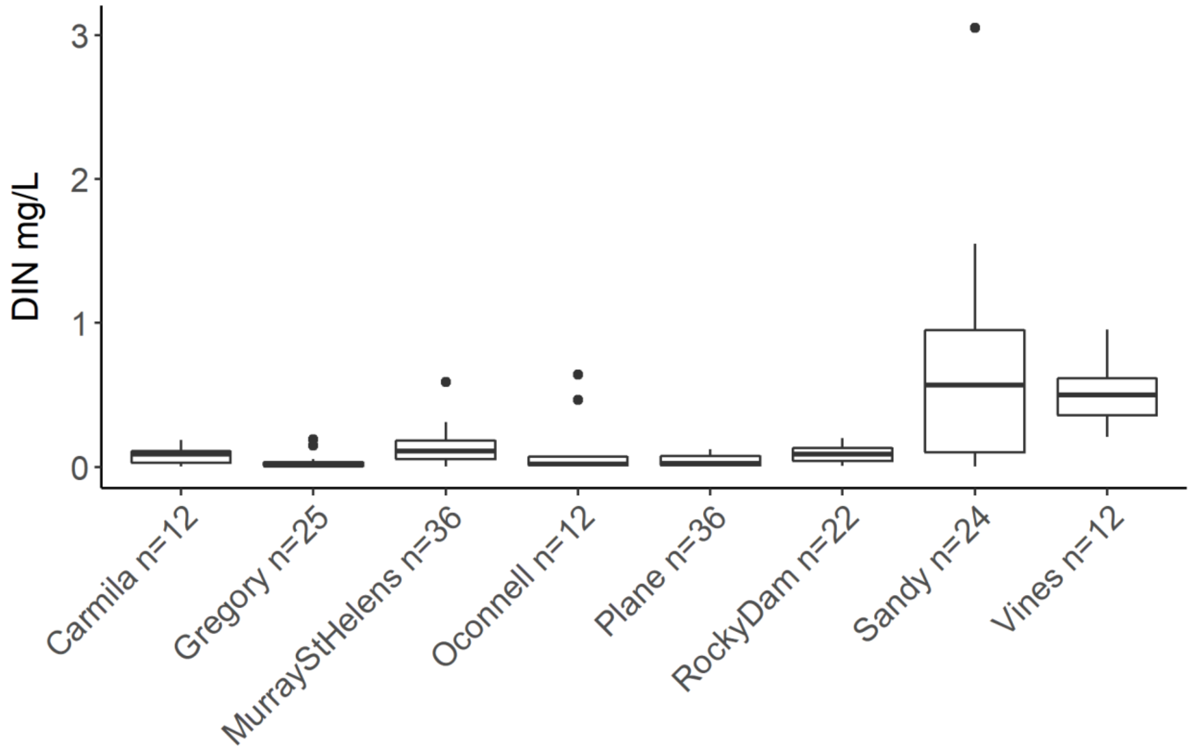

Figure C11. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of DIN concentrations in the MWI estuaries for 2020–21. Scaling factor is 0.645 and guideline value is 0.018. Outliers are also pictured. Sample sizes are shown after the estuary names.

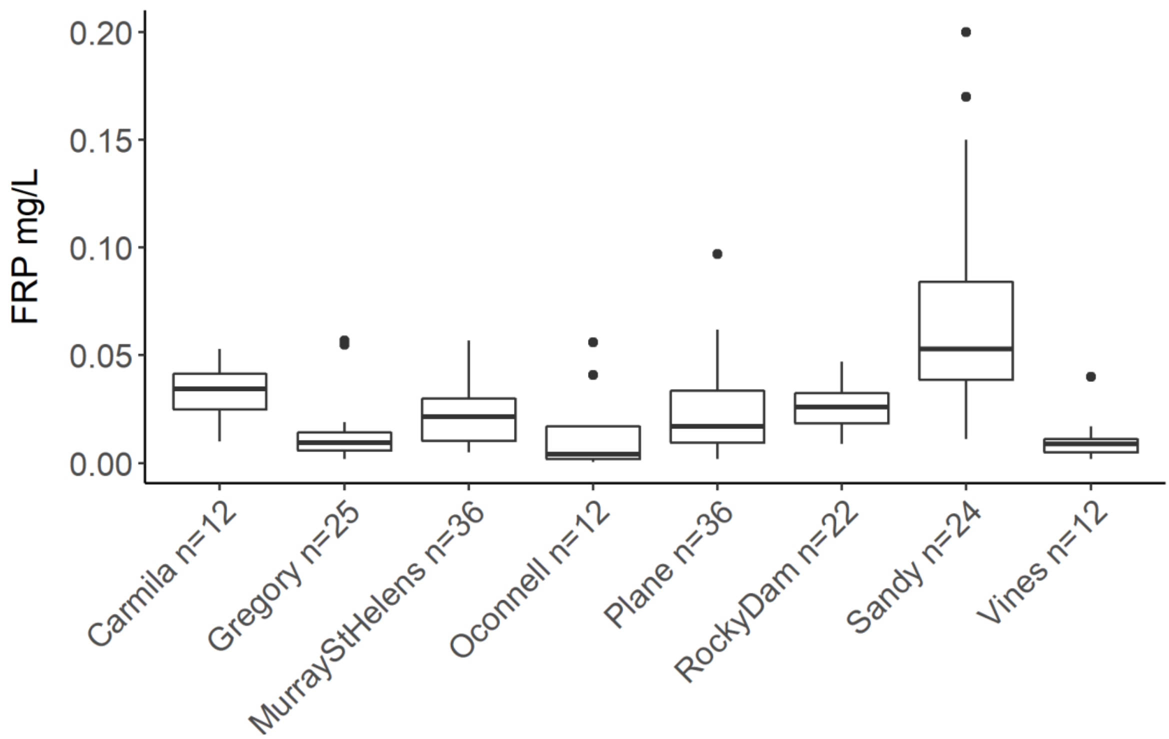

Figure C12. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of FRP concentrations in the MWI estuaries for 2020–21. Scaling factor is 0.08 and guideline values are 0.03 (Gregory, O'Connell, Murray/St Helens, Vines) and 0.06 (Sandy, Plane, Rocky Dam, and Carmila). Outliers are also pictured. Sample sizes are shown after the estuary names.

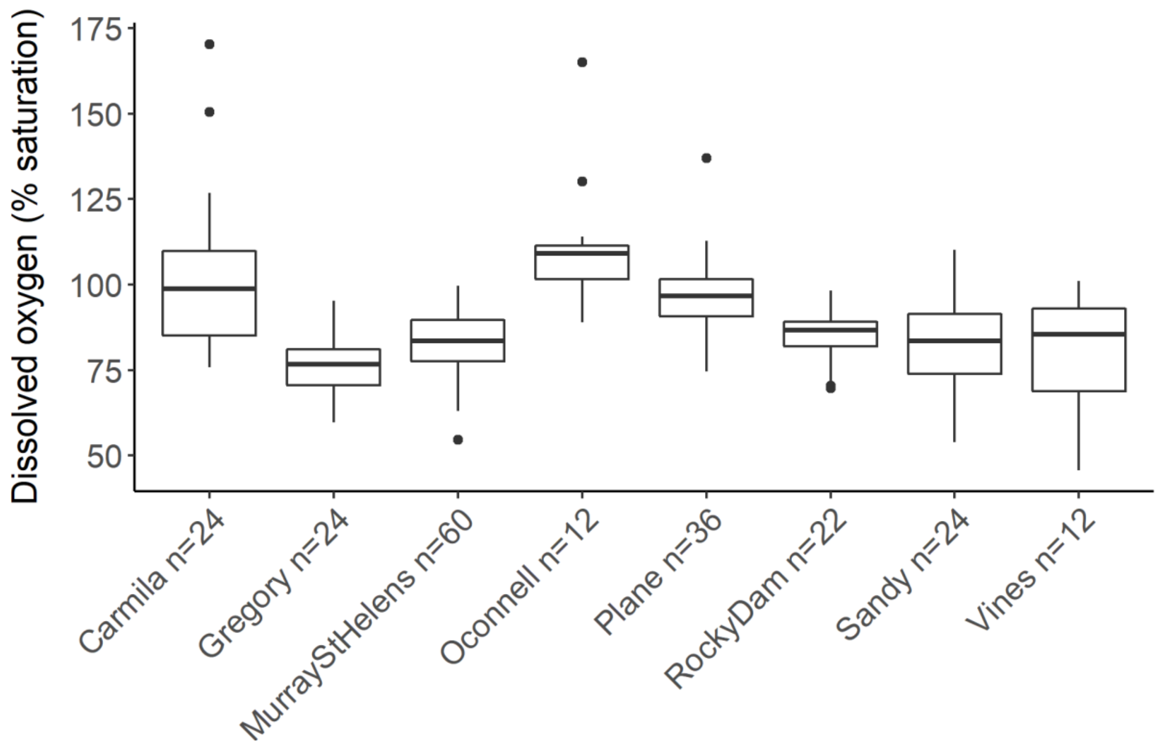

Figure C13. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of DO concentrations (reported as % saturation) in the MWI estuaries for 2020–21. Lower DO is 70 and Upper DO is 105. Outliers are also pictured. Sample sizes are shown after the estuary names

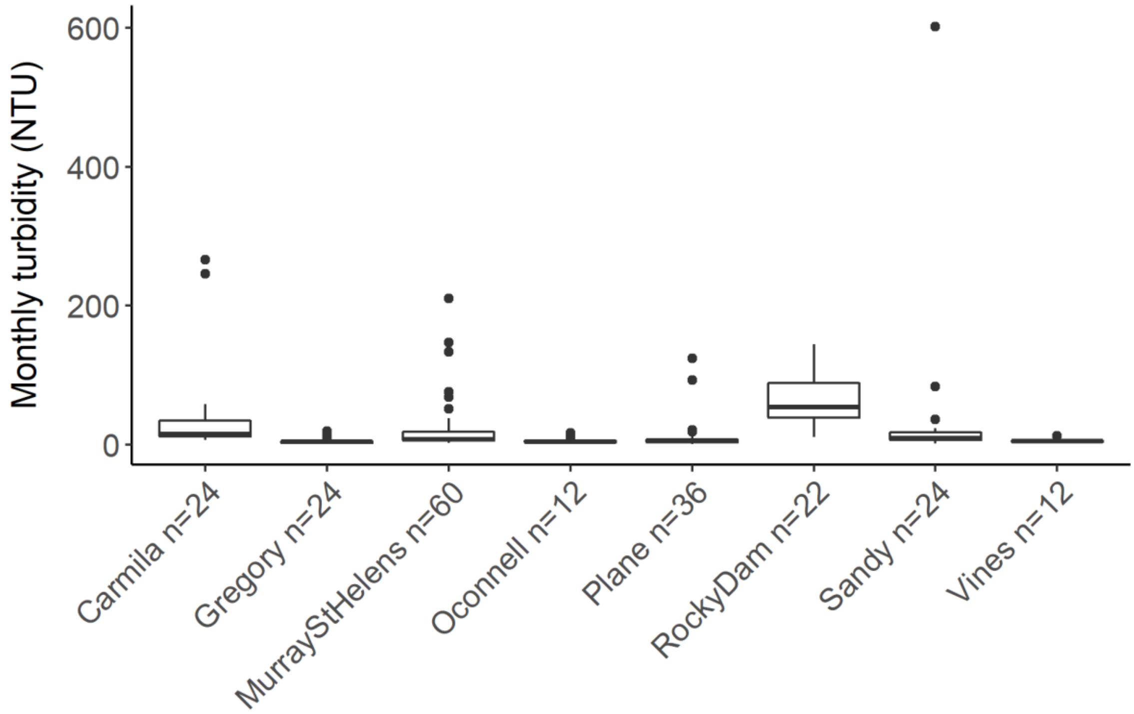

Figure C14. Box and whisker plot (box showing 20th, 50th and 80th percentiles, whiskers 1.5 x Interquartile range [IQR]) of turbidity levels in the MWI estuaries for 2020–21. Scaling factor is 0.16 and guideline value is 10 (Gregory, O'Connell, St Helens/Murray, Vines). Outliers are also pictured. Sample sizes are shown after the estuary names. For the Sandy, Plane, Rocky Dam and Carmila Creek estuaries, guideline values for turbidity were too variable to be derived.

Individual Water Quality Indicator Tables:

The following are tables representing FRP, DIN, turbidity, and DO indicator scores from the 2016–2021 Report Cards. For the messages associated with these score changes, please see Sections 3.1.1 and 3.1.3 above.

Table C2. DIN indicator scores within estuaries for the 2021 Report Card, compared to the 2016 – 2020 Report Cards.

	2021 Report Card		2020	2019	2018	2017	2016
Estuary	DIN		DIN				
Gregory River	90		64	90	59	66	66
O'Connell River	60		56	53	57	59	60
St Helens/Murray Creek	51		54	48	47	46	47
Vines Creek	14		37	30	45	29	32
Sandy Creek	21		48	32	43	33	28
Plane Creek	67		66	62	59	61	59
Rocky Dam Creek	54		53	47	46	43	42
Carmila Creek	57		60	52	59	49	50

Scoring range: ■ 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

Table C3. FRP indicator scores within estuaries for the 2021 Report Card, compared to the 2016–2020 Report Cards

	2021 Report Card	2020	2019	2018	2017	2016
Estuary	**FRP**	**FRP**				
Gregory River	90	90	90	90	90	90
O'Connell River	90	90	90	90	90	90
St Helens/Murray Creek	79	77	71	65	62	73
Vines Creek	90	90	69	90	72	90
Sandy Creek	65	74	73	65	65	64
Plane Creek	90	90	90	90	90	90
Rocky Dam Creek	90	90	90	90	90	90
Carmila Creek	90	90	90	90	90	76

Scoring range: ■ 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

Table C4. Turbidity indicator scores within estuaries for the 2021 Report Card, compared to the 2016–2020 Report Cards.

	2021 Report Card	2020	2019	2018	2017	2016
Estuary	**Turbidity**	**Turbidity**				
Gregory River	90	90	81	90	90	90
O'Connell River	90	90	77	4	72	25
St Helens/Murray Creek	65	70	30	9	30	14
Vines Creek	90	90	64	64	55	90
Sandy Creek						
Plane Creek						
Rocky Dam Creek						
Carmila Creek						

Scoring range: ■ 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

Table C5. Lower DO indicator scores within estuaries for the 2021 Report Card, compared to the 2016–2020 Report Cards.

	2021 Report Card	2020	2019	2018	2017	2016
Estuary	**Lower DO**	**Lower DO**				
Gregory River	78	72	90	69	79	79
O'Connell River	90	90	90	90	90	90
St Helens/Murray Creek	90	90	90	90	90	90
Vines Creek	74	90	65	90	77	90
Sandy Creek	80	79	90	78	90	77
Plane Creek	90	90	90	90	90	90
Rocky Dam Creek	90	90	90	90	90	90
Carmila Creek	90	90	90	90	90	90

Scoring range: ■ 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

Table C6. Upper DO indicator scores within estuaries for the 2021 Report Card, compared to the 2016–2020 Report Cards.

	2021 Report Card	2020	2019	2018	2017	2016
Estuary	**Upper DO**	**Upper DO**				
Gregory River	90	90	90	90	90	90
O'Connell River	19	10	27	0	53	11

Table C6. Upper DO indicator scores within estuaries for the 2021 Report Card, compared to the 2016–2020 Report Cards.

	2021 Report Card	2020	2019	2018	2017	2016
Estuary	Upper DO	Upper DO				
St Helens/Murray Creek	90	90	90	90	90	90
Vines Creek	90	90	90	90	73	90
Sandy Creek	90	90	90	90	90	90
Plane Creek	90	71	67	90	90	68
Rocky Dam Creek	90	90	90	90	90	90
Carmila Creek	70	66	62	0	0	90

Scoring range: ■ 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

Appendix C.3. Estuaries—Revision to Riparian Extent and Mangrove/Saltmarsh Extent Scores

Scores for estuarine vegetation extent (riparian and mangrove/saltmarsh) were last updated in the 2019 Report Card. Due to updates to the source mapping, such as error correction 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 C7, below.

Table C7. Results for riparian and mangrove/saltmarsh extent loss since pre-development (%), hectares remaining and standardised riparian and mangrove & saltmarsh extent in estuaries in the 2021 Report Card (2013–14 data). Hectares were rounded to the nearest whole number.

	2021 Report Card				2021 Report Card	
	Mangrove/Saltmarsh Extent		Riparian Extent			
Estuary	Hectares lost since pre-clearing	% loss since pre-clearing	Hectares lost since pre-clearing	% loss since pre-clearing	Standardised Mangrove/ Saltmarsh Extent	Standardised Riparian Extent
Gregory River	96.2	3.2	9.4	4.9	87	81
O'Connell River	108.9	4.0	40.5	57.2	84	17
St Helens/Murray Creek	-6.5*	-0.2*	54.2	17.1	100	58
Vines Creek	114.0	15.6	8.6	18.1	60	56
Sandy Creek	408.2	14.0	70.0	38.3	63	32
Plane Creek	26.1	2.2	23.0	17.0	91	58
Rocky Dam Creek	432.2	7.1	11.9	4.7	76	82
Carmila Creek	29.0	6.9	0.0	0.0	77	100

Riparian and mangrove/saltmarsh extent (% loss) scoring range: ■ 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 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

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

Appendix D—Inshore and Offshore Marine Environments

The scores and graphs presented below are for the inshore and offshore zones for the MWI 2020 Report Card. Boxplots are presented for inshore water quality indicators and summary statistics are tabulated for individual sites. Site-level scores are also presented for both the inshore and offshore zones for water quality, coral and seagrass indicators, compared to previous years.

Appendix D.1. Marine Water Quality

Appendix D.1.1. Inshore Site-level Results

Appendix D.1.1.1. Northern Inshore Zone

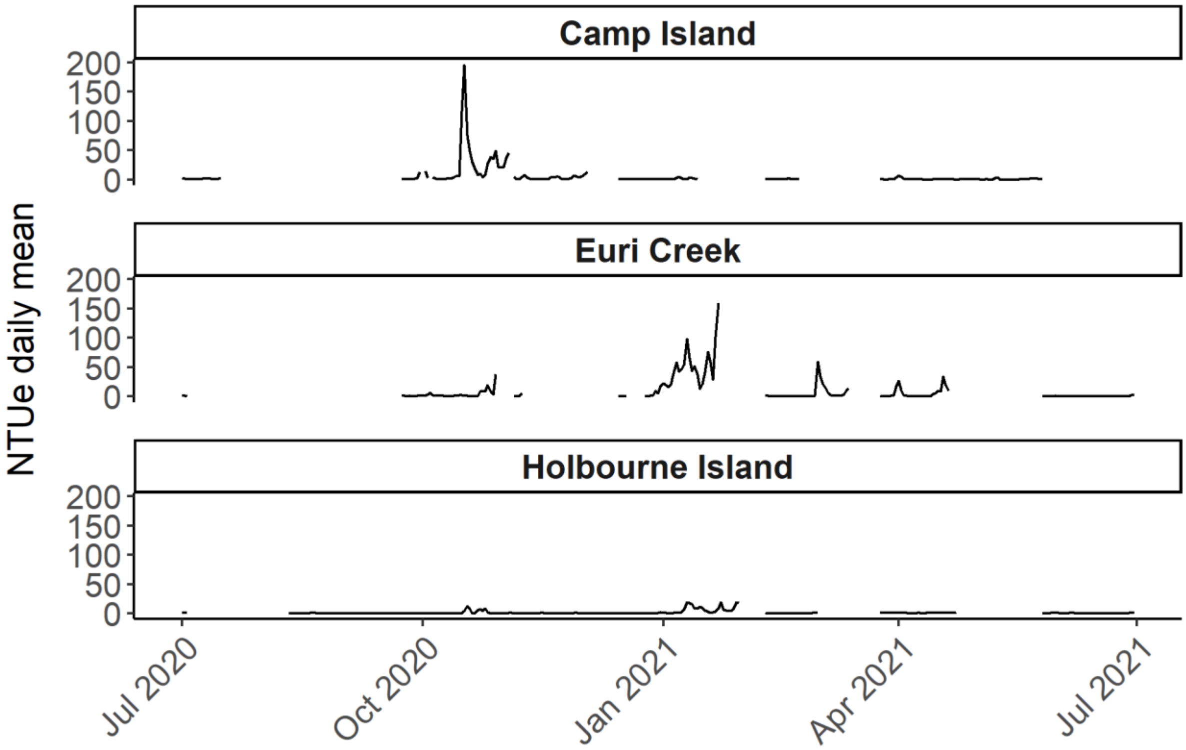

Figure D1. Northern Zone turbidity plots. Northern Inshore Zone daily mean turbidity (NTUe) from the NQBP Abbot Point monitoring program 2021 reporting cycle. Missing data removed due to spikes and/or fouling.

Table D1. **Northern Zone summary statistics.** Summary statistics for water quality indicators in the Northern Zone during the 2021 reporting cycle, with n representing sample size. Values are compared to site-specific Guideline Values (GV) set by GBRMPA and DES. For indicators to meet the criteria, the Comparison Statistic (CS) must be lower than the GV, bar Secchi, which must be higher than the GV. PN (µg/L), PP (µg/L), Chl-a (µg/L), TSS (mg/L), Secchi (m), Turbidity = NTU. Although turbidity measurements are captured continuously, sample sizes reflect daily means that are validated, as some data may be removed due to spikes or fouling.

Name	Indicator	n	Mean	Min	25th percentile	Median	75th percentile	Max	Comparison Statistic	Guideline Value
Camp Island	NOx (µg/L)									
	PN (µg/L)	6	45.17	5	16.75	38	76.5	91	mean	20
	PP (µg/L)	6	2.33	1	1.25	2	2.75	5	mean	2.8
	Chl-*a* (µg/L)	6	0.88	0.44	0.48	0.52	1.07	2.05	mean	0.45
	TSS (mg/L)	6	1.38	0.11	1.2	1.6	1.7	2.3	mean	2
	Secchi (m)	6	5.68	4	4.38	4.75	6.05	9.2	mean	10
	Turbidity (NTU)	193	5.84	0.124	0.54	1.12	3.05	195.37	median	1
Euri Creek	NOx (µg/L)									
	PN (µg/L)	6	27.83	5	7	10	49.75	73	mean	20
	PP (µg/L)	6	2.00	1	1	2	3	3	mean	2.8
	Chl-*a* (µg/L)	6	0.46	0.25	0.42	0.46	0.56	0.59	mean	0.45
	TSS (mg/L)	6	1.48	0.89	1.1	1.55	1.85	2	mean	2
	Secchi (m)	6	4.60	4.1	4.1	4.15	4.65	6	mean	10
	Turbidity (NTU)	173	9.68	0.11	0.51	1.06	8.39	158.95	median	1
Holbourne Island	NOx (µg/L)									
	PN (µg/L)	6	35.17	2	13.25	19	34.5	120	mean	20
	PP (µg/L)	6	1.17	0	1	1	1.75	2	mean	2.8
	Chl-*a* (µg/L)	6	0.45	0.22	0.39	0.43	0.52	0.68	mean	0.45
	TSS (mg/L)	6	1.43	0.33	0.6	1.6	1.8	2.9	mean	2
	Secchi (m)	6	9.53	5	8.3	10.35	11.58	12.4	mean	10
	Turbidity (NTU)	263	1.44	0.06	0.24	0.41	0.91	19.38	median	1

Table D2. Northern Zone standardised scores by indicator, Report Card (RC) 2021. Site-level standardised scores for water quality indicators in the Northern Zone during the 2021 reporting cycle.

Name	NOx	PN	PP	Chla	TSS	Secchi	NTU
Euri Creek		-0.48	0.49	-0.03	0.43	-1.00	-0.08
Camp Island		-1.00	0.26	-0.96	0.53	-0.82	-0.16
Holbourne Island		-0.81	1.00	0.01	0.49	-0.07	1.00

Table D3. Northern Zone standardised scores by indicator, RC 2021–2016. Zone-level standardised scores for water quality indicators in the Northern Zone from 2016 to 2021.

Year	NOx	PN	PP	Chla	TSS	Secchi	NTU
2021		-0.76	0.58	-0.33	0.37	-0.63	0.25
2020		-0.45	0.21	0.29	-0.62	-0.91	0.30
2019		-0.76	0.46	-0.07	-0.25	-0.89	-0.07
2018		0.57	0.82	0.01		-0.97	-0.45
2017	-0.22			0.72	0.27		-0.62
2016	0.33			0.74	-0.04		-0.72

Table D4. Northern Inshore Zone standardised scores by indicator category, RC 2021. Site-level standardised scores for water quality indicator categories in the Northern Zone during the 2021 reporting cycle.

Name	Nutrients	Chla	Clarity
Euri Creek	0.00	-0.03	-0.22
Camp Island	-0.37	-0.96	-0.15
Holbourne Island	0.09	0.01	0.47

Table D5. Northern Inshore Zone standardised scores by indicator category, RC 2021–2016. Zone-level standardised scores for water quality indicators in the Northern Zone from 2016 to 2021.

Year	Nutrients	Chl-*a*	Clarity
2021	-0.09	-0.33	0.036
2020	-0.12	0.29	-0.41
2019	-0.15	-0.07	-0.41
2018	0.69	0.01	-0.71
2017		0.72	-0.18
2016		0.74	-0.35

Appendix D.1.1.2. Whitsundays Inshore Zone

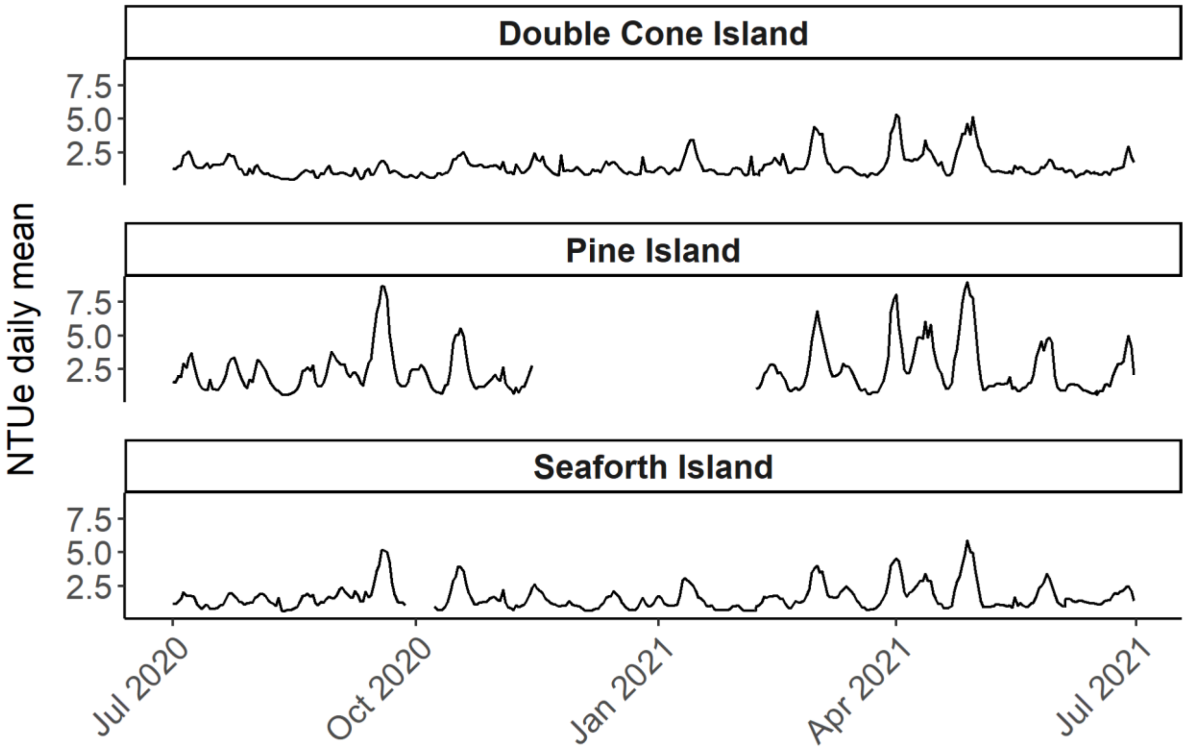

Figure D2. Whitsundays Zone turbidity plots. Whitsundays Inshore Zone daily mean turbidity (NTUe) from the MMP 2021 reporting cycle. Missing data removed due to spikes and/or fouling.

Table D6. Whitsundays Zone summary statistics. Summary statistics for water quality indicators in the Whitsundays Zone during the 2021 reporting cycle, with n representing sample size. Values are compared to site-specific Guideline Values (GV) set by GBRMPA and DES. For indicators to meet the criteria, the Comparison Statistic (CS) must be lower than the GV, bar Secchi, which must be higher than the GV. PN (µg/L), PP (µg/L), Chl-a (µg/L), TSS (mg/L), Secchi (m), Turbidity = NTU. Although turbidity measurements are captured continuously, sample sizes reflect daily means that are validated, as some data may be removed due to spikes or fouling.

Name	Indicator	n	Mean	Min	25th percentile	Median	75th percentile	Max	Comparison Statistic	Guideline Value
Double Cone Island	Chl-*a* (µg/L)	5	0.31	0.23	0.23	0.34	0.34	0.38	median	0.36
	NOx (µg/L)	5	3.72	0.95	1.05	2.2	2.94	11.45	median	1
	Turbidity (NTU)	368	1.45	0.47	0.95	1.21	1.64	5.34	median	1.1
	PN (µg/L)	5	25.54	17.94	19.84	25.79	26.59	37.54	median	13
	PP (µg/L)	5	2.75	2.29	2.52	2.54	3.09	3.29	median	2.4
	Secchi (m)	5	5.5	3.5	5	5	6	8	mean	10
	TSS (mg/L)	5	1.38	0.85	1.23	1.23	1.54	2.07	median	1.4
Pine Island	Chl-*a* (µg/L)	5	0.34	0.28	0.29	0.3	0.4	0.44	median	0.36
	NOx (µg/L)	5	6.11	0.32	1.71	5.64	7.38	15.5	median	1
	Turbidity (NTU)	283	2.44	0.58	1.19	1.93	2.95	8.99	median	1.1
	PN (µg/L)	5	25.25	15.19	18.39	19.39	22.74	50.54	median	13
	PP (µg/L)	5	2.52	2.11	2.21	2.44	2.62	3.2	median	2.4
	Secchi (m)	5	6.3	3.5	7	7	7	7	mean	10
	TSS (mg/L)	5	1.45	1.1	1.24	1.25	1.3	2.34	median	1.4
Seaforth Island	Chl-*a* (µg/L)	5	0.34	0.26	0.3	0.31	0.33	0.51	median	0.36
	NOx (µg/L)	5	3.37	0.28	1.75	2.24	5.32	7.28	median	1
	Turbidity (NTU)	357	1.66	0.62	1.05	1.39	1.93	5.88	median	1.1
	PN (µg/L)	5	24.86	19.04	19.94	25.58	29.64	30.09	median	13
	PP (µg/L)	5	2.99	2.68	2.82	2.82	2.99	3.63	median	2.4
	Secchi (m)	5	5	3	4	4.5	6	7.5	mean	10
	TSS (mg/L)	5	1.57	0.78	1.28	1.31	1.7	2.8	median	1.4

Table D7. Whitsundays Zone standardised scores by indicator, RC 2021. Site-level standardised scores for water quality indicators in the Whitsundays Zone during the 2021 reporting cycle. 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.

Name	Secchi	TSS	Chla	NOx	PN	PP	NTU
Double Cone Island	-0.86	0.19	0.09	-1.00	-0.99	-0.08	-0.14
Pine Island	-0.67	0.16	0.24	-1.00	-0.58	-0.02	-0.81
Seaforth Island	-1.00	0.09	0.22	-1.00	-0.98	-0.23	-0.33

Table D8. Whitsunday Zone standardised scores by indicator, RC 2021–2016. Zone-level standardised scores for water quality indicators in the Whitsunday Zone from 2016 to 2021. 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.

Year	NOx	PN	PP	Chla	TSS	Secchi	NTU
2021	-1.00	-0.85	-0.11	0.18	0.15	-0.84	-0.43
2020	-0.35	-0.92	0.04	-0.18	-0.01	-0.92	-0.16
2019	-0.04	-0.80	-0.96	-0.81	-0.73	-0.36	-0.92
2018	-0.34	-0.83	-0.26	-0.63	0.11	-0.95	-0.65
2017	-1.00	-1.00	-0.98	-0.99	-0.67	-1.00	-0.32
2016	-0.31	-1.00	-0.31	-0.12	0.14	-0.85	-0.43

Table D9. Whitsunday Inshore Zone standardised scores by indicator category, RC 2021. Site-level standardised scores for water quality indicator categories in the Whitsunday Zone during the 2021 reporting cycle. 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.

Name	Nutrients	Chla	Clarity
Double Cone Island	-0.69	0.09	-0.27
Pine Island	-0.53	0.24	-0.44
Seaforth Island	-0.74	0.22	-0.41

Table D10. Whitsunday Inshore Zone standardised scores by indicator category, RC 2021–2016. Zone-level standardised scores for water quality indicators in the Whitsunday Zone from 2016 to 2021. 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.

Year	Nutrients	Chla	Clarity
2021	-0.65	0.18	-0.38
2020	-0.41	-0.18	-0.36
2019	-0.60	-0.81	-0.67
2018	-0.48	-0.63	-0.50
2017	-0.98	-0.99	-0.65
2016	-0.54	-0.12	-0.38

Appendix D.1.1.3. Central Inshore Zone

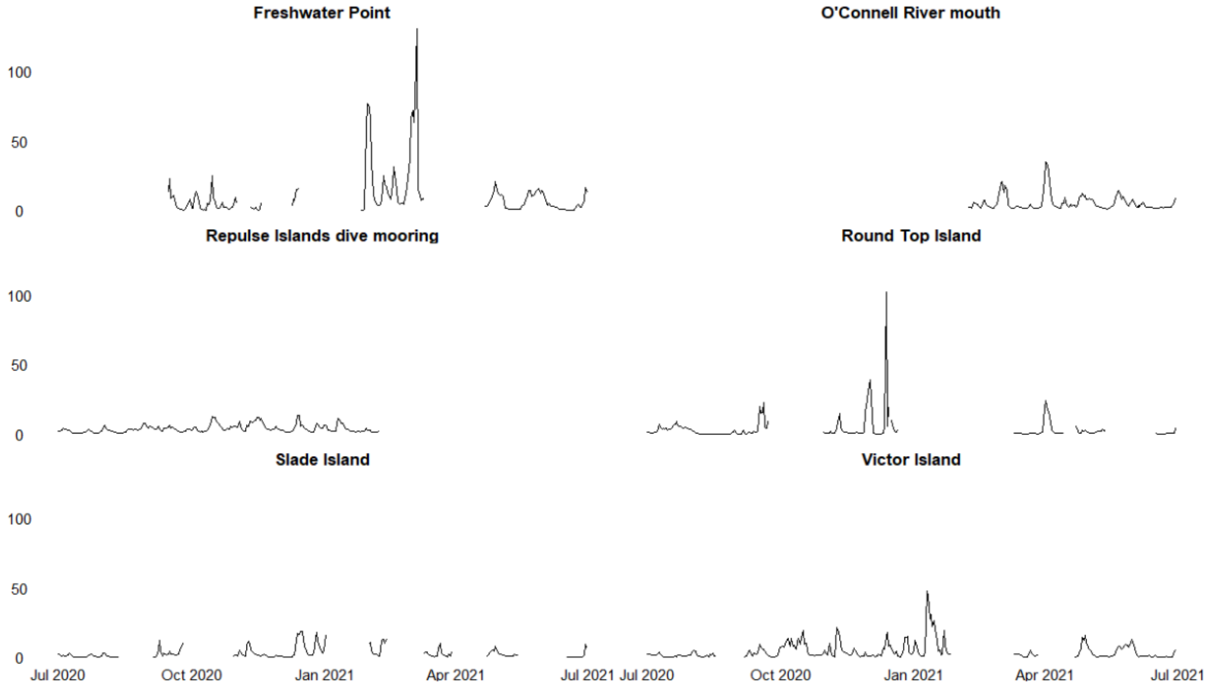

Figure D3. Central Zone turbidity plots. Central Inshore Zone daily mean turbidity (NTUe) from both the NQBP Hay Point monitoring program and the MMP 2021 reporting cycles. Missing data removed due to spikes and/or fouling.

Table D11. Central Zone summary statistics. Summary statistics for water quality indicators in the Central Zone during the 2021 reporting cycle, with n representing sample size. Values are compared to site-specific Guideline Values (GV) set by GBRMPA and DES. For indicators to meet the criteria, the Comparison Statistic (CS) must be lower than the GV, bar Secchi, which must be higher than the GV. Although turbidity measurements are captured continuously, sample sizes reflect daily means that are validated, as some data may be removed due to spikes or fouling. O'Connell River mouth has GVs only for Chl-a and NOx, and other indicators are not able to be incorporated into the Report Card.

Name	Indicator	n	Mean	Min	25th percentile	Median	75th percentile	Max	Comparison Statistic	Guideline Value
Freshwater Point	Secchi (m)	7	2.78	1.75	2.10	2.50	3.45	4.10	mean	10
	TSS (mg/L)	7	3.64	2.30	2.70	3.20	4.45	5.70	mean	2
	Chl-*a* (µg/L)	7	0.77	0.34	0.45	0.58	1.03	1.52	mean	0.45
	PN (µg/L)	7	18.29	4.00	6.00	21.00	28.00	35.00	mean	20
	PP (µg/L)	7	2.29	1.00	1.50	2.00	3.00	4.00	mean	2.8
	Turbidity (NTU)	177	10.59	0.00	1.84	5.14	12.08	130.78	median	1
O'Connell River mouth	Secchi (m)	5	3.40	1.50	2.50	3.00	5.00	5.00	NA	NA
	TSS (mg/L)	5	3.82	1.49	2.32	2.72	3.26	9.33	NA	NA
	Chl-*a* (µg/L)	5	0.63	0.37	0.50	0.66	0.73	0.86	median	1.3
	NOx (µg/L)	5	4.22	0.35	0.84	4.24	5.92	9.77	median	4
	PN (µg/L)	5	48.77	31.68	39.74	43.69	48.68	80.08	NA	NA
	PP (µg/L)	5	6.64	5.16	5.29	6.18	7.01	9.55	NA	NA
	Turbidity (NTU)	145	5.54	1.30	2.22	3.14	7.24	34.69	NA	NA
Repulse Islands dive mooring	Secchi (m)	5	3.80	2.50	3.00	3.50	4.50	5.50	mean	10
	TSS (mg/L)	5	3.51	0.98	2.01	2.64	4.79	7.15	median	1.4
	Chl-*a* (µg/L)	5	0.51	0.26	0.46	0.48	0.61	0.73	median	0.36
	NOx (µg/L)	5	5.03	0.28	2.59	4.34	6.02	11.90	median	1
	PN (µg/L)	5	32.39	18.64	30.24	31.68	35.88	45.49	median	13
	PP (µg/L)	5	5.12	4.11	4.39	4.80	6.12	6.19	median	2.4
	Turbidity (NTU)	223	3.81	0.58	1.87	3.10	5.08	13.34	median	1.1
Round Top Island	Secchi (m)	7	6.43	3.00	5.50	7.00	7.25	9.50	mean	10

Name	Indicator	n	Mean	Min	25th percentile	Median	75th percentile	Max	Comparison Statistic	Guideline Value
	TSS (mg/L)	7	1.97	0.89	1.35	1.70	2.30	3.90	mean	2
	Chl-*a* (µg/L)	7	0.42	0.10	0.30	0.38	0.59	0.70	mean	0.45
	PN (µg/L)	7	14.29	2.00	8.00	11.00	12.00	47.00	mean	20
	PP (µg/L)	7	1.71	0.00	1.50	2.00	2.00	3.00	mean	2.8
	Turbidity (NTU)	206	3.53	0.00	0.28	0.88	3.21	101.98	median	1
Slade Island	Secchi (m)	6	6.35	3.50	5.25	6.05	7.15	10.00	mean	10
	TSS (mg/L)	7	2.04	0.89	1.80	2.00	2.45	2.90	mean	2
	Chl-*a* (µg/L)	7	0.76	0.36	0.43	0.73	0.79	1.79	mean	0.45
	PN (µg/L)	7	23.57	2.00	9.50	18.00	21.50	83.00	mean	20
	PP (µg/L)	7	2.00	0.00	1.00	2.00	3.00	4.00	mean	2.8
Victor Island	Secchi (m)	7	3.79	1.90	2.85	3.50	4.55	6.30	mean	10
	TSS (mg/L)	7	3.13	2.20	2.55	2.90	3.50	4.70	mean	2
	Chl-*a* (µg/L)	7	1.36	0.34	0.52	0.95	1.38	4.46	mean	0.45
	PN (µg/L)	7	14.57	8.00	12.00	13.00	16.00	25.00	mean	20
	PP (µg/L)	7	2.00	0.00	1.00	1.00	3.50	4.00	mean	2.8
	Turbidity (NTU)	280	4.44	0.00	0.83	2.04	5.58	47.90	median	1

Table D12. Central Zone standardised scores by indicator, RC 2021. Site-level standardised scores for water quality indicators in the Central Zone during the 2021 reporting cycle. 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.

Name	NOx	PN	PP	Chla	TSS	Secchi	NTU
O'Connell River mouth	-0.08			0.98			
Repulse Islands dive mooring	-1.00	-1.00	-1.00	-0.40	-0.91	-1.00	-1.00
Freshwater Point		0.13	0.29	-0.77	-0.87	-1.00	-1.00
Victor Island		0.46	0.49	-1.00	-0.65	-1.00	-1.00
Round Top Island		0.49	0.71	0.09	0.02	-0.64	0.19
Slade Island		-0.24	0.49	-0.76	-0.03	-0.66	0.89

Table D13. Central Zone standardised scores by indicator, RC 2021–2016. Zone-level standardised scores for water quality indicators in the Central Zone from 2016 to 2021. 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.

Year	NOx	PN	PP	Chla	TSS	Secchi	NTU
2021	-0.54	-0.03	0.19	-0.31	-0.49	-1.00	-0.38
2020	0.01	-0.93	0.06	-0.66	-0.79	-0.98	0.27
2019	0.03	-0.80	-0.36	-0.40	-0.90	-0.80	-0.01
2018	0.42	0.01	0.08	-0.56	-0.93	-0.81	-0.02
2017	0.00	0.13	-0.19	-0.53	-1.00	-0.98	-0.20
2016	0.41	-0.67	-0.17	-0.38	-0.43	0.00	-0.15

Table D14. Central Inshore Zone standardised scores by indicator category, RC 2021. Site-level standardised scores for water quality indicator categories in the Central Zone during the 2021 reporting cycle. 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.

Name	Nutrients	Chla	Clarity
O'Connell River mouth		0.98	
Repulse Islands dive mooring	-1.00	-0.40	-0.97
Freshwater Point	0.21	-0.77	-0.96
Victor Island	0.47	-1.00	-0.88
Round Top Island	0.60	0.09	-0.14
Slade Island	0.12	-0.76	0.07

Table D15. Central Inshore Zone standardised scores by indicator category, RC 2021–2016. Zone-level standardised scores for water quality indicators in the Central Zone from 2016 to 2021. 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.

Year	Nutrients	Chla	Clarity
2021	0.08	-0.31	-0.44
2020	-0.43	-0.66	-0.55
2019	-0.56	-0.40	-0.67
2018	0.08	-0.56	-0.50
2017	-0.10	-0.53	-0.59
2016	-0.35	-0.38	-0.20

Appendix D.1.1.4. Southern Inshore Zone

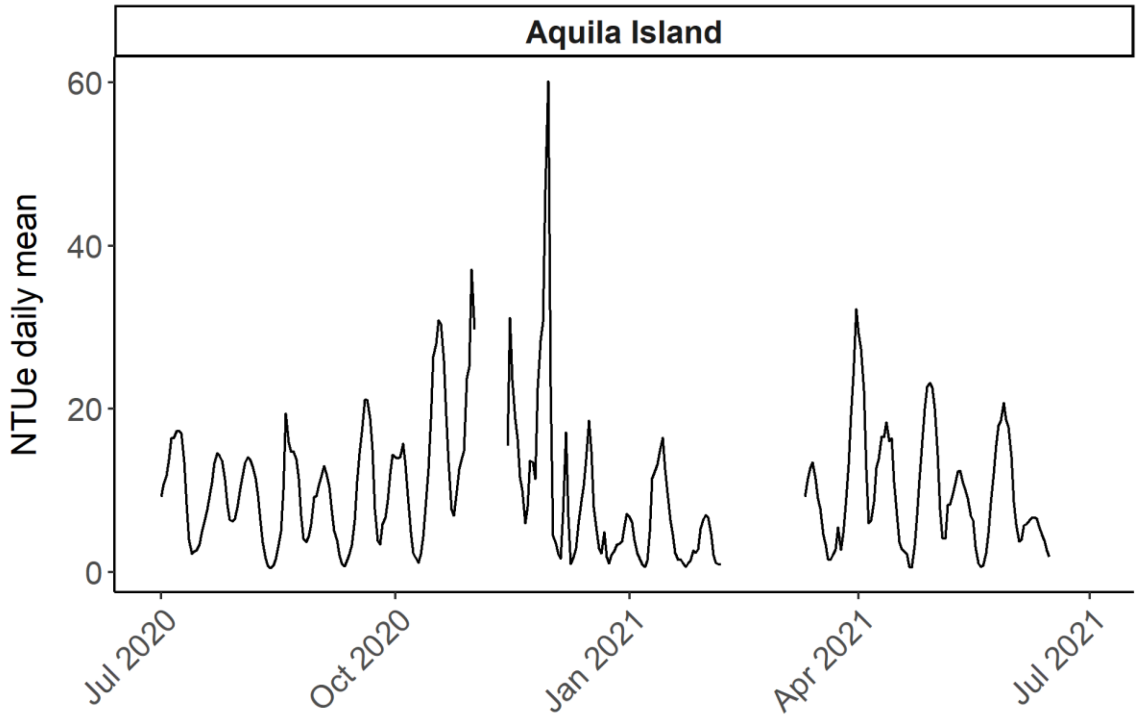

Figure D4. Southern Zone turbidity plots. Southern Inshore Zone daily mean turbidity (NTUe) from the SIP 2021 reporting cycle. Missing data removed due to spikes and/or fouling.

Table D16. Southern Zone summary statistics. Summary statistics for water quality indicators in the Southern Zone during the 2021 reporting cycle, with n representing sample size. Values are compared to site-specific Guideline Values (GV) set by GBRMPA and DES. For indicators to meet the criteria, the Comparison Statistic (CS) must be lower than the GV, bar Secchi, which must be higher than the GV. Although turbidity measurements are captured continuously, sample sizes reflect daily means that are validated, as some data may be removed due to spikes or fouling.

Name	Indicator	n	Mean	Min	25th percentile	Median	75th percentile	Max	Comparison Statistic	Guideline Value
Aquilla Island	TSS (mg/L)	7	8.31	2.9	5.45	7.4	11	15	mean	2
	NOx (µg/L)	7	1.29	0.5	0.5	0.5	1.5	4	median	3
	PN (µg/L)	7	21.86	2	5.5	11	34	61	mean	20
	PP (µg/L)	7	3.57	1	2	4	5	6	mean	2.8
	Chl-*a* (µg/L)	7	0.74	0.37	0.5	0.69	0.9	1.35	mean	0.45
	Secchi (m)	7	1.96	1.1	1.35	1.7	2.35	3.5	mean	10
	Turbidity (NTU)	306	9.99	0.48	3.75	8.28	13.86	60.14	mean	1
Carmila_2	TSS (mg/L)	8	5.73	1.6	3.95	5.1	7.25	11	mean	2
	NOx (µg/L)	8	2	0.5	1.25	2	2.5	4	median	3
	PN (µg/L)	8	11.43	3	7	11	14.5	23	mean	20
	PP (µg/L)	8	2.71	1	2	2	3.5	5	mean	2.8
	Chl-*a* (µg/L)	8	0.37	0.1	0.2	0.32	0.58	0.66	mean	0.45
	Secchi (m)	8	2.16	1.3	1.75	2.2	2.4	3.3	mean	10
Carmila_3	TSS (mg/L)	7	3.97	1.6	2.67	4.2	4.68	6.8	mean	2
	NOx (µg/L)	7	1.75	0.5	0.5	1.25	2.75	4	median	3
	PN (µg/L)	7	13.83	2	10.25	11	14	34	mean	20
	PP (µg/L)	7	2.17	1	1.25	2.5	3	3	mean	2.8
	Chl-*a* (µg/L)	7	2.47	0.22	0.24	0.34	0.43	13.27	mean	0.45
	Secchi (m)	7	2.56	2	2.1	2.7	3	3	mean	10

Table D17. Southern Zone standardised scores by indicator, RC 2021. Site-level standardised scores for water quality indicators in the Southern Zone during the 2021 reporting cycle. 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.

Name	TSS	NOx	PN	PP	Chla	Secchi	NTU
Carmila_3	-0.99	1.00	0.53	0.37	-1.00	-1.00	
Carmila_2	-1.00	0.58	0.81	0.04	0.27	-1.00	
Aquilla Island	-1.00	1.00	-0.13	-0.35	-0.73	-1.00	-1.00

Table D18. Southern Zone standardised scores by indicator, RC 2021–2016. Zone-level standardised scores for water quality indicators in the Southern Zone from 2016 to 2021. 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.

Year	NOx	PN	PP	Chla	TSS	Secchi	NTU
2021	0.86	0.40	0.02	-0.49	-1.00	-1.00	-1.00
2020	0.86	-0.53	0.31	-0.51	-1.00	-1.00	-1.00
2019	0.61	-0.22	-0.57	-0.43	-1.00		-1.00
2018	-0.19	-0.15	-0.22	-0.70		-1.00	-1.00

Table D19. Southern Inshore Zone standardised scores by indicator category, RC 2021. Site-level standardised scores for water quality indicator categories in the Southern Zone during the 2021 reporting cycle. 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.

Name	Nutrients	Chla	Clarity
Carmila_3	0.63	-1.00	-0.99
Carmila_2	0.48	0.27	-1.00
Aquilla Island	0.17	-0.73	-1.00

Table D20. Southern Inshore Zone standardised scores by indicator category, RC 2021–2016. Zone-level standardised scores for water quality indicators in the Southern Zone from 2016 to 2021. 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.

Year	Nutrients	Chla	Clarity
2021	0.43	-0.49	-1.00
2020	0.21	-0.51	-1.00
2019	-0.06	-0.43	-1.00
2018	-0.19	-0.70	-1.00

Appendix D.1.2. Pesticides

Table D21. Results for the Pesticide Risk Metric indicator accounting for up to 22 pesticides, reporting aquatic species protected (%) and overall standardised pesticide score for inshore zones for the 2021 Report Card, compared to the 2017–2020 Report Cards. The Pesticide Risk Metric reported for each passive sampler site is the maximum % species affected value out of *n* deployments per site. Previous years scores are presented behind diagonal lines as they are not directly comparable to the current year due to changes in methods. Note, Flat Top Is. was previously known as Round Top Is. MMP = Marine Monitoring Program, SIP = Southern Inshore Monitoring Program.

2021 Report Card								2020	2019	2018	2017
Zone	**Sample Type**	**Program**	**Site/s**	**Sample Timing and Size (*n*)**	**Value Reported**	**Pesticide Risk Metric (% Species Protected)**	**Pesticide Score**	**Pesticide Score**			
Northern	Passive	NQBP	Euri Creek	05/11/2020–15/12/2020 (1 deployment)	Max	100	**100**	**100**	**99**		
Whitsunday											
Central	Passive	MMP	Repulse Bay	01/11/2020–09/05/2021 (5 continuous deployments)	Max	99	**85**	**74**	**60**	**54**	**50**
			Flat Top Island	31/10/2020–08/06/2021 (6 continuous deployments)	Max	99					
			Sandy Creek	31/10/2020–06/01/21 and 07/02/21–08/06/21 (5 deployments)	Max	99					
	Passive	NQBP	Slade Island	30/10/2020–2/12/2020 and 2/01/2021–10/03/2021 (2 deployments)	Max	100	**100**	**100**	**99**		
Southern	Passive	SIP	Aquila Island	01/12/2020–21/04/2021 (3 continuous deployments)	Max	100	**100**	**75**	**100**		

Pesticide risk metric (% species protected) risk categories: Very High = <80 | High = 80 to <90 | Moderate = 90 to <95 | Low = 95 to <99 | Very Low = ≥99 | No score/data gap
Pesticide scoring range: Very Poor = 0 to 20 | Poor = >20 to 40 | Moderate = >40 to 60 | Good = >60 to 80 | Very Good = >80 | No score/data gap

Appendix D.1.3. Marine water quality back-calculations

Table D22. Comparison of 2020 and 2021 zone-level marine water quality scores using back-calculated scores.

		North	Whitsunday	Central
RC20	Previous	54	42	39
	Updated	59	36	39
RC21		53	42	56

Table D23. Comparison of 2020 and 2021 indicator category-level marine water quality scores using back-calculated scores.

		Zone	Nutrients	Chl-*a*	Water Clarity	Pesticides	Water Quality
RC20	Previous	North	53	72	36		54
	Updated		50	76	50		59
	Previous	Whitsunday	36	50	39		42
	Updated		33	43	33		36
	Previous	Central	35	20	27	74	39
	Updated		36	24	21	74	39
RC21		North	55	41	63		53
		Whitsunday	21	68	38		42
		Central	63	42	34	85	56

Table D24. Comparison of 2020 and 2021 site-indicator-level marine water quality scores for inshore zones using re-calculated scores. Light blue sites represent data included in the NQBP monitoring program, while dark blues sites represent data included in the MMP.

Zone		Site	NOx	PN	PP	Chl-a	TSS	Secchi	Turbidity	Turbidity (dry)	Turbidity (wet)
North	Previous	AP_AMB1 (Euri Ck)		0.08	0.54	0.76	-0.57	-0.94	0.392		
		AP_AMB2 (Spoil Grounds)		0.22	1.00	0.19	-0.97	-1.00	-0.910		
		AP_AMB3 (Elliot River)		-1.00	-0.41	0.11	-0.89	-1.00	0.347		
		AP_AMB4 (Camp Is.)		-1.00	-1.00	-0.18	-0.77	-0.87	0.670		
		AP_AMB5 (Holbourne Is.)		-0.57	0.90	0.57	0.10	-0.72	1.000		
	Updated	AP_AMB1 (Euri Ck)		0.08	0.54	0.76	-0.57	-0.94	0.392		
		AP_AMB2 (Spoil Grounds)									
		AP_AMB3 (Elliot River)									
		AP_AMB4 (Camp Is.)		-1.00	-1.00	-0.18	-0.77	-0.87	0.670		
		AP_AMB5 (Holbourne Is.)		-0.57	0.90	0.57	0.10	-0.72	1.000		
Whitsunday	Previous	WHI1 (Double Cone Island)	0.38	-0.85	0.10	-0.11	0.39	-0.84	-0.05		
		WHI4 (Pine Island)	-0.75	-1.00	0.07	-0.31	-0.60	-1.00	-0.36		
		WHI5 (Seaforth Island)	-0.69	-0.91	-0.05	-0.11	0.17	-0.92	-0.05		
	Updated	WHI1 (Double Cone Island)	0.51	-0.79	-0.05	-0.35	0.45	-0.84	-0.05		
		WHI4 (Pine Island)	-0.84	-1.00	-0.18	-0.37	-1.00	-1.00	-0.36		
		WHI5 (Seaforth Island)	-0.56	-0.99	-0.23	-0.17	-0.39	-0.92	-0.05		
Central	Previous	MKY_AMB1 (FW Point)		-1.00	0.13	-1.00	-1.00	-1.00	-1.00		
		MKY_AMB2 (Hay Reef)		-1.00	-0.10	-0.61	-1.00	-1.00	0.76	0.51	1.00
		MKY_AMB3B (Round Top Is.)		-0.93	0.26	-1.00	-0.67	-0.89	1.00		
		MKY_AMB5 (Slade Is.)		-0.99	0.20	-0.83	-0.88	-1.00	1.00	1.00	1.00
		MKY_AMB6B (Dudgeon Point)		-1.00	-0.56	-1.00	-1.00	-1.00			
		MKY_AMB8 (Spoil Grounds)		-1.00	0.95	-0.95	-0.28	-0.98	1.00	1.00	1.00
		MKY_AMB10 (Victor Is.)		-1.00	0.41	-0.66	-0.76	-1.00	-0.53		
		MKY_AMB12 (Keswick Is.)	-1.00	-0.42	0.07	-0.51	-0.70	-0.96	0.94		
		WHI6 (O'Connell River Mouth)	1.00			0.41					
		WHI7 (Repulse Islands dive mooring)	0.03	-1.00	-0.87	-0.49					
	Updated	MKY_AMB1 (FW Point)		-1.00	0.13	-1.00	-1.00	-1.00	-1.00		
		MKY_AMB2 (Hay Reef)									
		MKY_AMB3B (Round Top Is.)		-0.93	0.26	-1.00	-0.67	-0.89	1.00		
		MKY_AMB5 (Slade Is.)		-0.99	0.20	-0.83	-0.88	-1.00	1.00	1.00	1.00
		MKY_AMB6B (Dudgeon Point)									
		MKY_AMB8 (Spoil Grounds)									
		MKY_AMB10 (Victor Is.)		-1.00	0.41	-0.66	-0.76	-1.00	-0.53		
		MKY_AMB12 (Keswick Is.)									
		WHI6 (O'Connell River Mouth)	1.00			0.41					
		WHI7 (Repulse Islands dive mooring)	0.08	-1.00	-0.96	-0.53	-1.00	-1.00	-1.00		

Scoring range: Very Poor = -1 to -0.65 | Poor = -0.66 to -0.34 | Moderate = -0.01 to -0.33 | Good = 0 to 0.5 | Very Good = 0.51 to 1.00 | No score/data gap

Appendix D.1.4. Historic offshore marine water quality

Table D25. Offshore Zone water quality indicator scores 2016–2020 Report Cards.

	Indicator Categories		Water Quality Index
	Chlorophyll-*a*	Water Clarity (Sediments (TSS))	
2020 Report Card score: Very Good	99	99	**99**
2019: Very Good	99	99	**99**
2018: Very Good	99	99	**99**
2017: Very Good	94	89	**92**
2016: Very Good	99	87	**93**

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

Appendix D.2. Coral Index

Appendix D.2.1. Northern Inshore Zone

Table D26. Coral indicator scores for 2020–21 in the Northern Zone (Ports Coral Monitoring Program (Abbot Point)).

Region	Reef	Depth (m)	Cover	Macroalgae	Juvenile	Cover Change	Composition	Coral Index
Northern	Camp Is.	2	0.14	0.00	0.28	0.12		**0.14**
	Holbourne Is.	5	0.32	1.00	0.20	NA**		**0.51**
2021 Report Card score: Poor			**0.23**	**0.50**	**0.24**	**0.19**		**0.32^**
2020: Poor			0.11	0.66	0.07	0.30		**0.28***
2019: Poor			0.14	0.62	0.08	0.30		**0.29**
2018: Poor			0.12	0.61	0.07	0.20		**0.25**
2017: Poor			0.14	0.67	0.12			**0.31**
2016: Moderate			0.40	0.67	0.29			**0.45**

Coral index scoring range: ■ Very Poor = 0 to 0.20 | ■ Poor = >0.20 to 0.40 | ■ Moderate = >0.40 to 0.60 | ■ Good = >0.60 to 0.80 | ■ Very Good = >0.80 | ■ No score/data gap

*Previously index scores in the Northern Zone were calculated using individual sites and then aggregated into zone scores, whereas the current method calculates scores using island-level and then aggregates into zone scores. For reference, the 2020 Northern Zone score would have been 0.25 using the current aggregation method.

**Cover Change is not able to be calculated due to lack of representational data.

^2021 data are not directly comparable to previous years due to changes in sampling methodology.

Table D27. Comparison of 2020 and 2021 indicator site-level coral scores using back-calculated results to show the effect of decommissioned sites at Holbourne Island. 2020 shows historic Holbourne Island East and West sites at both shallow (2 m) and deep (5 m) sites. 2020 back-calculated shows scores as they would have been with East/West shallow sites decommissioned. 2021 scores show the scores with only East/West deep sites, and without the addition of the North/South sites.

	Reef	No. Sites	Depth (m)	Cover	Macroalgae	Juvenile	Cover Change	Composition	Coral index
2021	Holbourne East	1	5	0.18	1	0.03	0.51	NA	0.43
	Holbourne West	1	5	0.08	1	0.09	0	NA	0.29
2020 back-calculated	Holbourne East	1	5	0.18	1	0.02	0.27	NA	0.37
	Holbourne West	1	5	0.11	1	0.02	NA	NA	0.38
2020	Holbourne East	2	2-5	0.10	0.98	0.04	0.37	NA	0.37
	Holbourne West	2	2-5	0.05	1	0.05	0.23	NA	0.33

Coral index scoring range: ■ Very Poor = 0 to 0.20 | ■ Poor = >0.20 to 0.40 | ■ Moderate = >0.40 to 0.60 | ■ Good = >0.60 to 0.80 | ■ Very Good = >0.80 | ■ No score/data gap

Appendix D.2.2. Whitsunday Inshore Zone

Table D28. Weighting process for combining RCA and MMP data for the Whitsunday Zone with 2020–21 coral cover score. Lower weighting value for RCA data is due to reduced sample size their program. Reefs shaded grey were not included in 2020–21 surveys.

Zone	Program	Reef	Site (or depth (m))	Coral Cover Score	Weighting	Weighting to Apply	Weighted Coral Cover Score
Whitsunday	MMP	Border Is.	5	0.52	1.00	0.06	0.0288
		Daydream Is.	2	0.00	1.00	0.06	0.0000
		Daydream Is.	5	0.05	1.00	0.06	0.0028
		Dent Is.	2	0.35	1.00	0.06	0.0194
		Dent Is.	5	0.43	1.00	0.06	0.0238
		Double Cone Is.	2	0.03	1.00	0.06	0.0017
		Double Cone Is.	5	0.20	1.00	0.06	0.0111
		Hayman Is.	5	0.20	1.00	0.06	0.0111
		Hook Is.	2	0.14	1.00	0.06	0.0077
		Hook Is.	5	0.39	1.00	0.06	0.0216
		Langford Is.	5	0.19	1.00	0.06	0.0105
		Pine Is.	2	0.12	1.00	0.06	0.0066
		Pine Is.	5	0.25	1.00	0.06	0.0138
		Seaforth Is.	2	0.23	1.00	0.06	0.0127
		Seaforth Is.	5	0.23	1.00	0.06	0.0127
		Shute Harbour	2	0.72	1.00	0.06	0.0398
		Shute Harbour	5	0.32	1.00	0.06	0.0177
	RCA	Daydream Is.	Lovers Cove		0.32		
		Daydream Is.	Mermaids Cove		0.32		
		Hayman Is. Reefs	Blue Pearl Bay		0.32		
		Hook Is.	Butterfly Bay	0.45	0.32	0.02	0.0079
		Hook Island	Luncheon Bay	0.10	0.32	0.02	0.0017
		Whitsunday Is.	Peter's Bay	0.74	0.45	0.02	0.0182
					18.09	**1.00**	Summed Weighted Coral Cover Score: **0.2696**

Table D29. Coral indicator scores for 2020–21 in the Whitsunday Zone. The 2020–21 overall coral index for the Whitsunday Zone is calculated using MMP and RCA coral cover data for the second time. Weighted cover is calculated as per Table D11, where the cover indicator score is recalculated using weightings to reflect the reliability of the data. Weighted cover scores for each site are then summed to give the overall weighted cover indicator score.

Zone	Program	Reef	Depth (m)	Cover	Weighted Cover	Macroalgae	Juvenile	Cover Change	Composition	Coral Index
Whitsunday	MMP	Border Is.	5	0.52	0.03	1.00	0.60	0.00	0.00	**0.42**
		Daydream Is.	2	0.00	0.00	0.00	0.41	0.00	0.00	**0.08**
		Daydream Is.	5	0.05	0.00	0.23	1.00	0.13	0.00	**0.28**
		Dent Is.	2	0.35	0.02	0.00	0.23	0.17	0.00	**0.15**
		Dent Is.	5	0.43	0.02	0.38	0.24	0.18	0.00	**0.25**
		Double Cone Is.	2	0.03	0.00	0.00	0.18	0.20	0.00	**0.08**
		Double Cone Is.	5	0.20	0.01	0.00	0.16	0.00	0.00	**0.07**
		Hayman Is.	5	0.20	0.01	0.83	0.89	0.49	0.00	**0.48**
		Hook Is.	2	0.14	0.01	0.25	0.32	0.40	0.00	**0.22**
		Hook Is.	5	0.39	0.02	0.95	0.24	1.00	0.50	**0.61**
		Langford Is.	5	0.19	0.01	1.00	0.42	0.00	0.00	**0.32**
		Pine Is.	2	0.12	0.01	0.00	0.30	0.17	0.00	**0.12**
		Pine Is.	5	0.25	0.01	0.00	0.28	0.36	0.00	**0.18**
		Seaforth Is.	2	0.23	0.01	0.00	0.26	0.12	0.50	**0.22**
		Seaforth Is.	5	0.23	0.01	0.00	0.41	0.37	1.00	**0.40**
		Shute Harbour	2	0.72	0.04	0.85	0.34	0.56	1.00	**0.70**
		Shute Harbour	5	0.32	0.02	0.89	0.52	0.44	1.00	**0.63**
		Butterfly Bay	-	0.45	0.01					
		Luncheon Bay	-	0.10	0.00					
		Peter's Bay	-	0.74	0.01					
2021 Report Card score: Poor					**0.27***	**0.38**	**0.4**	**0.27**	**0.24**	**0.31***
2020: Poor					0.25*	0.30	0.34	0.25	0.27	0.28*
2019: Poor				0.22		0.51	0.22	0.24	0.29	0.30
2018: Moderate				0.32		0.60	0.32	0.37	0.47	0.42
2017: Moderate				0.37		0.93	0.34	0.43	0.53	0.52
2016: Good				0.68		0.76	0.62	0.40	0.59	0.61
2015: Moderate				0.64		0.74	0.60	0.40	0.53	0.58
2014: Moderate				0.61		0.74	0.61	0.39	0.44	0.56

Coral index scoring range: ■ Very Poor = 0–0.20 | ■ Poor = >0.20–0.40 | ■ Moderate = >0.40–0.60 | ■ Good = >0.60–0.80 | ■ Very Good = >0.80 | ■ No score/data gap

*Calculated with the weighted RCA coral cover data.

Appendix D.2.3. Central Inshore Zone

Table D30. Coral indicator scores for 2020–21 in the Central Zone (Ports Coral Monitoring Program (Hay Point).

Region	Reef	Depth (m)	Cover	Macroalgae	Juvenile	Cover Change	Composition	Coral Index
Central	Round Top	5	0.34	1.00	1.00	0.25		**0.65**
	Slade	2	0.19	0.83	0.51	0.29		**0.45**
	Victor	2	0.28	0.00	0.38	0.14		**0.20**
2021 Report Card score: Poor			**0.27**	**0.61**	**0.63**	**0.23**		**0.43^**
2020: Poor			0.35	0.15	0.22	0.38		**0.28**
2019: Poor			0.38	0.00	0.13	0.39		**0.23**
2018: Poor			0.36	0.00	0.16	0.39		**0.23**
2017: Poor			0.35	0.01	0.18	0.40		**0.23**
2016: Poor			0.44	0	0.15	0.64		**0.31**

Coral index scoring range: ■ Very Poor = 0–0.20 | ■ Poor = >0.20–0.40 | ■ Moderate = >0.40–0.60 | ■ Good = >0.60–0.80 | ■ Very Good = >0.80 | ■ No score/data gap

^2020–21 scores are not directly comparable to previous years due to a decrease in sites surveyed.

Appendix D.2.4. Southern Inshore Zone

Table D32. Coral indicator scores for 2020–21 in the Southern Zone (Partnership-funded program (aligning to MMP)) coral monitoring program.

Region	Reef	Depth (m)	Cover	Macroalgae	Juvenile	Cover Change	Composition	Coral Index
Southern	Pine Peak	2	0.19	0.00	0.05			**0.08**
	Pine Peak	5	0.33	0.00	0.04			**0.12**
	Pine Islets	2	0.10	0.00	0.08			**0.06**
	Pine Islets	5	0.28	0.00	0.17			**0.15**
	Henderson Island	2	0.51	0.00	0.06			**0.19**
	Henderson Island	5	0.78	0.00	0.06			**0.28**
	Temple Island	1	0.43	0.00	0.25			**0.23**
	Aquila Island	1	0.36	0.00	0.06			**0.14**
2021 Report Card score: Poor			**0.37**	**0.00**	**0.10**			**0.16**
2020: Poor			0.47	0.00	0.17			0.21
2019: Very Poor			0.49	0.00	0.13			**0.20**

Coral index scoring range: ■ Very Poor = 0–0.20 | ■ Poor = >0.20–0.40 | ■ Moderate = >0.40–0.60 | ■ Good = >0.60–0.80 | ■ Very Good = >0.80 | ■ No score/data gap

Appendix D.2.5. Offshore Zone

Table D33. Weighting process for combining RCA and MMP data for the Offshore Zone with 2020–21 coral cover score. Lower weighting value for RCA data is due to reduced sample size their program. Reefs shaded grey were not included in 2020–21 surveys.

Zone	Program	Reef	Site (or depth (m))	Coral Cover Score	Weighting	Weighting to Apply	Weighted Coral Cover Score
Offshore	LTMP	Hyde Reef	6-9m	0.68	1.00	0.06	0.0411
		Penrith Island	6-9m	0.26	1.00	0.06	0.0157
		Pompey Reef No.1	6-9m	0.20	1.00	0.06	0.0122
		Pompey Reef No.2	6-9m	0.41	1.00	0.06	0.0247
		Rebe Reef	6-9m	0.57	1.00	0.06	0.0347
		Reef 19-131	6-9m	0.56	1.00	0.06	0.0338
		Reef 19-138	6-9m	0.57	1.00	0.06	0.0346
		Reef 20-104	6-9m	0.66	1.00	0.06	0.0404
		Reef 20-348	6-9m	0.14	1.00	0.06	0.0087
		Reef 20-353	6-9m	0.47	1.00	0.06	0.0288
		Reef 21-060	6-9m	0.07	1.00	0.06	0.0043
		Reef 21-062	6-9m	0.04	1.00	0.06	0.0024
		Reef 21-064	6-9m	0.09	1.00	0.06	0.0054
		Reef 21-591	6-9m	0.35	1.00	0.06	0.0215
		Slate Reef	6-9m	0.64	1.00	0.06	0.0392
		Tern Island	6-9m	0.37	1.00	0.06	0.0225
	RCA	Hardy Reef	6-9m	0.67	0.45	0.03	0.0182
					16.45	**1.00**	Summed Weighted Coral Cover Score: **0.39**

Table D34. Coral indicator scores for 2020–21 in the Offshore Zone. The 2020–21 overall coral index for this zone is calculated using LTMP and RCA coral cover data. Weighted cover is calculated as per Table D15, where the cover indicator score is recalculated using weightings to reflect the reliability of the data. Weighted cover scores for each site are then summed to give the overall weighted cover indicator score.

Zone	Program	Reef	Depth	Cover	Weighted Cover	Macroalgae	Juvenile	Cover Change	Composition	Coral Index
Offshore	LTMP	Hyde Reef	6-9m	0.68	0.0411		1.00	0.62		0.77
		Penrith Island		0.26	0.0157		0.28	0.53		0.36
		Pompey Reef No.1		0.20	0.0122		1.00	NA		0.60
		Pompey Reef No.2		0.41	0.0247		1.00	0.43		0.61
		Rebe Reef		0.57	0.0347		1.00	0.53		0.70
		Reef 19-131		0.56	0.0338		1.00	0.15		0.57
		Reef 19-138		0.57	0.0346		1.00	0.51		0.69
		Reef 20-104		0.66	0.0404		1.00	0.50		0.72
		Reef 20-348		0.14	0.0087		1.00	0.00		0.38
		Reef 20-353		0.47	0.0288		1.00	0.40		0.63
		Reef 21-060		0.07	0.0043		1.00	0.39		0.49
		Reef 21-062		0.04	0.0024		1.00	NA		0.52
		Reef 21-064		0.09	0.0054		1.00	NA		0.54
		Reef 21-591		0.35	0.0215		1.00	0.45		0.60
		Slate Reef		0.64	0.0392		1.00	0.52		0.72
		Tern Island		0.37	0.0225		0.92	0.58		0.62
	RCA	Hardy Reef		0.67	0.0182					
2021 Report Card score: Moderate					**0.39**		**0.95**	**0.43**		**0.59***
2020 Report Card score: Moderate					**0.35**		**0.95**	**0.37**		**0.57**
2019: Moderate				0.32			0.93	0.41		**0.55**
2018: Moderate				0.33			0.93	0.41		**0.56**
2017: Moderate				0.36			0.98	0.38		**0.60**
2016: Moderate				0.32			0.95	0.42		**0.57***
2015: Moderate				0.34			0.87	0.38		**0.53***
2014: Moderate				0.32			0.68	0.33		**0.54***

Coral index scoring range: ■ Very Poor = 0–0.20 | ■ Poor = >0.20–0.40 | ■ Moderate = >0.40–0.60 | ■ Good = >0.60–0.80 | ■ Very Good = >0.80 | ■ No score/data gap

*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.

Appendix D.3. Seagrass Index

Table D35. Inshore seagrass sampling design and indicator results for the 2020–21 reporting year, which includes scores in the Southern Zone for the first time. The 2020 Report Card scores refer to the back-calculated scores. Scores reported without a colour grade indicate back-calculations that have not been incorporated into overall scores. Indicators are based on data collected from the Marine Monitoring Program (MMP) or North Queensland Bulk Ports' (NQBP) Queensland Ports Seagrass Monitoring Program (QPSMP).

Zone	Habitat	Depth	Location/Meadow	Meadow/Site	MMP		NQBP			Overall site/meadow score	Overall Zone Score	2020 Score
					Abundance	Resilience	Biomass	Area	Sp. Composition			
Inshore Marine Northern	Coastal	Inshore	Abbot Pt.	API3			91	73	72	73	70	63
Inshore Marine Northern	Coastal	Inshore	Abbot Pt.	API5			87	100	93	87	70	63
Inshore Marine Northern	Coastal	Inshore	Abbot Pt.	API9			85	83	91	83	70	63
Inshore Marine Northern	Coastal	Subtidal	Abbot Pt.	APD14			57	52	56	52	70	63
Inshore Marine Northern	Coastal	Intertidal	Bowen	BW1–3*	54					54	70	63
Inshore Marine Whitsunday	Reef	Intertidal	Hydeaway Bay	HB1 and2*	56					56	29	33
Inshore Marine Whitsunday	Reef	Intertidal	Hamilton Is. 1	HM1	0	30				15	29	33
Inshore Marine Whitsunday	Reef	Intertidal	Hamilton Is. 2	HM2	0	0				0	29	33
Inshore Marine Whitsunday	Reef	Intertidal	Lindeman Island	LN3	50	30				40	29	33
Inshore Marine Whitsunday	Reef	Subtidal	Tongue Bay	TO1 and 2^	25					25	29	33
Inshore Marine Whitsunday	Reef	Subtidal	Lindeman Island	LN1 and 2	8	40				24	29	33
Inshore Marine Whitsunday	Coastal	Intertidal	Pioneer Bay	PI2 and 3	44					44	29	33
Inshore Marine Central	Coastal	Intertidal	Midge Point	MP2 and 3	100	75				87	58	65
Inshore Marine Central	Coastal	Intertidal	St Helens Beach	SH1*#	100					100	58	65
Inshore Marine Central	Coastal	Subtidal	Newry Bay	NB1 and 2^	13					13	58	65
Inshore Marine Central	Estuarine	Intertidal	Sarina Inlet	SI1 and 2	13	29				21	58	65
Inshore Marine Central	Coastal	Intertidal/ Subtidal	Dudgeon Pt	DP1			68	58	91	58	58	65
Inshore Marine Central	Coastal	Subtidal	St Bees Island	SB10			93	64	95	64	58	65
Inshore Marine Central	Coastal	Subtidal	Keswick Island	KW14			92	73	98	73	58	65
Inshore Marine Central	Coastal	Subtidal	Hay Point	HPD1			70	47	100	47	58	65
Inshore Marine Southern	Coastal	Intertidal	Clairview	CV1 and 2*	25					25	60	64
Inshore Marine Southern	Coastal	Intertidal	Clairview	CVH2			51	20	100	20	60	64
Inshore Marine Southern	Coastal	Intertidal	Clairview	CVH6			77	81	88	77	60	64
Inshore Marine Southern	Coastal	Intertidal	Clairview	CVH7			84	88	87	84	60	64

Scoring range: ■ Very Poor = 0 to 20 | ■ Poor = >20 to 40 | ■ Moderate = >40 to 60 | ■ Good = >60 to 80 | ■ Very Good = >80 | ■ No score/data gap

*= Data also provided by SeagrassWatch; # = Not used in GBR-wide for MMP; ^ = QPWS drop-camera; na = not recorded

Table D36. Back-calculated inshore seagrass sampling design and indicator results for the 2019–20 reporting year. Indicators are based on data collected from the Marine Monitoring Program (MMP) or North Queensland Bulk Ports' (NQBP) Queensland Ports Seagrass Monitoring Program (QPSMP).

Zone	Habitat	Depth	Location/Meadow	Meadow/Site	MMP		NQBP			Overall site/meadow score	Overall Zone Score
					Abundance	Resilience	Biomass	Area	Sp. Composition		
Inshore Marine Northern	Coastal	Inshore	Abbot Pt.	API3	na	na	89	69	77	69	63
				API5	na	na	75	100	80	75	
				API9	na	na	41	70	97	41	
		Subtidal		APD1	na	na	67	na	0	34	
				APD2	na	na	85	na	94	85	
				APD3	na	na	57	na	94	57	
				APD4	na	na	91	na	78	85	
		Intertidal	Bowen	BW1 and 2	56	na	na	na	na	56	
Inshore Marine Whitsunday	Reef	Intertidal	Hydeaway Bay	HB1 and 2*	75	na	na	na	na	75	33
			Hamilton Is. 1	HM1	25	30	na	na	na	28	
			Hamilton Is. 2	HM2	0	5	na	na	na	3	
		Subtidal	Tongue Bay	TO1 and 2^	13	na	na	na	na	13	
			Lindeman Island	LN1 and 2	25	50	na	na	na	38	
	Coastal	Intertidal	Pioneer Bay	PI2 and 3*	44	na	na	na	na	44	
Inshore Marine Central	Coastal	Intertidal	Midge Point	MP2 and 3	100	70	na	na	na	85	65
			St Helens Beach	SH1*#	42	na	na	na	na	42	
		Subtidal	Newry Bay	NB1 and 2^	63	na	na	na	na	63	
		Intertidal	Sarina Inlet	SI1 and 2	6	46	na	na	na	26	
		Intertidal/Subtidal	Dudgeon Pt	DP1	na	na	79	86	90	79	
		Subtidal	St Bees Island	SB10	na	na	66	89	86	66	
			Keswick Island	KW14	na	na	73	73	93	73	
			Hay Point	HPD1	na	na	86	87	100	86	
Inshore Marine Southern	Coastal	Intertidal	Clairview	CV1 and 2*	13	na	na	na	na	13	64
				CVH2	na	na	72	84	100	72	
				CVH6	na	na	65	87	87	65	
				CVH7	na	na	55	82	93	55	

Scoring range: ■ Very Poor = 0 to 20 | ■ Poor = >20 to 40 | ■ Moderate = >40 to 60 | ■ Good = >60 to 80 | ■ Very Good = >80 | ■ No score/data gap
*= Data also provided by SeagrassWatch; # = Not used in GBR-wide for MMP; ^ = QPWS drop-camera; na = not recorded

Table D37. Back-calculated inshore seagrass sampling design and indicator results for the 2018–19 reporting year. Indicators are based on data collected from the Marine Monitoring Program (MMP) or North Queensland Bulk Ports' (NQBP) Queensland Ports Seagrass Monitoring Program (QPSMP).

Zone	Habitat	Depth	Location/Meadow	Meadow/Site	MMP		NQBP			Overall site/meadow score	Overall Zone Score
					Abundance	Resilience	Biomass	Area	Sp. Composition		
Inshore Marine Northern	Coastal	Inshore	Abbot Pt.	API3	na	na	71	85	57	64	52
				API5	na	na	92	85	69	77	
				API7	na	na	67	86	92	67	
				API8	na	na	0	0	0	0	
				API9	na	na	55	45	94	45	
		Subtidal		APD1	na	na	48	na	0	24	
				APD2	na	na	77	na	100	77	
				APD3	na	na	64	na	100	64	
				APD4	na	na	50	na	92	50	
Inshore Marine Whitsunday	Reef	Intertidal	Hydeaway Bay	HB1 and 2*	81	na	na	na	na	81	27
			Hamilton Is. 1	HM1	0	15	na	na	na	8	
			Hamilton Is. 2	HM2	0	7	na	na	na	4	
		Subtidal	Tongue Bay	TO1 and 2^	13		na	na	na	13	
			Lindeman Island	LN1 and 2	25	30	na	na	na	28	
	Coastal	Intertidal	Pioneer Bay	PI2 and 3*	31		na	na	na	31	
Inshore Marine Central	Coastal	Intertidal	Midge Point	MP2 and 3	69	76	na	na	na	73	56
			St Helens Beach	SH1*#	25		na	na	na	25	
		Subtidal	Newry Bay	NB1 and 2^	75		na	na	na	75	
	Estuarine	Intertidal	Sarina Inlet	SI1 and 2	0	22	na	na	na	11	
	Coastal	Intertidal/Subtidal	Dudgeon Pt	DP1	na	na	56	94	94	56	
		Subtidal	St Bees Island	SB10	na	na	92	92	85	89	
			Keswick Island	KW14	na	na	77	89	89	77	
			Hay Point	HPD1	na	na	47	65	100	47	
Inshore Marine Southern	Coastal	Intertidal	Clairview	CV1 and 2*	19	na	na	na	na	19	82
				CVH2	na	na	90	91	100	90	
				CVH6	na	na	94	82	82	82	
				CVH7	na	na	78	74	99	74	

Scoring range: Very Poor = 0 to 20 | Poor = >20 to 40 | Moderate = >40 to 60 | Good = >60 to 80 | Very Good = >80 | No score/data gap
*= Data also provided by SeagrassWatch; # = Not used in GBR-wide for MMP; ^ = QPWS drop-camera; na = not recorded