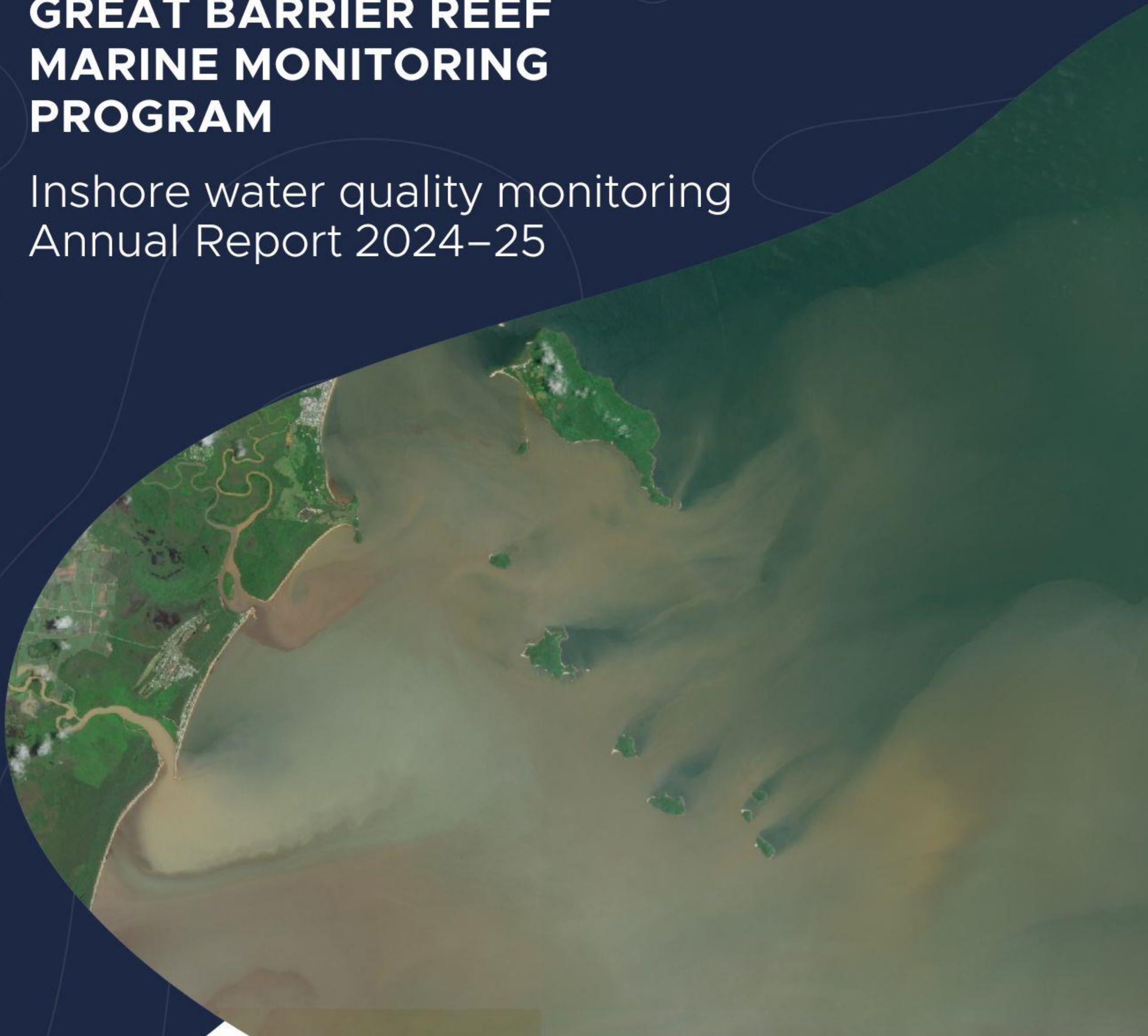
Australian Government
Great Barrier Reef Marine Park Authority

Reef Authority

GREAT BARRIER REEF MARINE MONITORING PROGRAM

Inshore water quality monitoring Annual Report 2024–25



Australian Government | Australian Institute of Marine Science | The University of Queensland Australia | James Cook University Australia | TropWATER | Cape York Water Partnership

Published by the Great Barrier Reef Marine Park Authority

ISSN: 2208-4096

A catalogue record for this publication is available from the National Library of Australia

This publication should be cited as:

Gruber, R., Waterhouse, J., Petus, C., Lewis, S., Howley, C., Thompson, K., James, C., Logan, M., Bove, U., Brady, B., Bray, L., Choukroun, S., Connellan, K., Davidson, J., Dick, E., Massuger, J., Mellors, J., Molinari, B., Moran, D., O'Callaghan, M., O'Dea, C., Polglase, L., Bushotts, M., Shellberg, J., White-Kiely, D., Shiels, R., Elisei, G., Paxman, C., Lei Li, S., Li, Y., Carswell, C., Xia, S., Prasad, P., Gallen, M., Reeks, T., Clokey, J.E., Jekimovs, L.J., Marano, K., and Kaserzon, S. 2026. *Great Barrier Reef Marine Monitoring Program Inshore Water Quality Monitoring: Annual Report 2024–25.* Great Barrier Reef Marine Park Authority, Townsville. 342 pp.

Front cover image: *Copernicus Sentinel-2 data of the Tully River plume (6 February 2025, True colour image). Snapshot extracted from the Copernicus Browser (@Sentinel Hub) by TropWATER, James Cook University (https://browser.dataspace.copernicus.eu/)*

The Great Barrier Reef Marine Park Authority acknowledges the continuing Sea Country management and custodianship of the Great Barrier Reef by Aboriginal and Torres Strait Island Traditional Owners whose rich cultures, heritage values, enduring connections and shared efforts protect the Reef for future generations.

DISCLAIMER

Comments and questions regarding this document are welcome and should be addressed to:

Australian Institute of Marine Science
PMB No 3
Townsville MC, Qld 4810

TropWATER- Centre for Tropical Water and Aquatic Ecosystem Research
James Cook University
Townsville, Qld 4811
Tropwater@jcu.edu.au

This project is supported by the Great Barrier Reef Marine Park Authority through funding from the Great Barrier Reef Marine Monitoring Program, the Australian Institute of Marine Science, and James Cook University.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES: LIST OF FIGURES

APPENDICES: LIST OF TABLES

COMMONLY USED ABBREVIATIONS, ACRONYMS, DEFINITIONS AND UNITS

Abbreviations, acronyms, and definitions

AIMS	Australian Institute of Marine Science
BoM	Bureau of Meteorology
CDOM	coloured dissolved organic matter
Chl-*a*	chlorophyll *a*
CTD	Conductivity Temperature Depth profiler
CYWP	Cape York Water Partnership
DIN	dissolved inorganic nitrogen
DOC	dissolved organic carbon
DON	dissolved organic nitrogen
DOP	dissolved organic phosphorus
ENSO	El Nino – Southern Oscillation cycle
GAMM	generalised additive mixed effect model
GV	guideline value
JCU	James Cook University
K_D	light attenuation coefficient
LOD	limit of detection
MMP	Marine Monitoring Program
Marine Park	Great Barrier Reef Marine Park
MODIS	Moderate Resolution Imaging Spectroradiometer
NH_3	ammonia
NO_x	nitrogen oxides
NRM	natural resource management
PN	particulate nitrogen
PO_4	phosphate (dissolved inorganic phosphorus)
POC	particulate organic carbon
PP	particulate phosphorus
PSII herbicide	photosystem II inhibiting herbicide
QA/QC	quality assurance/quality control
QAEHS	Queensland Alliance for Environmental Health Sciences
QLUMP	Queensland Land Use Mapping Program
Reef	Great Barrier Reef
Reef Authority	Great Barrier Reef Marine Park Authority
Reef 2050 WQIP	*Reef 2050 Water Quality Improvement Plan*
Reef 2050 Plan	*Reef 2050 Long-Term Sustainability Plan*
SDD	Secchi disk depth
TSS	total suspended solids
water year	1 October to 30 September (e.g., 2010–11)
WS colour scale	wet season colour scale
WQ Index	Water Quality Index

Units

GL	gigalitre
m	metre
mm d^{-1}	millimetres per day
mg L^{-1}	milligram per litre

ML	megalitre
km	kilometre
km h^{-1}	kilometres per hour
kt	kilotonne
t	tonne
µg L^{-1}	microgram per litre

ACKNOWLEDGEMENTS

We acknowledge the Australian Government funding through the Great Barrier Reef Marine Park Authority (the Reef Authority) for financial and technical support of this program. Thank you to Kaye Walker, Emma Henry, Susannah Leahy, and Bronte Claussen from the Reef Authority for their overall project management and program guidance. We thank 3 anonymous reviewers for their detailed comments which have improved earlier versions of this report.

We are grateful to all the people involved in the field work. We acknowledge Andrew Mead from Barra Charters for the Burdekin region sampling in partnership with TropWATER James Cook University (JCU). Thanks to the staff of Vision Environment, who undertake some of the Fitzroy region water quality sampling. Thanks to the Australian Institute of Marine Science (AIMS) Oceanographic Technician team, Marine Operations team, Data and Digital Engineering team, and the crews of the R.V. Cape Ferguson and R.V. Solander, who have been a critical part of this program for many years, as well as Keegan Vickers. We would also like to thank the Woppaburra TUMRA Steering Committee and the Darumbal People Aboriginal Corporation RNTBC for consent to access sites located in Woppaburra and Darumbal Sea Country. From the Cape York Water Partnership, we thank Katy Huett, the Lama Lama Rangers (Yintinga Aboriginal Corporation), and the Yuku Baja Muliku Land and Sea Rangers. We thank the Pascoe sampling crew: Steve Rehn (Albatross Boat Hire) and Tilly Rehn, and the Kuuku Ya'u rangers. We are grateful to the dedicated staff of the TropWATER laboratory for their assistance with sample preparation and processing and the AIMS Analytical Technology Laboratory who have analysed a large volume of samples for this program. We thank all volunteers that assisted with deployment of passive samplers for this project including Sailaway (Katrina Edmondson) and Steve Fisher (Whitsunday Channel sites).

EXECUTIVE SUMMARY

The water quality component of the Great Barrier Reef Marine Monitoring Program (MMP) reports on the annual and long-term condition in inshore water quality of the Great Barrier Reef (the Reef). This report presents the results for the 2024–25 water year (1 October 2024 to 30 September 2025) with reference to 20 years of monitoring data. The program design includes the collection of samples along transects in the Cape York, Wet Tropics, Burdekin, Mackay-Whitsunday, and Fitzroy regions year-round, with higher frequency sampling during the wet season to better characterise this period of episodic river discharge. Satellite imagery and remote sensing are linked with *in situ* monitoring data to estimate the exposure of inshore areas to end-of-catchment loads from rivers for all Reef catchment regions.

Drivers and pressures

Environmental conditions over the 2024–25 wet season were variable across the Reef. River discharge was 1.9 times the long-term median for the entire Reef catchment area but varied among Natural Resource Management (NRM) regions. River discharge in 2024–25 was the largest discharge since the extreme 2010–11 water year. On a regional basis, the Burdekin, Mackay-Whitsunday and Burnett Mary NRM regions had river discharge higher than their long-term medians (6.8, 2.8, and 3.4 times, respectively) with above-average discharge from the Cape York and Wet Tropics NRM regions (1.4 and 1.6 times, respectively). The river discharge from the Burdekin region for the 2024–25 water year (40.4 million ML) was the highest since the extreme 2010–11 water year (43.2 million ML). Discharge from the Fitzroy NRM region was slightly higher than the long-term median (1.2 times). The 2024–25 wet season had no notable cyclone influence in the Reef lagoon.

End-of-catchment sediment and nutrient load estimates are strongly correlated with river discharge and showed distinct variations between the focus regions. In the 2024–25 water year, modelled load estimates across the Cape York basins were generally consistent with long-term patterns, except in the Endeavour Basin where loads were elevated but remained below those associated with Cyclone Jasper in 2023–24. In the Wet Tropics, loads from the Russell-Mulgrave and Johnstone basins were above average yet lower than those associated with the previous year's high discharge conditions. The Tully-Murray-Herbert and Burdekin-Haughton basins recorded substantial increases, representing the second-highest loads since the major events of 2010–11, although the increases were more pronounced for nutrients in the Wet Tropics, and total suspended sediments in the Burdekin region. The Mackay-Whitsunday basins also experienced increased loads, coinciding with discharge levels 2.8 times the long-term median, while modelled loads in the Fitzroy region aligned with typical conditions observed over the past 9 years.

Sentinel-3 satellite images are assessed over a 22 week period within the wet season to assess the frequency of different Reef optical water types during the wet season (groups of water bodies that share similar optical and water quality properties). Sentinel-3 satellite data are categorised into 4 distinct optical water types using a water colour classification standard (the Forel-Ule colour scale): Reef Water Type 1 (Reef WT1) - brownish waters (enriched in sediment and coloured dissolved organic matter), Reef Water Type 2 (Reef WT2) - greenish waters (enriched in algae and coloured dissolved organic matter), and Reef Water Type 3 (Reef WT3) - clearer waters, with a lower risk of ecological impact. The frequency maps show the proportion of time that these conditions occur across the wet season. The results for several reference periods are used to provide context for the results for each wet season and includes long-term average 2001–2023, representative wet and representative dry periods. In 2024–25, and consistent with previous years, there was a high frequency of exposure to Reef WT1 in inshore areas. However, there was also a small percentage of the mid-shelf waterbody with a higher frequency of the occurrence of Reef WT1 (representing 3% of its total waterbody area), related to the high river discharge events that occurred in the Wet Tropics and Burdekin regions in late January and February 2025.

The potential risk of exposure of Reef ecosystems to wet season water quality (herein referred to as 'potential risk') is assessed using a relationship between the Reef Water Type frequency maps, and the characterisation of Reef Water Types with in-situ water quality data. The potential risk of exposure is categorised into 4 potential risk categories I to IV, where Category I is no or very low exposure to a potential risk, and IV is high exposure to a potential risk. The 2024–25 results indicated that 90% of the Reef area remained at no or very low potential risk, but the area in the highest potential risk categories (potential risk categories III and IV) reached 11,220 km² which is 3,166 km² above the long-term average. Regional exposure patterns varied significantly between regions. The Wet Tropics and Burdekin regions recorded the largest increases in potential risk of exposure compared to long-term averages (+8% and +5%, respectively), reflecting wetter conditions in these regions during the 2024–25 wet season. In contrast the total area of exposure to a potential risk (combined potential risk categories II–IV) was largely similar to the long-term averages in the Cape York region and in the southern regions (Mackay-Whitsunday, Fitzroy, and Burnett-Mary regions). However, river discharge was 2.8 times the long-term median in the Mackay-Whitsunday region, with 2 major flood events in February and March. The lower result is most likely influenced by persistent cloud cover during these events, resulting in limited satellite detection of flood plumes and an underestimation of exposure in this region.

Trends in key inshore water quality indicators

Key water quality indicators were used to derive a Water Quality Index which communicates the annual condition and long-term trends in water quality relative to guideline values (GVs) (Figure i).

The annual condition of inshore water quality in 2024–25 was:

- **‘good’** in the Cape York region, representing improvement compared with the previous year’s ‘moderate’ score following Tropical Cyclone Jasper;
- **‘moderate’** in the Wet Tropics region;
- **‘good’** in the Burdekin region, similar to 2023–24;
- **‘moderate’** in the Mackay-Whitsunday region following 7 years of ‘moderate’ scores; and
- **‘good’** in the Fitzroy region, similar to the previous 4 years.

The long-term Water Quality Index showed that inshore water quality has:

- **improved** in Cape York following a deterioration in 2023–24 associated with Tropical Cyclone Jasper;
- **deteriorated** this year in the Wet Tropics region, which was related to high river discharge during 2024–25;
- been **stable** in the Burdekin region after improvement since the late 2010s;
- **deteriorated** this year in the Mackay-Whitsunday region, which was related to high river discharge during 2024–25; and
- been **stable** in the Fitzroy region over the last 5 years after a trend of improvement from 2010 to 2015.

Individual water quality indicators were monitored for trends and compared against water quality GVs. This water year, GVs were:

- **met in most regions** for total suspended solids, particulate nitrogen, particulate phosphorus and chlorophyll *a*; and
- **not met in any region** for turbidity, Secchi depth, and nitrate/nitrite.

Trend analysis shows that since 2015, most water quality indicators have shown **stability** or **deterioration**, which is related to 2 consecutive years (2023–25) of above-median river discharge in many central and northern Reef focus regions. Despite this high discharge, nitrate/nitrite continued to show a trend of **improvement** in the Tully (within the Wet Tropics) and Burdekin focus regions, although concentrations continue to exceed GVs. This is a promising finding for nitrate/nitrite and if current trends continue, concentrations in some focus regions could meet GVs in the next few years. Multi-decadal trends suggest an overall improvement in many water quality indicators, following a period of deterioration from ~2007–2018 that occurred in many regions.

Changes in nutrient concentrations are related to changes in nutrient sources (i.e., inputs) and sinks (i.e., outputs) in the Reef lagoon and potentially changes in the rates of key ecological processes such as primary production or remineralisation. The spatial and temporal variability in the *in situ* water quality discussed in this report highlights the combination of complex factors that control water quality in the Reef lagoon including river discharge, multi-year cycles of wet/dry years, biogeochemical processes, physical forcing, and the variability of these drivers between focus regions.

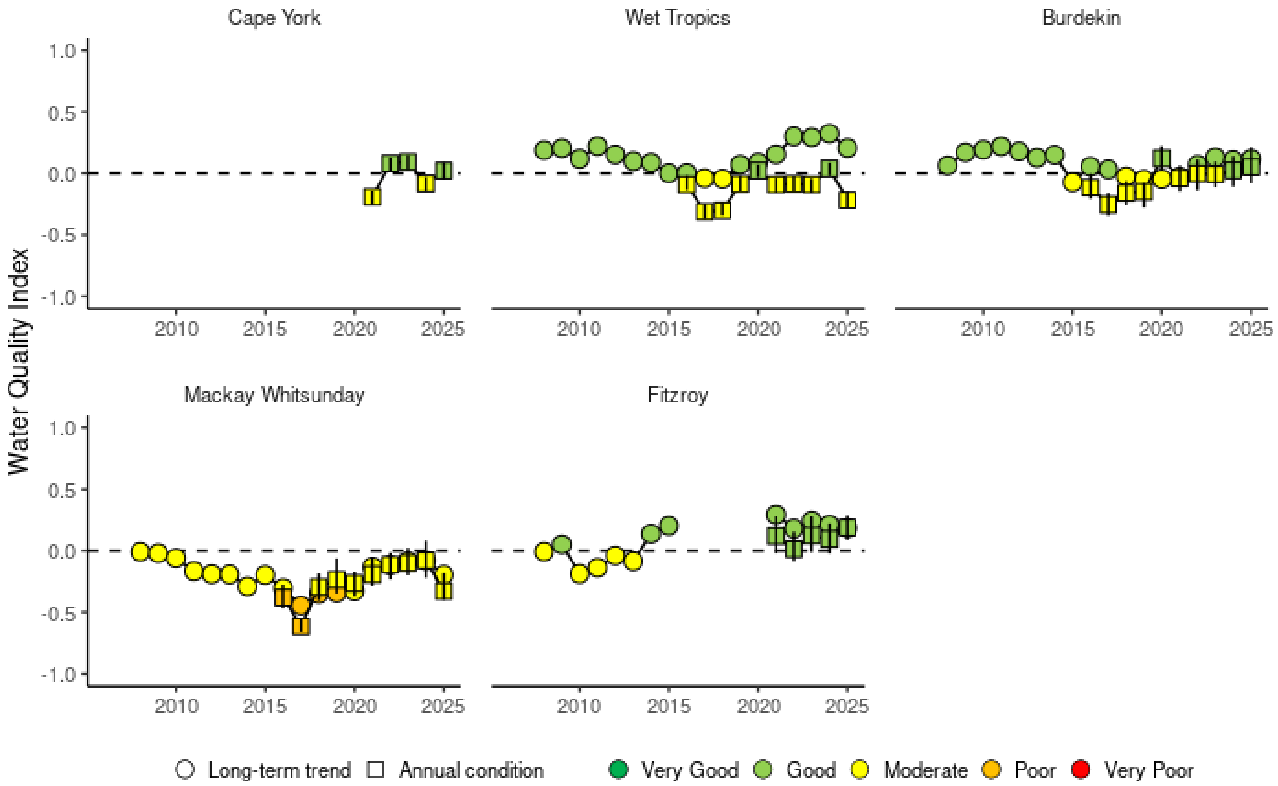


Figure i: Water Quality Index scores from 2008 to 2025 for the Cape York, Wet Tropics, Burdekin, Mackay-Whitsunday, and Fitzroy regions. The Index is calculated to show the long-term trend since the start of monitoring (circles), where seasonal and short-term variability signals are removed. An updated Index version communicating annual condition is calculated from 2015 onwards (squares) that includes increased temporal and spatial sampling and relates water quality values to wet and dry season Reef water quality guidelines. The Index includes 5 indicators: water clarity, nitrate/nitrite, particulate nitrogen, particulate phosphorus, and chlorophyll *a*.

Wet season event sampling

Pesticide monitoring in the Wet Tropics, Burdekin, and Mackay Whitsunday regions showed relatively consistent patterns with previous years, with peak concentrations detected during high river discharge in the Wet Tropics and Burdekin regions in January and February 2025. Diuron was found in all passive samplers and the composition of pesticide mixtures continued to reflect adjacent land uses. Metolachlor and tebuthiuron exceeded freshwater protection guidelines in event-based grab samples during Herbert and Burdekin River floods. Consistent with previous years, Sandringham Bay recorded the highest passive sampler concentrations this wet season.

Intensive event sampling was conducted for the Herbert and Burdekin Rivers which both experienced significant flooding across the wet season. The Herbert River recorded the third-largest seasonal discharge on record in February 2025. Monitoring across Halifax Bay, Palm Islands, and mid-shelf reefs showed strong salinity gradients, high suspended sediments, variable nutrients, and elevated chlorophyll *a* in mid-salinity zones, reflecting typical plume dynamics and productivity responses. The Burdekin River recorded 2 major floods in 2024–25, with the February peak producing the largest daily discharge since 2008–09, and a total annual flow of 30.6 million ML, the fourth highest in its 104 year record. The resulting plume spread across inshore to outer reefs for weeks, and was intensively sampled throughout February, showing strong salinity gradients, high suspended sediments concentrations, and elevated chlorophyll *a* concentrations extending beyond the inshore areas.

Conclusions

Results from the 2024–25 water year presented in this report demonstrate the close relationship between inshore water quality, interannual rainfall patterns, and coastal oceanographic drivers. Two consecutive years of above-median river discharge in many Reef regions led to deteriorating water quality conditions in the Wet Tropics and Mackay-Whitsunday regions and stable water quality conditions in the Burdekin and Fitzroy regions. Despite this, positive results from this year included the recovery of the Cape York region to 'good' condition following the devastating impacts of Tropical Cyclone Jasper in 2023–24, as well as a trend of improvement in nitrate/nitrate concentrations in the Burdekin and Tully focus regions. Some indicators (including nitrate/nitrite) remain above (not meeting) water quality guideline values in many focus regions and require continued improvement before guideline values may be met. However, this overall trend of improvement is promising given the high river discharge in the central Reef this year.

The relationship between river discharge, oceanographic drivers, and coastal water quality is complex and is confounded by large interannual and decadal rainfall variability in tropical catchments. Progress of catchment management practice adoption is incremental and slow response timeframes are expected between land-based changes and marine water quality. Episodic disturbance events such as cyclones and major floods reduce coastal water quality, which then typically improves during drier periods. It is therefore important to understand that catchment load reductions cannot be expected to result in a linear improvement in inshore water quality, especially in the shorter-term. Rather, reduced loads of sediment and nutrients from catchments will lower the overall sediment/nutrient inputs into the Reef and allow long-term improvement of coastal water quality. Further work is needed to distinguish oceanographic and climatic drivers of observed water quality trends and to predict how climate change impacts on cyclone frequency/intensity and rainfall patterns will affect coastal water quality. Trends in load reductions from catchment monitoring programs are an important line of evidence that need to be established before trends in inshore water quality could be conclusively related to catchment practices, and this work is currently underway through inter-agency collaborations.

The inshore water quality component of the Marine Monitoring Program continues to provide a high value, long-term dataset to inform management of The Reef in a variety of ways. The multiple lines of evidence utilised in the Marine Monitoring Program include *in situ* water chemistry sample collection, *in situ* water quality time-series' from dataloggers, remote sensing analysis, and marine modelling, which all assist in providing a high degree of confidence in the interpretation of the results. The Marine Monitoring Program's outputs have a wide application across scientific, management, government, and public audiences. Findings from the Marine Monitoring Program were used extensively in the recent update of the 2022 Scientific Consensus Statement, the Great Barrier Reef Outlook Report 2024, the updated Reef Spatial Management Prioritisation, the review of the Reef water quality targets, and continue to be used in the Regional Report Cards. The Marine Monitoring Program measurements are the primary *in situ* chemistry validation dataset for the eReefs Biogeochemical Model suite (a core tool for management and decision-making for the Reef), which provides confidence in model outputs and improvements over time. Continuation of the Marine Monitoring Program and strengthening of linkages with other Paddock to Reef components will further enhance the value of long-term monitoring efforts of the Reef.

1 INTRODUCTION

1.1 The Great Barrier Reef

The Great Barrier Reef (the Reef) is the most extensive reef system in the world, comprising over 2,900 km^2 of coral reefs. It also includes large areas of seagrass meadows, estimated to be over 43,000 km^2 or ~12.5% of the total area of the Great Barrier Reef Marine Park (the Marine Park) (Great Barrier Reef Marine Park Authority, 2019). The inshore Reef environment has high connectivity to the adjacent catchment area (424,000 km^2), as demonstrated by input of land-based materials (especially sediments, organic material, nutrients and pesticides) and movements in the life histories of many species (Davis and Pearson, 2024). The Reef catchment is divided into 6 natural resource management (NRM) regions, each with differing land use, biophysical, and socio-economic characteristics.

The Reef is one of the world's most complex natural systems, recognised for its considerable ecological, social, economic, and cultural values (Newlands and Olayioye, 2024). The Reef's economic, social, and icon value to Australia (as of 2023–24) is $95 billion, supporting 77,000 jobs and contributing $9 billion to the Australian economy over the 2023–24 period (Deloitte Access Economics, 2025). Human-induced climate change is the overriding threat to the Reef, and the ability of ecosystems to recover from climate impacts and acute disturbances continues to be compromised by poor water quality from pollutants such as fine sediments, nutrients and pesticides transported in land-based runoff, primarily in inshore areas (Waterhouse *et al*. 2024). It is estimated that climate action and investment in reef resilience creates a $124 billion economic opportunity over the next 50 years (Deloitte Access Economics, 2025).

1.2 Water quality monitoring in the Reef

The Outlook Report 2024 (Great Barrier Reef Marine Park Authority, 2024) recognises that the most urgent initiatives for the Reef are those that will halt and reverse climate change and those that will effectively improve water quality at the regional scale. Good water quality supports the health and resilience of coastal and inshore ecosystems of the Reef (Waterhouse *et al*., 2024; Great Barrier Reef Marine Park Authority, 2024).

Water quality improvement requires management from the catchment to the Reef. The Australian and Queensland governments have been collaborating across jurisdictions for more than 2 decades to improve Reef water quality. The Reef Water Quality Protection Plan was established by the Australian and Queensland governments in 2003 (Australian and Queensland governments, 2003). The Plan is updated periodically and was last updated by the Australian and Queensland governments in 2017 and was released as the *Reef 2050 Water Quality Improvement Plan* (Reef 2050 WQIP; Australian and Queensland governments, 2018a); it is currently under review. The Reef 2050 WQIP is a major component of the Reef 2050 Long-Term Sustainability Plan (Commonwealth of Australia, 2015, 2018, 2021, http://www.environment.gov.au/marine/gbr/reef2050), which provides a framework for the integrated management of the Great Barrier Reef World Heritage Area.

A key deliverable of the Reef 2050 WQIP is the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (Paddock to Reef program, Australian and Queensland governments, 2018b), which is used to evaluate the efficiency and effectiveness of the implementation of the Reef 2050 WQIP and report progress towards goals and targets. The Great Barrier Reef Marine Monitoring Program (MMP) forms an integral part of the Paddock to Reef program. The MMP has 3 components: inshore water quality, coral, and seagrass. Ecological components of the MMP (seagrass and coral health) are published in separate annual reports detailing the condition and trend of these ecosystems in relation to multiple stressors, including water quality presented in this report (for example, McKenzie *et al*., 2026; Thompson *et al*., 2026). In previous years, inshore pesticide monitoring had been presented in a separate report (Kaserzon *et al*., 2024) or as part of the MMP water quality report. This year it is incorporated into this report. Loads of sediments and nutrients, and concentrations of pesticides within rivers are monitored and reported by the Great Barrier Reef Catchment Loads Monitoring Program (Water Quality & Investigations, 2024a).

The overarching objective of the inshore water quality monitoring program is to '*Assess temporal and spatial trends in inshore marine water quality and link pollutant concentrations to end-of-catchment loads'* (Australian and Queensland governments, 2018b). Water quality monitoring has been delivered by the Australian Institute of Marine Science (AIMS), James Cook University (JCU), University of Queensland (UQ), and the Reef Authority since 2005; the Cape York Water Partnership (CYWP) was added as a collaborator in 2017.

1.3 Structure of the annual report

Section 2 presents a summary of the program's methods. Section 3 describes the factors influencing marine water quality, referred to as drivers and pressures in the Driver-Pressure-State-Impact-Response (DPSIR) framework (Figure 1-1). Water quality results from satellite imagery are presented in Section 4 at Reef and regional scales. Detailed results from focus regions are presented in Section 5, including river discharge, catchment loading, *in situ* water quality monitoring results, water quality condition relative to guideline values (GVs), and observed trends since 2005. This year the water quality and pesticides monitoring reports have been integrated and results from routine pesticides monitoring are provided in Section 6. Conclusions are given in Section 7. More information on monitoring sites and methods is given in Appendix A and Appendix B. Detailed results tables and figures are included in Appendix C. The program's major publications and presentations from the year are reported in Appendix D.

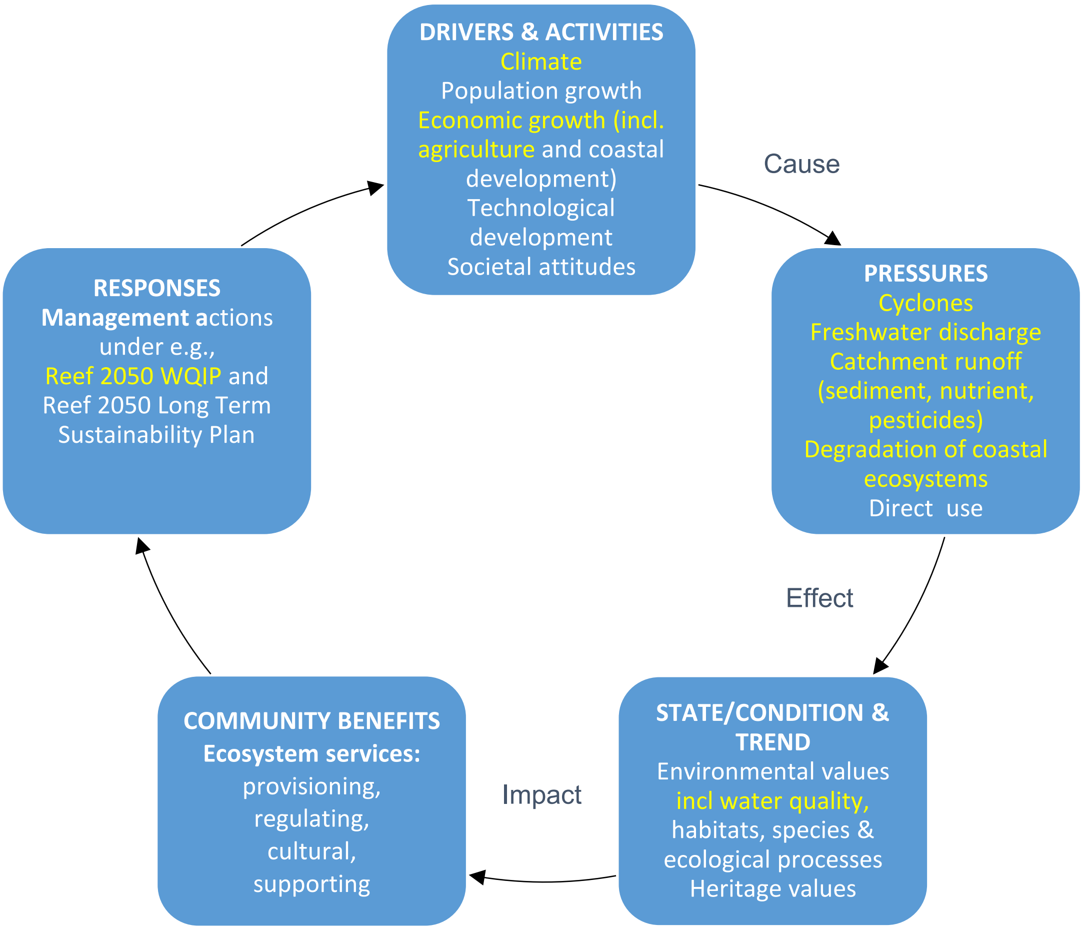


Figure 1-1: Driver Pressure State Impact Response (DPSIR) framework used to guide the structure of the MMP derived from the Great Barrier Reef Strategic Assessment (Great Barrier Reef Marine Park Authority, 2014). The aspects highlighted in yellow are included in this report.

2 METHODS

This Section provides an overview of the sampling design and indicators that are monitored as part of the MMP. More details are presented in Appendices and in a separate quality assurance and quality control (QA/QC) report (Gruber *et al.*, 2025). The information is presented for each of the main program components.

2.1 *In situ* water quality

2.1.1 Sampling design

The MMP inshore water quality monitoring component is designed to measure the annual condition and long-term trends in coastal water quality of the Reef. Tropical waters are characterised by high seasonal variability in river discharge, as rainfall from low pressure systems causes river flood plumes to extend into the coastal ocean during high rainfall periods, while river discharge becomes negligible during low rainfall periods. The annual period that defines the monitoring cycles is the 'water year' which extends from 1 October each year until 30 September of the following year. The water year is centred around each wet season in northern Queensland and encompasses a changeover point at the end of the previous dry season when rainfall influence is at a minimum.

Water quality monitoring by the MMP is conducted each water year during ambient conditions as well as during river discharge events.

- Ambient monitoring refers to routine sampling that occurs during the wet (1 November–30 April) and dry (1 May–31 October) seasons outside of major flood events. It has been conducted since 2005 under the MMP, although the program design (site location, site number, and monitoring frequency) has changed over time.
- Event-based monitoring occurs in response to river discharge events to capture conditions within flood plumes and occurs at the ambient sites, plus additional 'event' sites, which may vary in location depending on the characteristics of a particular flood event. The monitoring frequency depends on the number of flood events each year. While there is no single statistical definition of a flood event, event-based sampling is typically considered when the river level is classified as 'Minor' or above by the Bureau of Meteorology, but may vary depending on the local conditions and the river itself. For the analysis of the water quality data, data collected in conditions within or following a 'Moderate' event is identified as 'flood' data.

The program covers 5 NRM regions including Cape York, Wet Tropics, Burdekin, Mackay-Whitsunday, and Fitzroy regions, initially chosen on the basis of water quality risk assessments (Brodie *et al.*, 2013). Monitoring site locations were selected along expected water quality gradients related to exposure to land-based runoff, as demonstrated in the Results in Section 5. This was largely determined by increasing distance from a river mouth in a northerly direction to reflect the predominantly northward flow of surface water driven by the prevailing south-easterly winds (Brinkman *et al.*, 2011).

From 2005 to 2014, monitoring occurred 3 times per year at sites in the regions listed above (with the exception of Cape York). An independent statistical review of the MMP in 2014 (Kuhnert *et al.*, 2015) showed that additional sites and higher sampling frequency would provide necessary additional statistical power for the program. The current program design was implemented in February 2015 and includes most of the sampling sites in the pre-2015 design, allowing for the continuation of the long-term time-series, and inclusion of additional sites. This program re-design was reviewed in 2021 and the increase in power to detect change in the Reef's inshore water quality was verified (Lloyd-Jones *et al.*, 2022). Monitoring in the Fitzroy region was discontinued in 2015 but resumed in 2020 through funding from the Great Barrier Reef Foundation Reef Trust Partnership; this monitoring was formally re-incorporated into the MMP starting in the 2024–25 monitoring year.

The program currently includes 10 'focus regions', each with 5 to 6 sites measured routinely: Pascoe, Stewart, Normanby, and Annan-Endeavour (in the Cape York NRM, all added in 2017); Barron-

Daintree, Russell-Mulgrave, and Tully (all in the Wet Tropics NRM); Burdekin; Mackay-Whitsunday; and Fitzroy (Figure 2-1). The frequency of ambient monitoring was increased in 2015, and sites are now visited 3–10 times annually, depending on the focus region.

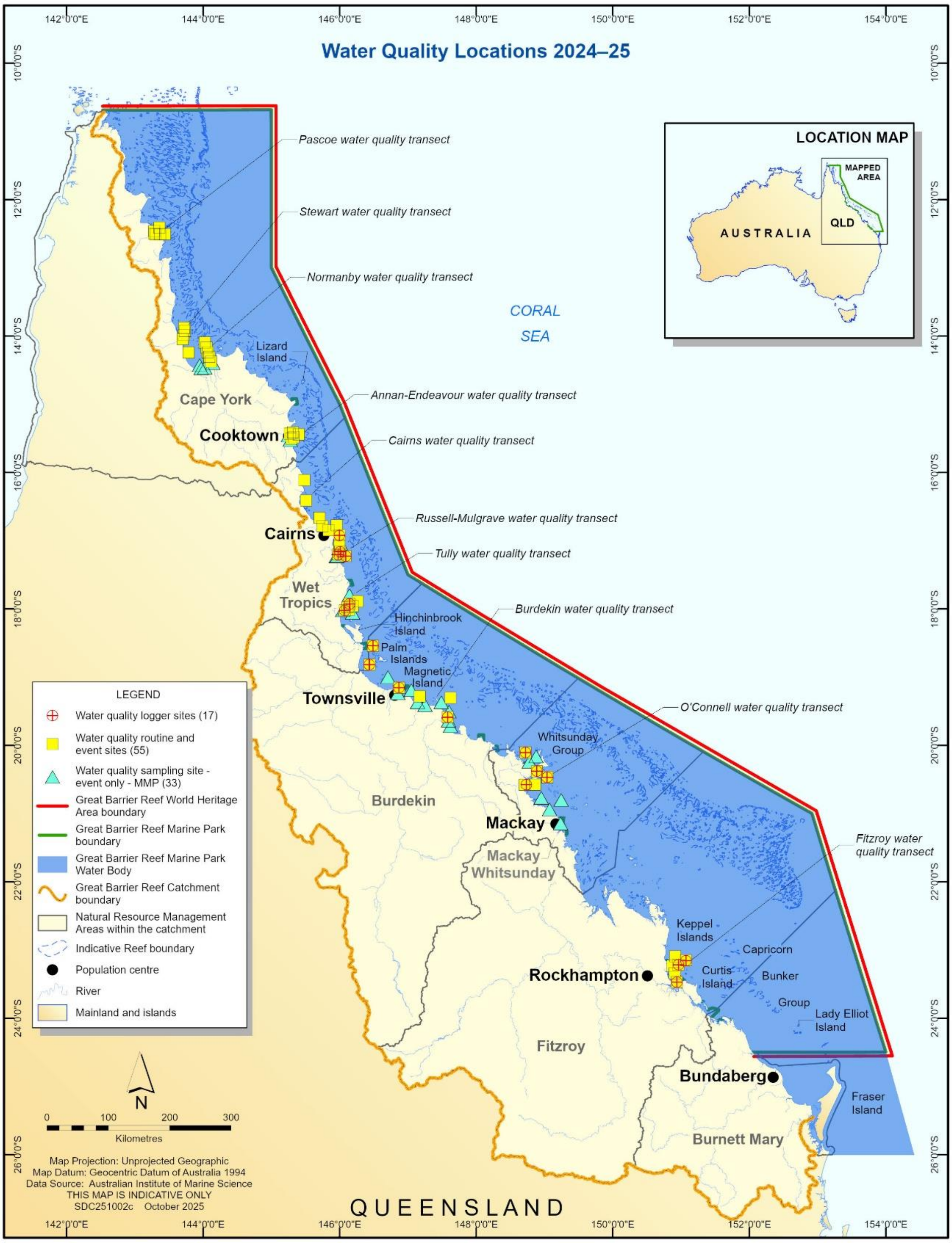


Figure 2-1: Site locations for routine water quality monitoring sampled from 2015 onwards as well as current water quality logger sites. Core event-based monitoring sites are also shown.

The list of parameters sampled by the MMP is provided in Table 2-1 and includes:

- continuous measurement of salinity and temperature at 9 sites
- continuous measurement of chlorophyll and turbidity at 19 sites
- 55 ambient sites with more frequent sampling during the wet season
- 26 event-based sites identified for sampling during flood conditions.

Table 2-1: List of parameters measured during ambient and event-based water quality monitoring. Note that +/- signs identifying the charge of the nutrient ions were omitted for brevity.

Condition	Parameter	Abbreviation	Units of Measure
Physico-chemical	Salinity	Salinity	(unitless)
	Temperature	Temperature	Celsius degree
	Light attenuation coefficient[1]	K_D	m^{-1}
	Secchi depth	Secchi	m
	Total suspended solids	TSS	mg L^{-1}
	Coloured dissolved organic matter	CDOM	m^{-1}
	Turbidity	Turb	NTU
Nutrients	Ammonia	NH_3	µg N L^{-1}
	Nitrite[2]	NO_2	µg N L^{-1}
	Nitrate[2]	NO_3	µg N L^{-1}
	Dissolved inorganic phosphorus	PO_4	µg P L^{-1}
	Silica [as silicate $Si(OH)_4$]	Si	µg Si L^{-1}
	Particulate nitrogen	PN	µg N L^{-1}
	Particulate phosphorus	PP	µg P L^{-1}
	Total dissolved nitrogen	TDN	µg N L^{-1}
	Total dissolved phosphorus	TDP	µg P L^{-1}
	Particulate organic carbon	POC	µg C L^{-1}
	Dissolved organic carbon	DOC	µg C L^{-1}
Biological	Chlorophyll *a*	Chl-*a*	µg L^{-1}

[1]Derived from vertical profiles of photosynthetically active radiation and not sampled at all sites

[2] NO_x is the sum of NO_2 and NO_3

2.1.2 Water quality sampling

At each sampling location (Figure 2-1, Appendix A), vertical profiles of water salinity and temperature were measured with a Conductivity Temperature Depth (CTD) profiler (Sea-Bird Electronics SBE19plus). The CTD also incorporates external sensors including chlorophyll fluorescence, turbidity and Photosynthetically Active Radiation (PAR), or alternative parameters depending on sensor availability. CTD profiles are used to characterise the water column and to identify its state of vertical mixing. See the QA/QC report for a detailed description of CTD data processing (Gruber *et al*., 2025).

Immediately following the CTD cast, field observations and sample metadata are recorded along with visual measurement of water clarity using a Secchi disc. Discrete water samples are then collected using Niskin bottles. Surface (~0.5 m below water surface) and bottom (~1 m above the seabed) samples were collected during ambient monitoring, whereas for some event-based monitoring only surface water samples were collected. Samples from the Niskin bottles were taken in duplicate and were analysed for a suite of water quality parameters (Table 2-1). Detailed descriptions of analytical chemistry techniques can be found in the QA/QC report (Gruber *et al*., 2025). Values of water quality variables from discrete water samples presented in this report are depth-weighted means calculated using surface and bottom samples.

Below is a brief description of each of the main water quality variables measured as part of the MMP relevant to this report. These variables are indicators of the primary pollutants transported to the Reef in land-based runoff, i.e. fine sediment, nutrients and pesticides, and were chosen due to their specific relevance to the Reef 2050 WQIP and the Paddock to Reef Program (Paddock to Reef program, Australian and Queensland governments, 2018b). These definitions are not all-encompassing but are meant to provide a short description of what aspects of water quality they measure and what processes influence the variables:

- **Total Suspended Solids (TSS)** is a measure of the suspended particulate material in the water column. This includes suspended sediments (sand, silt, and clay), living plankton, and detrital (non-living organic) material. TSS concentrations are affected by oceanographic processes including primary production and wind and tide-driven resuspension, as well as inputs from other sources such as dredging and land-based runoff.
- **Secchi depth** is a visual measure of water clarity and proxy for light penetration, which is measured using a high-contrast black and white patterned disc called a Secchi disc. Water clarity increases with increasing Secchi depth. The Secchi depth is the average of the vertical disappearance and reappearance depths of the disc as it is lowered and then raised in the water. Secchi depth is a simple method that has been used for over 150 years, so is excellent for assessing long-term change and for cross-system comparisons.
- **Turbidity** is a measure of light scattering caused by fine suspended particles, such as sediment, detritus, and plankton. Turbidity is affected by a wide range of factors including oceanographic processes such as resuspension of bottom sediments by wind and tides; river discharge; and anthropogenic factors such as dredging. Turbidity data presented in this report come from *in situ* loggers (see Section 2.1.3 below).
- **Chlorophyll *a* (Chl-*a*)** concentration is a measure of phytoplankton biomass in a water body. Chl-*a* concentration can vary depending on the species of phytoplankton (due to the presence of different pigments in their cells) but is nonetheless a widely-used and reliable indicator. Phytoplankton grow quickly in response to nutrient availability, so elevated values of Chl-*a* can indicate increased nutrient loading.
- **Dissolved inorganic nutrients (NH_3, NO_X, PO_4 and Si)** measure the amount of readily available nutrients for plankton growth in water samples. Inorganic nitrogen (NH_3, NO_x) and phosphate (PO_4) represent around 1% of the nutrient pools in the Reef. The inorganic nutrient pools are affected by a complex range of biogeochemical processes including both natural (for example, plankton uptake, upwelling, nitrogen fixation, and remineralisation) and anthropogenic (for example, dredging and nutrient inputs from changed land use) processes.
- **Particulate nutrients (POC, PN, and PP)** are a measure of the suspended material retained on a filter with a pore size of approximately 0.7 μm. This material consists of a minor fraction of living biomass (e.g., bacteria, phytoplankton) and a major fraction of detritus (e.g., dead cells, faecal pellets). Particulate nutrient concentrations are affected by

oceanographic processes (primary production, bacterial production, resuspension, and remineralisation) as well as sources such as dredging and land-based runoff.

- **Dissolved organic carbon (DOC)** is a measure of organic carbon concentrations passing through a filter with a pore size of 0.45 µm. DOC has a complex chemical composition and is used by bacteria as a source of energy. The DOC pool is affected by a range of production and degradation pathways. The sources include primary production by phytoplankton, zooplankton grazing, resuspension events, river runoff, and abiotic breakdown of POC. DOC can be degraded by sunlight.

2.1.3 In situ loggers

Continuous *in situ* chlorophyll fluorescence and turbidity were measured using WET Labs ECO FLNTUSB Combination Fluorometer and Turbidity Sensors located at 19 sites (Appendix A), which were deployed at 3 m (Cape York region) or 5 m (all other regions) below the surface and sampled at 10 min intervals. Water samples for analyses of Chl-*a* and TSS were collected 3 times per year to validate logger fluorescence and turbidity against *in situ* conditions. Diver-operated Niskin bottles were used to sample close to the moored loggers and samples were preserved and analysed in the same manner as ship-based water samples.

Daily averages of the chlorophyll and turbidity collected by the ECO FLNTUSB instruments are presented as time-series graphs in Figure C-1. Annual means and medians of turbidity were also calculated for each site based on the ‘water year’ (1 October to 30 September the following year) and compared with the guideline value (GV) (Table C-2).

Salinity and temperature loggers (Sea-Bird Electronics SBE37) were deployed at 9 locations, with 5 of these being placed on fixed moorings near the Fitzroy, O’Connell, Russell-Mulgrave, Tully, and Burdekin River mouths (Figure 2-1; Appendix A). See the QA/QC report (Gruber *et al*., 2025) for detailed descriptions of logger pre- and post-deployment procedures. Site-specific time-series’ from these loggers can be found in Figure C-2.

2.1.4 Data analyses – Summary statistics and trends

Concentrations of water quality parameters at each sampling occasion were calculated as depth-averages (i.e., the mean of surface and bottom samples). Measurements falling below the analytical detection limit were replaced with values of half the detection limit (Gruber *et al*., 2024). Summary statistics for all water quality variables are presented for all monitoring sites in Table C-1. Concentrations were compared to site-specific GVs (Table C-9), which are defined for Chl-*a*, PN, PP, TSS, Secchi depth, NO_x, and PO_4 at most sites. Concentrations of water quality parameters are presented along the sampling transects for each focus region with distance from major river mouth. Trends in water quality with distance are represented with generalised additive models, fitted with a maximum of 5 knots and modelled with a gamma-distributed response and log-link function. Gamma distribution was used because the data are positive real numbers (distance from source) and tend to be positively skewed. The canonical link for a gamma distribution is the identity link which is more suitable for applications in which the response represents the duration of time that has elapsed since an event. In the case of positively skewed real numbers, the log-link is typically more suitable. A maximum of 5 knots was used as the transects have 4–6 discrete sites (representing 4–6 distances from source); restricting the maximum number of knots to 5 ensured that the models did not exceed the degrees of freedom available in instances where sample sizes were low. Note that in almost all cases, the realised degrees of freedom (and thus knots) were well below this maximum.

Temporal trends in key water quality variables (Chl-*a*, TSS, Secchi depth, turbidity, NO_x, PO_4, PN, PP, DOC, and POC) since 2005 are reported for all focus regions. Only open coastal and mid-shelf sites are used for these analyses because GVs for enclosed coastal waters are derived differently and are not available for all variables, creating statistical imbalance.

Generalised additive mixed effects models (GAMMs) were used to decompose each irregularly spaced time-series into its trend cycles (long-term) and periodic (seasonal) components (Wood, 2006). GAMMs are an extension of additive models (which allow flexible modelling of non-linear relationships by incorporating penalised regression spline types of smoothing functions into the estimation process), where the degree of smoothing of each smooth term (and by extension, the estimated degrees of freedom of each smoother) is treated as a random effect and thus can be estimated via its variance as with other effects in a mixed modelling structure (Wood, 2006).

For each water quality variable within each focus region, the variable was modelled against a thin-plate smoother for date and a cyclical cubic regression spline (maximum of 5 knots) over months within the year. Spatial and temporal autocorrelation in the residuals was addressed by including sampling locations as a random effect and imposing a first-order continuous-time auto-regressive correlation structure (Pinheiro and Bates, 2000). All GAMMs were fitted using the mgcv (Wood 2006, 2011) package in R 3.6.1 (R Core Team, 2022).

GAMMs represent long-term trends in water quality variables measured during ambient periods (i.e., not peak flood events) of the dry and wet seasons and are presented in Section 5. It is important to note that this trend analysis removes variability associated with seasons. Thus, individual data points will have different values from raw data. This analysis is designed to detect **long-term** and **regional-scale** trends in water quality by removing the effect of short-term changes associated with weather and seasonal variability.

In order to provide a more quantitative assessment of trend since the start of monitoring under the current monitoring design (2015), linear change in values of GAMMs was measured from the present sampling year to 2015. This period was chosen as it incorporates the MMP re-design, which was introduced in 2015; using earlier data would unbalance this analysis as the amount of sampling greatly increased in 2015. As GAMMs are de-trended to remove the effects of seasons, this analysis aims to quantify long-term trends occurring outside of this cycle. The proportion of change that occurred between 2015 and the present year was calculated as the ratio between concentrations in those years (e.g., for TSS): $Ratio_{TSS} = \frac{TSS_{present}}{TSS_{2015}}$, where a Ratio > 1 indicates an increase in concentration and a Ratio < 1 indicates a decrease in concentration. Upper and lower 95% confidence limits were calculated for each ratio. A statistically significant increase was defined as a Ratio where the lower confidence limit > 1, while a statistically significant decrease was defined as a Ratio where the upper confidence limit < 1. Trend analysis results are presented for each focus region in Section 5.

2.1.5 Data analyses – Water Quality Index

The Water Quality Index (WQ Index) is an interpretation tool developed by AIMS to visualise trends in the suite of water quality variables measured and to compare monitored water quality to existing Water Quality Guidelines (Department of Environment and Resource Management, 2009; Great Barrier Reef Marine Park Authority, 2010). The WQ Index uses a set of 5 key indicators:

- Water clarity (see definitions below for Index versions),
- Chl-*a* concentrations,
- PN concentrations,
- PP concentrations, and
- NO_x concentrations.

These 5 indicators are a subset of the comprehensive suite of water quality variables measured in the MMP inshore water quality program. They have been selected because GVs are available for these measures, and they can be considered as relatively robust indicators that integrate a number of bio-physical processes in the coastal ocean.

For each monitoring site, these indicators are scored based on performance relative to GVs and averaged to give an overall site-specific score. Sites are then averaged over a region or focus region to give a regional score (see Appendix B for details of Index calculation). Results are presented in Section 5.

The WQ Index is calculated using 2 different methods due to the objectives of the program needing to report both the long-term trend in water quality condition and the annual conditions that ecosystems experience. Changes in the MMP design that occurred in 2015 (increased number of sites, increased sampling frequency, and higher sampling frequency during the wet season [1 November to 30 April]) also needed to be incorporated into WQ Index calculation. The 2 versions of the WQ Index have different purposes:

1. **Long-term trend**: This version is based on the pre-2015 MMP sampling design and uses only the original sites (open coastal water body) and 3 sampling dates per year. This sampling design had low temporal and spatial resolution and was aimed at detecting long-term trends in inshore water quality. See Appendix B for details of Index calculation. Key aspects of this version are:
   - annual water quality GVs are used for scoring monitoring data (Table B-1),
   - only AIMS monitoring data are used,
   - a four-year running mean is applied to data to reduce the effect of sampling time on the Index, and
   - the Index is an average of 5 equally-weighted indicator scores: water clarity (the average of TSS and turbidity from loggers, where available), Chl-*a*, NO_x, PN, and PP weighted equally.

2. **Annual condition:** This version is based on the post-2015 MMP sampling design and uses all sites (except enclosed coastal sites) and sampling dates per year. See Appendix B for details of Index calculation. Key aspects of this version are:
   - seasonal site-specific water quality GVs are used (i.e., wet season data are compared to a wet season GV and dry season data are compared to a dry season GV) (Table C-9
   - both AIMS and JCU monitoring data are used,
   - a running mean is not applied, and
   - the Index is a hierarchical combination of scores for 5 indicators: water clarity (the average of TSS, Secchi depth, and turbidity from loggers, where available), productivity (combined score of Chl-*a* and NO_x), and particulate nutrients (combined score of PN and PP), which are weighted equally.

2.2 Remote sensing

2.2.1 Mapping Reef water types

The current Program utilises optical information available from medium resolution optical satellite images combined with modelling and *in situ* data to monitor Reef water quality (e.g., Petus *et al.,* 2019; Waterhouse *et al.,* 2021). Until 2020, trends in Reef marine water composition during the wet season were monitored using a combination of Moderate-Resolution Imaging Spectroradiometer (MODIS) satellite imagery and a “wet season” colour scale specifically developed for the Reef (Alvarez-Romero *et al*., 2013). MODIS satellite pixels were reclassified into 6 colour classes, then into 4 broad groups of water type characteristics: the primary (corresponding to colour classes 1 to 4), secondary (colour class 5), and tertiary (colour class 6) wet season water types and the marine water type (Figure 2-2a and Table 2-2).

These water types represented typical colour and water quality gradients encountered in the Reef during the wet season (December to April), including river plumes. Catchment runoff in sediment-laden river discharge appears in satellite images as brownish flood plumes, while productive chlorophyll-rich waters appear with a greenish colour, and ambient (clear) marine waters are a blueish colour. Brownish-green waters also appear when sediments are re-suspended by wind or tide, and it is impossible to fully separate the direct influence of riverine plume from wind- and wave-driven sediment resuspension (some of which may have been originally derived from river discharge in previous events) in optical satellite images. Therefore, the term “wet season waters” referred collectively to flood river plumes, associated resuspension, and oceanographic processes occurring in the Reef during the wet season.

However, MODIS sensors were ageing, and the quality of the MODIS imagery was declining (MODIS-Aqua was launched in 2002). A transition to Sentinel-3 Ocean Land Colour Instrument (OLCI) satellite imagery and another colour scale (the Forel-Ule [FU] colour scale) was proposed for the continuous mapping of Reef waters in 2019 and adopted in 2020 (Petus et a, 2019) (Table 2-2). The FU colour scale is an historical colour scale standard to determine water colour and classifies waterbodies worldwide (Novoa *et al.*, 2013). It is composed of 22 colours from indigo blue to ‘cola’ brown, and is applicable for all natural waters (inland, estuarine, inshore and offshore) and all environmental conditions, including wet and dry season conditions (Wernand *et al.*, 2012, 2013; Van der Woerd *et al.*, 2016; Van der Woerd and Wernand, 2018). In a case study focusing on Wet Tropics and Burdekin regions of the Reef over the 2017–18 wet season, the MODIS-Aqua WS and Sentinel-3 FU colour class maps showed very similar patterns (Petus *et al.*, 2019; Figure 2-2 and Table 2-2).

Equivalent FU water types were defined by grouping:

- FU colour classes 1–3 (equivalent to marine waters in the wet season scale used before 2020–21),
- FU colour classes 4–5 (equivalent to tertiary water type in the wet season scale),
- FU colour classes 6–9 (equivalent to the secondary water type), and
- FU colour classes ≥10 (equivalent to the primary water type).

In the 2021–22 report (Moran *et al*., 2023), the water type (WT) terminology was modified to: Reef WT1, WT2, WT3, and WT4 instead of primary, secondary, tertiary, and marine wet season water types. This change was made in response to recognition that the previous terminology may be misleading and systematically implied the presence of flood plume waters, while the Reef WT1 (primary waters) may also represent sediment resuspension in shallower parts of the Reef lagoon, and the Reef WT3 (tertiary waters) may represent oceanographic processes such as upwelling or sediment resuspension around reefs and islands (Table 2-2). Importantly, while names of the water types changed, the definition of the water types in Table 2-2 essentially remained the same.

Several monitoring products are derived from the Sentinel-3 FU water type maps to report on water quality trends. These products map water quality gradients during the wet season and are used to:

- Map the extent of river flood plumes during high flow conditions;
- Characterise the composition of the Reef water types (mean long-term total suspended solids [TSS], chlorophyll *a* [Chl-*a*], coloured dissolved organic matter [CDOM], dissolved inorganic nitrogen [DIN], dissolved inorganic phosphorus [DIP], particulate phosphorus [PP], and particulate nitrogen [PN] concentrations and Secchi disk depth [SDD] values) and identify where mean long-term concentrations of TSS, Chl-*a*, PP, and PN are likely to be above wet season GVs. Wet season GVs for the whole of the Reef (hereafter Reef-wide GVs) are derived from De’ath and Fabricius (2008) (Table B-4); and
- Assess the exposure of coral reefs and seagrass ecosystems to potential risk from exposure to land-based pollutants.

These products are used to illustrate wet season conditions for every wet season and to compare seasonal trends with baseline reference trends in water composition including long-term conditions, typical wet year and dry year conditions and conditions over a documented recovery period for coral reefs. Available satellite data are biased toward clear, non-cloudy days, and may underrepresent poor water quality in regions of higher rainfall and cloudiness like the Wet Tropics and Cape York. However, they provide a unique large-scale and long-term view of the Reef that is not available using water quality data only.

Table 2-2: Description of the Sentinel-3 Reef water types (WT) and corresponding Forel-Ule (FU) colour classes (and comparison with MODIS wet season (WS) water types). Mean long-term (2004–2023) concentrations of water quality parameters (± standard deviation) across the Reef water types are indicated in the right column (modified from Petus *et al.*, 2019 and Waterhouse *et al.*, 2018). Refer to Appendix C4 for further detail.

Reef water types	FU colour classes (and WS colour classes)	Description	Mean long-term (2004–23) concentrations of water quality parameters*
WT1 (previously primary)	FU ≥ 10 (WS1–4)	Brownish to brownish-green turbid waters typical of inshore regions of the Reef that receive land-based discharge and/or have high concentrations of resuspended sediments during the wet season. In flood conditions, this water type typically contains high sediment and dissolved organic matter concentrations resulting in reduced light levels. It is also enriched in coloured dissolved organic matter and phytoplankton concentrations and has elevated nutrient levels.	SDD: 2.1 ± 2.1 m TSS: 17.4 ± 44.1 mg L^{-1} Chl-*a*: 1.5 ± 2.2 μg L^{-1}
WT2 (previously secondary)	FU6–9 (WS5)	Greenish to greenish-blue turbid water typical of coastal waters with colour dominated by phytoplankton (Chl-*a*) but also containing dissolved organic matter and fine sediment. This water body is often found in open coastal waters of the Reef as well as in the mid-shelf where relatively high nutrient availability and increased light levels due to sedimentation favour coastal productivity (Bainbridge *et al.*, 2012).	SDD: 4.6 ± 2.8 m TSS: 4.6 ± 7.0 mg L^{-1} Chl-*a*: 0.6 ± 0.7 μg L^{-1}
WT3 (previously tertiary)	FU4–5 (WS6)	Greenish-blue waters corresponding to waters with slightly above-ambient suspended sediment concentrations and high light penetration typical of areas towards the open ocean. This water type includes the outer areas of river flood plumes, fine sediment resuspension around reefs and islands and oceanographic processes such as upwelling. Reef WT3 waters are associated with low land-based contaminant concentrations and the ecological relevance of these waters is likely to be minimal although not well researched. The Type III areas have a low magnitude score in the Reef exposure assessment.	SDD: 8.2 ± 4.1 m TSS: 2.3 ± 3.9 mg L^{-1} Chl-*a*: 0.4 ± 0.4 μg L^{-1}
WT4 (previously marine)	FU1–3 No number	Blueish marine waters with high light penetration.	SDD**: 11.0 ± 4.8 m TSS**: 1.8 ± 3.5 mg L^{-1} Chl-*a***: 0.5 ± 0.9 μg L^{-1}

*SDD = Secchi disk depth, TSS = total suspended solids, and Chl-*a* = chlorophyll *a*.

**Note that the number of data points collected in the Reef WT4/Marine water type is limited in comparison to the data available in the other water types (Appendix B). Long-term concentrations of water quality parameters in the Reef WT4 are thus just given as an indication and are not used in the monitoring products presented in this report. A pilot study funded by Reef Trust Partnership collected water quality data in mid-shelf and offshore locations via the Crown of Thorns Starfish Control Program (Waterhouse *et al*., 2023). Water quality data collected as part of this study are included in the long-term dataset to help in progressing the characterisation of the Reef WT4, but more data are still needed to improve accuracy of the characterisation.

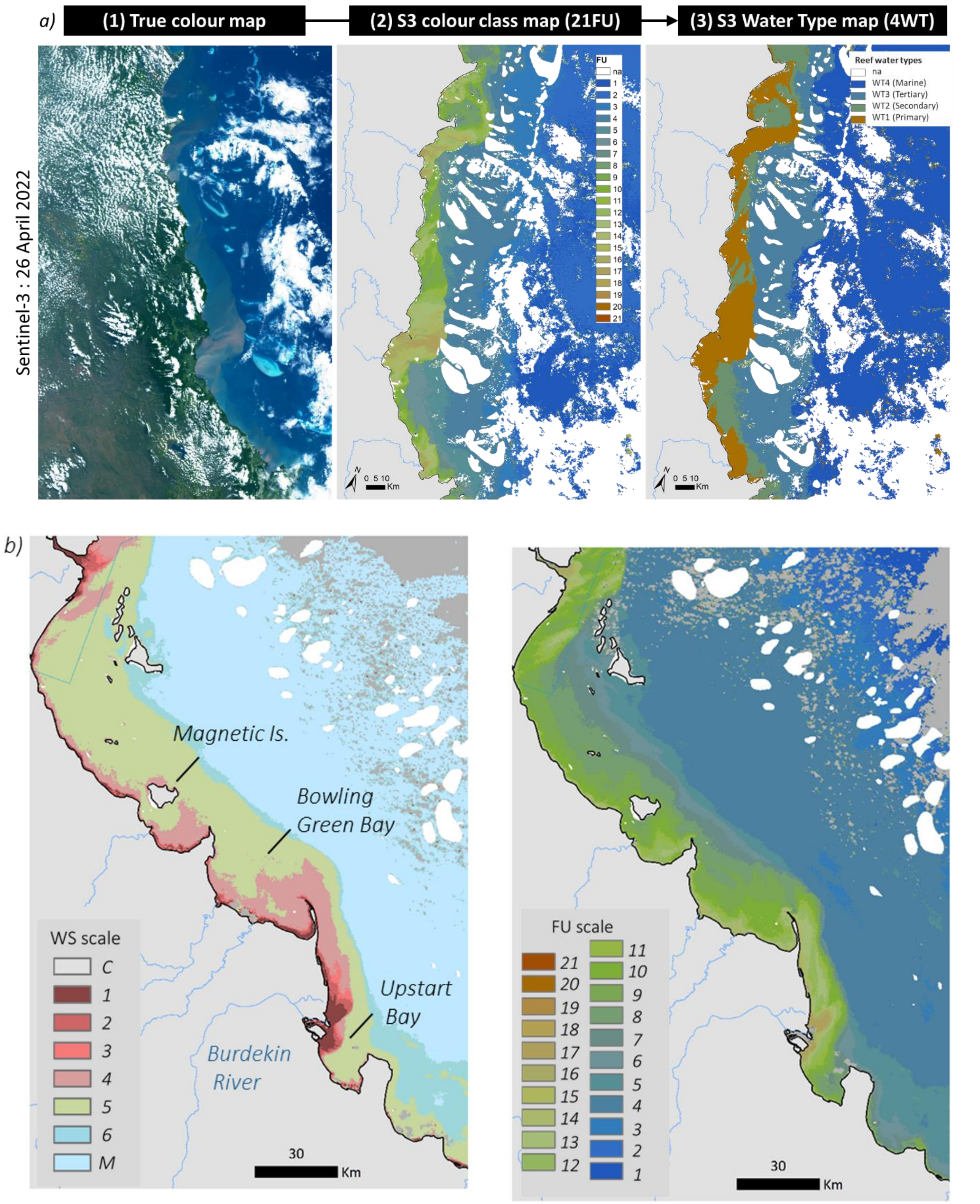


Figure 2-2: Methods for Reef water type, frequency, and exposure maps using Sentinel-3-OLCI true colour imagery: a) Summary of the process to produce the Reef water type maps (1) downloading of the true colour imagery, (2) processing of colour class map using the Forel-Ule (FU) colour scale Toolbox implemented in the Sentinel Application Platform, and (3) reclassification into Reef water types. Images are from the Eumetsat data centre and were captured on 26 April 2022 (source: Sentinel Hub EO browser). b) Burdekin River plume (14 March 2018) (the Wet Season [WS] scale ranges from 1–6, plus marine [M]; the catchment [C] is shown in grey). This panel illustrates the similar colour patterns between the (right) Sentinel-3 Forel-Ule colour class maps and (left) the MODIS wet season water type maps. Panel b was mapped using a supervised classification of MODIS true colour data developed by Álvarez-Romero *et al*. (2013) (modified from Devlin *et al*., 2015).

2.2.2 Characterising composition of wet season Reef water types

The classification of 4 Reef water types allows mapping of a broad grouping of water type characteristics with different colours, concentrations of optically active components (TSS, CDOM, and Chl-*a*), water quality indicators (e.g., nutrient concentrations; Devlin *et al*., 2015; Petus *et al*., 2019), and light attenuation levels (Petus *et al*., 2018) typically found in the Reef during the wet season (Table 2-2 and Figure 2-2). These characteristics vary the potential impact on the underlying ecological systems. In summary:

- The **brownish Reef WT1** ***(FU ≥ 10)*** represents turbid waters from river flood plumes, and also sediment resuspension in the shallower parts of the Reef;
- The **greenish Reef WT2** ***(FU6–9)*** represents the less turbid parts of flood plumes enriched in Chl-*a* and fine sediment. It is usually found in the inshore to mid-shelf regions of the Reef;
- The **greenish-blue Reef WT3** ***(FU4–5)*** represents waters with suspended sediment concentrations slightly above ambient conditions and high light penetration typically found in the outer areas of river flood plumes. It can also represent oceanographic processes such as upwelling or the fine sediment resuspension around reefs and islands; and
- The **blueish Reef WT4** ***(FU1–3)*** represents ambient waters with high light penetration and negligible concentrations of optically active water quality constituents.

Match-ups of *in situ* concentrations of water quality parameters (surface samples) and the 4 Reef water types are regularly performed to validate this concept and quantify the range and average of concentrations of water quality parameters found in each Reef water type. The previous update was in 2022–23 (Gruber *et al.,* 2024). As part of this update, all mean concentrations of water quality parameters were reviewed to ensure that the water type characterisation remains appropriate, and to improve its accuracy building on the field data that are collected every wet season. The colour class category and water type corresponding to the location and week of acquisition of each water quality sample were extracted from the archive of MODIS-Aqua (wet seasons 2003–2020) and Sentinel-3 (wet seasons 2020–2023) weekly colour class maps (see method in Appendix B). Weekly composites were used rather than daily colour class/water type data to minimise data loss due to the periodic dense cloud cover in the Reef. This approach maximises the incorporation of water quality parameters measured during each wet season since 2003–04 that can be associated with a Reef water type (and colour class) category.

Ideally, match-ups between satellite and *in situ* water quality information should be performed using field data collected ±2 hours from the satellite overpass. This is very complicated to achieve in the MMP, which is in part focused on responsive monitoring of flood events and in areas of the Reef where the cloud cover has a major influence during the wet season. The methodology above was thus selected to maximise the number of data points used to assess the water quality characteristics of each Reef water type. The limitations are considered acceptable as the mean concentrations of water quality parameters are used as a relative measure to assign a potential risk grading for each Reef water type (see below). However, the long-term average concentration values should not be used as an exact value *per se.*

The long-term concentrations of water quality parameters were reviewed in 2023. They were calculated using all surface data (<0.2 m) available at this date. This included data collected between December and April by JCU since the 2003–04 water year, and up to April 2023. It included data collected by AIMS and the CYWP since the 2016–17 water year and covered all regions and waterbodies of the Reef, and all Reef water types. TSS and Chl-*a* data collected in mid-shelf and offshore areas as part of a Reef Trust Partnership project with the locations via the Crown of Thorns Starfish Control Program between December 2021 and April 2023 (Waterhouse *et al*., 2023) were also included. In previous assessments, long-term mean DIN, PP, and PN concentrations were calculated as: DIN = nitrite + nitrate + ammonia, PP = Total Phosphorus – Total Dissolved Phosphorus, and PN = Total Nitrogen – DIN, respectively. In the current assessment, mean long-term direct measurements of PP and PN were used (rather than indirectly estimated values as above), and NO_x was used instead of DIN and calculated as NO_x = nitrite/nitrate due to its greater robustness than ammonia as an indicator of N availability in marine waters.

Boxplots of water quality concentration and Secchi disk depth were plotted against their water type and colour class categories. The mean long-term TSS, Chl-*a*, PP, and PN concentrations were then assessed against wet season GVs as a relative measure to assign potential risk grading for each Reef water type. Reef-wide wet season GVs were derived from De'ath and Fabricius (2008) (Table B-4).

Reef water type, frequency, and exposure maps

Several summary maps are produced every wet season including weekly panel maps of environmental and marine wet season conditions, frequency maps of occurrence of wet season water types and exposure maps. The area (km^2) and percentage (%) of coral reefs and seagrass meadows affected by different relative categories of potential risk of exposure of Reef ecosystems to wet season water quality (hereafter referred as 'potential risk' categories) was summarised. Detailed methods for these products are in Appendix B.

Reef water type maps of the 2024–25 wet season were produced using daily Sentinel-3 OLCI Level 2 (hereafter, Sentinel-3 or S3) imagery (Figure 2-2a, Step 1) reclassified to 21 distinct colour classes defined by their colour properties and using the FU colour classification scale (Figure 2-2a, Step 2). Sentinel-3 imagery of the study area was downloaded on the EUMETSAT Data centre (https://www.eumetsat.int/eumetsat-data-centre). Sentinel-3 images are atmospherically corrected and were processed with the FU Satellite Toolbox implemented in the Sentinel Application Platform (https://step.esa.int/main/toolboxes/snap/) and using automated tools (Python scripts and ArcGIS toolboxes) developed through MMP funding.

Weekly water type composites were created to minimise the image area contaminated by dense cloud cover and intense sun glint (Álvarez-Romero *et al.*, 2013). The maximum FU value of each pixel/week was used to keep the colour class with the highest turbidity and/or colour for each wet season week. The weekly composite maps were cleaned to remove single or small clusters of cells sometimes misclassified by the FU satellite algorithm in the offshore regions of the Reef (e.g., around coral reefs due to bottom interference and residual glint contamination). The method involved sequentially infilling contiguous areas one FU class at a time from FU1 through to FU21 then replacing nearshore pixels in FU classes ≥10 with the original pixels using Python 2.7.3 (Python Software Foundation, 2012) and ArcGIS 10.2 (ESRI, 2013). In order to produce weekly Reef water type maps, the FU maps were subsequently clustered by grouping the Reef WT1 (previously primary waters) as FU colour classes ≥10 (FU≥10), the Reef WT2 (previously secondary waters) as FU6–9, the Reef WT3 (previously tertiary waters) as FU4–5 and the Reef WT4 (previously marine waters) as FU1–3 (Figure 2-2a, Step 3).

Frequency maps were produced to predict the areas affected by the Reef WT1, WT2 and WT3 individually (i.e., of the brownish, greenish and greenish-blue waters, respectively) and by the Reef WT1–2 combined (previously a combination of WT1–3; this has been modified to recognise that the ecological relevance of the water quality variables at concentrations in WT3 waters is not well understood, but expected to be relatively minor).

Average frequency maps were produced for this reporting wet season and compared to average frequency maps representing relevant reference periods (Gruber *et al.*, 2024), including:

(i) the long-term reference composite (2002–03 to 2021–22: 20 wet seasons),
(ii) a documented recovery period for coral reefs (2012–2017; Thompson *et al.*, 2026) intended to represent a favourable exposure scenario, and
(iii) composite frequency maps produced to represent typical wet year and dry year conditions, considering the wettest and driest years for each NRM region over the previous 20 years (Gruber *et al.*, 2024). This is explained further in Appendix B.

Except for the 'coral recovery period', reference maps (long-term, representative Wet and Dry frequency maps) were last revised in the 2022–23 report (Gruber *et al*., 2024) (20 years: 2002–03 to 2021–22).

The presence and spatial extent of each Reef water type is the result of the complex physico-chemical transformations occurring within river plumes, but also of resuspension, transport, and other oceanographic processes. As a result, the extent of the Reef WT2 and WT3 is rarely attributed to an individual river and is usually merged into one heterogeneous area.

Exposure maps were produced for this reporting wet season for the whole of the Reef, for all focus regions, and compared to reference exposure maps produced for the same timeframe as those reported for the frequency maps above. The maps were produced using an exposure assessment framework developed through a collaborative effort between the MMP monitoring providers and modified from Petus *et al*. (2016). Reference exposure composites were last revised in the 2022–23 report (Gruber *et al*., 2024) to produce 20-year composite maps.

In this *magnitude × likelihood* framework, the 'potential risk' corresponds to an exposure of land-based pollutants to above Reef-wide wet season GV concentrations during the wet season and focuses on TSS, Chl-*a*, PP, and PN concentrations. The *'magnitude of the exposure'* corresponds to the mean long-term wet season concentration of pollutants (the proportional exceedance of the Reef-wide wet season GV) mapped through the Reef WT1, WT2 and WT3. The *'likelihood of the exposure'* is estimated by calculating the frequency of occurrence of each Reef water type mapped through the frequency maps (see above).

The exposure for each of the water quality parameters defined is the proportional exceedance of the GV multiplied by the likelihood of exposure in each of the Reef water types.

1. *Calculation of the magnitude scores:* The long-term mean concentrations of water quality parameters (Reef-wide) measured across the Reef water types were assessed against Reef-wide wet season GVs to calculate magnitude scores for TSS, Chl-*a*, PP, and PN. The GVs were calculated based on annual GVs (Great Barrier Reef Marine Park Authority, 2010) that were seasonally adjusted as described in De'ath and Fabricius (2008) (see Table B-4). Mean long-term concentrations of water quality parameters include samples collected from the enclosed coastal zone, where high TSS, Chl-*a*, PN, and PP concentrations are likely to contribute to exceedances of the Reef-wide GVs (see Table B-1). The only GV currently available for Secchi depth is an annual mean, and thus comparison with wet season Secchi depth data was not possible.
2. *Production of the potential risk maps:* The magnitude scores were used in combination with the seasonal, long-term, coral recovery, wet-year and dry-year frequency maps (described above) to derive seasonal, long-term, coral recovery, wet-year, and dry-year potential exposure maps, respectively. Exposure from each map produced was then grouped into potential risk categories (I to IV) based on a "Natural Break (or Jenks)" classification[1] (Appendix B-3). The potential risk categories were defined by applying the Jenks classification to the mean long-term (2003–2022) exposure map, because this map presented the highest number of observations (20 wet seasons). Category I and areas not exposed were re-grouped into a unique category corresponding to no or very low exposure to a potential risk. Magnitude scores have no designated ecological significance but are used in the risk framework as a relative measure to assign relative potential risk grading for each Reef water type.
3. *Exposure assessment*: Potential risk maps were overlaid with information on the spatial distribution of coral reefs and surveyed seagrass meadows to identify areas and percentages of these ecosystems that may experience potential risk from exposure to pollutants during the wet season. The area (km^2) and percentage (%) of coral reefs and seagrass meadows affected by the different potential risk categories (I to IV) was calculated in the Reef and marine NRM regions. Potential risk maps are presented in the context of the long-term reference period

[1] Jenks is a statistical procedure, embedded in ArcGIS that analyses the distribution of values in the data and finds the most evident breaks in it (i.e., the steep or marked breaks; Jenks and Caspall 1971).

(average of 20 wet seasons), the representative coral recovery period (2012–2017), and representative wet-year and dry-year composites. Areas and percentages of exposure are presented in the context of the long-term reference period.

The 'potential risk' is influenced by the available satellite data on cloud-free days, with the likelihood of exposure likely to be underestimated in higher rainfall and areas with high cloud cover like the Wet Tropics and Cape York regions.

2.3 River discharge and catchment loads

River flow is reported annually and can be derived from several sources. In many cases, river flow gauges that measure discharge (and used to calculate constituent loads) are located well upstream of the river mouth and only capture a certain proportion of the catchment/basin area. Such disparities mean that river gauge data should not be directly compared across basins and NRM regions. For example, the Daintree and Barron Basins within the Wet Tropics region contain a similar area (2,100–2,200 km^2); however, the Daintree River at Bairds and the Bloomfield River at China Camp gauges collectively only measure 56% of the Daintree Basin whereas the Barron River at Myola gauge captures 89% of the Barron Basin. If gauge data are used to compare discharge between these basins, the gauge on the Barron Basin is covering a much larger proportion of the area compared to the gauges on the Daintree Basin. A scaling factor is used on these data so that discharge (and constituent loads) can be directly compared across basins and NRM regions.

To account for these differences, the relevant discharge data for each basin were compiled, where available (Table 2-3; Department of Local Government, Water and Volunteers Water Monitoring Information Portal [WMIP], 2025). The total annual discharge for each gauge was then up-scaled using the recommended scaling factors outlined in Puignou Lopez *et al*. (2025). Briefly, this work examined different upscale factors based on basin area to total gauged area, mean annual flow for the gauged basin and the mean annual basin flow from either the Bureau of Meteorology's G2G model (BoM, 2017; Wells et al., 2018) or the Source Catchments model (McCloskey et al., 2021) or the linear relationships between river gauge data and the 2 models; the most appropriate upscale factor was then recommended for each basin (Puignou Lopez *et al*., 2025). Where a flow gauge did not exist in a basin (e.g. Jacky Jacky Creek, Lockhart River, Jeannie River, Proserpine River, Styx River, Shoalwater Creek and Boyne River—marked with an asterisk), the gauge from the nearest neighbouring basin was used. The calculation of the long-term medians for each basin has been anchored to cover the 30-year period from the 1990–91 to 2019–20 water years.

The gauge data for the 2024–25 water year were mostly complete with only some minor data interpolations required for periods where low flows would have been expected. On exception was the Bloomfield at China Camp gauge which contained a major data gap during the wet season between 10 February and 14 April 2025. The Daintree at Bairds daily data were used to fill this gap as it is the closest neighbouring gauge where a strong linear relationship between daily flows can be applied. With the large wet season in the Townsville region, the Ross River at Aplins Weir height data were obtained from the Bureau of Meteorology and were converted to daily flow. This conversion was also performed for previous years and so the discharge for the Ross Basin has been updated back to the 2021–22 water year.

Table 2-3: The 35 basins of the Reef catchment, the gauges for each Basin, and the correction factors used to upscale flows to provide annual discharge estimates. (AWRC = Australian Water Resources Council).

NRM Region	Basin	AWRC No.	Basin area (km^2)	Relevant gauges	% of Basin covered by key gauges	Correction factor
Cape York	Jacky Jacky Creek	101	2,963	Jardine River at Monument*	0	1.1x + 560,000
	Olive Pascoe River	102	4,180	Pascoe River at Garraway Creek	31	3.1
	Lockhart River	103	2,883	Pascoe River at Garraway Creek*	0	1.5
	Stewart River	104	2,743	Stewart River at Telegraph Road	17	5.6
	Normanby River	105	24,399	Normanby River at Kalpowar Crossing + Hann River at Sandy Creek (from 2005/06). Previous upscale period uses Normanby at Battle Camp + Hann River gauges with factor of 4.7	53	1.8
	Jeannie River	106	3,638	Endeavour River at Flaggy + Annan at Beesbike	0	3.2
	Endeavour River	107	2,182	Endeavour River at Flaggy + Annan at Beesbike	27	3.5x + 21,000
Wet Tropics	Daintree River	108	2,107	Daintree River at Bairds + Bloomfield River at China Camp	56	1.6
	Mossman River	109	473	Mossman River at Mossman	22	2.3
	Barron River	110	2,188	Barron River at Myola	89	1.3
	Mulgrave-Russell River	111	1,983	Mulgrave River at Peets Bridge + Russell River at Bucklands	42	2.0x + 450,000
	Johnstone River	112	2,325	South Johnstone River at Upstream Central Mill + North Johnstone at Tung Oil	57	1.6x + 540,000
	Tully River	113	1,683	Tully River at Euramo	86	1.1
	Murray River	114	1,107	Murray River at Upper Murray	14	5.0x + 600,000
	Herbert River	116	9,844	Herbert River at Ingham	87	1.2

NRM Region	Basin	AWRC No.	Basin area (km^2)	Relevant gauges	% of Basin covered by key gauges	Correction factor
Burdekin	Black River	117	1,057	Black River at Bruce Highway + Bluewater Creek at Bluewater	32	3.1
	Ross River	118	1,707	Ross River at Aplins Weir + Alligator Creek at Allendale (from 2001–02). Previous upscale period uses Ross River Dam HW + Bohle at Hervey Range Rd + Alligator Creek with factor of 1.6x + 75,000	52	1.9
	Haughton River	119	4,051	Haughton River at Powerline + Barratta at Northcote	62	1.6
	Burdekin River	120	130,120	Burdekin River at Clare	100	1.0
	Don River	121	3,736	Don River at Reeves + Elliot River at Guthalungra + Euri Creek at Koonandah (from 1999/00). Previous upscale period uses Don + Elliot gauges with factor of 2.9x + 170,000	46	1.5x + 210,000
Mackay-Whitsunday	Proserpine River	122	2,494	O'Connell River at Staffords Crossing + Andromache River at Jochheims + St Helens Creek at Calen	0	3.6
	O'Connell River	124	2,387	O'Connell River at Staffords Crossing + Andromache River at Jochheims + St Helens Creek at Calen	29	3.5
	Pioneer River	125	1,572	Pioneer River at Dumbleton Weir TW	95	1.1
	Plane Creek	126	2,539	Sandy Creek at Homebush + Carmila Creek at Carmila	16	5.6x + 210,000
Fitzroy	Styx River	127	3,013	Waterpark Creek at Byfield*	0	5.7x + 260,000
	Shoalwater Creek	128	3,601	Waterpark Creek at Byfield*	0	6.6x + 300,000
	Water Park Creek	129	1,836	Waterpark Creek at Byfield	12	5.4x + 43,000
	Fitzroy River	130	142,552	Fitzroy River at The Gap	95	1.1

NRM Region	Basin	AWRC No.	Basin area (km^2)	Relevant gauges	% of Basin covered by key gauges	Correction factor
	Calliope River	132	2,241	Calliope River at Castlehope	57	1.9x + 95,000
	Boyne River	133	2,496	Calliope River at Castlehope*	0	2.1
Burnett-Mary	Baffle Creek	134	4,085	Baffle Creek at Mimdale	34	2.4x + 95,000
	Kolan River	135	2,901	Kolan River at Springfield + Gin Gin Creek at Brushy Creek	37	2.4x + 19,000
	Burnett River	136	33,207	Burnett River at Figtree Ck (from 1996/97). Previous upscale period uses Burnett River at Mount Lawless with factor of 1.2x + 84,000	92	1.1
	Burrum River	137	3,362	Gregory River at Leesons + Elliott River at Dr Mays Crossing + Isis River at Bruce Highway	40	3.0x + 27,000
	Mary River	138	9,466	Mary River at Home Park	72	1.4
* Gauges used which are not in the basin area						

Current annual and pre-development TSS, DIN, and PN load estimates were calculated for all basins using a systematic approach. The pre-development loads represent a modelled period before 1850 when Europeans first arrived in the Reef catchment – the hydrology is kept the same but the catchment is modelled as a pristine landscape (see McCloskey et al. 2021). These species of nitrogen are the most labile (readily used or converted to useable forms for uptake by phytoplankton and macroalgae) and are thus the most biologically relevant in the Reef lagoon (Great Barrier Reef Marine Park Authority, 2010). The DIN loads for the basins of the Wet Tropics and Haughton Basin were calculated using the model originally developed in Lewis *et al*. (2014) which used a combination of the annual nitrogen fertiliser applied in each basin coupled with basin discharge; a relationship is established with measured loads to calculate the average percentage of fertiliser lost as DIN (calculated as per previous description). DIN loads for the Burdekin, Pioneer and Fitzroy basins were taken from those measured in the Great Barrier Reef Catchment Loads Monitoring Program. If the measured data for the most recent years in these basins were unavailable, a mean of the long-term annual mean concentration from the previous monitoring data were coupled with the annual discharge to calculate a load. DIN loads for the remaining basins were calculated using an annual mean concentration which was multiplied by the corresponding annual basin discharge calculations. The annual mean concentration for each basin was informed using a combination of available monitoring data and Source Catchments model outputs. The pre-development DIN loads were calculated using a combination of the estimates from the Source Catchments model as well as available monitoring data from ‘pristine’ locations (Lewis *et al*., 2023).

The TSS and PN loads were similarly determined through a step-wise process. For the basins where the Great Barrier Reef Catchment Loads Monitoring Program captured >95% of the basin area (e.g. Burdekin, Pioneer, and Fitzroy) the measured/reported TSS and PN loads were used. If the measured data for the most recent years were unavailable, a mean of the long-term annual mean concentration from the previous monitoring data was coupled with the annual discharge to calculate a load. For other basins with monitoring data, the range of annual mean concentrations were compiled and compared with the latest Source Catchment modelling values. From these data a 'best estimate' of an annual mean concentration was produced and applied with the annual discharge data to calculate loads. Finally, for the basins that have little to no monitoring data, the annual mean concentration from the Source Catchments data was examined along with nearest neighbour monitoring data to determine a 'best estimate' concentration to produce the load. The pre-development TSS and PN loads were calculated using a combination of the annual mean concentrations from the Source Catchments model and available monitoring data from 'pristine' locations. The corresponding discharge was used (as calculated previously) to produce a simulation of the pre-development load for the water year.

2.4 Load mapping

Maps representing the dispersion of river-derived DIN, TSS, and PN loads into the Reef have been developed as part of the MMP since 2003 to provide an indication of the relative extent of the influence of land-based runoff across the Reef. The maps were initially produced using the relatively simple method described in Gruber *et al.*, (2018) which had several limitations related to the influence of variable hydrodynamics, and environmental conditions including wind, tides and currents. In 2018–19 a revised approach was developed using the eReefs GBR1 model (1 km resolution) (Margvelashvili *et al.*, 2018; Skerratt *et al*., 2019; Steven *et al*., 2019) to estimate river dispersion (Gruber *et al*., 2020), providing a much-improved representation of hydrodynamics and environmental conditions. In keeping with the principle of continuous improvement, the method was further refined in 2024–25 to incorporate the latest eReefs marine model capability(https://marlin.csiro.au/geonetwork/srv/eng/catalog.search#/metadata/dcc8462c-8dc5-4d78-b9d8-6f1c31ae0001), using the results of a hindcast run of a newly updated version 4.0 of the GBR4 Hydrodynamic model (4 km resolution) due to the timing of several major model improvements. For the GBR4 model, recent enhancements include a better representation of shelf-break currents and upwellings, updated heat penetration, and importantly, greater representation of freshwater inputs along the GBR coast, increasing from 17 rivers to 54 rivers.

River discharge footprints were modelled using a conservative tracer in GBR4 hindcast version H4p0 (Maggiorano *et al.*, 2025) from November 2022 to April 2025. The hydrodynamic model was forced with atmospheric and ocean reanalysis: Surface Atmospheric Data from the Bureau of Atmospheric high resolution Regional Reanalysis for Australia, using Data Assimilation of Quality Control observations (BARRA R2, Su *et al*., 2019), ocean boundaries from the CSIRO Bluelink Reanalysis using Data Assimilation of Quality Control observations (BRAN2023, Chamberlain *et al*., 2021). Tides are specified using tidal harmonics from the global TPXO tide model (Egbert and Erofeeva, 2002) and stream flow for 64 rivers come from a combination of the GBR dynamic SedNet model (McCloskey *et al*., 2021) and flow gauges. River temperature is derived from the BARRA surface air temperature using a low-pass filter. The daily files, containing individual river tracer plumes available on NCI (ih54), were used to estimate the cumulative sum of each river tracer concentration per year from the beginning of the wet season (i.e. 1 November to 30 October the following year). Tracer concentrations were calculated based on the available model output data for the period (1 November 2022 to 3 April 2025).

The cumulative exposure index integrates the tracer concentration above a defined threshold (1%). It is a cumulative measurement of the exposure concentration and duration of exposure to dissolved inputs from individual river sources. It is expressed as Concentration × Days (Conc.Days). For example, if a grid cell was exposed to concentrations of 5% river water for 2 days, this gives an exposure index of 0.1 (0.05 x 2). If a grid cell was exposed to concentrations of 50% river water for 10 days, this gives an exposure index of 5 (0.5 x 10). Whenever river water concentration is greater than 1%, the exposure index is calculated and added to all other exposures in that wet season (i.e., it is cumulative). This index provides a consistent approach to assessing relative differences in exposure of Reef shelf waters to inputs from the 54 rivers.

The mathematical formulation that expresses this concept is given below:

$$\text{Conc.Days} = \sum_{t=0}^{T} \text{Conc}_{exceedance} * \text{t}$$

where,

$$\text{Conc}_{exceedance} = \begin{cases} \text{Conc(t) - Conc}_{threshold}, \text{ where Conc(t)} > \text{Conc}_{threshold} \\ 0, \quad \text{where Conc(t)} \leq \text{Conc}_{threshold} \end{cases}$$

and $\text{Conc}_{threshold}$ is defined here as 1% of the river concentration, Conc(t) represents the time-varying tracer concentration, and t is time in days from the beginning of the wet season (t_0 = 1 October) and $T_{\text{end of wet season}}$ = 1 May. Cumulative exposure is calculated for each grid point in the model domain.

In this step, the end-of-catchment load for fine sediment, DIN, or PN was dispersed for each river assuming a direct relationship between pollutant and tracer concentration (conservative mixing). Thus, the surface load of fine sediment, DIN, or PN per km^2 was calculated as:

$$Surf.load = \frac{\text{tracer}}{pixel} \times \frac{[\text{total load}]}{[\text{sum of tracer}]} \times \frac{pixel}{km^2}$$

The total Reef surface load was calculated by summing the surface load outputs for the 54 rivers for which tracer data were available. This includes all 35 major drainage basins in the Reef catchment, with an additional 19 smaller rivers and streams (see Appendix B).

The difference between the estimated wet season fine sediment, DIN, and PN loadings (tonnes km^2) in the Reef lagoon for the current water year was calculated and compared to the pre-development loads derived from the Source Catchments model (which have a degree of uncertainty; refer to McCloskey *et al.,* 2021). This can be interpreted as 'anthropogenic' fine sediment, DIN, or PN loadings, highlighting the areas of greatest change with current land use characteristics.

2.5 Pesticides

2.5.1 Sampling design

The monitoring campaign used grab sample and passive sampling technologies for the monitoring of 25 pesticides (Table 2-4) at 8 fixed sites. In addition, flood events were monitored using grab water samples to capture pesticides in flood waters entering inshore locations. The 2024–25 campaign continued to assess the risk from pesticides posed to the Reef, as well as add to a longitudinal dataset to aid with catchment management.

The typically low concentrations of pesticides present in marine waters raise analytical challenges as well as challenges in obtaining representative samples. Grab samples collected at a single time point are extremely effective at capturing episodic contaminant events and can conveniently be taken at monitoring sites to measure acute exposure. However, they may not allow sufficient concentration of pesticides when concentrations are extremely low. Further, they may not reflect chronic exposure of contaminants as the timing of the sample collection (whether at a peak or low concentration event) would not be representative of chronic exposure over time. The use of passive sampling technologies has been introduced to complement and overcome some of these challenges, substantially furthering contaminant monitoring in liquid phases over the last 30 years. Benefits of passive sampling tools include *in situ* concentration of chemical pollutants, increased sensitivity, the provision of time-weighted average concentration estimates for chemicals over periods of approximately one month, increased data resolution, and risk profiling. Passive samplers designed to monitor polar chemical pollutants (called Empore™ Disks; EDs) have been chosen for deployment in this program due to their effectiveness at capturing the target pesticides. Polydimethylsiloxane (PDMS) samplers have been used in previous monitoring campaigns to monitor non-polar pesticides but were not utilised during the 2024–25 monitoring year. The list of target chemicals for inclusion in the monitoring campaign was identified based on an assessment and review by the MMP and the Department of Environment Tourism Science and Innovation (DETSI). They include 25 pesticides (Table 2-4) that are of potential high use in the catchment areas and that may pose high risk based on marine species sensitivity indexes.

Table 2-4: List of pesticides sampled by the MMP and pesticides used in the Pesticide Risk Metric (PRM) calculation. For pesticides sampled by the MMP, limits of reporting (LOR) in Empore Disk (ED) passive samplers and grab samples are given.

Group	Analyte	ED LOR (ng sample^{-1})	Grab sample LOR (ng sample^{-1})
PSII Herbicide	Ametryn*	5.00	0.070
	Atrazine*	1.00	0.170
	Bromacil	1.00	0.200
	Diuron*	0.500	0.130
	Fluometuron	1.00	0.100
	Hexazinone*	1.00	0.170
	Metribuzin*	1.00	0.300
	Prometryn*	1.00	0.200
	Propazine	1.00	0.170
	Simazine*	1.00	0.130
	Tebuthiuron*	1.00	0.100
	Terbuthylazine*	1.00	0.200
	Terbutryn	5.00	0.170
Other Herbicide	2,4-D*	5.00	0.230
	Fluazifop	0.100	0.170
	Fluroxypyr*	1.00	0.400
	Haloxyfop*	1.00	0.170
	Imazapic*	1.00	0.530
	Isoxaflutole (DKN)*^	n/a	n/a
	MCPA*	5.00	0.230
	Metsulfuron methyl*	1.00	0.270
	Pendimethalin*^	n/a	n/a
	Metolachlor (S+R)*	1.00	0.100
	Triclopyr*^	n/a	n/a
Herbicide Metabolites	Atrazine desethyl	1.00	0.170
	Atrazine desisopropyl	1.00	0.200
Insecticide	Chlorpyrifos*^	n/a	n/a
	Fipronil*^	n/a	n/a
	Imidacloprid*	1.00	0.170
Fungicide	Tebuconazole	1.00	0.130

*Pesticides included in the Pesticide Risk Metric (PRM) calculation (Warne *et al*. 2020)

^Pesticides not sampled as part of the MMP (5 of the 22 in the PRM)

2.5.2 Pesticide sampling

Eight fixed monitoring sites were sampled over the wet season only, between November 2024 and May 2025 (Table A-2 and Table A-3). Sampling sites were chosen based on catchment information, modelled predictions of pesticide exposure (Skerratt et al., 2023) and to address eReefs modelling input and validation needs. The sites were located in 3 NRM regions including the Wet Tropics (3 sites at Low Isles, High Island, and Dunk Island), Burdekin (Haughton River Mouth), and Mackay-Whitsunday (4 sites at Whitsunday Channel, Repulse Bay, Flat Top, and Sandringham Bay) (Figure 2-3).

Empore disk (ED) passive samplers (n = 40) were deployed at each site during this campaign (Table A-2). Grab samples (n = 45) were collected for assessing baseline chemical levels during the passive sampler deployment/retrieval periods at the same monitoring locations (Table A-3). In addition, flood grab samples (n = 71) for assessing flood plume effects were collected from the Wet Tropics, Burdekin, and Mackay-Whitsunday regions in February 2025 (Table A-3). Chemical analyses included 25 polar pesticide chemicals (ED passive samplers and grab samples) using the latest analytical methods and established standard operating protocols (SOPs).

Two methods were used to assess the risk from pesticides detected across sites and sampling periods. Maximum concentrations of pesticides detected from grab and passive samplers were compared with Australian Freshwater and Marine Species Protection Guidelines (ANZG 2018), and the pesticide risk metric (PRM) (Warne *et al*. 2020; 2023). As described in Section 2.5.8 the PRM considers the combined mixture toxicity of 22 pesticides, of which 17 are measured for this program (see Table 2-4).Figure 2-3Table A-2

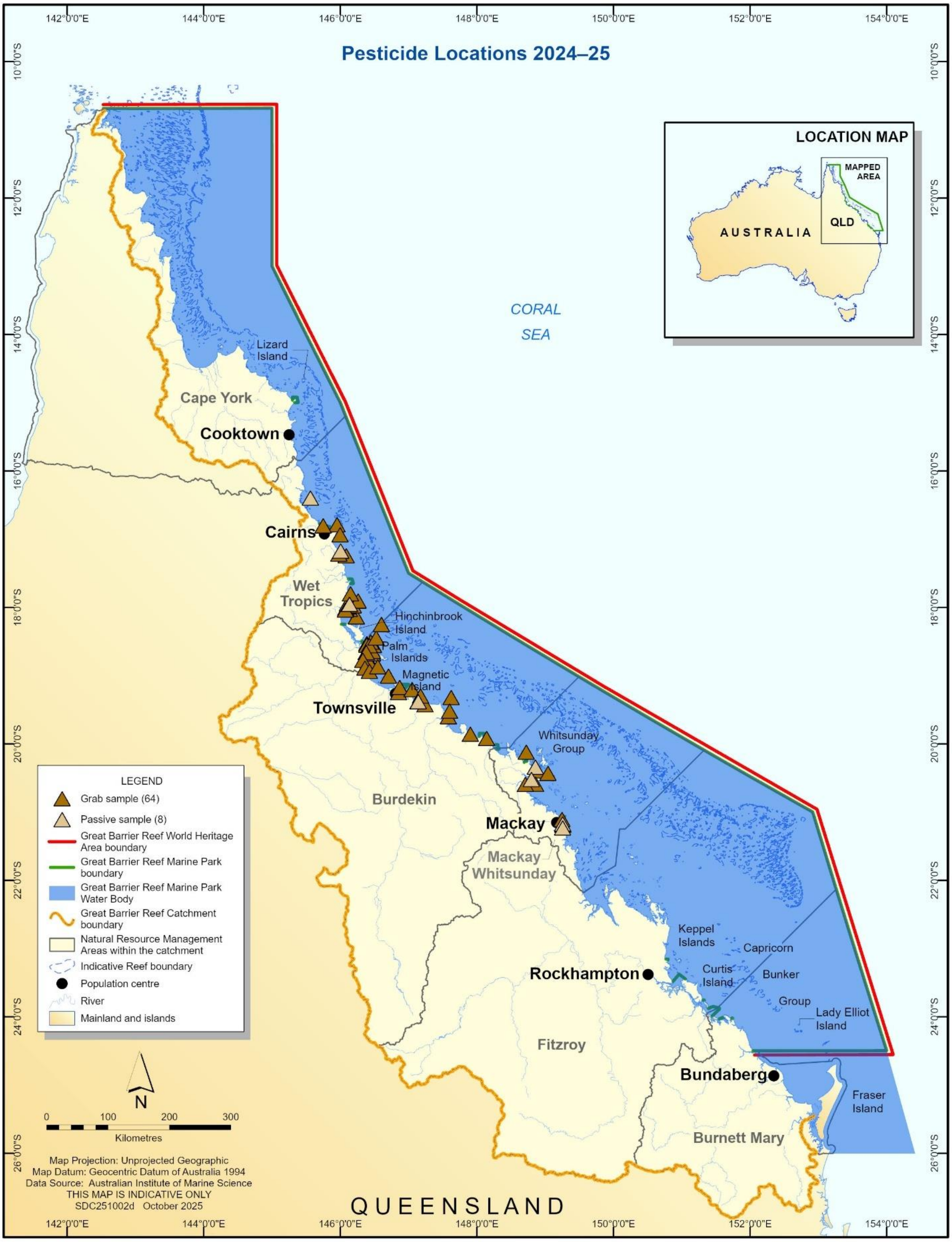


Figure 2-3: Site locations for pesticide monitoring sampled during the 2024–25 water year.

2.5.3 Grab samples

2.5.4 Passive flow monitors

Passive flow monitors (PFMs) were co-deployed in duplicate with passive samplers and were used to estimate water velocity (Appendix C) during the deployment period of the samplers (O'Brien *et al.* 2009, 2011a, 2011b; Figure 2-4). As the rate of diffusion of chemicals into a passive sampling device is a function of the turbulence or water velocity at the surface of the sampler, it is important to monitor this parameter to accurately estimate water concentrations of the target chemicals. PFMs provide a means of estimating water velocity based on the dissolution of calcium sulfate hemihydrate from the surface of the exposed PFM (13.85 cm^2) which is equal to that of the exposed surface of the membranes within the ED passive samplers.

The PFMs were prepared according to the method of O'Brien *et al*. (2009). Further details can be found in QA/QC Manual (Gruber *et al.* 2025).

Figure 2-4: Passive flow monitors (PFMs) prior to deployment (left) and after deployment (right).

2.5.5 Sampler preparation and extraction

ED passive samplers were all prepared and extracted according to established SOPs and previously published procedures and methods described in Kaserzon *et al.* (2017).Grab samples (using 1 L high-density polyethylene bottles) were prepared and extracted according to established SOPs and previously published procedures and methods described in Kaserzon *et al.* (2014). Briefly, samplers were extracted using hydrophilic-lipophilic balanced solid phase extraction (SPE) cartridges (Strata X, Phenomenex, Melbourne). Samples were concentrated 1,000 times to increase analytical limits of detection.

2.5.6 Analytical methods

Chemical analyses were performed at Queensland Alliance for Environmental Health Sciences (QAEHS) using established standard operating procedures (SOPs). ED and grab extracts were analysed by liquid chromatographic-triple quadrupole tandem mass spectrometry for 25 polar pesticides. The analytical methods for pesticides are detailed in previously published reports (Kaserzon *et al.,* 2018; Gruber *et al.,* 2025). QAEHS laboratory procedures are performed in accordance with established Standard Operating Procedures (SOPs). Blank ED passive samplers were prepared, extracted and analysed in parallel with exposed samplers for each deployment period to ensure quality control and to prevent false positives. Laboratory blanks (n = 4) were prepared before each deployment and were retained at QAEHS for the duration of the deployment. These samplers were included with each batch to provide insight into any contamination arising in the laboratory from preparation or extraction. ED travel blanks (n = 5) were prepared in a similar manner, then were sent into the field and opened briefly before sealing and returned with the deployed samplers. Similarly blank grab water samples (containing ultrapure water) were extracted with each grab sample batch (n = 13). Duplicate passive samplers (n = 4) and grab samples (n = 9) were analysed to test replication of results. Where an analyte is detected in field or lab blanks above the Limit of Quantification (LOQ), the effective Limit of Reporting (LOR) is raised to the average blank value plus 3 times the standard deviation.

2.5.7 Data analyses - Modelling and reporting of results

Passive sampling enables estimation of time-integrated water concentrations (C_w) (i.e. an average water concentration over the deployment period) based on the amount of chemicals accumulated in the sampler within a given exposure period (Vrana *et al.,* 2005). The size and polarity of the contaminant, and other environmental factors, such as water flow, turbulence, and temperature can affect the rate at which chemicals are taken up into the sampler. This rate of uptake is referred to as a sampling rate (R_s) which is measured as volume of water sampled per day (L day^{-1}). Sampling rates are pre-determined from laboratory and/or field experiments for each chemical. A pre-determined R_s is used along with information on the duration of the deployment period and the mass accumulated in the sampler to estimate the average water concentration over the deployment period. The equation below describes the estimation of water concentration based on linear phase sampling.

$$C_W = \frac{C_S \times M_S}{R_S \times t} = \frac{N_S}{R_S \times t}$$

Where:

C_W = time-integrated concentration of the compound in water (ng L^{-1})

C_S = concentration of the compound in the sampler (ng g^{-1})

M_S = mass of the sampler (g)

N_S = amount of compound accumulated by the sampler (ng)

R_S = sampling rate (L day^{-1})

t = time deployed (days)

Calibration data (i.e. sampling rates (R_s) for each chemical) obtained in laboratory or field studies were used to derive concentration estimates in this report. Together with the sampling rates derived from calibration data, deployment-specific PFM data are used to correct for site-specific effects of water flow velocity on the sampling rates of chemicals (O'Brien *et al.,* 2009, 2011a, 2011b). For chemicals detected where no calibration data were available, results were either reported as ng sampler^{-1} or the data were reported via normalisation of sampling rate data with the sampling rate of a reference compound (i.e. atrazine). Methodologies used to calculate site-specific sampling rates during the deployment periods are fully described in Kaserzon *et al*. (2018).

2.5.8 Pesticide Risk Metric calculation

The Pesticide Risk Metric (PRM) developed by Warne *et al*. (2020; 2023) considers the toxicity of 22 pesticides, with results expressed as estimated percentage of species affected. These pesticides were classified into 3 categories: PSII herbicides, 'other' herbicides and insecticides (Table 2-4). Seventeen of the twenty-two pesticides were analysed during this sampling campaign for the ED and grab samples: ametryn, atrazine, diuron, hexazinone, metribuzin, prometryn, simazine, tebuthiuron, terbuthylazine, 2,4-D, fluroxypyr, haloxyfop, imazapic, MCPA, metsulfuron-methyl, metolachlor and imidacloprid.

The PRM method estimates the toxicity mixtures using species sensitivity distributions (SSDs), and the combining of mixture toxicity using the independent action (IA) model of joint action developed by Traas *et al.* (2002). The IA model of joint action can be described as below.

$$Pesticide\ mixture\ toxicity = 1 - \prod_i (1 - PAF_i)$$

Where ∏ represents the product of a sequence of numbers, and PAF_i is the potentially affected fraction of each pesticide active ingredient (PAI) calculated using SSDs. The resulting PAI mixture toxicity is expressed as the proportion of species affected (i.e., between 0 and 1), so this number is multiplied by 100 to achieve the percentage of species affected. Calculations were performed using the WQI PRM calculator (Water Quality & Investigations 2024b).

The PAF estimates represent instantaneous mixture toxicity at the time of collection for grab samples, and time weighted average mixture toxicity for the duration of deployment for passive samples. Each PAF estimate is the percentage of species affected by the mixtures and concentrations of PAIs observed in the grab and passive samplers, respectively. The PRM method replaces values below the LOR with a fraction of the batch-specific LOR that is standardised according to the toxicity of each PAI. This is done to minimise the introduction of toxicity through treatment of <LOR data that would occur with other more popular treatment methods (e.g., by halving the LOR). Further information on the methods for PRM calculation, including treatment of <LOR data, is provided in Warne *et al.* (2023).

Results are presented as percentage of species affected by the mixtures and concentrations observed in the grab and passive samplers, respectively, and are useful for comparison against the Reef 2050 WQIP target which is to protect at least 99% of aquatic species at the end of catchments.

3 DRIVERS AND PRESSURES INFLUENCING WATER QUALITY IN 2024–25

3.1 Coastal development including agriculture

The Wet Tropics, Burdekin, Mackay-Whitsunday, and Fitzroy regions are characterised by a variety of land uses including agricultural (sugarcane, grazing, cropping, and other horticulture), mining, and urban development. Parts of the Cape York region are less developed than other Reef catchments. Land-based activities in this region are assumed to have a reduced impact on marine ecosystems (Waterhouse *et al.*, 2025) despite a history of widespread grazing and mining impacts. Specifically:

- Cape York
    - The Pascoe River catchment has an area of 2,088 km^2 with a high proportion (84%) of nature/conservation land use (QLUMP, 2015), and limited active grazing areas (Polglase pers. comm., February 2023). Feral cattle and pigs, fire, and road erosion are the main pressures affecting water quality. These impacts are considered to be minimal in this focus region relative to other Cape York and Reef catchments (Cape York NRM and South Cape York Catchments, 2016).
    - The Stewart River catchment has an area of 2,770 km^2 and is mostly conservation lands (94%) with approximately 2% current grazing land use (QLUMP, 2021). However, feral cattle continue to graze much of the catchment area. Current and legacy cattle grazing impacts and road erosion are current pressures affecting sediment loads within the catchment.
    - The Normanby Basin is 24,550 km^2 and has a high proportion of nature/conservation land use (~52%) and grazing (~47%) (QLUMP, 2021). Horticulture accounts for less than 1% of land use but has been expanding in the Laura and West Normanby sub-catchments. Current and historic cattle grazing, post-European initiation and acceleration of gully erosion, agricultural land clearing, alluvial mining, wildfires, and road erosion are the primary pressures affecting water quality across the Normanby catchment (Brooks *et al.*, 2013; Shellberg and Brooks, 2013; Cape York NRM and South Cape York Catchments, 2016; Spencer *et al.*, 2016). Horticulture in the Laura sub-catchment has also increased nutrient concentrations in the Laura River (Howley 2020).
    - The Annan-Endeavour River Basin is 2,186 km^2 and has a high proportion of conservation lands (72%) and grazing (24%) (QLUMP, 2021). Approximately 80% of the Annan catchment is under conservation or Aboriginal freehold. Sources of pollution in the Endeavour catchment include urban runoff (Cooktown), cattle grazing, horticulture, and road erosion. Historic mining disturbances, cattle grazing impacts (current and historic), wildfires, and road erosion are the primary sources of pollution to the Annan River (Shellberg *et al.*, 2016).
- Wet Tropics
    - The Barron-Daintree focus region is primarily influenced by discharge from the Daintree, Mossman, and Barron catchments and, to a lesser extent, by other Wet Tropics rivers south of the focus region (Waterhouse *et al.*, 2025). The Daintree catchment is 2,107 km^2 and has a high proportion of protected areas (86% conservation lands). The remaining area consists of 8% grazing and, to a lesser extent, sugarcane and urban areas. The Mossman catchment is 479 km^2 and consists of 73% natural/minimal use lands, 9% sugarcane, and smaller areas of grazing and urban land uses. The Barron catchment has an area of 2,189 km^2 and consists of 35% conservation lands, 31% grazing, 11% forestry, 11% cropping (including sugarcane, horticulture, and irrigated crops), and smaller areas of dairy and urban land uses (QLUMP 2021). The Barron River is the most hydrologically modified river in the Wet Tropics region and is heavily regulated by water supply infrastructure.
    - The Russell-Mulgrave Basins contain a high proportion of conservation lands (72%), with 12% of the area used for sugarcane production on the coastal floodplain (QLUMP 2021). The Johnstone Basin is 2,326 km^2 and has a relatively high proportion of conservation lands (56%). The remaining area has 23% grazing, 11% sugarcane, 2%

bananas, and small areas of dairy (in the upper catchment), other crops, and urban land uses (QLUMP 2021).
  - The Tully River Basin is 1,685 km^2 and has a high proportion of conservation lands (73%). The remaining area is comprised of 12% sugarcane, 3% bananas, 7% grazing, and smaller areas of forestry, other crops and urban land uses (QLUMP 2021). The Murray River Basin has an area of 1,115 km^2 and has a high proportion of conservation lands (62%). The remaining area is comprised of 17% sugarcane, 9% forestry, 7% grazing and smaller areas of bananas, other crops and urban land uses. The Herbert River Basin is 9,842 km^2 and consists of 32% conservation lands, 50% grazing (in the upper catchment), 8% sugarcane (largely on the coastal floodplain), and smaller areas of forestry (QLUMP 2021).
- The Burdekin region is one of the 2 large dry tropical catchment regions adjacent to the Reef. The region is primarily influenced by discharge from the Burdekin and Haughton, and to a lesser extent, the Ross and Black Rivers, with cattle grazing as the primary land use on over 86% of the catchment area (QLUMP 2021). There is also intensive irrigated sugarcane on the floodplains of the Haughton and Burdekin basins, with smaller areas in the Don and Black basin. The city of Townsville is located in the Ross basin with residential extending into the Black basin. Fluctuations in climate and cattle numbers greatly affect the state and nature of vegetation cover and, therefore, the susceptibility of soils to erosion and off-site transport of suspended sediments and associated nutrients.
- The Mackay-Whitsunday region has a mixed wet and dry tropical climate. The region is influenced by the Proserpine, O'Connell, Pioneer, and Don basins. Land use in the region is dominated by agriculture broadly divided into grazing in the upper catchments (43%), sugarcane cultivation on the coastal plains (17%), and dispersed areas of conservation (19%) (QLUMP 2021). The largest areas of sugarcane are in Plane basin (26% of the basin area). In addition, there are expanding urban areas along the coast with the major centres of Mackay in the Pioneer Basin (4% of the basin area).
- The Fitzroy region has a sub-tropical, semi-arid climate with high inter-annual variability in rainfall, high evaporation rates, and prolonged dry periods followed by infrequent major floods. It is largest NRM region in the Reef catchment area. The region is mainly influenced by the Fitzroy River and to much a lesser extent, the Styx, Shoalwater, Calliope, and Boyne Rivers. The primary land use in the Fitzroy region is cattle grazing (77%), followed by conservation lands (8%) and forestry (7%) (QLUMP 2021). This extensive grazing area supports 55% of the cattle in the Reef catchment area (Lewis *et al*., 2021). Mining is another prominent industry in the area, accounting for 1,023 km^2 of the catchment. The region holds 75% of Queensland's active coal mines and 47% of its gas mines (QLUMP, 2019).

3.2 Climate and cyclone activity

Climate is a major driver of the condition of water quality and ecosystems and can vary substantially between years. It is heavily driven by the El Niño Southern Oscillation (ENSO) cycle. Climate models predict continued warming, increasing intensity of extreme rainfall events, fewer but more intense tropical cyclones, and more frequent and extreme La Niña and El Niño events (Schaffelke *et al.*, 2017).

The 2024–25 wet season had no notable cyclone influence in the Reef (Figure 3-1). Tropical Cyclone Alfred influenced South East Queensland but remained well offshore from the Reef and did not influence the southern areas of the Reef.

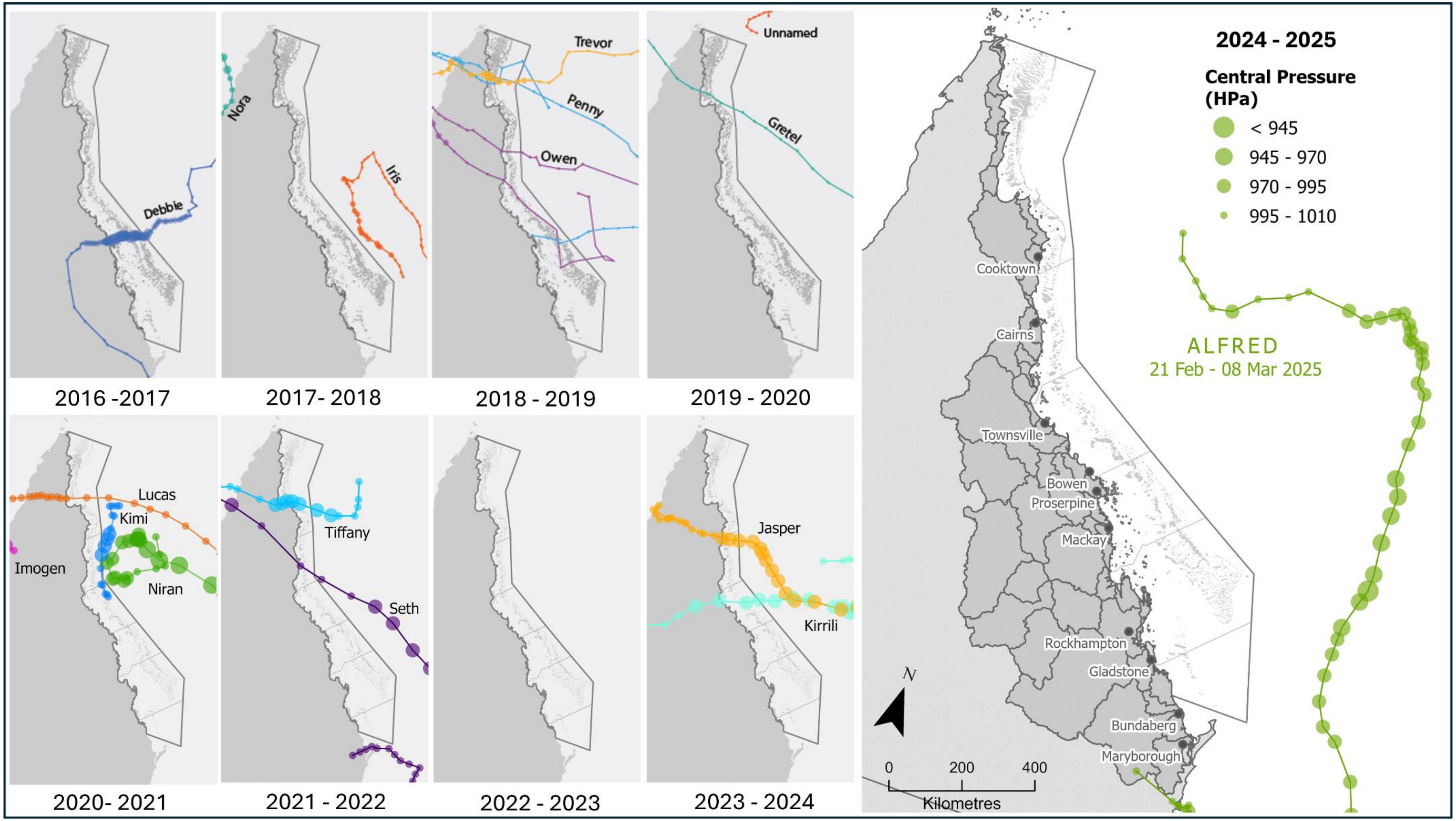


Figure 3-1: Trajectories of tropical cyclones affecting the Reef in the 2024–25 water year (1 October to 30 September) and in previous 8 years.

3.2.1 *Rainfall for the Reef, NRM regions, and basins*

Queensland rainfall is highly variable on seasonal, inter-annual, and decadal timescales. Wet season (December to April) rainfall in 2024–25 was above the 30-year long-term average (1961 to 1990) in the Wet Tropics, Burdekin, Mackay-Whitsunday, and Burnett-Mary regions, and similar to the average for the Cape York and Fitzroy regions (Figure 3-2 and

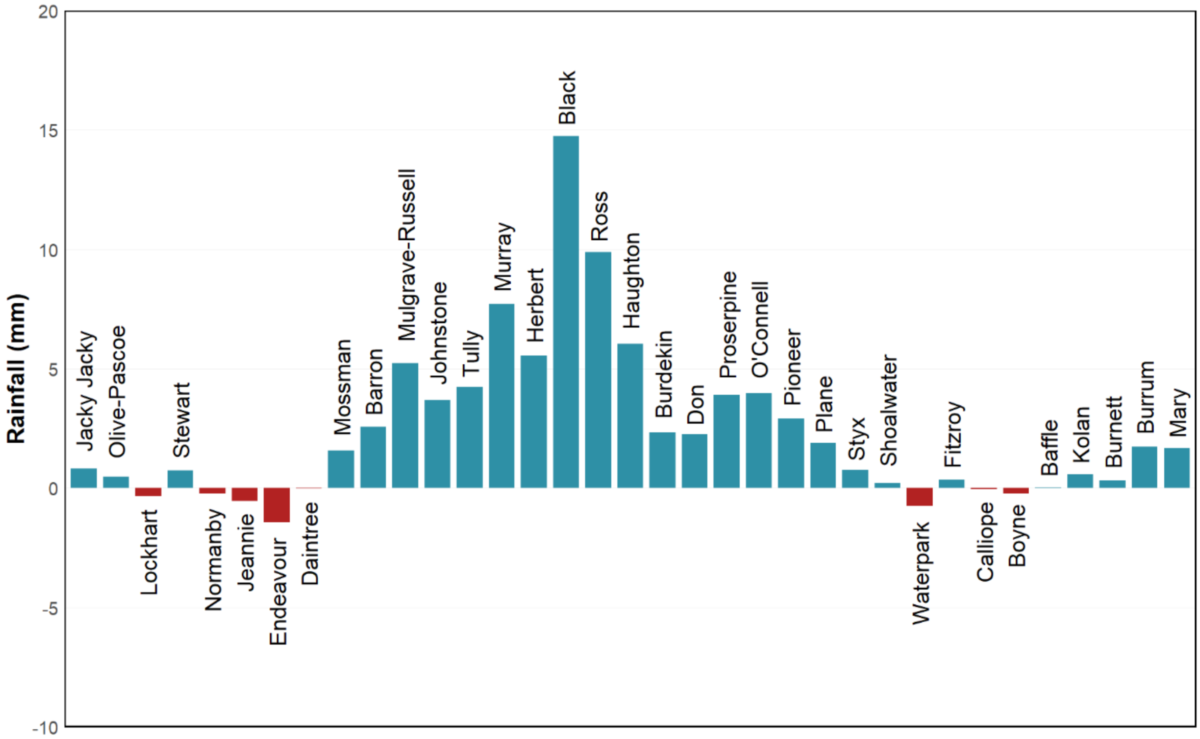


Figure 3-3). Some basins in the central region of the Reef including the Murray, Herbert, Black, Ross and Haughton had substantially higher rainfall rates than long-term averages.

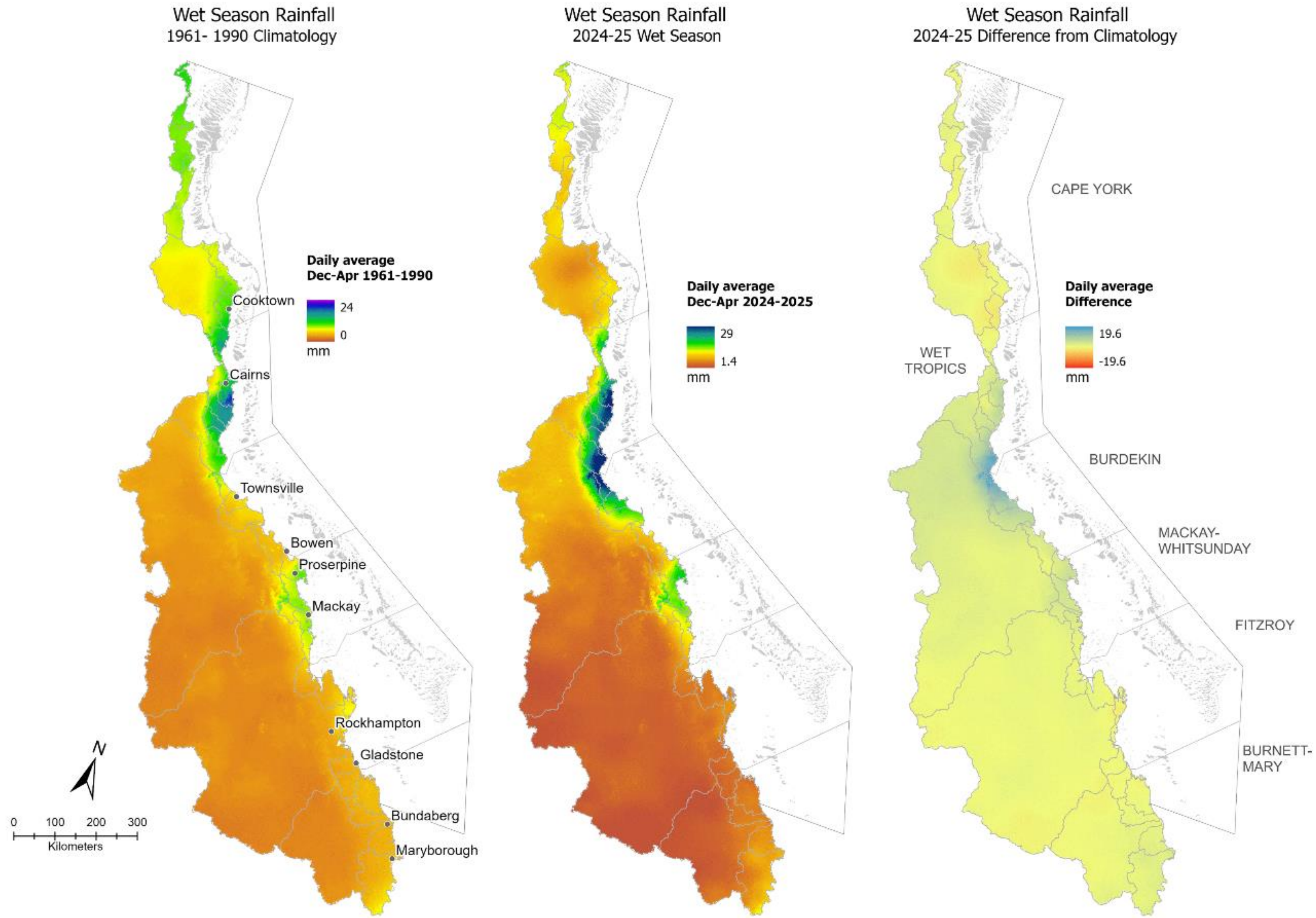


Figure 3-2: Average daily wet season rainfall (mm d^{-1}) in the Reef catchment (left) long-term daily average (1961–1990, produced by BoM), (centre) 2024–25 wet season, and (right) the difference between the long-term average and 2024–25 rainfall. Source data: Bureau of Meteorology (2025).

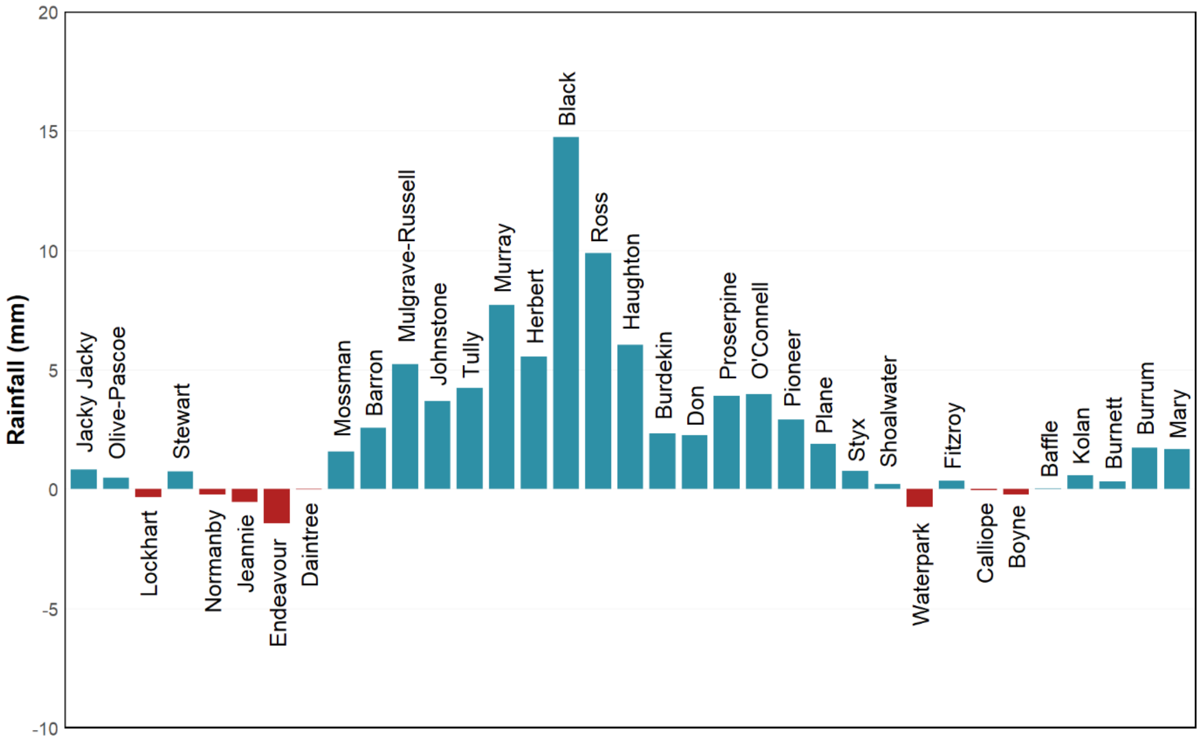


Figure 3-3: Difference between daily average rainfall (for the period December 2024–April 2025 within the 2024–25 wet season) and the long-term rainfall average (for the same period within each wet season from 1961–1990). Red and blue bars denote basins with rainfall below and above the long-term average, respectively. Note that the basins are ordered from north to south (left to right). Source data: Bureau of Meteorology (2025).

3.2.2 Freshwater discharge for the Reef, NRM regions, and basins

Freshwater discharge volumes into the Reef lagoon are closely related to rainfall during the wet season and have a significant influence on coastal water quality (Lough et al., 2015; Moran et al., 2025). The total annual freshwater discharge for all of the Reef basins relative to long-term medians is shown in Figure 3-4. Discharge at the regional level is shown in Figure 3-5.

In 2024–25, the overall Reef catchment area had discharge of 1.9 times the long-term median, the largest discharge since the extreme 2010–11 water year. On a regional basis, the Burdekin Mackay-Whitsunday and Burnett Mary NRM regions had discharge much higher than their respective long-term medians (6.8, 2.8, and 3.4 times, respectively) with above long-term median discharge from the Cape York and Wet Tropics NRM regions (1.4 and 1.6 times, respectively). Indeed, discharge from the Burdekin region for the 2024–25 water year was the highest since the extreme 2010–11 water year. Discharge from the Fitzroy NRM region was slightly above the long-term median (1.2 times).

Annual discharge for each of the 35 Reef basins in 2024–25 is shown in Table 3-1 and compared to long-term median annual flows. All 5 basins within the Burdekin NRM region had discharge exceeding 3 times their respective long-term medians. The Burnett, Burrum, and Mary basins also had discharge exceeding 3 times their respective long-term medians. All 4 basins of the Mackay-Whitsunday region as well as the Barron and Herbert basins had discharge between 2 and 3 times their respective long-term medians. The Jacky Jacky, Jeannie, Endeavour, Mossman, and Murray basins all recorded discharge between 1.5 and 2.0 times their long-term medians (Table 3-1).

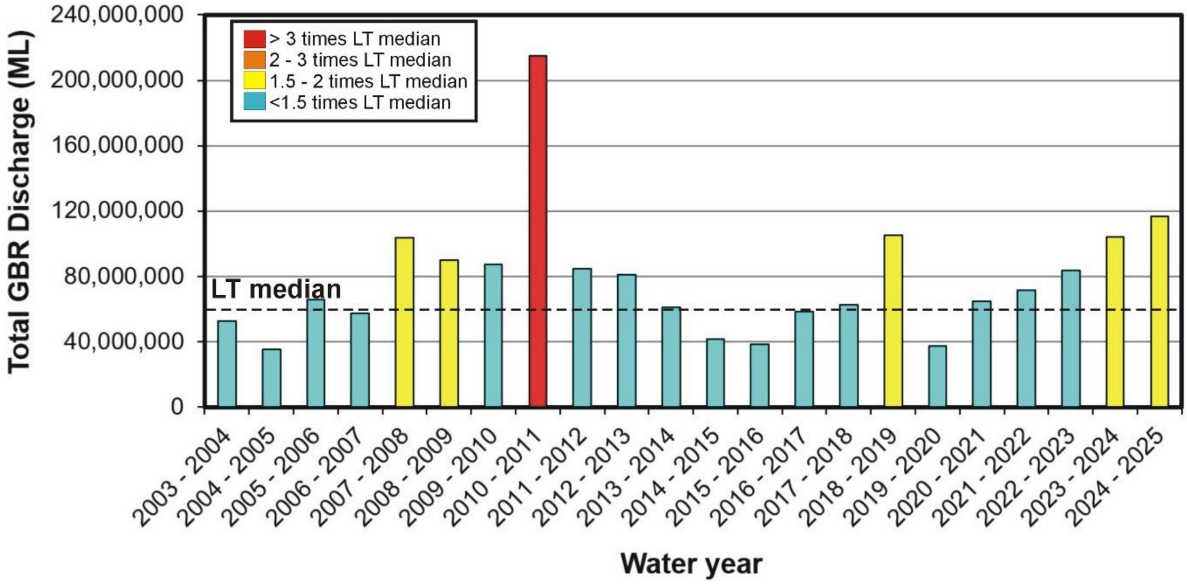


Figure 3-4: Long-term total annual discharge in ML (water year: 1 October to 30 September) for the 35 main Reef basins. Source: QLD Department of Local Government, Water and Volunteers (2025), https://water-monitoring.information.qld.gov.au/.

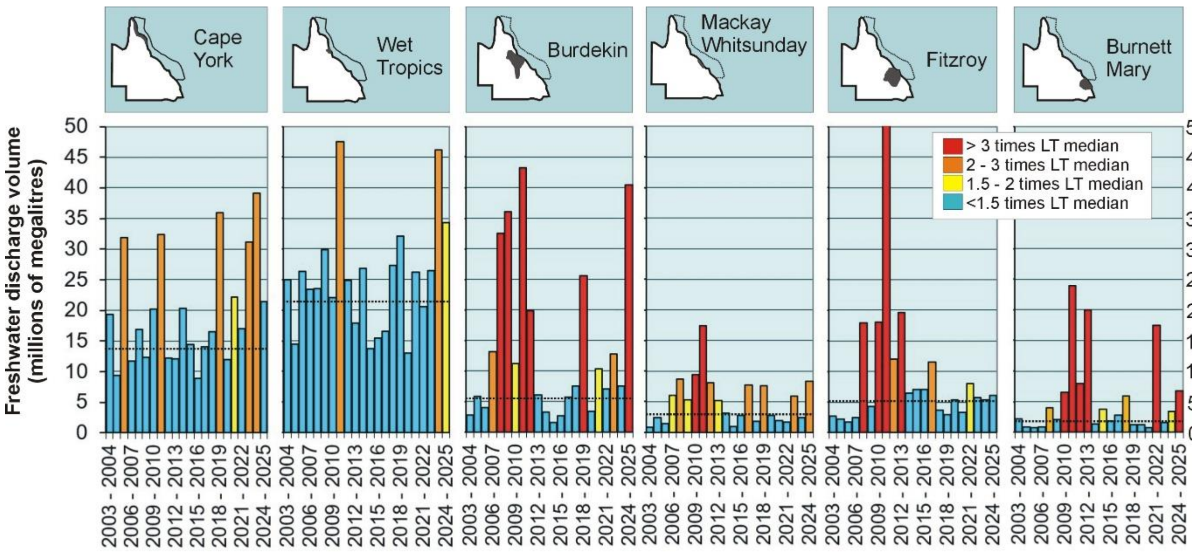


Figure 3-5: Corrected annual water year (1 October to 30 September) discharge from each NRM region (using the correction factors in Table 2-3) for 2003–04 to 2024–25 in (ML per year). The dotted line for each NRM region represents the 30-year long-term median taken from 1990–91 to 2019–2020. Data derived from QLD Department of Local Government, Water and Volunteers (2025), https://water-monitoring.information.qld.gov.au/.

Table 3-1: Annual water year discharge (millions of ML) of the 35 main Reef basins (1 October 2021 to 30 September 2025, inclusive) and 30-year long-term (LT) median discharge (1990–91 to 2019–20). Colours indicate levels above the long-term median: yellow for 1.5 to 2 times, orange for 2 to 3 times and red greater than 3 times.

Basin	LT median	2021–22	2022–23	2023–24	2024–25
Jacky Jacky Creek	2.47	2.37	4.61	3.49	4.04
Olive Pascoe River	3.18	4.88	6.05	6.05	3.79
Lockhart River	1.54	2.36	2.93	2.93	1.83
Stewart River	0.76	0.57	1.37	1.10	0.04
Normanby River	3.86	3.56	11.79	16.30	5.28
Jeannie River	1.43	1.57	2.09	4.44	2.73
Endeavour River	1.58	1.73	2.31	4.88	3.01
Daintree River	1.92	2.52	4.69	9.18	2.75
Mossman River	0.60	0.80	0.82	1.75	0.97
Barron River	0.62	0.69	1.22	3.60	1.36
Mulgrave-Russell River	4.22	4.09	4.29	6.79	5.09
Johnstone River	4.80	4.71	5.39	8.16	6.55
Tully River	3.39	3.18	3.66	5.56	4.58
Murray River	1.48	1.27	1.53	2.60	2.28
Herbert River	3.88	3.28	4.92	8.52	10.74
Black River	0.29	0.27	0.35	0.53	2.34
Ross River	0.28	0.26	0.48	0.31	2.40
Haughton River	0.56	0.74	1.22	0.58	3.58
Burdekin River	4.41	5.44	9.70	5.75	30.58
Don River	0.50	0.38	1.00	0.37	1.54
Proserpine River	0.86	0.45	1.87	0.62	2.48
O'Connell River	0.84	0.43	1.82	0.60	2.41
Pioneer River	0.62	0.28	0.76	0.59	1.34
Plane Creek	1.06	0.49	1.44	0.63	2.14
Styx River	0.63	1.08	0.85	1.03	0.65
Shoalwater Creek	0.73	1.25	0.98	1.19	0.75
Water Park Creek	0.39	0.82	0.60	0.77	0.41
Fitzroy River	2.88	4.51	3.08	2.10	3.86
Calliope River	0.26	0.25	0.14	0.17	0.23
Boyne River	0.18	0.17	0.04	0.09	0.15
Baffle Creek	0.35	1.00	0.17	0.42	0.28
Kolan River	0.12	0.82	0.08	0.14	0.13
Burnett River	0.26	3.89	0.36	0.60	1.25
Burrum River	0.13	1.61	0.27	0.48	0.93
Mary River	0.91	10.14	0.67	1.81	4.18
Sum of basins	60.75	71.87	83.55	104.11	116.66

4 MODELLING AND MAPPING MARINE WATER QUALITY

4.1 Satellite remote sensing of Reef water types

To illustrate wet season influence on coastal water quality and identify potential risk to ecosystems, annual satellite-derived map products were produced for the whole Reef. This includes frequency maps predicting the areas affected by the Reef WT1–2 combined (Figure 4-1) or the 3 Reef water types individually (Figure 4-2) for the period from December 2024 to April 2025 (within the 2024–25 wet season). The December–April period is used here to provide consistency with other remote sensing products and historical satellite data.

4.1.1 Areas affected

The extent and frequency of the occurrence of combined Reef WT1 and WT2 was variable across regions, cross-shelf, and between years, reflecting the concentrations and intensity of the river discharge and resuspension events (Figure 4-1). A well-documented inshore to offshore gradient is clearly visible (for example, Devlin *et al.*, 2013, 2015), with coastal areas experiencing the highest frequency of the Reef WT1 and mid-shelf and offshore areas less frequently exposed to the Reef WT1 (Figure 4-2) and more frequently to the Reef WT2 and WT3. Cloud cover can influence the availability of data and therefore influence the results, and is accounted for to some extent in the methodology of the products (as described in Appendix B).

Frequency of occurrence: The frequencies of occurrence of the combined Reef WT1 and WT2 were greater than the mean long-term frequencies in the central Reef, including the southern Cape York, parts of the Wet Tropics and Burdekin regions, and in the Burnett-Mary region (Figure 4-1a,e,f), reflecting wetter conditions in these regions. Frequencies were lower in the northern Cape York, the Mackay-Whitsunday, and Fitzroy regions, but with some local variability in the Mackay-Whitsunday region. These results generally agreed with the rainfall distribution in 2025, except in the Mackay-Whitsunday region where there was high cloud cover during large discharge events, likely resulting in underestimations in the frequency of all water types (Figure 3-2). The frequencies of occurrence measured across the Tully focus region were above the frequencies recorded during typical wet seasons (Figure 4-1g, blue and black lines) particularly in the mid-shelf and offshore areas, highlighting the scale of the flood events across the region in February and March, and the potential influence from the Herbert and Burdekin rivers moving north. The frequencies of occurrence in the Burdekin River also showed a higher occurrence in offshore areas (Figure 4-1g).

Reef area exposed: In 2024–25, 5% of the Reef was exposed to the Reef WT1, 21% to the Reef WT2 and 61% to the Reef WT3 (Figure 4-3b and Table C-10). The area exposed to the Reef WT1 exceeded both the long-term and coral recovery period percentages (3% of the Reef). Inshore Reef waters (enclosed coastal and open coastal) were significantly exposed to the Reef WT1 (Figure 4-3c: 73% and 32% of their respective total waterbody areas). Additionally, a small percentage of the mid-shelf waterbody was also exposed to the Reef WT1, representing 3% of its total waterbody area). The area exposed to the Reef WT2 (21% of the Reef) exceeded both the long-term (17%) and coral recovery period percentages (16% of the Reef). 99% of the total open coastal, 64% of the total enclosed coastal, 30% of the total mid-shelf waterbody areas were exposed to the Reef WT2. Additionally, 4% of the total offshore area was also exposed to the Reef WT2.

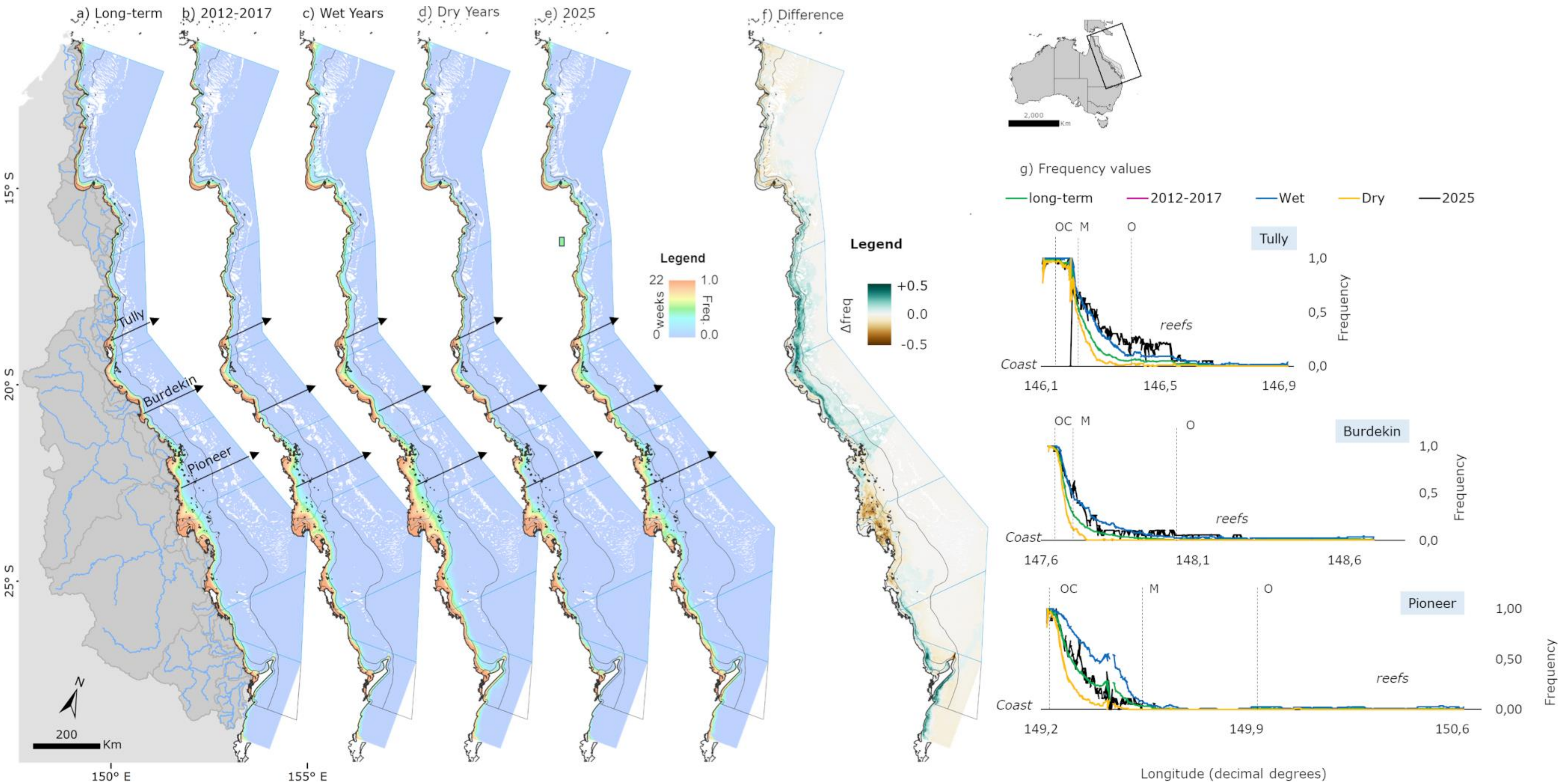


Figure 4-1: Map showing the frequency of the Reef WT1–2 combined in the a) long-term (20 wet seasons since 2002–03) b) representative coral recovery period (2011–12 to 2016–17, 6 wet seasons or 132 weeks), c) typical wet-year composite, d) typical dry-year wet season composites and e) 2024–25 wet season (represented by the 22 weeks from December - April). The 2024–25 frequency maps were produced using Sentinel-3 images and the FU colour scale. Previous wet seasons (prior to 2021) and reference period composites have been produced using both MODIS satellite imagery and the wet season colour scale (Waterhouse et al., 2021) and Sentinel-3 satellite imagery and the Forel-Ule colour scale (from 2021). The highest frequency is shown in orange and the lowest frequency is shown in blue. f) Difference map showing areas with an increase (in blue) and decrease (in brown) in exposure to Reef WT1–2 in 2024–25 against long-term trends (calculated as (e) 2025 minus (a) long-term). g) Plots on the right show the frequency values recorded along 3 transects extending from the Tully, Burdekin, and Pioneer Rivers to the external boundaries of the Marine Park and illustrate the differences in the spatial distribution and frequency of occurrence between the different representative periods. OC: open coastal, M: mid-shelf and O: offshore marine water body boundaries.

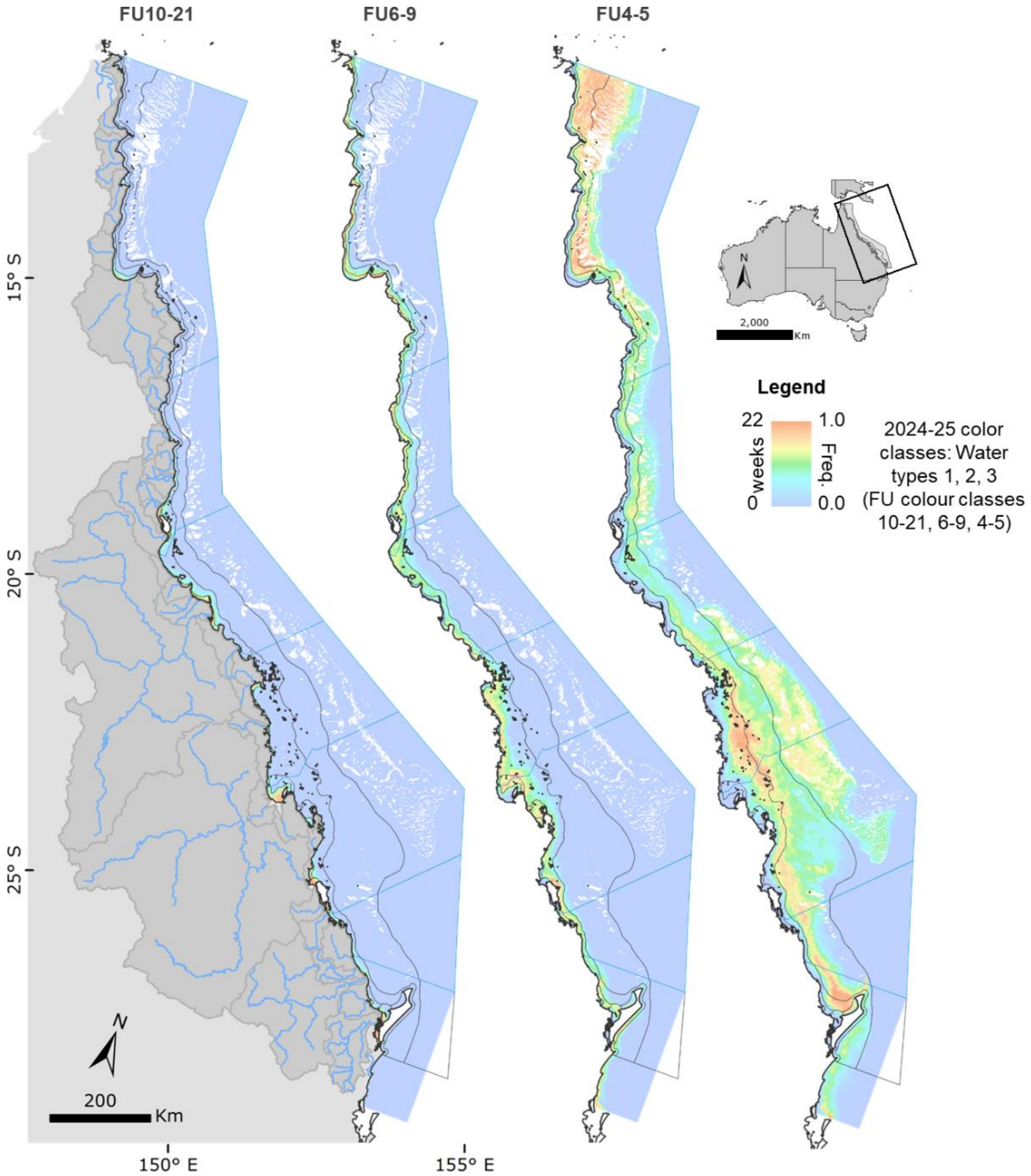


Figure 4-2: Map showing the frequency of the Reef WT1 (FU10–21), WT2 (FU6–9), and WT3 (FU4–5) in the 2024–25 wet season (represented by the 22 weeks from December - April). The highest frequency is shown in orange and the lowest frequency is shown in blue. These maps are used in the exposure assessment to represent the spatial likelihood of exposure of each of the wet season water types in 2024–25.

Figure 4-3: a) Areas (km²) and b) percentages (%) of the Reef lagoon (total 348,839 km²) affected by the different Reef water types including division by waterbodies (enclosed coastal, open coastal, mid-shelf, and offshore) and waters affected by the Reef WT1–2 combined, and c) the 3 Reef water types individually during the current wet season and for a range of reference periods (24: 2024–25 wet season, LT: long-term, CR: Coral Recovery, W: Wet years, and D: Dry years). The data are presented in detail in Table C-10.

In 2024–25, as in the 4 previous years, the Reef area exposed to Reef WT3 (61% of the Reef) was greater than the long-term average (53% of the Reef) and the ‘wet’ year’s area (58% of the Reef) (Figure 4-2 and Figure 4-3). This result is related to large areas exposed to Reef WT3 measured in the mid-shelf and offshore Reef (97% and 30% of the total mid-shelf and offshore waterbody areas, respectively). This result may be a reflection of the large extent of river influence observed in satellite imagery in February 2025 but can also be linked to shelf upwelling in the central and southern Reef areas. Image classification by optical type does not directly elucidate the cause of variations in water colour, and Reef WT3 in particular (but also, to some extent, Reef WT1 and WT2 in some coastal areas) is sometimes due to oceanographic processes not related to catchment runoff. This could be further investigated in a future case study by comparing Reef WT3 areas with sea-surface temperature climatology (for example, Wijffels *et al.*, 2018) and comparison with eReefs modelling results to understand the drivers of these conditions. While Reef WT3 areas were larger than in the reference periods, this did not result in increasing the potential risk offshore as 100% of the offshore areas were classified as no/very low potential risk in the 2024–25 exposure assessment (Figure 4-6 and Figure 4-7). Reef WT3 is associated with low land-based contaminant concentrations and has a low magnitude score in the Reef exposure assessment (Figure 4-4 and Figure 4-5).

4.1.2 Composition of Reef water types

Detailed summaries of water quality parameters for the long-term period (20 wet seasons) and reporting year are provided in Appendix B. Boxplots of long-term water quality parameters are shown in Figure 4-4 and are fully described below.

Mean long-term concentrations of water quality parameters showed similar patterns between focus regions, with maximum concentrations measured in Reef WT1 and minimum concentrations in Reef WT3 (Figure 4-4). However, there were distinct differences in the concentrations of individual parameters across regions. Across years, the frequency of sampling in flood events as well as the location, timing, and number of samples historically collected in each region is a major influence on these results. 4.1.3Figure 4-5

The long-term mean TSS, Chl-*a*, PP, and PN concentrations (± standard deviation) were above the Reef-wide wet season guideline values (GVs) in the Reef WT1 and WT2, with Chl-*a* only slightly above in Reef WT2 (Chl-*a* = 0.65 ± 0.75 µg L^{-1}) and only the long-term mean PN concentration was above the wet season GV in the Reef WT3 (PN = 28.30 ± 21.31 µg L^{-1}) (Figure 4-5). Using these data, magnitude scores in the exposure mapping were calculated as the proportional exceedance of the GVs, and negative magnitude scores capped to zero (Figure 4-5). Magnitude scores have no defined ecological significance but are used in the risk framework as a relative measure to assign potential risk grading (through the magnitude scores) for each Reef water type (refer Section 4.1.3).

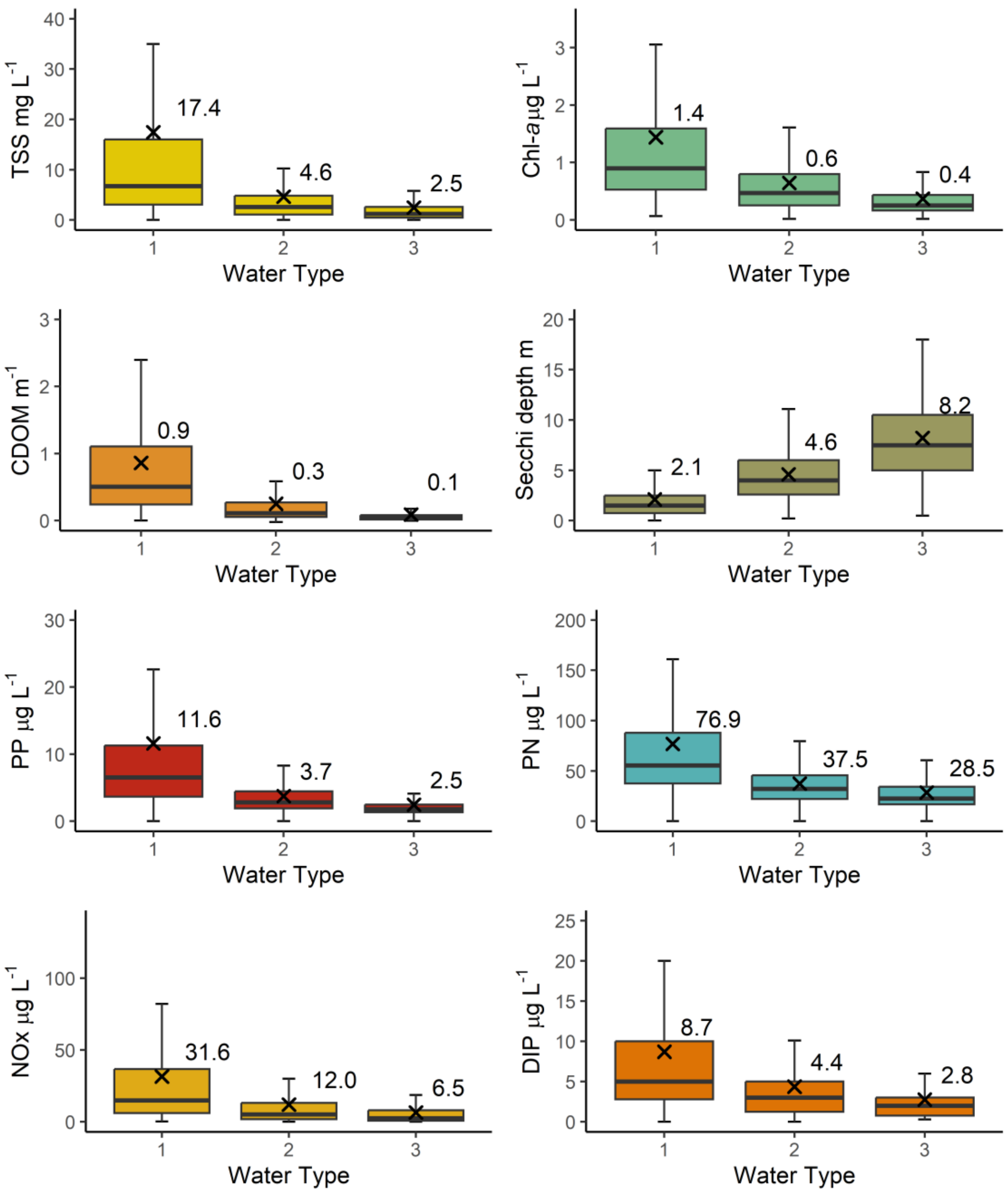


Figure 4-4: Long-term (2004–2023) concentrations of water quality parameters and Secchi disk depth boxplots for each Reef Water Type. (WT1, WT2, and WT3). Water types were extracted from the MODIS-Aqua (2004–2020) and Sentinel-3 (2021–2023) weekly satellite databases. The mean is plotted as a cross (x) and its numerical value is indicated in text. The interquartile range is delimited by the box and the median by the line inside the box. Whiskers indicate variability outside the upper and lower quartiles. Data beyond the whiskers range are considered outliers and are not plotted.

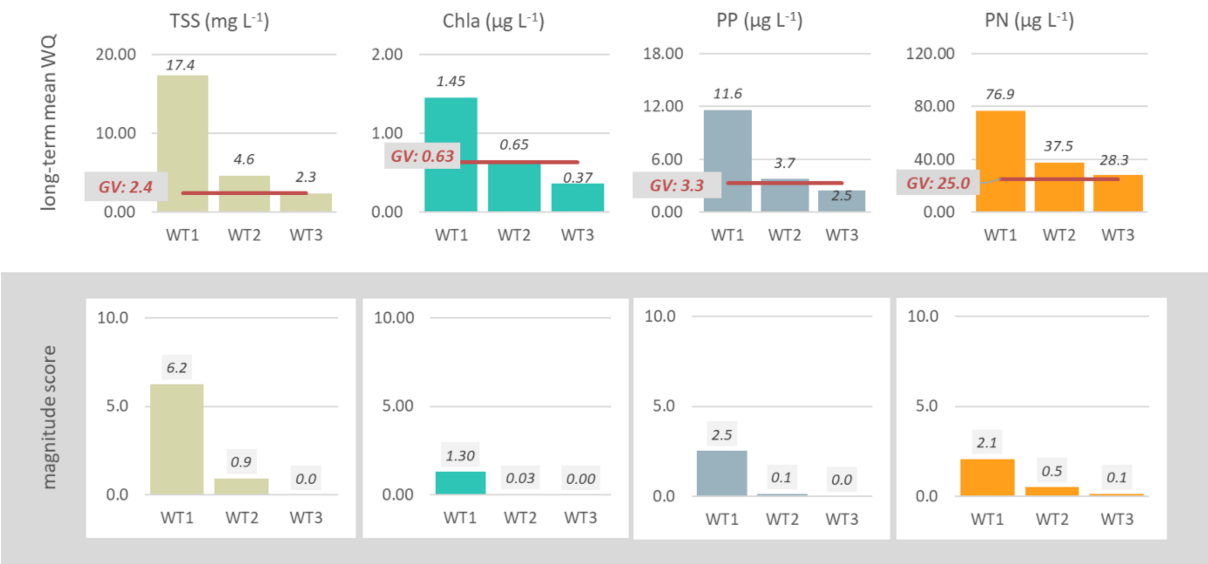


Figure 4-5: Mean long-term concentrations of water quality parameters (top) and magnitude scores across the 3 Reef water types (bottom). Red lines show the Reef-wide wet season GVs (Table B-4). Magnitude scores are calculated as the proportional exceedance of the guideline: $magnitude_{water\ type} = ([Poll.]_{water\ type} - GV)/GV$ and Poll. = TSS, Chl-*a*, PP, or PN. Negative magnitude scores are scored as zero.

4.1.3 Potential exposure risk of Reef ecosystems to wet season water quality

This section reports the area (km^2) and percentage (%) of coral reefs and seagrass meadows exposed to different categories of potential risk, based on satellite-derived Reef water types.

It is outside the scope of this report to validate the potential risk categories against ecological health data and the categories therefore represent relative potential risk for seagrass and coral reef ecosystems. However, the relationship between Reef WT1 and Reef WT2 conditions and ecosystem health has been explored in several published papers (e.g. Ceccarelli *et al.*, 2020; Wenger *et al.*, 2016; Petus *et al.*, 2014). The areas and percentages of ecological communities affected by the different potential risk categories were calculated as a relative measure between regions and the long-term average. The Wet Tropics and Burdekin regions had the largest areas with elevated exposure compared to the long-term average. There were also some areas of elevated exposure in the open coastal areas within the Burnett-Mary region, most likely related to relatively high river discharge in the region (3.4 times long-term median).

Reef-wide: The area exposed to a potential risk from wet season water quality in 2024–25 was spatially limited relative to the scale of the Reef with 90% exposed to no or very low potential risk (Table 4-1 and Figure 4-6e). This result is similar to the long-term average (91% of the Reef), although there were variations at a regional scale which reflect the patterns in river discharge. Approximately 10% of the Reef was exposed to combined potential risk categories II–IV, which is still a relatively large area at approximately 33,900 km^2. However, only 1% of the Reef was in the highest potential risk category (IV) and only 2% of the Reef was in category III (Table 4-1); the total area of these categories combined was 11,226 km^2. These patterns were very similar to the long-term averages (Table 4-1). Patterns were also similar across marine regions, with more than 79% of each region classified as no/very low potential risk and less than 4% classified as category III or less than 2% in category IV (Figure 4-7b). It is important to note that while these percentages are relatively small, the total areas are still significant, especially when considering specific habitat areas. The Wet Tropics and Burdekin regions had the highest exposure to the potential risk categories III and IV.

Reef waterbodies: The inshore Reef waters, including the enclosed (macro-tidal enclosed coastal and enclosed coastal waterbodies combined) and open coastal (macro-tidal open coastal and open coastal waterbodies combined) were the most largely exposed to the highest categories of potential risk (III and IV, Figure 4-7a), and a very small proportion of the mid-shelf water (0.1 %) was also exposed to the potential risk category III this wet season, related to higher potential risk exposures measured in the Wet Tropics and Burdekin regions which occurred over relatively large areas (Figure 4-7b). Open coastal waters were largely exposed to the lowest category of potential risk (no/very low potential risk = 44% and II: 41%) and only 14% and 1% of the open coastal waters where exposed to the potential risk category III and IV. The enclosed coastal waters had the largest proportion of waters classified as higher relative potential risk, with 48% of the combined inshore waters exposed to potential risk category IV. Approximately 77% (<3,600 km^2) of Reef seagrasses occur in the inshore waters, but only 4% (<900 km^2) of coral reefs. The mid-shelf and offshore waterbodies were largely classified as no/very low potential risk (92% of the mid-shelf and 100% of the offshore waters) (Figure 4-7a).

Table 4-1: Areas (km^2) and percentages (%) of the Reef, Reef-wide coral reefs, and Reef-wide surveyed seagrass exposed to different potential risk categories during the 2024–25 wet season and the long-term (2003–2022). The last 3 rows show the differences between % exposed in 2024–25 and the long-term average (red: increase, blue: decrease, and green: no change, difference <5%). Areas south of the Marine Park (Hervey Bay) are not included.

Total surface area exposed		Total		Potential Risk category				Total area exposed II–IV
				No / very low	Lowest		Highest	
				I	II	III	IV	
Reef-wide	area	348,839	2025	314,982	22,632	7,428	3,798	33,857
			LT	317,183	23,596	4,247	3,813	31,657
	%	*100%*	2025	90%	6%	2%	1%	10%
			LT	91%	7%	1%	1%	9%
Reef-wide coral reefs	area	24,914	2025	24,111	431	227	146	803
			LT	24,072	564	179	99	842
	%	*100%*	2025	97%	2%	1%	1%	3%
			LT	97%	2%	1%	0%	3%
Reef-wide surveyed seagrass	area	4,660	2025	1,329	1,869	854	608	3,331
			LT	1,373	1,943	609	734	3,287
	%	*100%*	2025	29%	40%	18%	13%	71%
			LT	29%	42%	13%	16%	71%
Difference (2024–25 to long-term average)	*Reef-wide*			<-1%	<-1%	<1%	<-1%	<1%
	Reef-wide coral reefs			<1%	<-1%	<1%	<1%	<-1%
	Reef-wide surveyed seagrass			-1%	-2%	5%	-3%	0.9%

Similar cross-shore patterns were observed across Reef marine regions, and all mid-shelf and offshore waterbodies were largely classified as no/very low potential risk (Figure 4-7c). Mid-shelf waterbodies in the Wet Tropics region had the greatest exposure to potential risk category II (53% of the Wet Tropics mid-shelf waterbody), followed by the Burdekin region (18% of the Burdekin mid-shelf waterbody). The Wet Tropics and Burdekin region open coastal waterbodies had the greatest exposure to potential risk categories III (38–39% of the Wet Tropics and Burdekin open coastal waterbodies, respectively), followed by the Burnett-

Mary region (26% of the Burnett-Mary region open coastal waterbody). In the other Reef regions, <10% of the open coastal waterbodies were exposed to potential risk categories III. Differences across regions are further described in the Regional Results section below (Section 4.3).

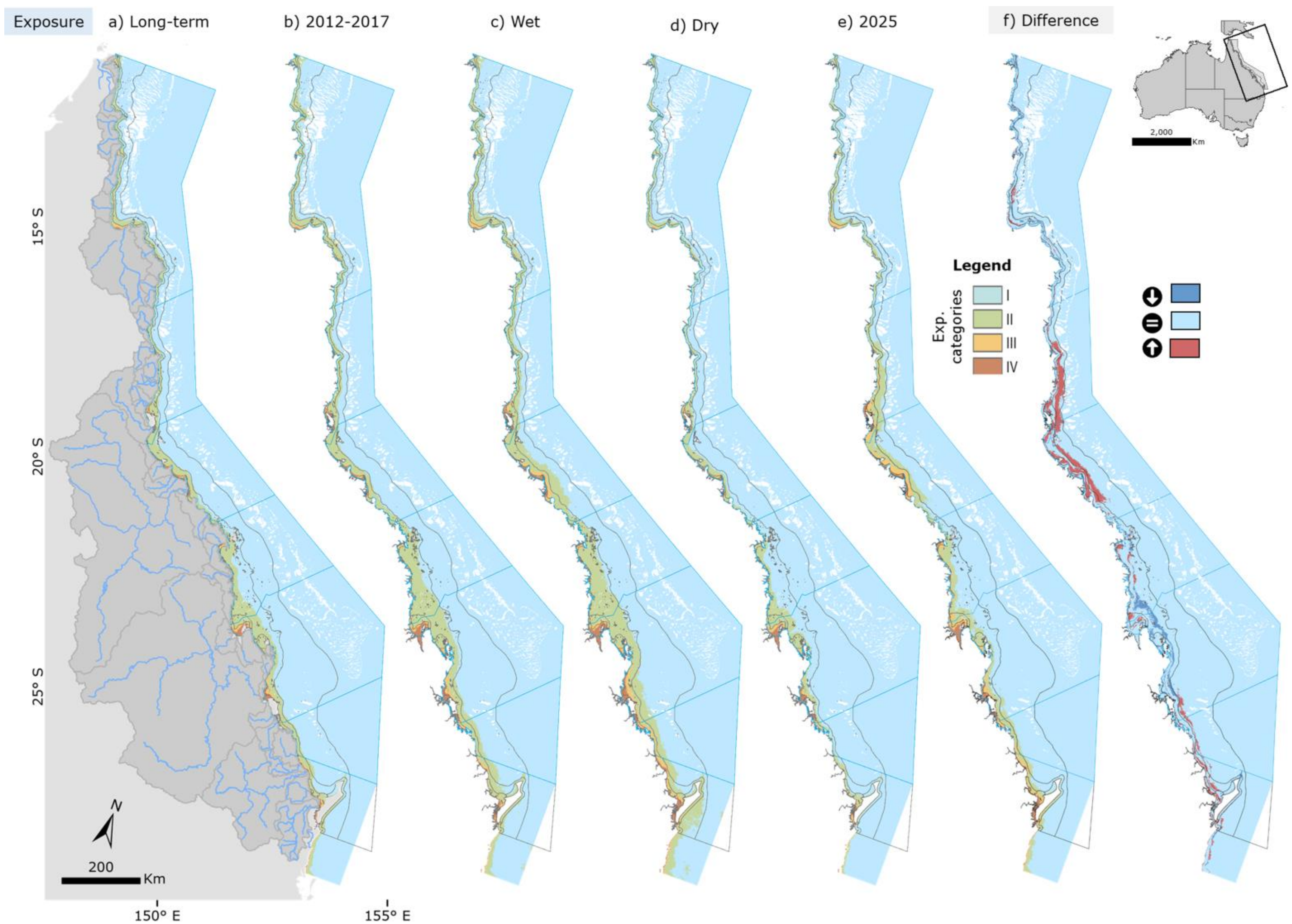


Figure 4-6: Map showing the potential risk of exposure of Reef ecosystems to wet season water quality measured in the a) long-term (20 wet seasons since 2002–03), b) representative coral recovery period (2012–2017, 132 weeks), c) typical wet-year and d) typical dry-year wet season composites and e) 2024–25 wet season (represented by the 22 weeks from December - April). Relative potential risk categories range from I: no/low potential risk to IV: highest relative potential risk. f) Difference map showing areas with an increase (in red, 🡅) and decrease (in purple, 🡇) in potential risk category in 2024–25 against long-term trends (calculated as (e) 2025 minus (a) long-term).

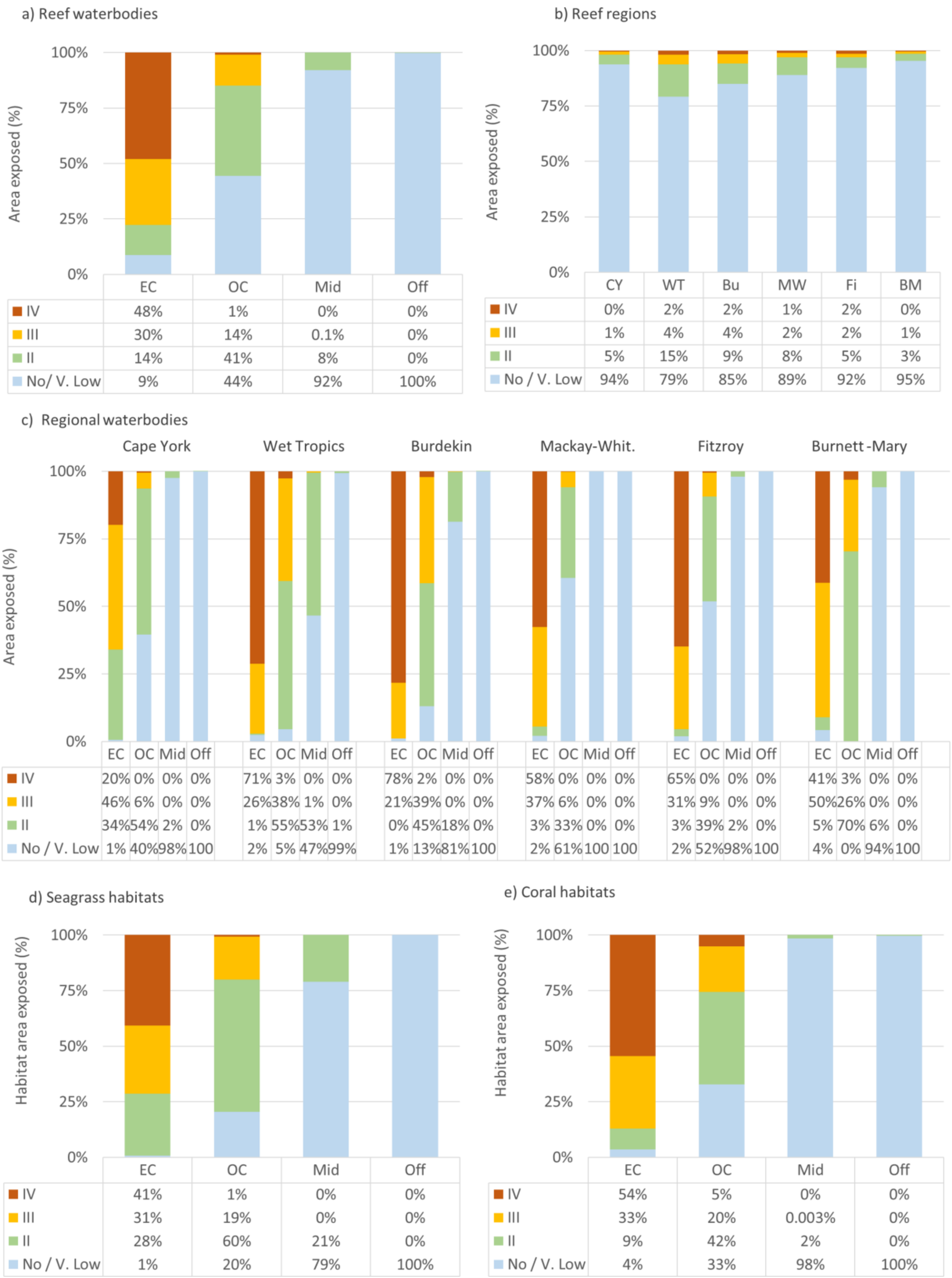


Figure 4-7: Percentage of the a) Reef waterbodies, b) Reef regions, c) regional Reef waterbodies, d) seagrass and e) coral habitats affected by different potential risk categories during the 2024–25 wet season. Water body classifications are shown along the x-axes: enclosed coastal (EC), open coastal (OC), mid-shelf (Mid), and offshore (Off).

Reef habitats (coral reefs and seagrasses): In 2024–25, it was estimated that:

- Approximately 3% of coral reefs (or 803 km^2) were exposed to combined potential risk categories II–IV (Table 4-1). Less than 2% were in the highest potential risk categories IV and III combined, and in all regions but the Burdekin, only the enclosed coastal and open coastal coral reef habitats were exposed, equating to 372 km^2. In the Burdekin region, a small proportion of the Burdekin mid-shelf corals were exposed to potential risk category III (less than 0.1 km^2). The total enclosed coastal coral reef area exposed to the highest potential risk categories was 87% (54% to potential cat. IV and 33% to cat. III, Figure 4-7e). Only 5% of the open coastal reefs were exposed to potential risk category IV and 20% to potential risk category III. Mid-shelf and offshore coral reefs were predominantly exposed to the lowest potential risk category II or to no potential risk, with a small proportion of the mid-shelf coral exposed to potential risk category III (2% of the mid-shelf coral reefs). The coral areas exposed to potential risk categories III and IV in 2024–25 were similar to the long-term averages (<2% of the coral reefs, Table 4-1) at the Reef-wide scale. However, exposure results varied widely between regions (see Section 4.3).
- Approximately 71% of seagrasses (or 3,331 km^2) were exposed to combined potential risk categories II–IV. Approximately 13% (608 km^2) were in the highest exposure category (IV) and 18% were in category III (854 km^2) and only the enclosed coastal and open coastal seagrass habitats were exposed (Figure 4-7d). The total enclosed coastal seagrass area exposed to the highest potential risk categories was 72% (41% to cat. IV and 31% to cat. III, Figure 4-7d). Approximately 19% of the open coastal seagrasses were exposed to potential risk categories III and 1% only were exposed to the highest potential risk category IV. Mid-shelf and offshore seagrasses were only exposed to the lowest potential risk category II or to no potential risk, although a majority of seagrass meadows are located in inshore areas. The seagrass areas exposed to combined potential risk categories II to IV in 2024–25 were similar to the long-term average. There was, however, an increase in area exposed to the potential risk category III (+5%).

4.2 Mapping the dispersal of river-derived DIN, fine sediment, and PN

An improved understanding of dispersal of river-derived DIN, fine sediment, and PN has been developed using the eReefs marine models. The process uses modelled dispersal of river plumes to assess potential cumulative annual exposure of each location to terrestrially-derived fine sediment or nitrogen. This analysis focuses on nitrogen derived from DIN or PN that might be transformed to other forms within the marine receiving environment, as these are the main labile (or biologically-available) fractions of nitrogen compared to the much more refractory (or non-biologically-available) dissolved organic nitrogen fraction (Lønborg *et al*. 2018). For all variables, the ‘anthropogenic’ influence was predicted by calculating the difference between a pre-development load scenario (i.e. using the flow data for 2024–25 and an annual mean concentration that represents natural land use) and the 2024–25 loading (see section 2.3 on how the loads were calculated). As described in Section 2 the method was adjusted to utilise the most recent eReefs model, which currently runs from to 2022 to April 2025. Therefore, the assessment was run for 2022–23, 2023–24 and 2024–25 to provide a point of comparison for the current year. The analysis is run for a pre-development load scenario and the 2024–25 load scenario, with the difference between the 2 used to generate an ‘anthropogenic’ loading map. Panels showing the 3 years of the anthropogenic loading maps for DIN, PN and TSS are presented in Figure 4-8 to Figure 4-13. The full suite of maps is available by contacting the authors of this report.

4.2.1 River-derived DIN dispersal

The estimated wet season river-derived DIN loading in the Reef lagoon for the 2024–25 water year is shown in Figure 4-8 with pre-development, anthropogenic and total load scenarios.

The spatial extent and intensity of the anthropogenic and total DIN load scenarios reflects the very high river discharge and DIN loads in the Wet Tropics, Burdekin, and Mackay-Whitsunday regions.

Figure 4-9 illustrates the spatial distribution of anthropogenic DIN across the Reef for 3 water years: 2022–23, 2023–24, and 2024–25 to provide an indication of the scale of influence between years. It shows that annual DIN loading and dispersal varies significantly across regions and years, with higher loadings consistently associated with the Burdekin, Herbert, and Fitzroy Rivers. The patterns are consistent with those from the previous methodology, extending back to 2003, with loading typically constrained to inshore areas. However, in large events like those experienced in 2024–25 the loading extends to mid-shelf areas. The 2022–23 map is typical of conditions generally seen in a year with river discharge close to the long-term median. However, 2023–24 shows the influence of the intensive events associated in the Barron and Daintree Rivers associated with Cyclone Jasper.

4.2.2 River-derived TSS dispersal

The estimated wet season river-derived TSS loading in the Reef lagoon for the 2024–25 water year is shown in Figure 4-10 with pre-development, anthropogenic and total load scenarios. The spatial extent and intensity of the anthropogenic and total TSS load scenarios reflects the well above average river discharge (6.8 times the long-term median) and associated TSS loads in the Burdekin region. The Wet Tropics rivers south of Cairns and particularly the Tully and Herbert Rivers, rivers in the Mackay Whitsunday region, and the Fitzroy and Mary Rivers, also experienced above-median discharge (1.2–3.4 times the long-term median), which is reflected in these scenarios.

Figure 4-11 illustrates the spatial distribution of anthropogenic TSS across the Reef for 3 water years: 2022–23, 2023–24, and 2024–25 to provide an indication of the scale of influence between years. It shows that TSS loading varies significantly across regions and years. The patterns are consistent with previous assessments, extending back to 2003 (e.g. Gruber et al., 2025), with loading typically constrained to inshore and in many places, coastal areas. However, similarly to TSS, the loading influence does extent to mid-shelf areas in 2024–25, which is comparable to the patterns observed in the large Burdekin floods in 2010–11 and 2019. The extent of loading influence was constrained in 2022–23 and 2023–24 with limited influence evident at the Reef-wide scale, however, small intensive areas are evident adjacent to river mouths.

4.2.3 River-derived PN dispersal

The estimated wet season river-derived PN loading in the Reef lagoon for the 2024–25 water year is shown in Figure 4-12 with pre-development, anthropogenic and total load scenarios. The spatial extent and intensity of the anthropogenic and total PN load scenarios reflect the end of catchment loads with the highest extent of loading in the Burdekin region, and to a lesser extent, the Wet Tropics rivers, rivers in the Mackay Whitsunday region, the Fitzroy River and rivers in the Burnett Mary region.

Figure 4-13 illustrates the spatial distribution of anthropogenic PN across the Reef for 3 water years: 2022–23, 2023–24, and 2024–25. As for DIN and TSS, it shows that PN loading varies significantly across regions and years, with higher loadings typically near river mouths including the Normanby, Russell Mulgrave, Johnstone, Herbert, Burdekin, Fitzroy and Mary Rivers. The areas of elevated PN loading are relatively constrained to the inshore areas, except in 2024–25 where the influence extended to the mid-shelf areas in the Wet Tropics region.

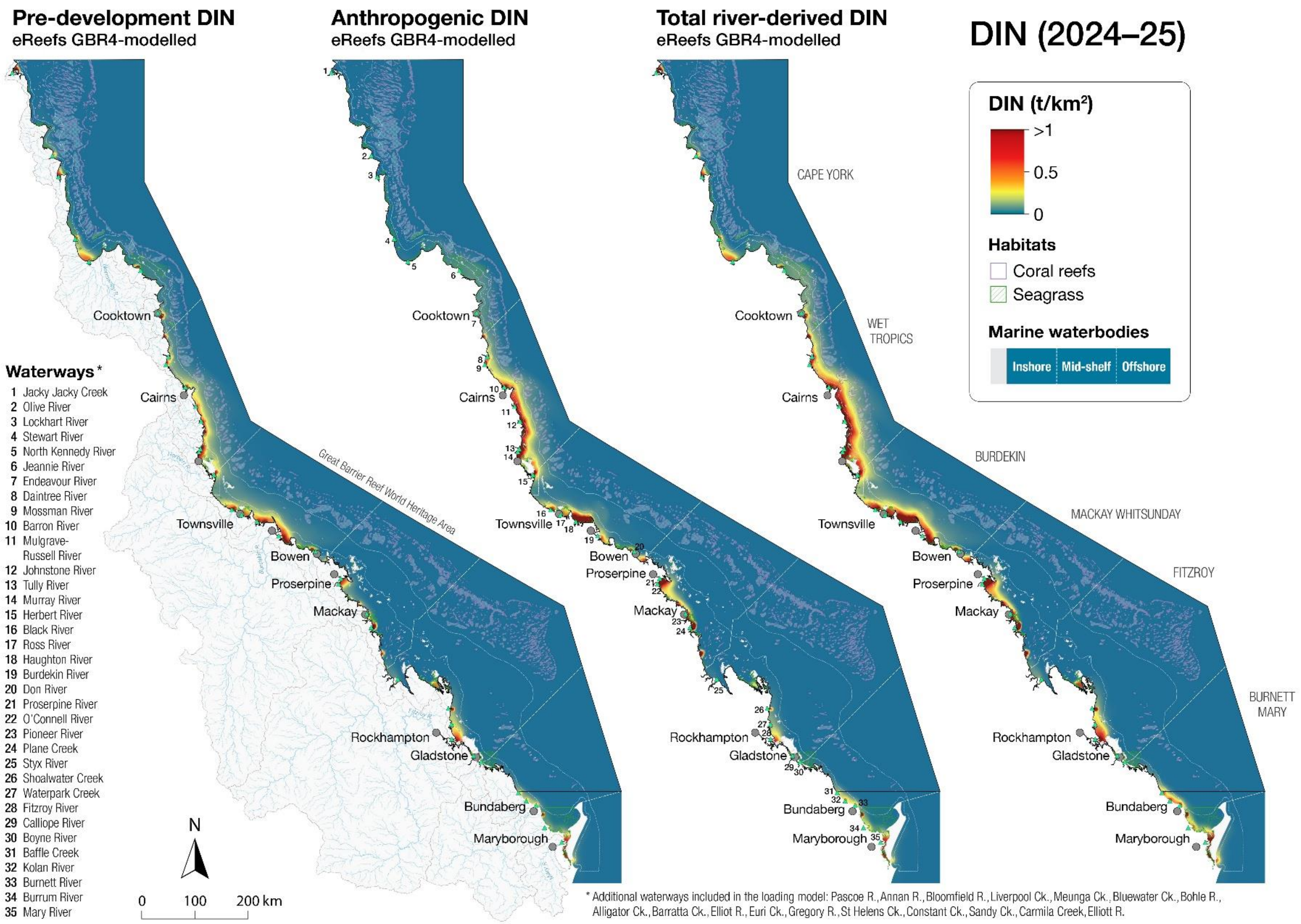


Figure 4-8: River-derived 'anthropogenic' DIN loading (tonnes km^{-2}, relative scale) in the Reef lagoon, modelled for the pre-development loads scenario (left panel), anthropogenic loads (difference between total and pre-development scenario, centre panel), and total load scenario (right panel) for the 2024–25 water year.

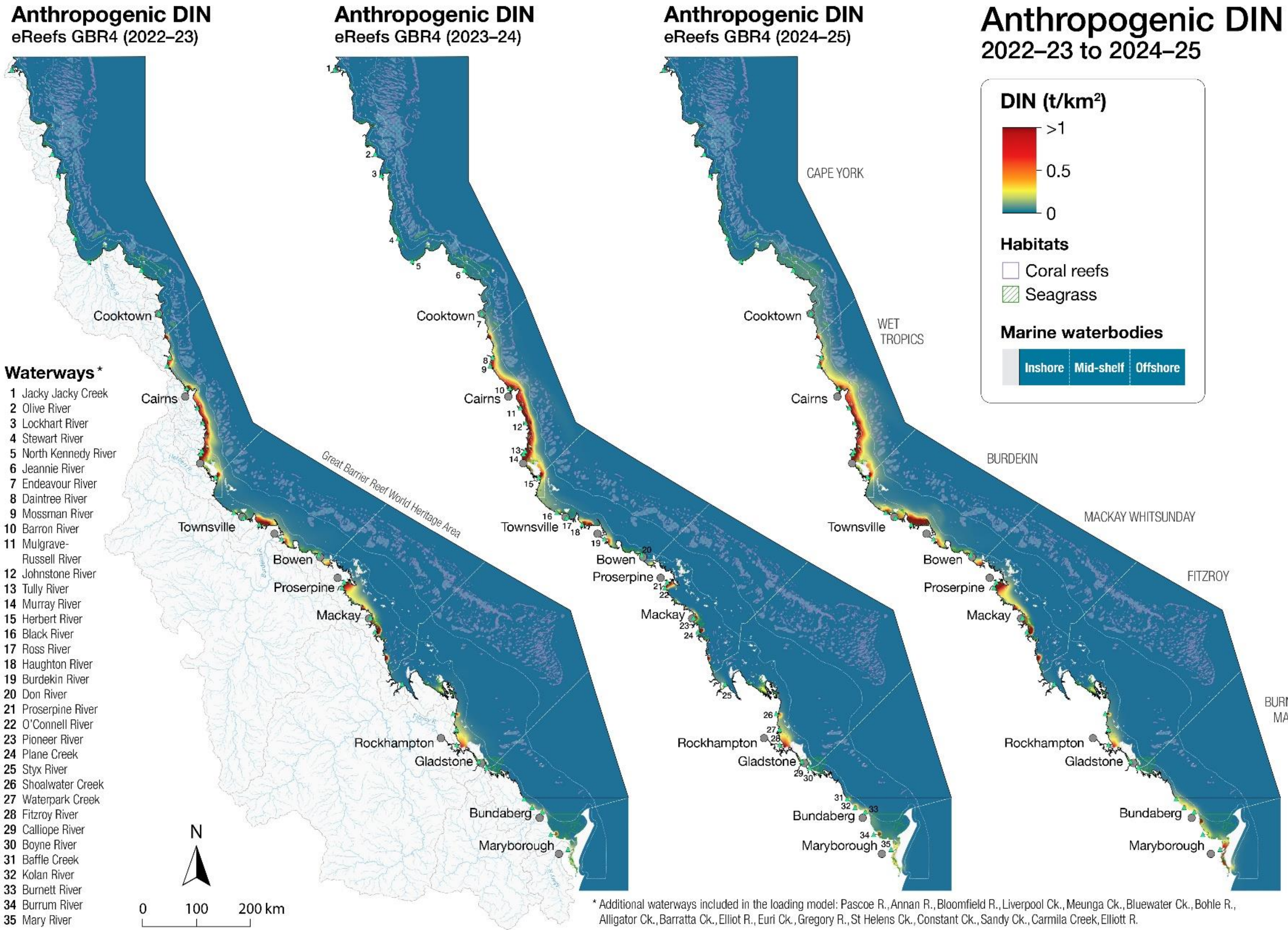


Figure 4-9: River-derived 'anthropogenic' DIN loading (tonnes km^{-2}, relative scale) in the Reef lagoon, modelled for the (left panel) 2022–23 water year (1 October to 30 September), (centre panel) 2023–24 water year, and (right panel) 2024–25 water year.

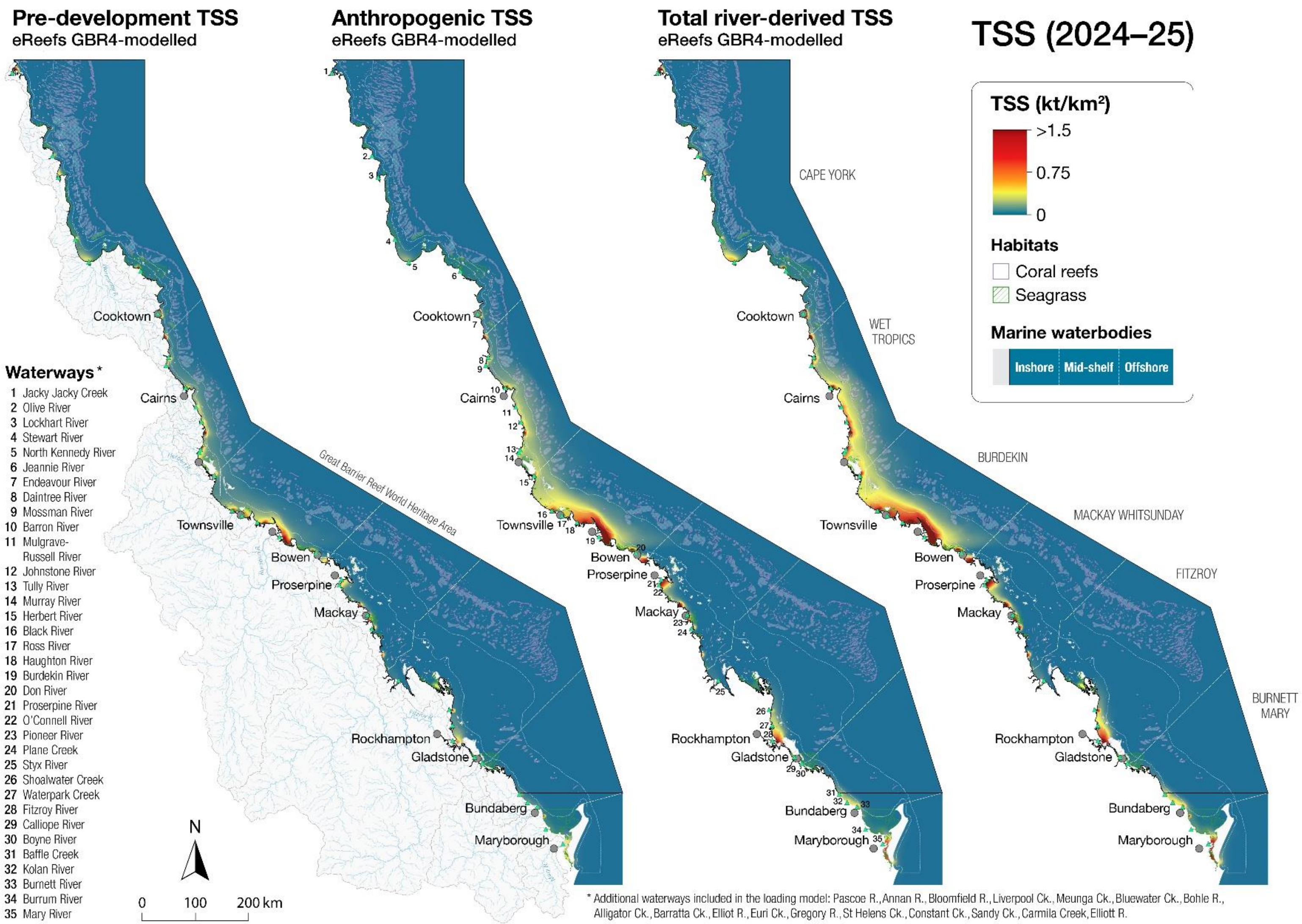


Figure 4-10: River-derived 'anthropogenic' TSS loading (tonnes km^{-2}, relative scale) in the Reef lagoon, modelled for the pre-development loads scenario (left panel), anthropogenic loads (difference between total and pre-development scenario, centre panel), and total load scenario (right panel) for the 2024–25 water year.

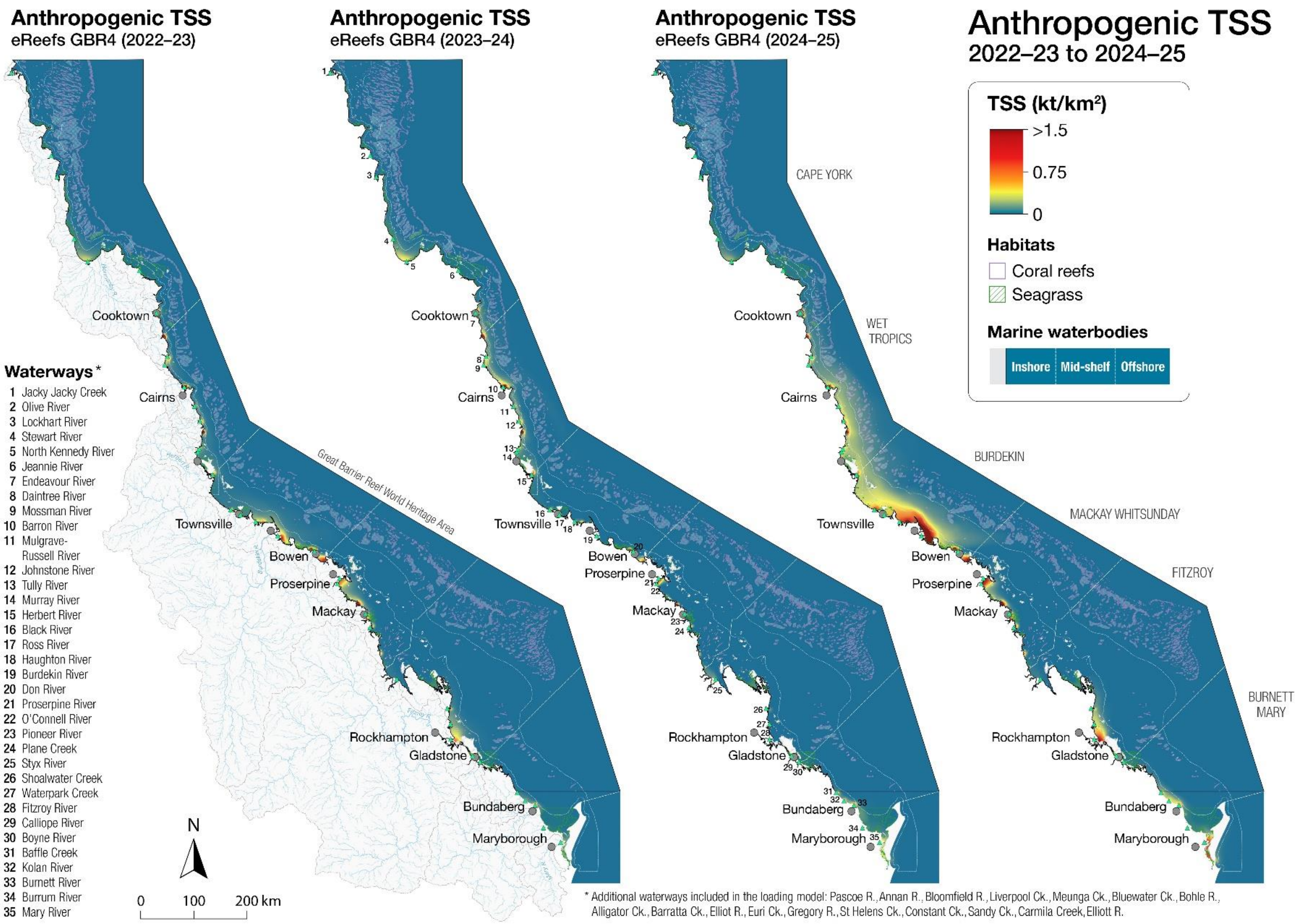


Figure 4-11: River-derived ‘anthropogenic’ TSS loading (tonnes km^{-2}, relative scale) in the Reef lagoon, modelled for the (left panel) 2022–23 water year (1 October to 30 September), (centre panel) 2023–24 water year, and (right panel) 2024–25 water year.

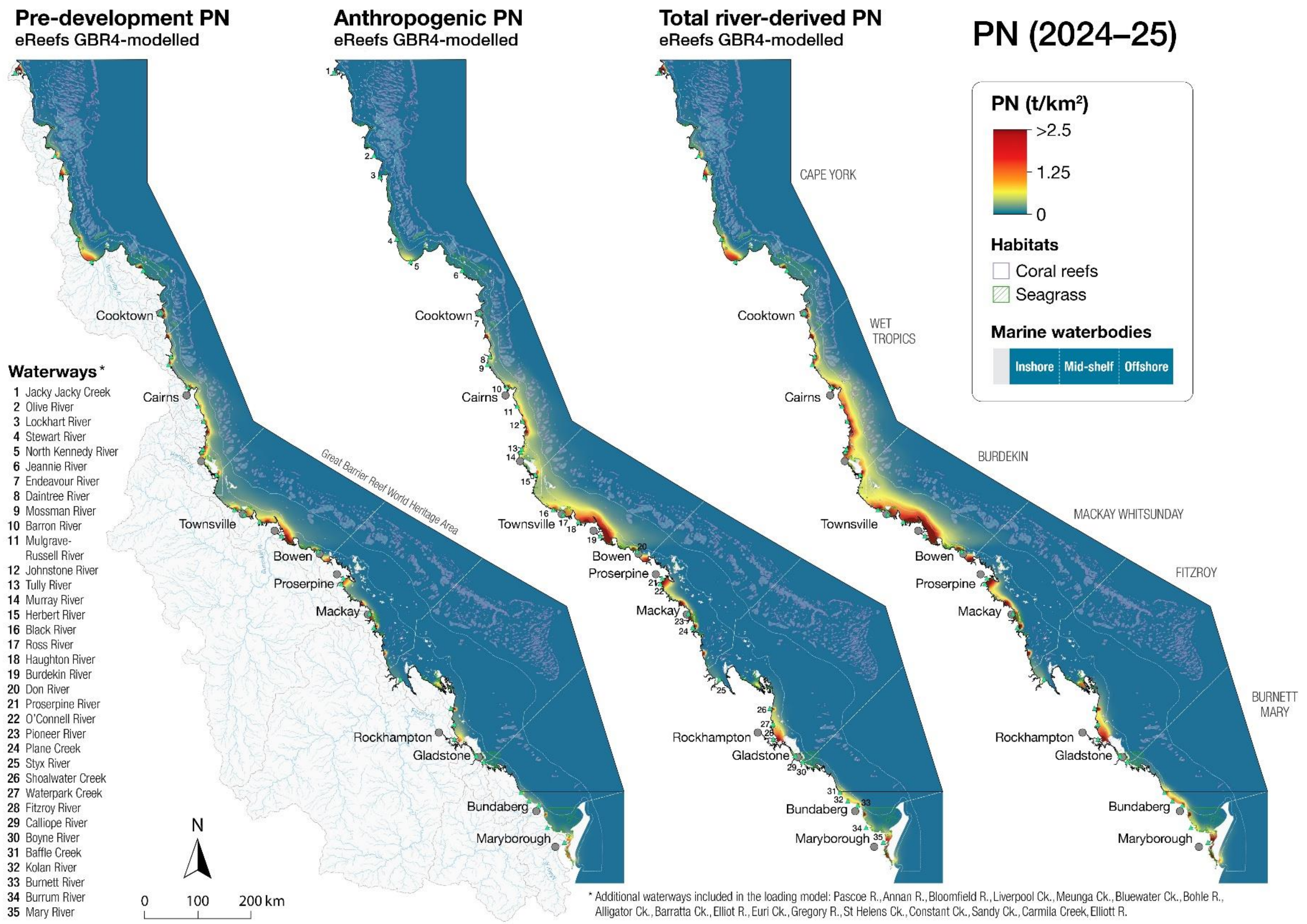


Figure 4-12: River-derived ‘anthropogenic’ PN loading (tonnes km^{-2}, relative scale) in the Reef lagoon, modelled for the pre-development loads scenario (left panel), anthropogenic loads (difference between total and pre-development scenario, centre panel), and total load scenario (right panel) for the 2024–25 water year.

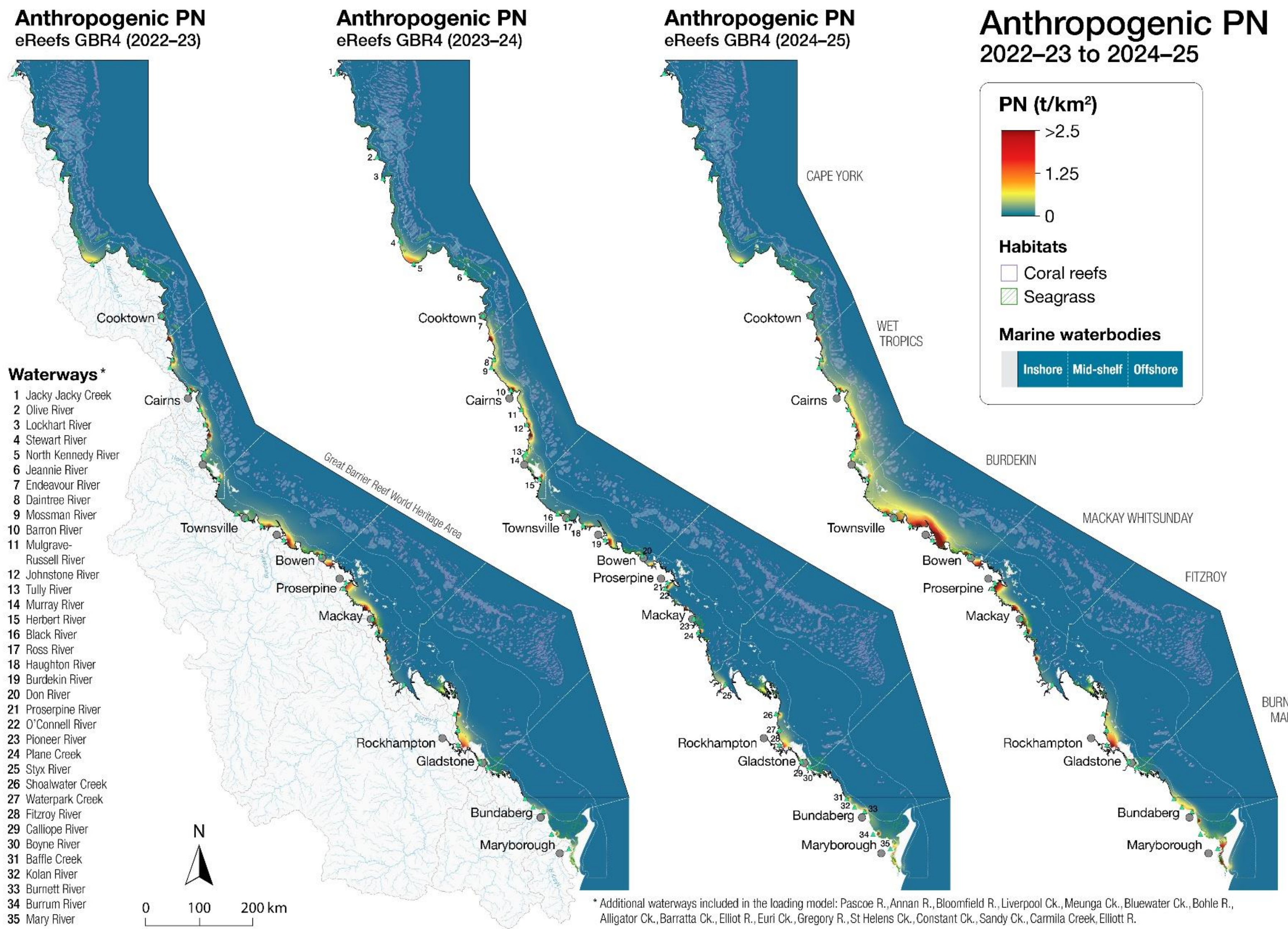


Figure 4-13: River-derived 'anthropogenic' PN loading (tonnes km^{-2}, relative scale) in the Reef lagoon, modelled for the (left panel) 2022–23 water year (1 October to 30 September), (centre panel) 2023–24 water year, and (right panel) 2024–25 water year.

4.3 Potential risk of exposure of Regional Reef ecosystems to wet season water quality

The results of the remote sensing products are presented for each Region below and summarised in Section 4.4.

4.3.1 Cape York region

As described for the whole Reef in Section 4.1, remote sensing products were generated to represent wet season water quality conditions in the Cape York region. These products are presented in 3 outputs:

1. the panels of weekly characteristics through the 22 week period between 1 December and 30 April (Figure 4-14 and Figure 4-15);
2. the frequency of the combined Reef WT1–2, and the frequency of Reef WT1, WT2, and WT3 individually (Figure 4-16);
3. the potential risk maps – each in the long-term and 2024–25 wet season; and a difference map showing areas exposed to an increased potential risk in 2024–25 (also in Figure 4-16).

The weekly Sentinel monitoring products (when not obstructed by cloud cover) clearly illustrate wet season surface water movements in the Cape York region, as well as the influence of river discharge including changes in water colour from nutrient and sediment inputs and resuspension (Figure 4-14 and Figure 4-15). There were 2 minor flood events captured in the Sentinel images around the first half of February (weeks 10–11) and in March (weeks 21–22). Primary flood waters generally had minimal exposure on mid-shelf reefs in Princess Charlotte Bay and the Northern Cape York. Sampling of the Cape York waters occurred regularly during the wet season, and around these events (Figure 4-14 and Figure 4-15, black dots).

The frequency and potential risk maps in Figure 4-16 show patterns that are relatively consistent with long-term average conditions, but vary between coral reef and seagrass ecosystems. Table 4-2 presents the areas (km^2) and percentages (%) of Cape York region, coral reef, and seagrass areas exposed to different categories of potential risk based on satellite-derived Reef water types.

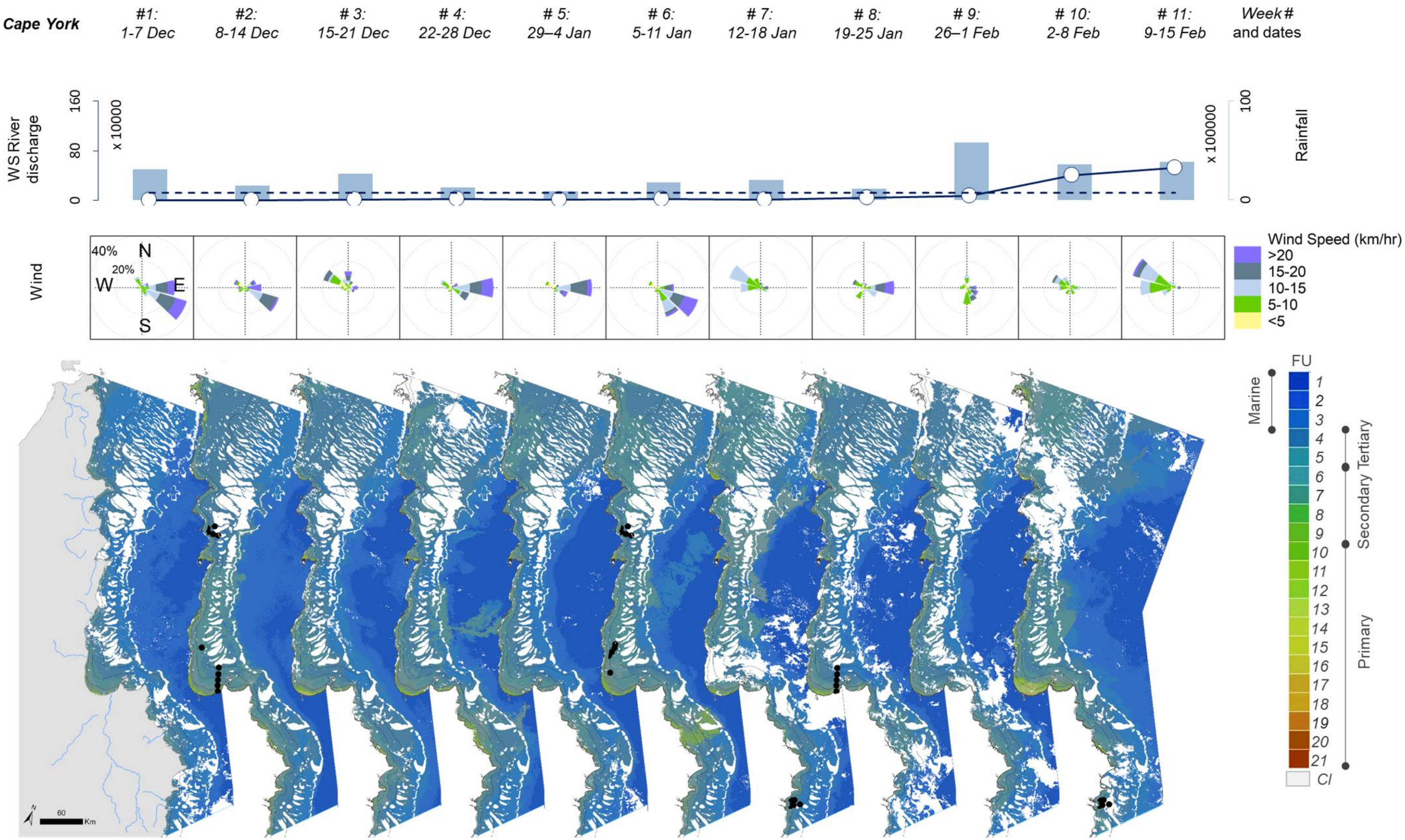


Figure 4-14: Panel of water quality and environmental characteristics in the Cape York region throughout the 2024–25 wet season period: weeks 1 to 11. Includes: 2024–25 weekly river discharge (ML) and rainfall (ML); wind roses showing the wind direction and speed (km h^{-1}) for each week; and FU colour class maps showing the location of the *in situ* data collected (black dots). The mean long-term weekly river discharge is indicated by a dotted blue line. Weekly river discharges are the sum of discharge (ML) from the Pascoe, Stewart, Normanby, and Endeavour Rivers.

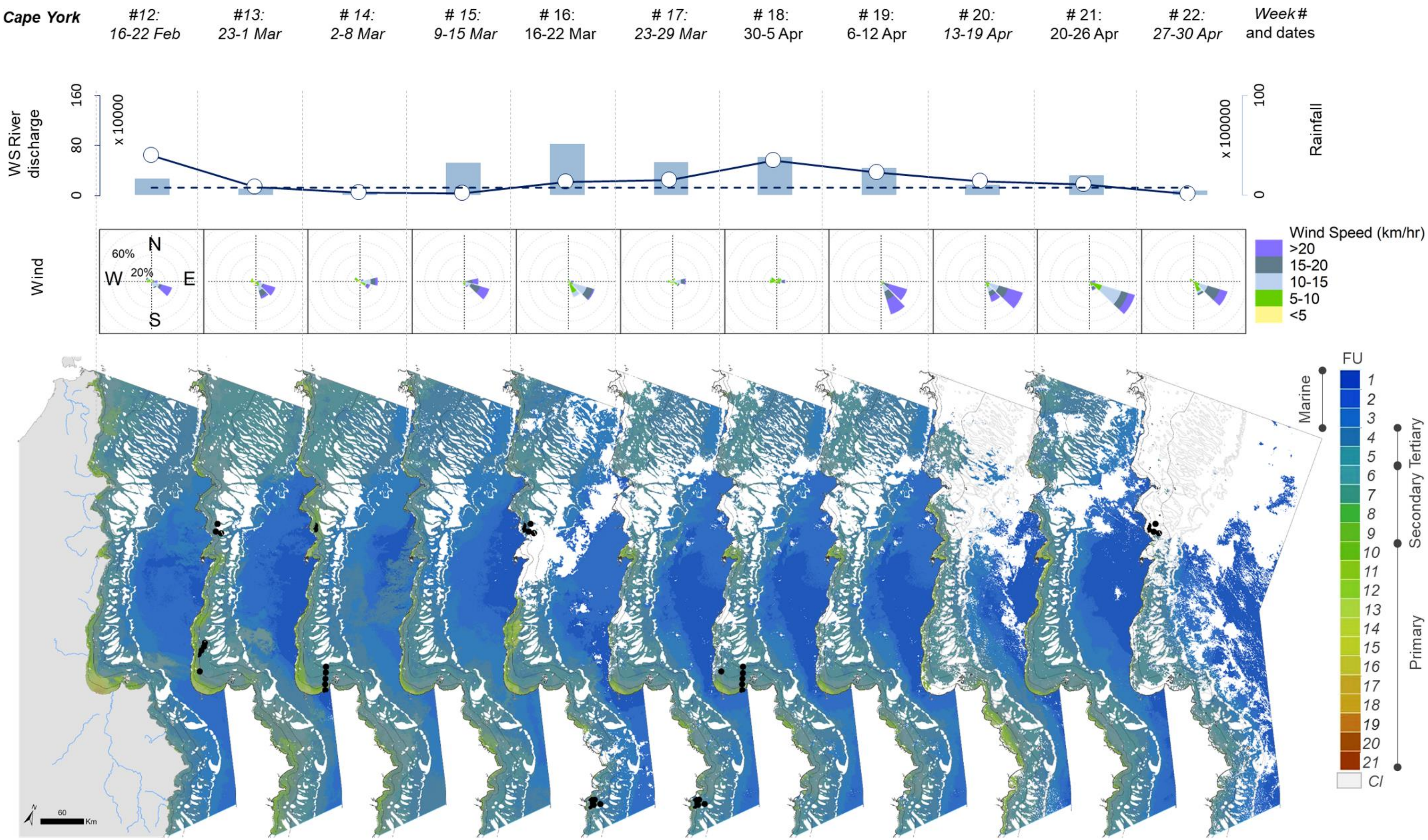


Figure 4-15: Panel of water quality and environmental characteristics in the Cape York region throughout the 2024–25 wet season period: weeks 12 to 22. Includes: 2024–25 weekly river discharge (ML) and rainfall (ML); wind roses showing the wind direction and speed (km h^{-1}) for each week; and FU colour class maps showing the location of the *in situ* data collected (black dots). The mean long-term weekly river discharge is indicated by a dotted blue line. Weekly river discharges are the sum of discharge (ML) from the Pascoe, Stewart, Normanby, and Endeavour Rivers.

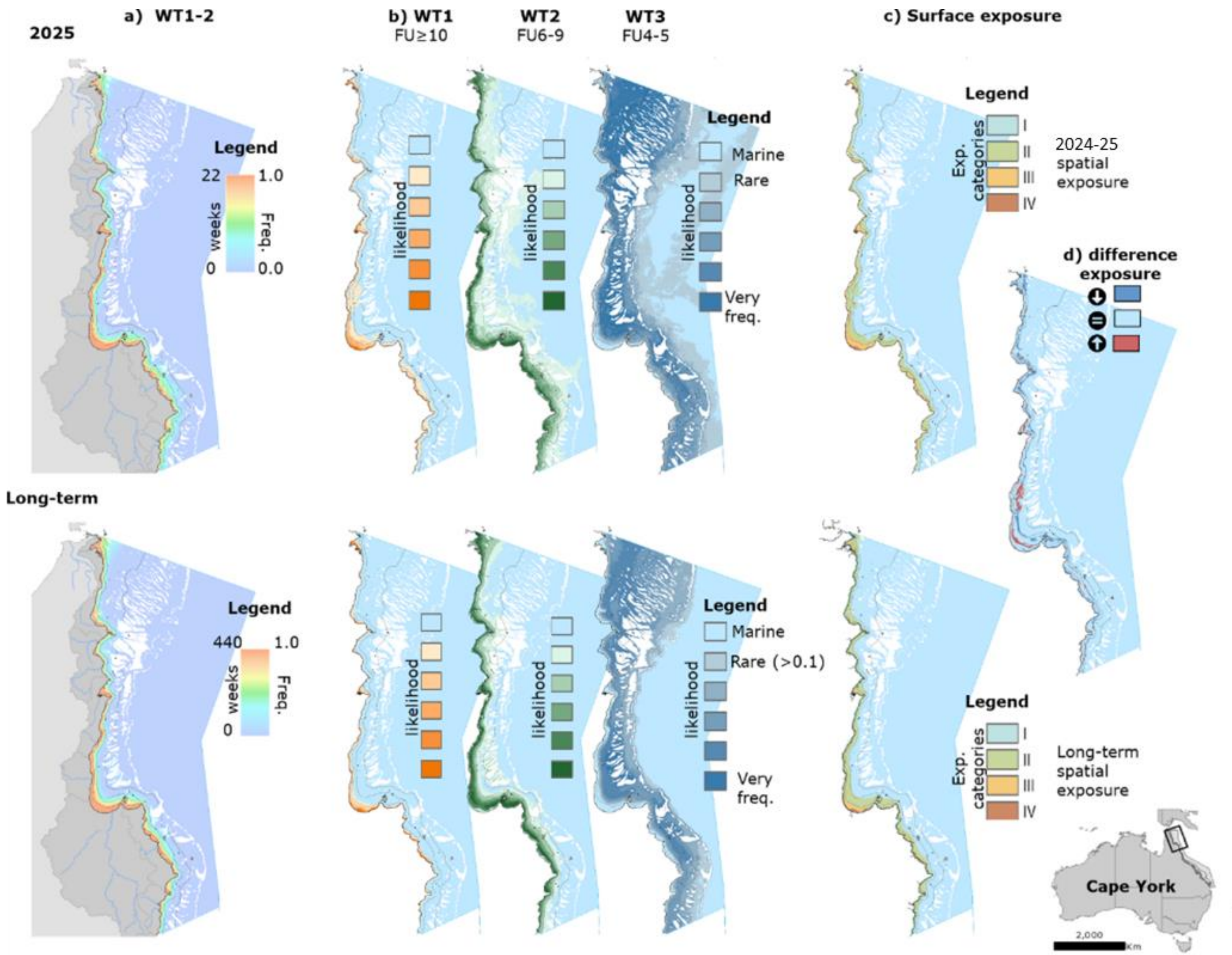


Figure 4-16: Long-term and current year remote sensing results for the Cape York region. showing the a) frequency of combined Reef WT1–2; b) the frequency of Reef WT1, WT2 and WT3 individually regrouped into 5 likelihood categories [<0.2 (Rare), 0.2–0.4, 0.4–0.6, 0.6–0.8 and 0.8–1 (very frequent)]; c) potential risk maps- each in the long-term (bottom) and 2024–25 wet season (top). d) Difference map showing any areas with an increase (in red, ➊) or decrease (in purple, ➋) in potential risk category in 2024–25 against long-term trends [calculated as (c, top) exposure in 2025 minus (c, bottom) long-term]. Note that optical water types – especially the Reef WT3– do not always correspond to direct catchment discharge influence and can also be due to oceanographic processes (see definitions in Table 2-2).

In 2024–25, it was estimated that:

- Cape York region: Approximately 94% of Cape York was not exposed to a potential risk, which was similar to the long-term average (93%, Table 4-2). Approximately 6% (or about 6,099 km^2) of the Cape York region was exposed to combined potential risk categories II–IV, with 0.5% (451 km^2) of the Cape York region in the highest exposure category (IV) and 1% (1,303 km^2) in category III.
- Cape York waterbodies: The mid-shelf and offshore waterbodies were largely exposed to no/very low potential risk (98% and 100% of the Cape York mid-shelf and offshore waterbodies, Figure 4-7c). Only the enclosed coastal and open coastal Cape York waters were exposed to the highest categories of potential risk (III and IV). The area exposed corresponded to 46% (cat. III) and 20% (cat. IV) of the total Cape York enclosed coastal area (Figure 4-7c) and 6% (cat. III) and <1% (cat. IV) of the open coastal areas.
- Cape York habitats:
  - **Coral reefs**: Approximately 97% of coral reefs in the Cape York region were not exposed to a potential risk, which was identical to the long-term average (97%). About 1% of corals were in the highest potential risk category (IV) and 1% in category III (combined 149 km^2) and they were all inshore and enclosed coastal reefs (Figure 4-17a). Approximately 1% and 2% (<300 km^2) of the Cape York corals reefs occur in the enclosed and open coastal waters, respectively (Appendix C).
    The coral area exposed to higher potential risk corresponded to 39% (cat. III) and 46% (cat. IV) of the total enclosed coastal coral reef area in Cape York, and to 22% (cat. III) and 6% (cat. IV) of the total open coastal coral reef area (Figure 4-17a). Mid-shelf reefs were exposed to the lower potential risk category II or to no/very low potential risk (1% and 99% of the total mid-shelf coral reef area in Cape York). 100% of the Cape York offshore reefs were classified as no/very low potential risk.
  - **Seagrasses**: Approximately 55% (or 1,450 km^2) of seagrasses in the Cape York region were exposed to combined potential risk categories II–IV (Table 4-2). 4% (114 km^2) of seagrasses were in the highest potential risk category (IV) and 11% were in category III (284 km^2), and they were all inshore and enclosed coastal seagrasses (Figure 4-17b). A total of 27% and 40% (~1,800 km^2) of the Cape York seagrass occur in the enclosed and inshore waters respectively (Appendix C).
    The seagrass area exposed to higher potential risk corresponded to 32% (cat. III) and 15% (cat. IV) of the total enclosed coastal seagrass area in Cape York and to 5% (cat. III) and <1% (cat IV) of the total open coastal seagrass area (Figure 4-17b). Mid-shelf and offshore seagrasses were classified as no/very low risk (100% of the Cape York mid-shelf and offshore seagrasses).
    Comparison to long-term trends: The area of coral reef and seagrass exposed to highest potential risk categories III and IV in the Cape York region were similar to the long-term average (≤1% change).

Table 4-2: Areas (km²) and percentages (%) of the Cape York region, Cape York coral reefs, and Cape York surveyed seagrass exposed to different potential risk categories during the 2024–25 wet season and the long-term (2003–2023). The last 3 rows show the differences between % exposed in 2024–25 and the long-term average (red: increase, blue: decrease, green: no change, difference <5%).

Total surface area exposed		**Total**		**Potential Risk category**				**Total area exposed II–IV**
				No / Very low	**Lowest**		**Highest**	
				I	**II**	**III**	**IV**	
Cape York region	area	96,316	2025	90,217	4,345	1,303	451	6,099
			LT	89,387	5,351	1,026	553	6,929
	%	*100%*	2025	94%	5%	1%	0%	6%
			LT	93%	6%	1%	1%	7%
Cape York coral reefs	area	10,375	2025	10,082	144	85	64	293
			LT	10,030	209	92	44	345
	%	*100%*	2025	97%	1%	1%	1%	3%
			LT	97%	2%	1%	0%	3%
Cape York surveyed seagrass	area	2,655	2025	1,205	1,052	284	114	1,450
			LT	1,175	1,012	265	203	1,480
	%	*100%*	2025	45%	40%	11%	4%	55%
			LT	44%	38%	10%	8%	56%
Difference (2024–25 to long-term average)	*Cape York Region*			<1%	-1%	<1%	<-1%	<-1%
	Cape York coral reefs			<1%	<-1%	<-1%	<1%	<-1%
	Cape York surveyed seagrass			1%	2%	<1%	-3%	-1%

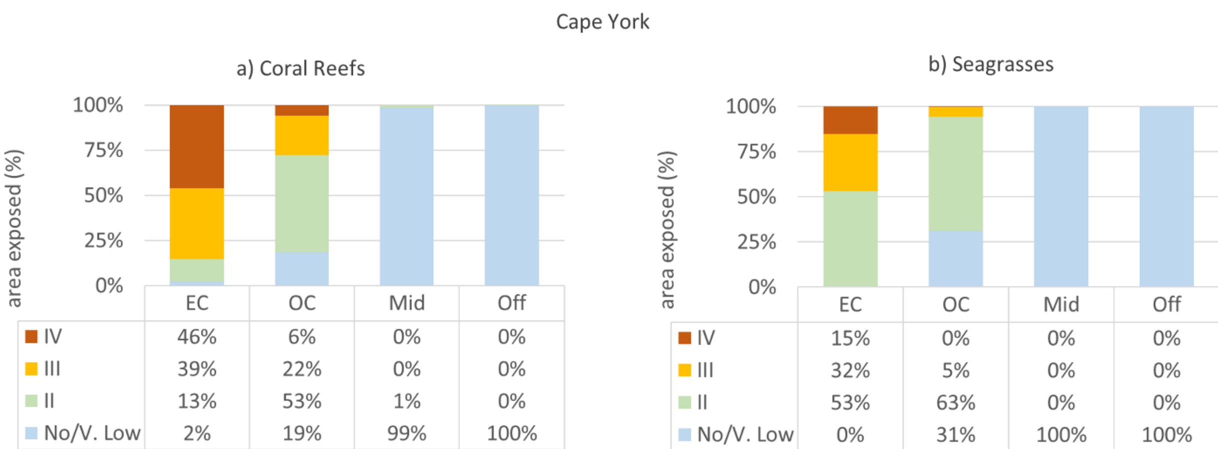


Figure 4-17: Percentage of the Cape York region a) coral reef and b) surveyed seagrass habitats exposed to different risk categories of exposure during the 2024–25 wet season. Water body classifications are shown along the x-axes: enclosed coastal (EC), open coastal (OC), mid-shelf (Mid), and offshore (Off).

4.3.2 *Wet Tropics region*

The remote sensing products for the Wet Tropics region include:

1. the panels of weekly characteristics through the 22 week period between 1 December and 30 April (Figure 4-18 and Figure 4-19);
2. the frequency of the combined Reef WT1–2, and the frequency of Reef WT1, WT2, and WT3 individually (
3. Figure 4-20);
4. the potential risk maps – each in the long-term and 2024–25 wet season; and a difference map showing areas exposed to an increased potential risk in 2024–25 (also in
5. Figure 4-20).

The weekly Sentinel monitoring products (when not obstructed by cloud cover) clearly illustrate wet season surface water movements in the Wet Tropics region, as well as the influence of river discharge including changes in water colour from nutrient and sediment inputs and resuspension (Figure 4-18 and Figure 4-19). Discharge in the Wet Tropics region was 1.6 times the long-term median. There were 2 major flood events captured in the Sentinel images, one around February to early March (weeks 9–13) and one around the end of March (weeks 16–18). Following the February event, extensive flood plumes were observed, with WT1 waters extending to the mid-shelf waters and even reaching some offshore reef areas. Persistent cloud cover during late January (week 9) and the late March events partially degraded the quality of the weekly composites, which might have influenced the exposure assessment for the Wet Tropics region.

Sampling of the Wet Tropics waters occurred during and between the main flood events in February and March (Figure 4-18 and Figure 4-19, black dots). A full description of water quality patterns and large flood plumes captured is available in Section 5 of this report.

The frequency and potential risk maps in 4-20 show patterns that are typically above long-term average conditions, but vary between coral reef and seagrass ecosystems. Table 4-3 presents the areas (km^2) and percentage (%) of Wet Tropics region, coral reef, and seagrass areas exposed to different categories of potential risk based on satellite-derived wet season water maps.

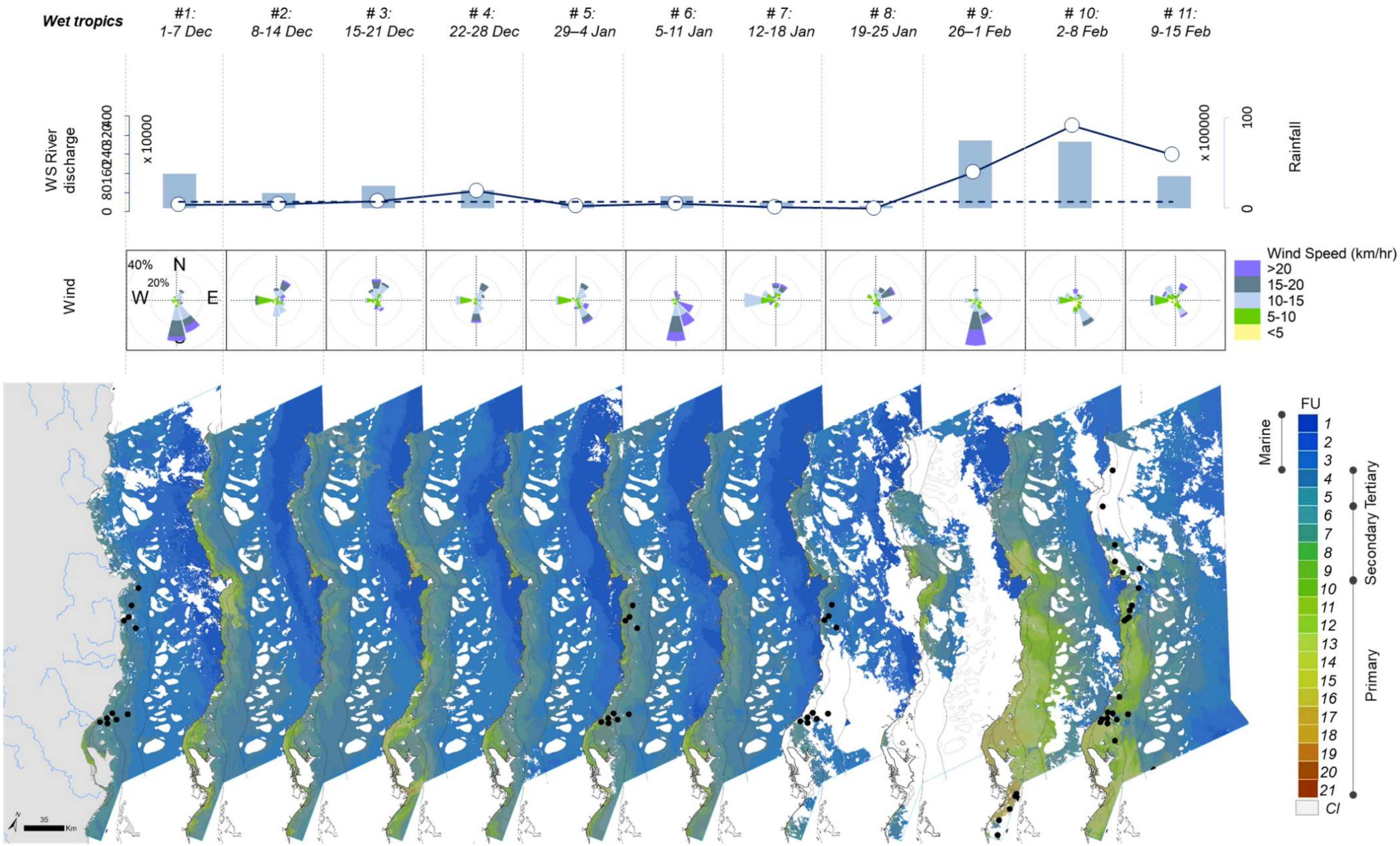


Figure 4-18: Panel of water quality and environmental characteristics in the Wet Tropics region throughout the 2024–25 wet season period: weeks 1 to 11. Includes: 2024–25 weekly river discharge (ML) and rainfall (ML); wind roses showing the wind direction and speed (km h^{-1}) for each week; and FU colour class maps showing the location of the *in situ* data collected (black dots). The mean long-term weekly river discharge is indicated by a dotted blue line. Weekly river discharges are the sum of discharge (ML) from the Daintree, Mossman, Barron, Mulgrave, Russell, North Johnstone, South Johnstone, Tully, Murray, and Herbert Rivers.

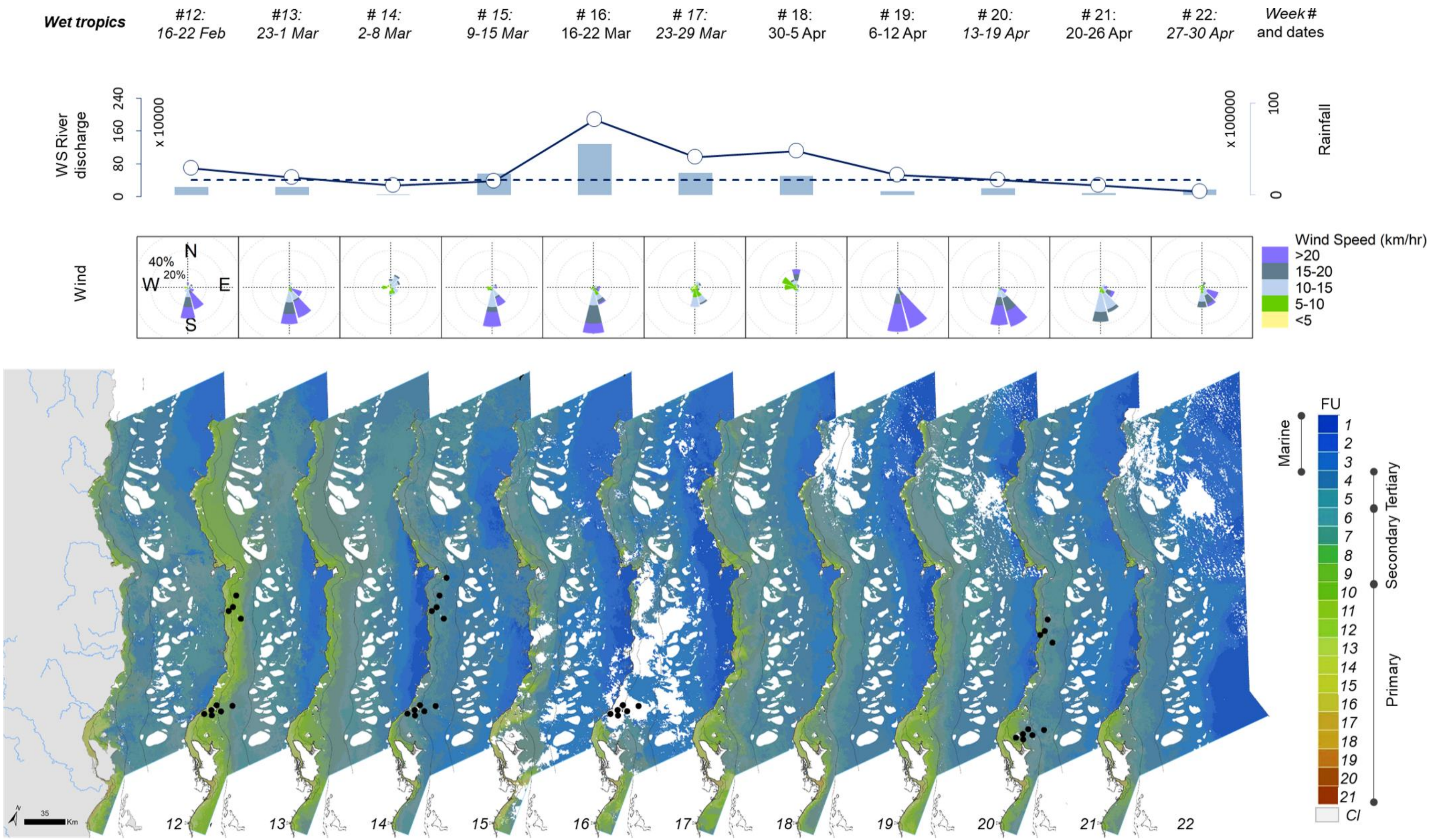


Figure 4-19: Panel of water quality and environmental characteristics in the Wet Tropics region throughout the 2024–25 wet season period: weeks 12 to 22. Includes: 2024–25 weekly river discharge (ML) and rainfall (ML); wind roses showing the wind direction and speed (km h^{-1}) for each week; and FU colour class maps showing the location of the *in situ* data collected (black dots). The mean long-term weekly river discharge is indicated by a dotted blue line. Weekly river discharges are the sum of discharge (ML) from the Daintree, Mossman, Barron, Mulgrave, Russell, North Johnstone, South Johnstone, Tully, Murray, and Herbert Rivers.

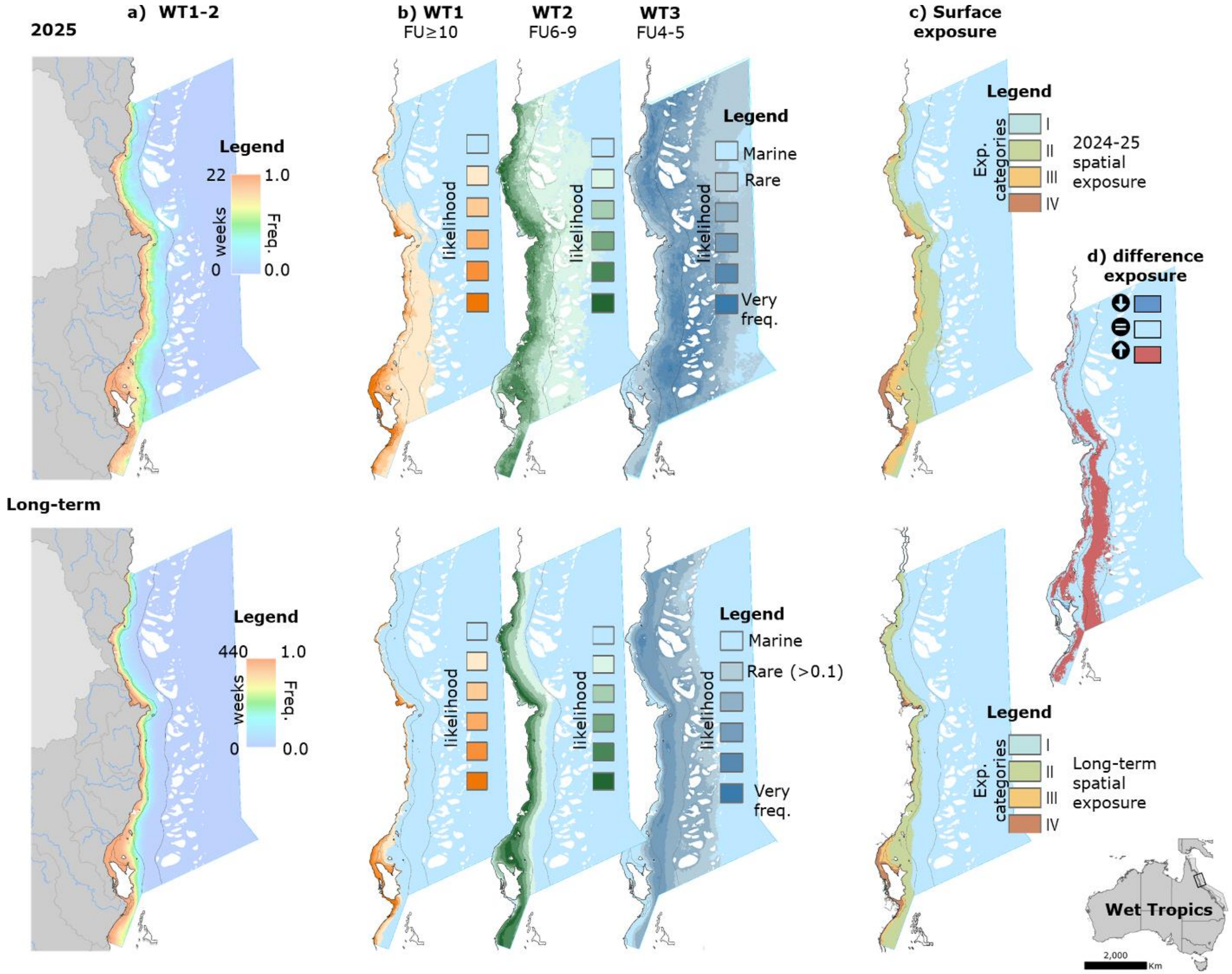


Figure 4-20: Long-term and 2024–25 remote sensing results for the Wet Tropics region showing the a) frequency of combined Reef WT1–2 II; b) the frequency of Reef WT1, WT2, and WT3 individually regrouped into 5 likelihood categories [<0.2 (Rare), 0.2–0.4, 0.4–0.6, 0.6–0.8 and 0.8–1 (very frequent)]; c) potential risk maps- each in the long-term (bottom) and 2024–25 wet season (top). d) Difference map showing any areas with an increase (in red, ⬆) or decrease (in purple, ⬇) in potential risk category in 2024–25 against long-term trends [calculated as (c, top) exposure in 2025 minus (c, bottom) long-term]. Note that optical water types – especially Reef WT3– do not always correspond to direct catchment discharge and can also be due to oceanographic processes (see definitions in Table 2-2)

In 2024–25, it was estimated that:

- Wet-Tropics region: 79% of the Wet Tropics region was not exposed to a potential risk, which was below the long-term average (88%, Table 4-3), indicating wetter conditions in this region. Approximately 21% (or about 6,647 km^2) of the Wet Tropics region was exposed to combined potential risk categories II–IV. Around 2% (443 km^2) of the region was in the highest exposure category (IV), which was just above the long-term average (1%) and 4% was in category III (1,413 km^2), also above the long-term average (2%). It is noted that there was extensive cloud cover during some of the periods of highest river discharge in late January and early February, limiting the assessment in some areas and therefore potentially underestimating exposures.

- Wet Tropics waterbodies: The enclosed coastal and open coastal Wet Tropics waters were the most exposed to the highest categories of potential risk (III and IV), and 1% of the mid-shelf Wet Tropics waters were also exposed to the potential risk category III. The open coastal area exposed corresponded to 38% (cat. III) and 3% (cat. IV) of the total Wet Tropics inshore area (Figure 4-7c). A total of 26% and 71% of the enclosed coastal areas were exposed to potential risk categories III and IV, respectively. Approximately 53% of the mid-shelf waterbody in the region was exposed to a low potential risk (cat II) and 47% to no potential risk. Nearly all of the offshore Wet Tropics waterbodies were exposed to no/very low potential risk (99% of the offshore waterbodies).

- Wet Tropics habitats:
    - **Coral reefs:** 6% of coral reefs in the Wet Tropics region were exposed to a potential risk (combined potential risk categories II–IV, Table 4-3), which was above the long-term average (3%). 1% of coral reefs were in the highest potential risk category (IV) and 1% were in the potential risk category III (combined 58 km^2) and they were all enclosed coastal or open coastal reefs (Figure 4-21a). Only 3% (~80 km^2) of the Wet Tropics corals occur in the inshore waters (Appendix C). The open coastal coral area exposed to higher potential risk corresponded to 48% (cat. III) and 21% (cat. IV) of the total open coastal reef area in the Wet Tropics (Figure 4-21a), which were larger areas than the previous 2023–24 wet season (+3% and +9%, respectively). A total of 23% and 76% of the enclosed coastal areas were exposed to potential risk categories III and IV respectively. Mid-shelf and offshore reefs were largely exposed to no potential risk (>85% of the total mid-shelf and offshore reef areas in the Wet Tropics), but 15% of the mid-shelf Wet Tropics reefs were exposed to the lowest potential risk category II.
    - **Seagrasses:** A total of 98% (or 229 km^2) of seagrasses in the Wet Tropics region were exposed to a potential risk: which was identical to the long-term average (98%) (combined potential risk categories II–IV, Table 4-3). A total of 33% (77 km^2) of seagrasses were in the highest potential risk category (IV) and 56% (131 km^2) were in potential risk category III (Figure 4-21b). 98% (~230 km^2) of the Wet Tropics seagrass occur in the inshore waters (Appendix C). The open coastal seagrass area exposed to potential risk corresponded to 77% (cat. III) and 3% (cat. IV) of the total inshore coastal seagrass in the Wet Tropics (Figure 4-21b). A total of 44% and 55% of the total enclosed coastal seagrass were exposed to potential risk categories III and IV, respectively. Mid-shelf seagrasses were classified as no/very potential low risk (75% of the Wet Tropics mid-shelf seagrasses) or as the lowest category of potential risk (II, 25% of the Wet Tropics mid-shelf seagrasses).
    - **Comparison with long-term trends:** The total area and area of coral reef exposed to combined potential risk categories II–IV in the Wet Tropics region were above long-term averages (+8% and +3%, respectively), highlighting the wet conditions this wet season in this region. There was, furthermore, a shift in seagrass exposure, with decreases in potential risk category II (-13%) and category IV (-8%), and a significant increase in category III (+21%).

Table 4-3: Areas (km²) and percentages (%) of the Wet Tropics region, Wet Tropics coral reefs, and Wet Tropics surveyed seagrass exposed to different potential risk categories during the 2024–25 wet season and the long-term (2003–2023). The last 3 rows show the differences between % exposed in 2024–25 and the long-term average (red: increase, blue: decrease, green: no change, difference <5%).

Total surface area exposed		**Total**		**Potential Risk category** No / Very low I	Lowest II	III	Highest IV	**Total area exposed II–IV**
Wet Tropics region	area	31,976	2025	25,328	4,670	1,413	565	6,647
			LT	28,022	2,912	605	436	3,953
	%	*100%*	2025	79%	15%	4%	2%	21%
			LT	88%	9%	2%	1%	12%
Wet Tropics coral reefs	area	2,425	2025	2,273	95	34	24	153
			LT	2,349	41	29	7	77
	%	*100%*	2025	94%	4%	1%	1%	6%
			LT	97%	2%	1%	0%	3%
Wet Tropics surveyed seagrass	area	232	2025	4	20	131	77	229
			LT	5	51	82	95	227
	%	*100%*	2025	2%	9%	56%	33%	98%
			LT	2%	22%	35%	41%	98%
Difference (2024–25 to long-term average)	*Wet Tropics region*			-8%	5%	3%	<1%	8%
	Wet Tropics coral reefs			-3%	2%	<1%	<1%	3%
	Wet Tropics surveyed seagrass			<-1%	-13%	21%	-8%	<1%

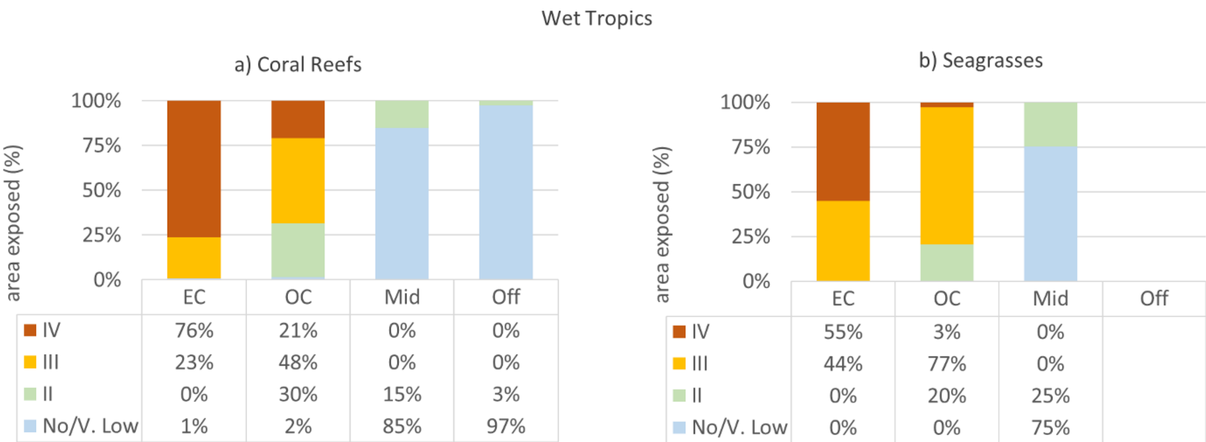


Figure 4-21: Percentage of the Wet Tropics region a) coral reef and b) surveyed seagrass habitats exposed to different potential risk categories during the 2024–25 wet season. Water body classifications are shown along the x-axes: enclosed coastal (EC), open coastal (OC), mid-shelf (Mid), and offshore (Off).

4.3.3 Burdekin region

The remote sensing products for the Burdekin region include:

1. the panels of weekly characteristics through the 22 week period between 1 December and 30 April (Figure 4-22 and Figure 4-23);
2. the frequency of the combined Reef WT1–2; and the frequency of Reef WT1, WT2, and WT3 individually (Figure 4-24);
3. the potential risk maps – each in the long-term and 2024–25 wet season; and a difference map showing areas exposed to an increased potential risk in 2025 (also in Figure 4-24).

The weekly Sentinel monitoring products (when not obstructed by cloud cover) clearly illustrate wet season surface water movements in the Burdekin region, as well as the influence of river discharge including changes in water colour from nutrient and sediment inputs and resuspension (Figure 4-22 and Figure 4-23). Discharge in the Burdekin region was much higher than its long-term median (6.8 times) and was the highest recorded since the extreme 2010–11 water year. There were 2 major flood events captured in the Sentinel images, one around February to early March (weeks 9–13) and one in end of March to early April (weeks 17–18). Following the February event, extensive flood plumes were observed, with WT1 waters extending to the mid-shelf Burdekin waters and even reaching some offshore reef areas off the Burdekin River (Old Reef).

Sampling of the Burdekin waters occurred during and between the main flood events (Figure 4-22 and Figure 4-23, black dots). A full description of water quality patterns and large flood plumes captured in the satellite images is available in Section 5 of this report.

The frequency and potential risk maps in Figure 4-24 show patterns that are typically above long-term average conditions, but they vary between coral reef and seagrass ecosystems. Table 4-4 presents the areas (km^2) and percentage (%) of Burdekin region, coral reef, and seagrass areas exposed to different categories of potential risk based on satellite-derived Reef water types.

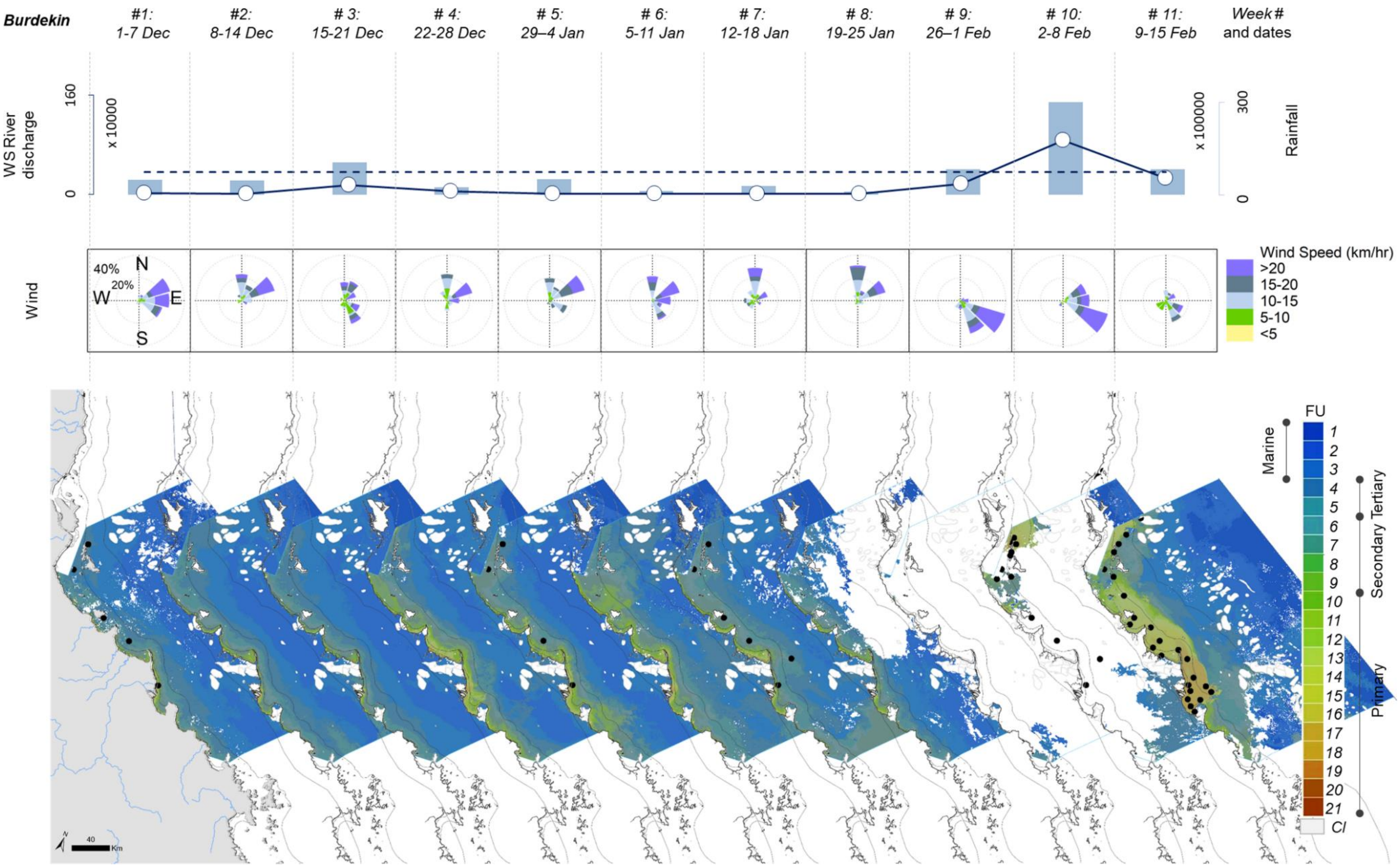


Figure 4-22: Panel of water quality and environmental characteristics in the Burdekin region throughout the 2024–25 wet season period: weeks 1 to 11. Includes: 2024–25 weekly river discharge (ML) and rainfall (ML); wind roses showing the wind direction and speed (km h^{-1}) for each week; and FU colour class maps showing the location of the *in situ* data collected (black dots). The mean long-term weekly river discharge is indicated by a dotted blue line. Weekly river discharges are the sum of discharge (ML) from the Black, Ross, Haughton, Burdekin, and Don Rivers.

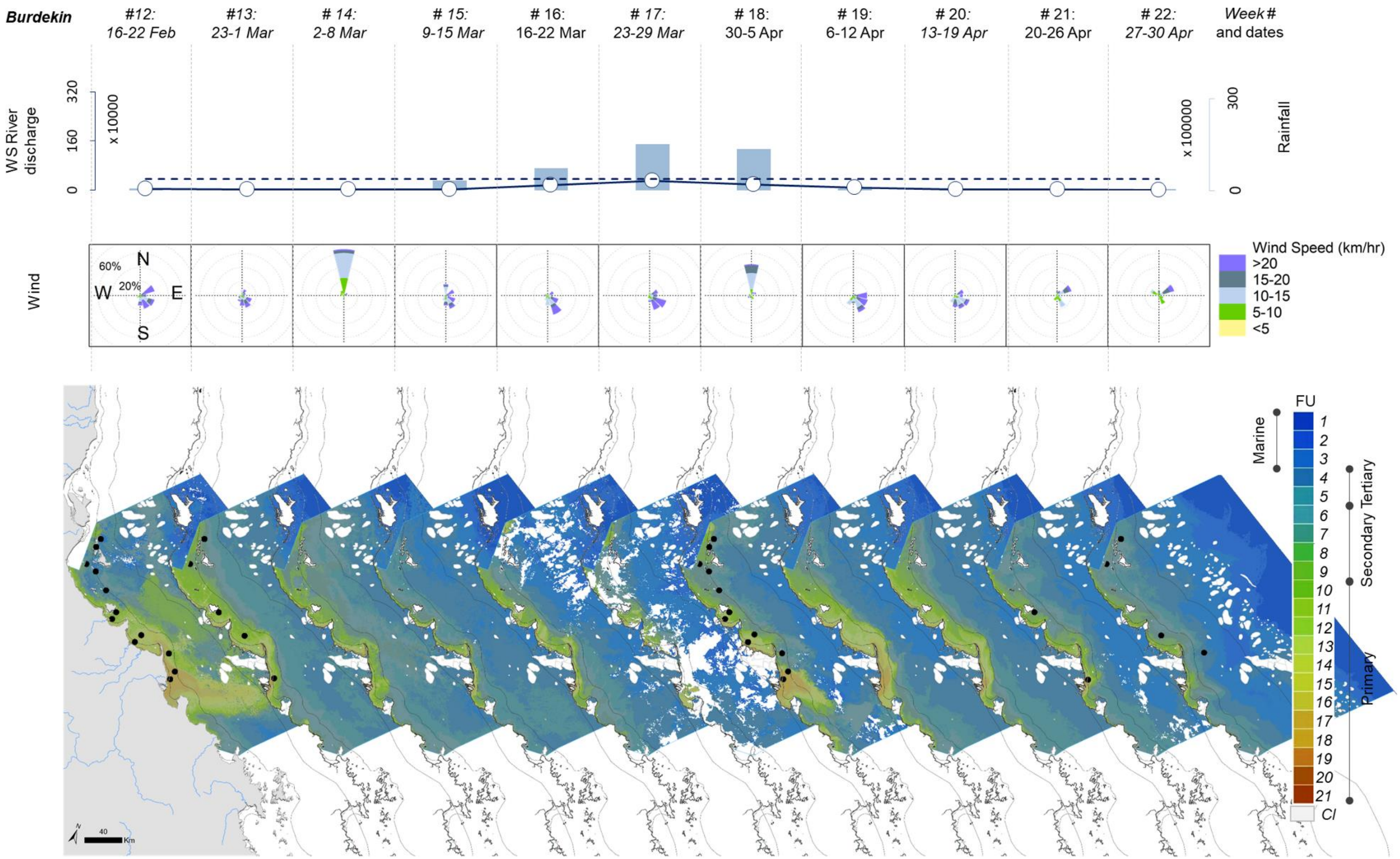


Figure 4-23: Panel of water quality and environmental characteristics in the Burdekin region throughout the 2024–25 wet seasonperiod: weeks 12 to 22. Includes: 2024–25 weekly river discharge (ML) and rainfall (ML); wind roses showing the wind direction and speed (km h^{-1}) for each week; and FU colour class maps showing the location of the *in situ* data collected (black dots). The mean long-term weekly river discharge is indicated by a dotted blue line. Weekly river discharges are the sum of discharge (ML) from the Black, Ross, Haughton, Burdekin, and Don Rivers.

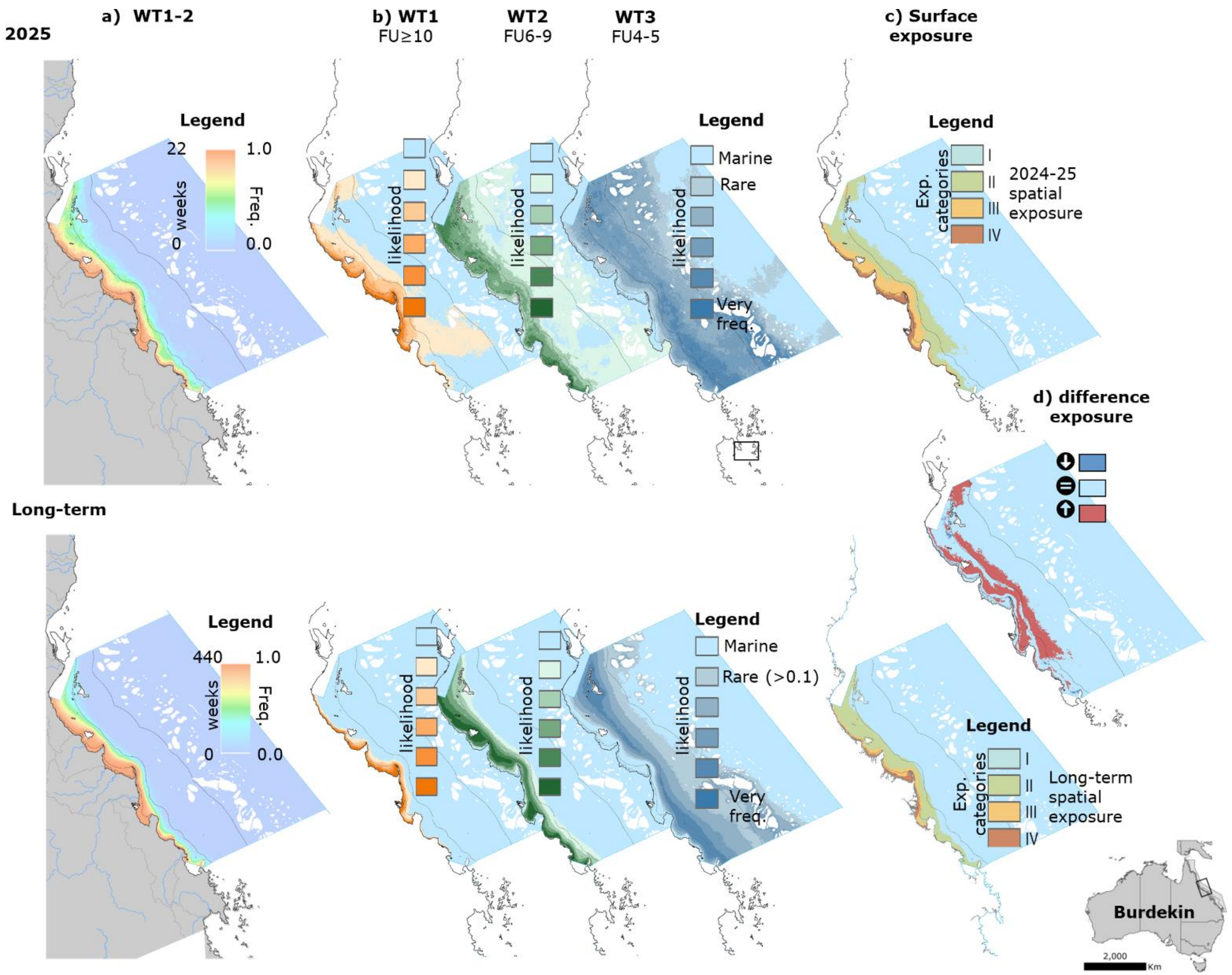


Figure 4-24: Long-term and current year remote sensing results for the Burdekin region showing the a) frequency of combined Reef WT1–2; b) the frequency of Reef WT1, WT2, and WT3 individually regrouped into 5 likelihood categories [<0.2 (Rare), 0.2–0.4, 0.4–0.6, 0.6–0.8 and 0.8–1 (very frequent)]; c) potential risk maps- each in the long-term (bottom) and 2024–25 wet season (top). d) Difference map showing any areas with an increase (in red, ➊) or decrease (in purple, ➋) in potential risk category in 2024–25 against long-term trends [calculated as (c, top) exposure in 2025 minus (c, bottom) long-term]. Note that optical water types – especially the Reef WT3 – do not always correspond to direct catchment discharge and can also be due to oceanographic processes (see definitions in Table 2-2).

In 2024–25, it was estimated that:

- Burdekin region: 15% of the region (or 7,093 km^2) was exposed to a potential risk, which was over the long-term average (10%, Table 4-4). 2% (796 km^2) of the region was in the highest potential risk category (IV) and 4% (1,962 km^2) was in category III. It is noted that there was extensive cloud cover during some of the periods of highest river discharge in late January and mid-February, limiting the assessment in some areas and therefore potentially underestimating exposure.
- Burdekin waterbodies: The enclosed coastal and open coastal Burdekin waters were the most exposed to the highest categories of potential risk (III and IV), but a small proportion (0.04%) of the mid-shelf coastal waters were also exposed to the potential risk category III. The open coastal area exposed corresponded to 39% (cat. III) and 2% (cat. IV) of the total Burdekin open coastal area (Figure 4-7c). 21% and 78% of the enclosed coastal areas were exposed to potential risk categories III and IV, respectively. The mid-shelf and offshore Burdekin waterbodies were largely exposed to no/very low potential risk (81 and 100% of each respective waterbody), and 18% of the mid-shelf Burdekin waterbody was also exposed to potential risk category III.

- Burdekin habitats:
  - Coral reefs: Approximately 1% of coral reefs in the Burdekin region were exposed to combined potential risk categories II–IV, with less than 1% in the highest exposure categories IV and III (combined 23 km^2, Table 4-4). Only 1% (<40 km^2) of the Burdekin corals occur in the inshore waters (Appendix C). The open coastal coral area exposed to higher potential risk corresponded to 61% (cat. III) and 2% (cat. IV) of the total open coastal reefs area in the Burdekin region (Figure 4-25a). A total of 20% and 80% of the enclosed coastal areas were exposed to potential risk categories III and IV, respectively. Mid-shelf and offshore coral reefs were largely exposed to no potential risk (>95%), but 0.04% of the Burdekin mid-shelf reefs were also exposed to the potential category of risk III, and 5% to the lowest potential risk category II. Offshore coral reefs were exposed to no potential risk (>95% in both waterbodies).
  - Seagrasses: 89% (or 632 km^2) of seagrasses in the Burdekin region were exposed to combined potential risk categories II–IV. 25% (176 km^2, Table 4-4) of seagrasses were in the highest potential risk category (IV) and 40% (281 km^2) were in potential risk category III, and they were all inshore seagrasses (Figure 4-25b). A total of 99% (~700 km^2) of the Burdekin seagrasses occur in the inshore waters (Appendix C). The open coastal seagrass area exposed to higher potential risk corresponded to 50% (cat. III) and 1% (cat. IV) of the total inshore seagrass area in the Burdekin region (Figure 4-25b). A total of 17% and 83% of the enclosed coastal seagrass areas were exposed to potential risk categories III and IV respectively. Mid-shelf seagrasses were largely exposed to no/very low potential risk (67% of the Burdekin mid-shelf seagrasses), and to the lowest potential risk category II (33% of the Burdekin mid-shelf seagrasses).
  - **Comparison to long-term trends:** The area of coral reef and seagrass exposed to combined potential risk categories II–IV in 2024–25 in the Burdekin region were similar to the long-term average (± <1% change). There was however a notable shift from potential risk category II (-19%) to potential risk category III (+18%), primarily due to high local discharge from the Burdekin River, much higher than its long-term median (6.8 times above).

Table 4-4: Areas (km²) and percentages (%) of the Burdekin region, Burdekin coral reefs, and Burdekin surveyed seagrass exposed to different potential risk categories during the 2024–25 wet season and the long-term (2003–2023). The last 3 rows show the differences between % exposed in 2024–25 and the long-term average (red: increase, blue: decrease, green: no change, difference <5%).

Total surface area exposed		Total		**Potential Risk category**				**Total area exposed II–IV**
				No / very low	**Lowest**		**Highest**	
				I	**II**	**III**	**IV**	
Burdekin region	area	47,009	2025	39,916	4,335	1,962	796	7,093
			LT	42,281	3,363	747	617	4,728
	%	*100%*	2025	85%	9%	4%	2%	15%
			LT	90%	7%	2%	1%	10%
Burdekin coral reefs	area	2,966	2025	2,923	20	18	5	43
			LT	2,924	28	12	3	42
	%	*100%*	2025	99%	1%	1%	0%	1%
			LT	99%	1%	0.4%	0%	1%
Burdekin surveyed seagrass	area	708	2025	76	175	281	176	632
			LT	88	311	154	156	621
	%	*100%*	2025	11%	25%	40%	25%	89%
			LT	12%	44%	22%	22%	88%
Difference (2024–25 to long-term average)	Burdekin region			-5%	2%	3%	<1%	5%
	Burdekin *coral reefs*			<-1%	<-1%	<1%	<1%	<1%
	Burdekin *surveyed seagrass*			-2%	-19%	18%	3%	2%

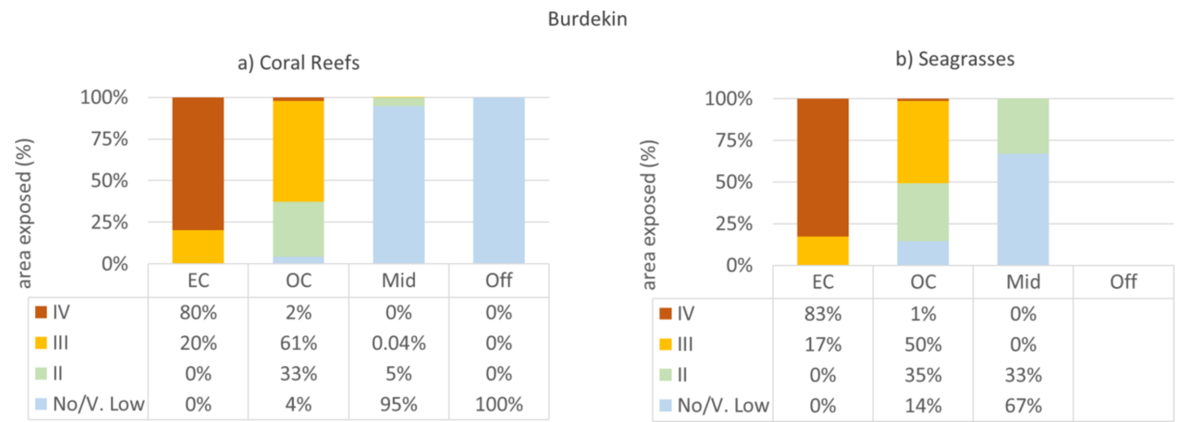


Figure 4-25: Percentage of the Burdekin region a) coral reef and b) surveyed seagrass habitats exposed to different potential risk categories during the 2024–25 wet season. Water body classifications are shown along the x-axes: enclosed coastal (EC), open coastal (OC), mid-shelf (Mid), and offshore (Off).

4.3.4 Mackay-Whitsunday region

The remote sensing products for the Mackay-Whitsunday region include:

1. the panels of weekly characteristics through the 22 week period between 1 December and 30 April (Figure 4-26 and Figure 4-27);
2. the frequency of the combined Reef WT1–2; and the frequency of Reef WT1, WT2, and WT3 individually (Figure 4-28);
3. the potential risk maps – each in the long-term and 2024–25 wet season; and a difference map showing areas exposed to an increased potential risk in 2024–25 (also in Figure 4-28).

The weekly Sentinel monitoring products (when not obstructed by cloud cover) clearly illustrate wet season surface water movements in the Mackay-Whitsunday region, as well as the influence of river discharge including changes in water colour from nutrient and sediment inputs and resuspension (Figure 4-26 and Figure 4-27). Discharge in the Mackay-Whitsunday region was 2.8 times the long-term median. There were 2 flood events around the first half of February (weeks 10–11) and in March (weeks 21–22). The quality of the weekly composites during these events was however compromised due to persistent cloud cover, particularly during the February events. It is likely that resulting flood plume have been missed during weeks 9–11, which may have affected the accuracy of exposure assessments in this region. Sampling of the Mackay-Whitsunday waters occurred regularly during the wet season, and around these events (Figure 4-26 and Figure 4-27, black dots).

The frequency and potential risk maps in Figure 4-28 show patterns that are relatively consistent with long-term average conditions, but vary between coral reef and seagrass ecosystems. Table 4-5 presents the areas (km^2) and percentage (%) of Mackay-Whitsunday region, coral reef, and seagrass areas affected by different categories of potential risk based on satellite-derived Reef water types.

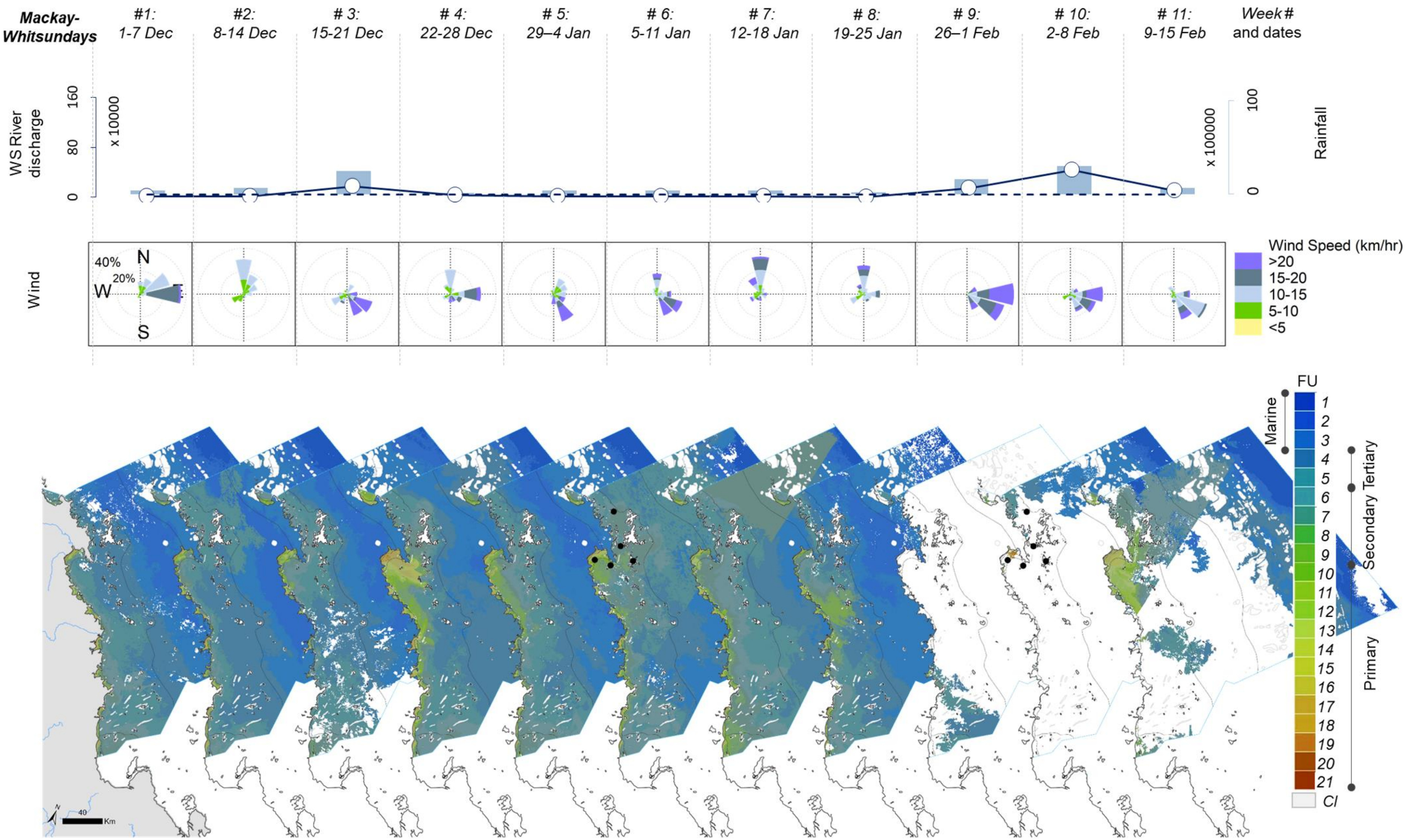


Figure 4-26: Panel of water quality and environmental characteristics in the Mackay-Whitsunday region throughout the 2024–25 wet season period: weeks 1 to 11. Includes: 2024–25 weekly river discharge (ML) and rainfall (ML); wind roses showing the wind direction and speed (km h^{-1}) for each week; and FU colour class maps showing the location of the *in situ* data. The mean long-term weekly river discharge is indicated by a dotted blue line. Weekly river discharges are the sum of discharge (ML) from the O'Connell and Pioneer Rivers and Sandy Creek.

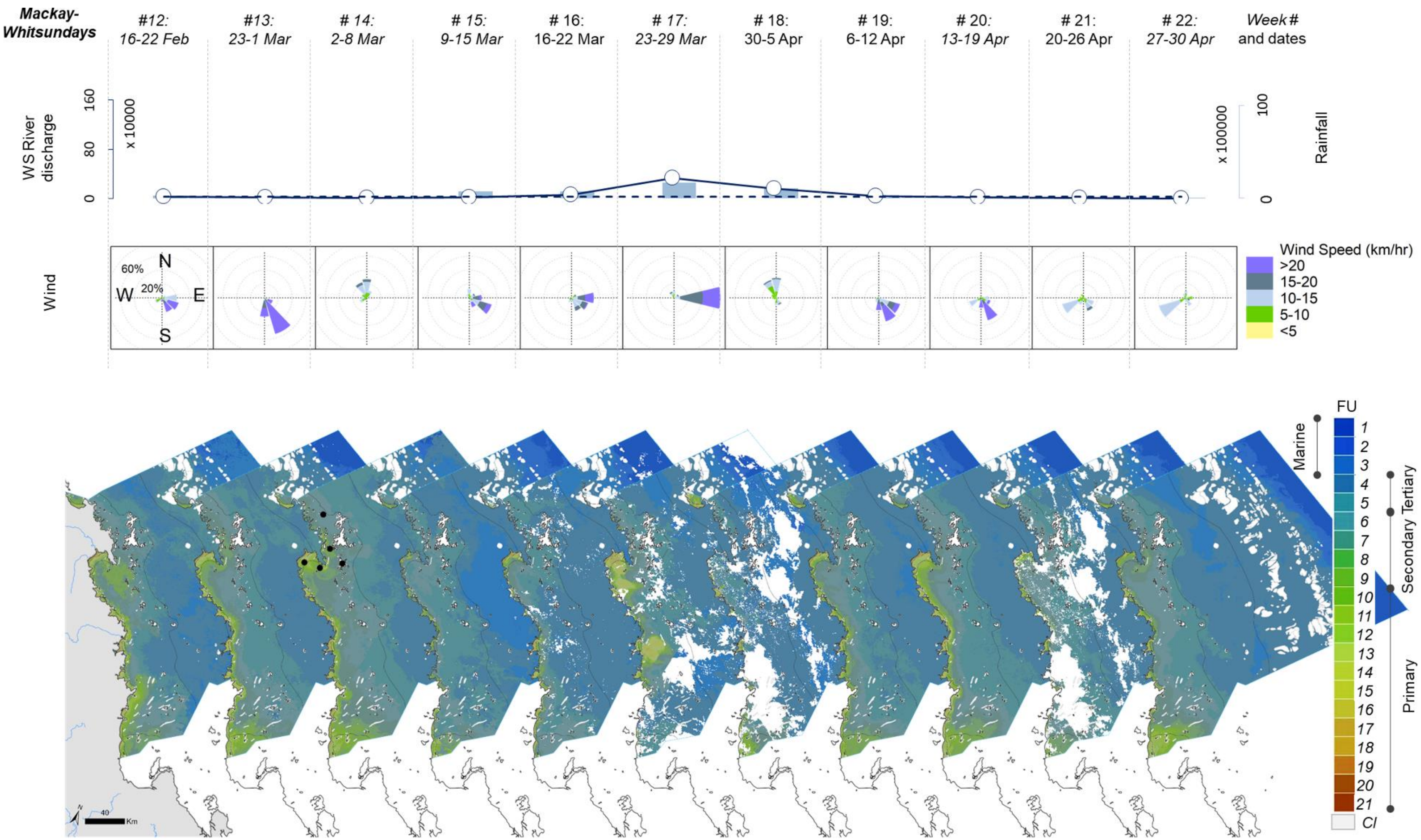


Figure 4-27: Panel of water quality and environmental characteristics in the Mackay-Whitsunday region throughout the 2024–25 wet season period: weeks 12 to 22. Includes: weekly river discharge (ML) and rainfall (ML); wind roses showing the wind direction and speed (km h-1) for each week; and FU colour class maps showing the location of the *in situ* data. The mean long-term weekly river discharge is indicated by a dotted blue line. Weekly river discharges are the sum of discharge (ML) from the O'Connell and Pioneer Rivers and Sandy Creek.

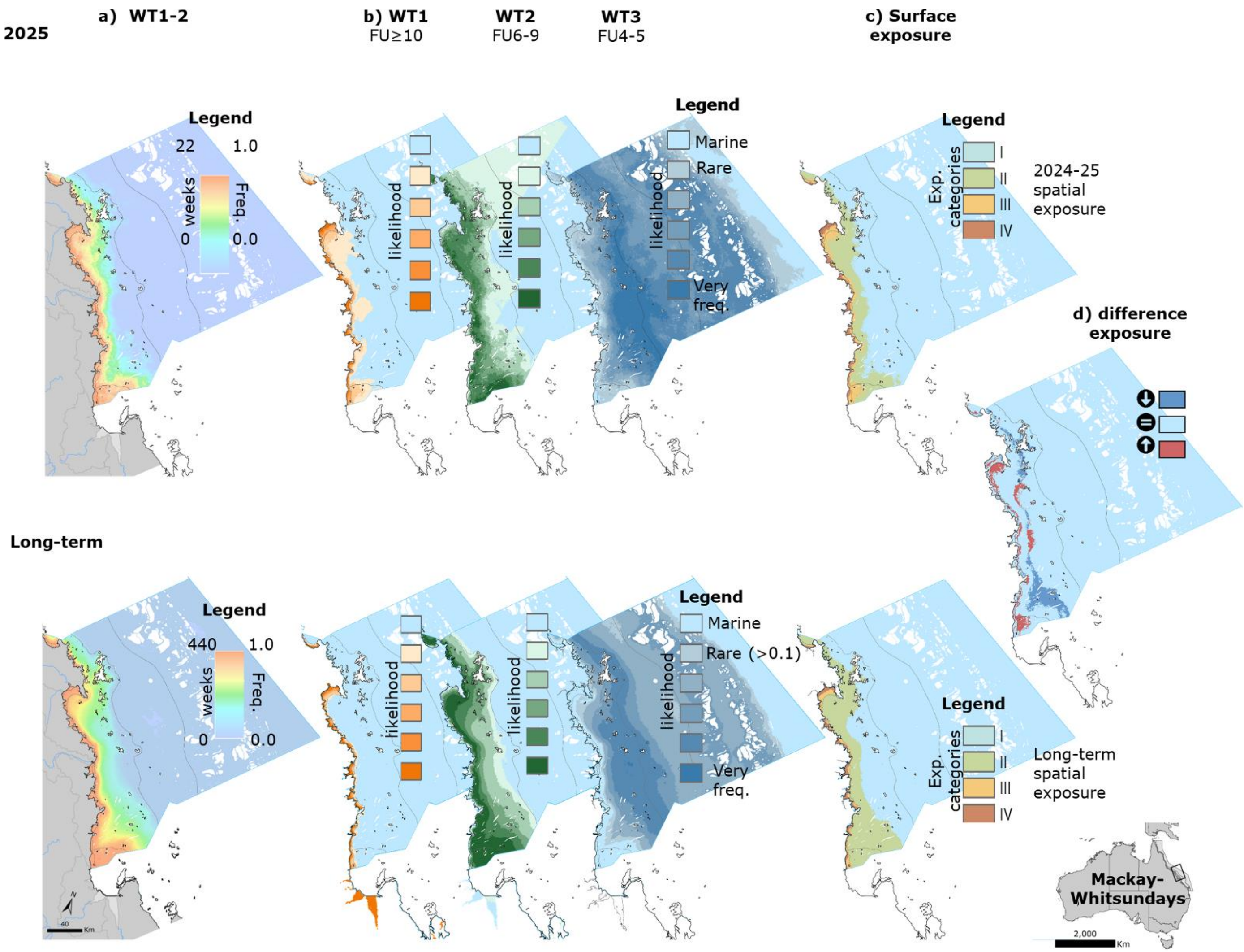


Figure 4-28: Long-term and current year remote sensing results for the Mackay-Whitsunday region showing the a) frequency of Reef WT1–2; b) the frequency of Reef WT1, WT2, and WT3 individually regrouped into 5 likelihood categories [<0.2 (Rare), 0.2–0.4, 0.4–0.6, 0.6–0.8 and 0.8–1 (very frequent)]; c) potential risk maps - each in the long-term (bottom) and 2024–25 wet season (top). d) Difference map showing areas with an increase (in red, ➊) or decrease (in purple, ➋) in potential risk category in 2024–25 against long-term trends [calculated as (c, top) exposure in 2025 minus (c, bottom) long-term]. Note that optical water types – especially the Reef WT3 – do not always correspond to direct catchment discharge and can also be due to oceanographic processes (see definitions in Table 2-2). .

In 2024–25, it was estimated that:

- Mackay-Whitsunday region: 89% of the region was not exposed to a potential risk, above the long-term average (87%, Table 4-5), indicating relatively drier conditions in this region. A total of 11% of the Mackay-Whitsunday region was exposed to combined potential risk categories II–IV (or about 5,399 km^2). However, only 1% (504 km^2) of the region was in the highest potential risk category (IV) and 2% (978 km^2) in potential risk category III. It is noted that there was extensive cloud cover during most of the periods of highest river discharge in late January and mid-February, limiting the assessment and therefore potentially underestimating exposure.
- Mackay-Whitsunday waterbodies: only the enclosed coastal and open coastal waters were exposed to the highest categories of potential risk (III and IV, (Figure 4-7c). The open coastal area exposed was however spatially limited and corresponded to 6% (cat. III) of the total Mackay-Whitsunday inshore area. A total of 37% and 58% of the enclosed coastal areas were exposed to potential risk categories III and IV, respectively. The mid-shelf and offshore Mackay-Whitsunday waterbodies were not exposed to potential risk.
- Mackay-Whitsunday habitats:
    - **Coral reefs:** Approximately 4% (or 138 km^2) of coral reefs in the Mackay-Whitsunday region were exposed to combined potential risk categories II–IV (Table 4-5). However, less than 1% of coral were in the highest potential risk category (IV) and 1% in potential risk category III (combined 52 km^2), and they were all enclosed coastal or open coastal reefs (Figure 4-29a). A total of 9% (<300 km^2) of the Mackay-Whitsunday corals occur in the inshore waters (Appendix C). The open coastal coral area exposed to higher potential risk was spatially limited and corresponded to 11% (cat. III) and 1% (cat. IV) of the total open coastal reef area in the Mackay-Whitsunday region. A total of 33% and 46% of the enclosed coastal areas were exposed to potential risk categories III and IV, respectively. Mid-shelf and offshore reefs were not exposed to a potential risk.
    - **Seagrasses:** All of the surveyed seagrass beds in the Mackay-Whitsunday region are located in the inshore area (Appendix C). Approximately 92% of seagrasses in the Mackay-Whitsunday region were exposed to combined potential risk categories II–IV (283 km^2, Table 4-5), under the long-term average (97%). A total of 24% (74 km^2) of seagrasses were in the highest potential risk category (IV) and 16% (50 km2) were in potential risk category III. The open coastal seagrass area exposed to higher potential risk was spatially limited and corresponded to 10% (cat. III) of the total open coastal seagrass area in the Mackay-Whitsunday region (Figure 4-29b). Approximately 27% and 65% of the enclosed coastal areas were exposed to potential risk categories III and IV, respectively.
    - **Comparison with long-term trends:** The area of coral reef exposed to combined potential risk categories II–IV in 2024–25 in the Mackay-Whitsunday region was similar to the long-term average (-2% change). There was a decrease in the seagrass area exposed to the potential risk category II (-6%) toward the no/very low potential risk category (+5%), and the total seagrass area exposed to combined potential categories risk II–IV was below the long-term average (-5%).

Table 4-5: Areas (km^2) and percentages (%) of the Mackay-Whitsunday region, Mackay-Whitsunday coral reefs, and Mackay-Whitsunday surveyed seagrass exposed to different potential risk categories during the 2024–25 wet season and the long-term (2003–2023). The last 3 rows show the differences between % exposed in 2024–25 and the long-term average (: increase, : decrease, : no change, difference ≤5%).

Total surface area exposed		**Total**		**Potential Risk category**				**Total area exposed II–IV**
				No / very low	**Lowest**		**Highest**	
				I	**II**	**III**	**IV**	
Mackay-Whitsunday region	area	48,957	2025	43,558	3,917	978	504	5,399
			LT	42,449	5,602	471	434	6,507
	%	*100%*	2025	89%	8%	2%	1%	11%
			LT	87%	11%	1%	1%	13%
Mackay-Whitsunday coral reefs	area	3,216	2025	3,079	86	36	15	138
			LT	3,019	166	25	7	197
	%	*100%*	2025	96%	3%	1%	0%	4%
			LT	94%	5%	1%	0%	6%
Mackay-Whitsunday surveyed seagrass	area	307	2025	25	159	50	74	283
			LT	10	186	36	76	297
	%	*100%*	2024	8%	52%	16%	24%	92%
			LT	3%	60%	12%	25%	97%
Difference (2024–25 to long-term average)	Mackay-Whitsunday region			2%	-3%	1%	<1%	-2%
	Mackay-Whitsunday *coral reefs*			2%	-2%	<1%	<1%	-2%
	Mackay-Whitsunday *surveyed seagrass*			5%	-9%	4%	<-1%	-5%

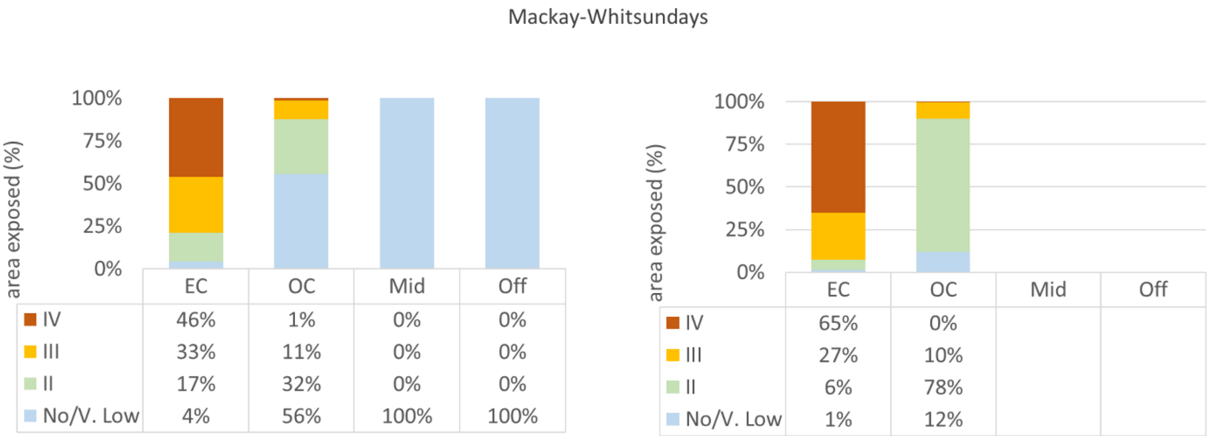


Figure 4-29: Percentage of the Mackay-Whitsunday region a) coral reef and b) surveyed seagrass habitats exposed to different potential risk categories during the 2024–25 wet season. Water body classifications are shown along the x-axes: enclosed coastal (EC), open coastal (OC), mid-shelf (Mid), and offshore (Off).

4.3.5 Fitzroy and Burnett-Mary regions

It is currently out of scope of the MMP design to produce the full suite of remote sensing products for the Fitzroy and Burnett Mary regions. It should be noted that exposure maps have a higher degree of uncertainty in the Fitzroy and Burnett-Mary regions than in those described above due to limited validation from *in situ* monitoring. In particular, there is no formal water quality monitoring program in the Burnett-Mary region that is reported as part of the Paddock to Reef program. As with all regions, the potential risk categories are not validated against ecological health data and should therefore be interpreted as relative levels of potential risk for seagrass and coral reef ecosystems

Discharge in the Fitzroy region was just above the long-term median (1.2 times long-term median) and discharge in the Burnett Mary region was much higher than the long-term median (3.4 times long-term median) (Figure 3-5).

Fitzroy

The assessment of potential risk of exposure of ecosystems to land-based runoff for the Fitzroy region identified patterns that are relatively consistent with long-term average conditions, but vary between coral reef and seagrass ecosystems. Table 4-6 presents the areas (km^2) and percentage (%) of Fitzroy region, coral reef, and seagrass areas affected by different categories of potential risk based on satellite-derived wet season water maps. In 2024–25, it was estimated that:

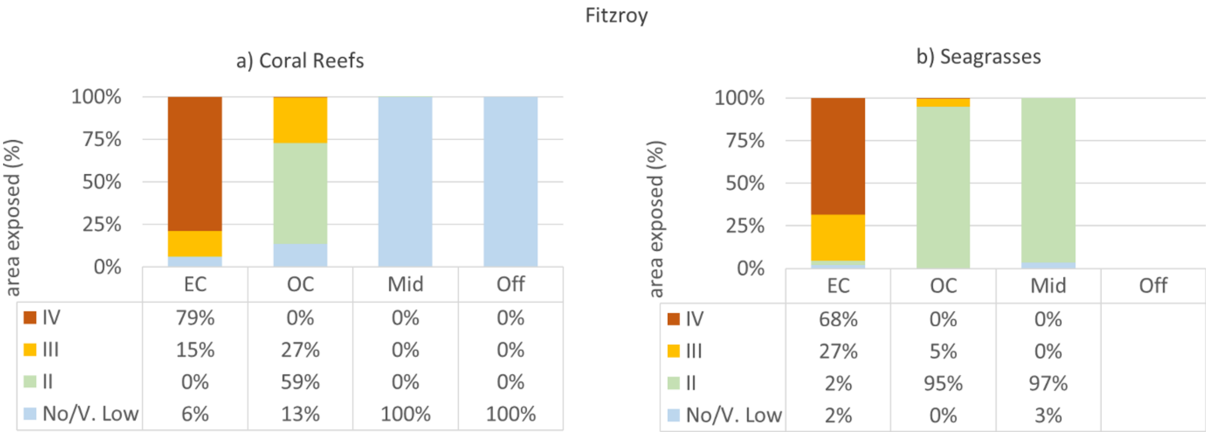
- Fitzroy region: 92% of the Fitzroy region was not exposed to a potential risk, similar to the long-term average (91%, Table 4-6). 8% (or about 6,848 km^2) of the Fitzroy region was exposed to combined potential risk categories II–IV. However, only 2% (1,332 km^2) of the region was in the highest potential risk category (IV) and 2% (1,397 km^2) in potential risk category III.
- Fitzroy waterbodies: only the enclosed coastal and open coastal Fitzroy waters were exposed to the highest categories of potential risk (III and IV). The open coastal area exposed was however spatially limited and corresponded to 9% (cat. III) and <1% (cat. IV) of the total Fitzroy inshore area (Figure 4-7c). Approximately 31% and 65% of the enclosed coastal areas were exposed to potential risk categories III and IV, respectively. The offshore Fitzroy waterbody was not exposed to a potential risk, and only 2% of the mid-shelf Fitzroy waterbody was exposed to the lowest potential category of risk (II).
- Fitzroy habitats:
    - **Coral reefs:** Approximately 3% of coral reefs in the Fitzroy region were exposed to combined potential risk categories II–IV (Table 4-6). 1% of coral were in the highest potential risk category (IV) and 1% in potential risk category III (combined 70 km^2), and they were all enclosed coastal or mid-shelf reefs (Figure 4-30a). Only 4% (<200 km^2) of the Fitzroy corals occur in the inshore waters (Appendix C). The open coastal coral area exposed to higher potential risk was limited and corresponded to 27% (cat. III) and <1% (cat. IV) of the total open coastal coral reef area in the Fitzroy. Approximately 15% and 79% of the enclosed coastal areas were exposed to potential risk categories III and IV, respectively. All mid-shelf and offshore reefs were classified as no/very low risk.
    - **Seagrasses:** Approximately 99% (or about 471 km^2) of seagrasses in the Fitzroy region were exposed to combined potential risk categories II–IV (Table 4-6), which was over the long-term average (90%) and linked to an increase in the exposure of Fitzroy seagrasses to the lowest potential risk category II. Approximately 24% (114 km^2) of seagrasses were in the highest potential risk category (IV) and 11% (55 km^2) were in potential risk category III, and they were all inshore seagrasses (Figure 4-30b). Approximately 81% (<400 km^2) of the Fitzroy seagrasses occur in the inshore waters (Appendix C). The open coastal seagrass area exposed to higher potential risk was limited and corresponded to 5% (cat. III) of the total open

coastal seagrass area in the Fitzroy region (no open coastal seagrasses were exposed to the higher potential risk category IV). 27% and 68% of the enclosed coastal areas were exposed to potential risk categories III and IV, respectively, and 97% of the mid-shelf areas were exposed to the lowest potential risk category II.

- **Comparison with long-term trends:** The area of coral reef exposed to the highest potential risk categories (II to IV) in the Fitzroy region was consistent with long-term averages in 2024–25. In contrast, seagrass areas in the Fitzroy region showed a shift: there was a 12% increase in areas exposed to potential risk category II, but a 6% decrease in areas exposed to the highest potential risk category (IV). Overall, this resulted in a net increase of 9% in the total seagrass area in the Fitzroy region exposed to potential risk during 2024–25 when compared to the long-term average.

Table 4-6: Areas (km^2) and percentages (%) of the Fitzroy region, Fitzroy coral reefs, and Fitzroy surveyed seagrass exposed to different potential risk categories during the 2024–25 wet season and the long-term (2003–2023). The last 3 rows show the differences between % exposed in 2024–25 and the long-term average (red: increase, blue: decrease, green: no change, difference ≤5%). Areas south of the Marine Park (Hervey Bay) are not included.

Total surface area exposed		Total		Potential Risk category				Total area exposed II–IV
				No / Very low	Lowest		Highest	
				I	II	III	IV	
Fitzroy region	area	86,869	2025	80,021	4,120	1,397	1,332	6,848
			LT	78,805	5,265	1,189	1,610	8,064
	%	*100%*	2025	92%	5%	2%	2%	8%
			LT	91%	6%	1%	2%	9%
Fitzroy coral reefs	area	4,881	2025	4,727	84	43	27	153
			LT	4,719	113	14	35	161
	%	*100%*	2025	97%	2%	1%	1%	3%
			LT	97%	2%	0%	1%	3%
Fitzroy surveyed seagrass	area	478	2025	7	302	55	114	471
			LT	49	243	41	145	429
	%	*100%*	2025	1%	63%	11%	24%	99%
			LT	10%	51%	9%	30%	90%
Difference (2024–25 to long-term average)	Fitzroy region			1%	-1%	<1%	<-1%	-1%
	Fitzroy *coral reefs*			<1%	<-1%	<1%	<-1%	<-1%
	Fitzroy *surveyed seagrass*			-9%	12%	3%	-6%	9%



a) Coral Reefs	EC	OC	Mid	Off
IV	79%	0%	0%	0%
III	15%	27%	0%	0%
II	0%	59%	0%	0%
No/V. Low	6%	13%	100%	100%

b) Seagrasses	EC	OC	Mid	Off
IV	68%	0%	0%	
III	27%	5%	0%	
II	2%	95%	97%	
No/V. Low	2%	0%	3%	

Figure 4-30: Percentage of the Fitzroy region a) coral reef and b) surveyed seagrass habitats affected by different potential risk categories during the 2024–25 wet season. Water body classifications are shown along the x-axes: enclosed coastal (EC), open coastal (OC), mid-shelf (Mid), and offshore (Off).

Burnett-Mary

The assessment of potential risk of exposure of ecosystems to land-based runoff for the Burnett-Mary region identified patterns that are typically higher than long-term average conditions for seagrass, but relatively consistent in terms of total area and coral reef exposure. Table 4-7 presents the areas (km^2) and percentage (%) of Burnett-Mary region, coral reef, and seagrass areas exposed to different categories of potential risk based on satellite-derived wet season water maps.

In 2024–25, it was estimated that:

- Burnett-Mary region: Approximately 95% of the Burnett-Mary region was not exposed to a potential risk, which was similar to the long-term average (96%, Table 4-7). A total of 5% of the Burnett-Mary region (or about 1,770 km^2) was exposed to combined potential risk categories II–IV, with <1% in the highest potential risk category (IV) and 1% in potential risk category III (combined 526 km^2).
- Burnett-Mary waterbodies: only the enclosed costal and open coastal Burnett-Mary waters were exposed to the highest categories of potential risk (III and IV). The open coastal area exposed corresponded to 26% (cat. III) and 3% (cat. IV) of the total Burnett-Mary inshore area (Figure 4-7c). A total of 50% and 41% of the enclosed coastal areas were exposed to potential risk categories III and IV, respectively. >94% of the mid-shelf Burnett-Mary waterbody and 100% of the offshore waterbody were exposed to no/very low potential risk.
- Burnett-Mary habitats:
    - **Coral reefs:** Approximately 2% of coral reefs in the Burnett-Mary region were exposed to combined potential risk categories II–IV (Table 4-7). <1% of coral reefs were exposed to the highest potential risk category IV (about 1 km^2) and 2% to cat. III (5 km^2) these were all enclosed coastal or open coastal reefs (Figure 4-31a). Only 2% (<10 km^2) of the Burnett-Mary corals occur in the inshore waters (Appendix C). The open coastal coral area exposed to potential risk category III and IV corresponded to 67% and 30% of the total open coastal coral reef area in the Burnett-Mary region. The enclosed coastal area exposed to potential risk category III and IV corresponded to 89% and 10% of the total enclosed coastal area in the Burnett-Mary region. All mid-shelf coral reefs were exposed to no/very low potential risk. There are no offshore reefs in the Burnett-Mary region.
    - **Seagrasses:** Approximately 97% (or 251 km^2) of seagrasses in the Burnett-Mary region were exposed to combined potential risk categories II–IV (Table 4-7), which was over the long-term average (83%). Approximately 15% (40 km^2) of seagrasses

were in the highest potential risk category (IV) and 19% (49 km^2) were in potential risk category III and they were all enclosed coastal or open coastal seagrasses (Figure 4-31b). A total of 71% (<200 km^2) of the Burnett-Mary coral reefs occur in the enclosed coastal and open coastal waters (Appendix C). The open coastal seagrass area exposed to higher potential risk corresponded to 10% (cat. III) of the total inshore seagrass area in the Burnett-Mary region. A total of 44% and 44% of the enclosed coastal seagrass areas were exposed to potential risk categories III and IV respectively. 7% of the mid-shelf seagrasses in the Burnett-Mary region were exposed to no/very low potential risk and 93% to the lowest category of potential risk II.

- **Comparison to long-term trends:** The area of coral reef exposed to combined potential risk categories II–IV in 2024–25 in the Burnett-Mary region was similar to long-term averages. There was an increase in the seagrass area exposed to the potential risk categories II (+8%) and III (+8%) resulting in a net increase of 13% in the total seagrass area in the Burnett-Mary region exposed to potential risk during 2024–25 when compared to the long-term average.

Table 4-7: Areas (km^2) and percentages (%) of the Burnett-Mary region, Burnett-Mary coral reefs, and Burnett-Mary surveyed seagrass exposed to different potential risk categories during the 2024–25 wet season and the long-term (2003–2023). The last 3 rows show the differences between % exposed in 2024–25 and the long-term average (: increase, : decrease, : no change, difference ≤5%). Areas south of the Marine Park (Hervey Bay) are not included.

Total surface area exposed		Total		Potential Risk category				Total area exposed II–IV
				No / Very low	Lowest		Highest	
				I	II	III	IV	
Burnett-Mary region	area	37,713	2025	35,943	1,245	374	152	1,770
			LT	36,238	1,103	209	163	1,475
	%	*100%*	2025	95%	3%	1%	0%	5%
			LT	96%	3%	1%	0%	4%
Burnett-Mary coral reefs	area	285	2025	279	0	5	1	6
			LT	279	3	3	0	6
	%	*100%*	2025	98%	0%	2%	0%	2%
			LT	98%	1%	1%	0%	2%
Burnett-Mary surveyed seagrass	area	259	2025	9	161	49	40	251
			LT	43	140	30	46	217
	%	*100%*	2025	3%	62%	19%	15%	97%
			LT	17%	54%	12%	18%	83%
Difference (2024–25 to long-term average)	Burnett-Mary region			<-1%	<1%	<1%	<-1%	<1%
	Burnett-Mary *coral reefs*			<-1%	<-1%	<1%	<1%	<1%
	Burnett-Mary *surveyed seagrass*			-13%	8%	8%	-2%	13%

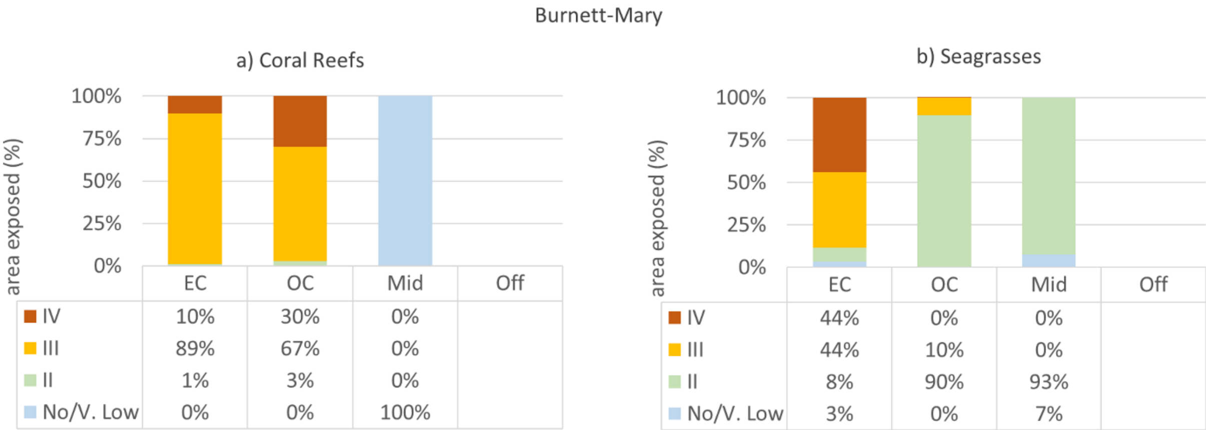


Figure 4-31: Percentage of the Burnett-Mary region a) coral reef and b) surveyed seagrass habitats affected by different potential risk categories during the 2024–25 wet season. Water body classifications are shown along the x-axes: enclosed coastal (EC), open coastal (OC), mid-shelf (Mid), and offshore (Off).

4.4 Modelling and mapping summary

Water type frequency maps (Sentinel-3 data)

A summary of the key findings of the regional remote sensing outputs is presented below. This is further summarised in Table 7-1.

This year's results are relatively consistent with previous results and confirm that Sentinel-3 satellite data and the FU scale are useful for mapping Reef optical water types. Sentinel maps showed an inshore-to-offshore spatial pattern similar to the well-documented MODIS patterns (for example, Waterhouse *et al.*, 2021), with the highest frequency of the Reef WT1 (typically enriched in sediment and dissolved organic matter, brownish turbid waters) in the inshore waterbody, and more particularly in the enclosed coastal waters. Mid-shelf waterbodies were most frequently exposed to the Reef WT2 and WT3, although a small percentage of the mid-shelf waterbody was also exposed to the Reef WT1, and offshore waterbodies were most frequently exposed to the Reef WT3 (typically with low land-based contaminant concentrations and including the influence of oceanographic processes). These patterns were also observed in satellite imagery, showing extensive river plumes extending in the mid-shelf and offshore waters in the Wet Tropics and Burdekin regions.

Approximately 5% of the Reef was exposed to Reef WT1 waters during the 2024–25 wet season. Inshore Reef waters (enclosed coastal and open coastal) were significantly exposed (73% and 32% of their respective total waterbody areas). Additionally, a small percentage of the mid-shelf waterbody was also exposed, representing 3% of its total waterbody area. Approximately 21% of the Reef was exposed to Reef WT2, which exceeded both the long-term (17%) and coral recovery period percentages (16% of the Reef). Exposure to Reef WT2 was significant, affecting 99% of open coastal waters, 64% of enclosed coastal areas, and 30% of mid-shelf zones, with even 4% of offshore areas. In 2024–25, as in the previous 4 years, the Reef area exposed to Reef WT3 (63% of the Reef) exceeded both the long-term average (53% of the Reef) and the wet year reference periods (58% of the Reef). This result is related to anomalously large Reef WT3 areas measured in the mid-shelf and offshore waterbodies, and may be a reflection of the large extent of river influence observed in satellite imagery in February 2025, but can also be linked to shelf upwelling in the central and southern Reef areas. The drivers of Reef WT3 conditions should be further investigated in a future case study using the eReefs model and by comparing the Reef WT3 maps with sea surface temperature climatology (for example, Wijffels *et al.*, 2018). Oceanographic processes that influence water colour might in turn be influenced by climate change, further justifying investigation.

Potential risk of ecosystem exposure maps (Sentinel-3 and field water quality data)

Reef WT3 waters are typically associated with low land-based sediment, nutrient, and contaminant concentrations with only the long-term mean PN concentration above the wet season GV in the Reef WT3, and a low magnitude score in the Reef exposure assessment (Figure 4-5). While Reef WT3 areas in 2024–25 were larger than the long-term average due to the large extent of river influence and potential shelf upwelling in central and southern Reef areas, this did not result an increase in the Reef-wide potential risk. The total Reef area exposed to a potential risk in 2024–25 was spatially limited and similar to the long-term average. Ninety percent of the Reef was exposed to no/very low potential risk and only 3% (but about 11,200 km^2) of the Reef was in the highest exposure categories III and IV.

The offshore and mid-shelf and waterbodies were largely classified as no/very low potential risk of exposure (100% and 92%, respectively).This pattern was observed in all Reef regions, except in the Wet Tropics and the Burdekin region where the mid-shelf waterbodies were significantly exposed to the lowest potential risk category II (53% and 18% of the Wet Tropics and Burdekin mid-shelf waterbodies), reflecting the high river discharge conditions in both regions. Open coastal waters were largely exposed to the lowest category of potential risk (II, 41% of the open coastal waterbody) or to no/very low potential risk (44% of the open coastal waterbody). 14% and 1% of the total Reef open coastal waters were exposed to the highest potential risk categories III and IV. The Reef enclosed coastal waters had the highest relative potential risk, with 30% and 48% of the enclosed coastal waters exposed to categories III and IV, respectively. This, however, represents a very small proportion of the total size of the Reef (less than 2% of the Reef). The Wet Tropics, Burdekin, and Burnett-Mary region open coastal waterbodies had the greatest exposure to potential risk categories III (38%, 39% and 26%, respectively), with all other regions between 6% and 9% (Figure 4-7).

As a result, mid-shelf and offshore Reef habitats (surveyed seagrass and coral reefs) were either exposed to the lowest potential risk category II or to no potential risk. Open coastal seagrasses and coral reefs were largely exposed to the lowest category of potential risk (II, 60% and 42% of the total Reef seagrass and coral areas, respectively), but 5% of the total area of the open coastal coral reef areas was exposed to the highest category of potential risk (IV). Enclosed coastal habitats were the most likely at risk, with 87% (less than 1% of the total coral reef area of the Reef) and 72% (~22% of the total seagrass area in the Reef) of the total enclosed area of coastal seagrass and coral reef in the Reef classified as combined category III–IV. The enclosed coastal areas are shallow regions of the Reef and it is likely that wind-driven resuspension (some of which was originally derived from river discharge in previous events) may also influence the TSS concentrations and resulting exposure results in this very inshore region.

Regional areas exposed to a potential risk (combined potential risk categories II–IV) were largely similar to the long-term average, but an 8% and 5% increase was observed in the total areas exposed in the Wet Tropics and Burdekin regions, respectively, when compared to the long-term average (Figure 4-32).

In the Wet Tropics region, the total coral reef area exposed to a potential risk (II–IV) was above the long-term average (+3%), which was consistent with the high discharge measured in 2024–25. There was also an increase in seagrass areas exposed to the potential risk category III (+21%).

While the total areas in the Burdekin region exposed to a potential risk (combined potential risk categories II–IV) were greater than the average long-term average (+5% changes), this did not significantly impact the ecosystem exposure results. The total area of coral reef exposed to the potential risk categories II–IV was similar to the long-term average (changes

≤1%) and the seagrass area exposed was slightly above the long-term average (+2%). However, there was an increase in seagrass area exposed to the potential risk category III (+18%) when compared to the long-term average.

In the Mackay-Whitsunday region, the total seagrass area exposed to a potential risk (categories II–IV) was below the long-term average (-5%) linked to a decrease in the seagrass area exposed to the lowest potential risk (category II) with greater areas in the no/very low potential risk category.

There were increases in the areas of seagrass exposed to combined potential risk categories II–IV in the Fitzroy and Burnett-Mary regions (III: +10%), which was related to an increase in exposure to the lowest potential risk category in the Fitzroy region (II: +12%) and to an increase in exposure to both potential risk categories II and III in the Burnett-Mary region.

It should be noted there are several caveats and limitations to the potential exposure maps:

- Reef-wide water quality GVs are applied rather than site or waterbody-specific GVs. While the development of waterbody- or regionally-specific water quality guidelines would significantly improve the estimation of the magnitude of potential risk at smaller scales, it is currently outside the scope of the MMP.
- This assessment does not take into account the current condition of Reef ecosystems and long-term impacts on these communities. For example, it is recognised that inshore communities may have adapted to the most turbid Reef water types and exposure history; therefore, the highest potential risk of an ecological response could be during large events when Reef WT1 and WT2 extend into otherwise low exposure (more offshore) areas. The relationship between ecosystem condition and pollutant exposure is explored further in Waterhouse et al. (2025) in terms of scaled management responses for the Reef and its catchments.
- Reporting the areas of coral reefs and seagrass in the highest potential exposure categories cannot be assessed in terms of ecological relevance at this stage and is included as a comparative measure between regions and between years. However, the products are useful to provide context for interpreting the MMP coral and seagrass condition assessments undertaken each year. For example, the assessment highlights where exposure is elevated relative to historical patterns, and supports regional comparisons and long-term tracking of changes in exposure regimes which is referenced in relation to coral reef and seagrass condition reporting where relevant.
- One-week exposures are reported. The ecological consequence of exposure of this duration is not presently known. This could be partially addressed by adding sequential exposure duration to the assessment and improving the characterisation of water types relative to ecologically relevant water-quality guideline values (which is currently undertaken by integrating all new field data collected every 5 years). Both would strengthen the ability to estimate the magnitude of potential risk of exposure to wet season water quality.
- The degree of validation against *in situ* data varies between regions, with limited water quality data in the Burnett-Mary region and lower frequency sampling in the Cape York, Mackay-Whitsunday and Fitzroy regions.
- It is impossible to fully separate the direct influence of riverine plume conditions from wind- and wave-driven sediment resuspension in optical satellite images, and this may particularly influence exposure results in the shallow enclosed coastal Reef waters. Similarly, it is impossible at this stage to separate catchment versus oceanographic processes in offshore Reef WT3 waters.

Importantly, advancing these caveats and limitations requires time, sustained investment, and support for both the current monitoring program and the development of new methods thought case studies and scientific publication.

Satellite methods and tools developed though the MMP to map Reef water types have now proved to be efficient for the mapping of water quality trends. However, there is a need to strengthen the integration of spatial and temporal information obtained from the water type maps and *in situ* water quality measurements with environmental data to better understand physical influences that can lead to light reduction and water colour changes in both wet and dry seasons, and from the inshore to offshore Reef areas. Multivariate statistical analyses would be useful to gain further understanding of these processes. These conditions could also be evaluated and compared with different scenarios in the eReefs model. These improvements require additional resources beyond the scope of the existing program.

Furthermore, it would be highly valuable to collect extra samples in the transition zone between Reef WT1 and WT2 in the future to better understand drivers of water colour variability and further characterise concentrations and productivity in this region of flood plumes. The results and satellite observation of the 2024–25 flood events in the Burdekin and Wet Tropics regions highlighted that river discharge can extend into mid-shelf and offshore areas for periods of days to weeks; however, the characteristics of this exposure are poorly understood.

There are some limitations to the assessment in the enclosed coastal waters as GVs for enclosed coastal waters are different from other areas of the Reef. Separating the enclosed coastal waters information in the exposure assessment process and applying higher water quality guideline values to these samples should be investigated in a future case study to improve the accuracy of the risk classification. Another option would be to conduct a sensitivity analysis by removing water quality samples collected in the enclosed coastal waters in the characterisation of the water type composition (Section 2.2.2) and the calculations of the exposure scores (Figure 4-5). However, this would discard important water quality information collected in the flood plumes where the highest turbidity is typically measured.

Finally, there is a major gap in the availability of *in situ* water quality data in the Burnett-Mary region and in mid-shelf and offshore waterbodies across the Reef. These data are essential for improving confidence in the remote sensing products across all regions and waterbodies. The pilot study to investigate options for water quality sampling as part of the Reef Trust Partnership Crown of Thorns Starfish Control Program (Waterhouse *et al.*, 2023) is a good example of the opportunities that exist to expand these water quality datasets. The pilot study also highlighted the potential of using a Smartphone app, the Eye on Water (https://www.eyeonwater.org/) to collect vessel-based Forel-Ule colour information. Using the Eye on Water app concomitantly to the water quality data allowed retrieval of water colour information at the exact site location, even when satellite images are obscured by clouds. It thus increases the number of data available to match up concentrations of water quality parameters and the 4 Reef water types and can help improve the characterisation of water quality concentrations across Reef water types. Citizen-science observations can play a valuable supporting role particularly in promoting and demonstrating the value of the methods we use (the Forel-Ule colour scale). They also provide an effective way to engage the public and improve communication about water-quality conditions, and flood plume impacts across the Reef. While valuable, ensuring consistent, high-quality citizen-science datasets is time-consuming, and the balance between the value gained and the effort required would need to be clearly defined before such an effort is engaged in this program. A combined approach, where current (or expended) field monitoring and satellite observations remain the core of the assessment, and citizen science contributes additional context and communication value might also be valuable and could be explored.

Dispersal of river-derived DIN, fine sediment and PN

In 2024–25, the spatial extent and intensity of the anthropogenic and total load scenarios reflect the patterns of high river discharge across the Reef:

- For DIN – intensive loading in the Wet Tropics, Burdekin and Mackay Whitsunday regions.
- For TSS - intensive loading in the Burdekin region, and to a lesser extent, the Wet Tropics rivers south of Cairns and particularly the Tully and Herbert Rivers, rivers in the Mackay Whitsunday region, and the Fitzroy and Mary Rivers.
- For PN - intensive loading in the Burdekin region, and to a lesser extent, the Wet Tropics rivers, rivers in the Mackay Whitsunday region, the Fitzroy River and rivers in the Burnett Mary region.

There is good alignment between these results and the exposure maps presented in Section 4.3. The maps highlight consistent hotspots showing the influence of river-derived pollutant on the Reef.

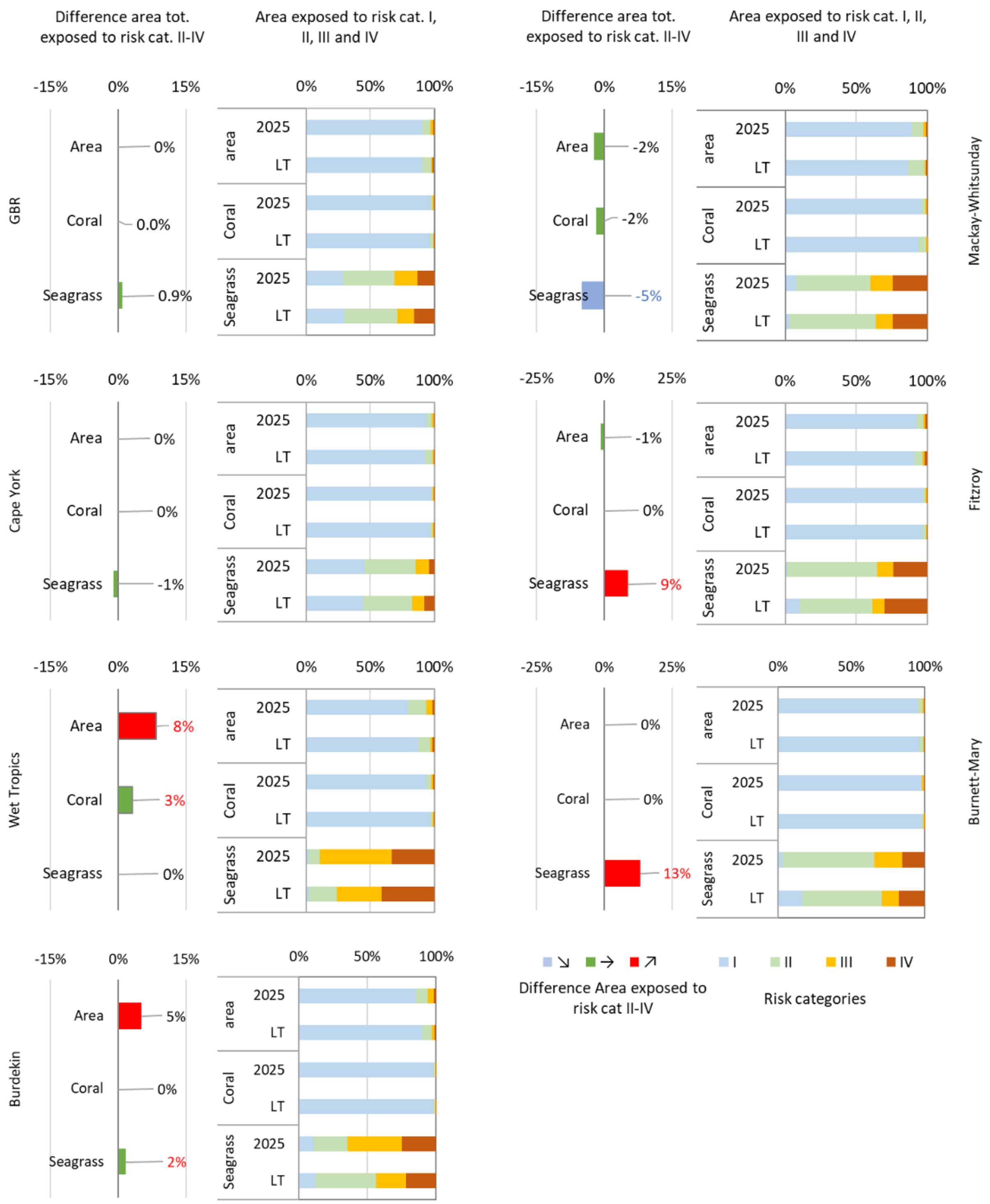


Figure 4-32: Areas (km²) and percentages (%) of the Reef and Reef regions, coral reefs, and surveyed seagrass affected by different potential risk categories during the 2024–25 wet season and the long-term (2003–2023). The left figures show the differences between % exposed in 2024–25 and the long-term average (red: increase, blue: decrease, green: no change, difference ≤5%). Note the different x-axis scale for the Fitzroy and Burnett-Mary difference plots.

5 FOCUS REGION WATER QUALITY AND WATER QUALITY INDEX

The following sections provide detailed analysis of key water quality variables from *in situ* water quality monitoring in ten focus regions (sub-regions of NRM regions) in the context of local environmental drivers, specifically focused on the annual water quality condition and long-term trends. Monitoring results from the duration of the MMP (since 2005) are used to provide context for interpreting recent monitoring. Results from routine sampling of pesticides are discussed in Section 6, while event sampling of pesticides is discussed here (so that it can be included with other event data). For each of the focus regions, the following information is included and discussed:

- a map of monitoring locations,
- time-series of the combined discharge from local rivers that influence the focus region,
- regional trends in key water quality parameters since monitoring began in the focus region (since 2005 for many focus regions),
- presentation of the long-term trend and annual condition of ambient water quality relative to guideline values (GVs) using the WQ Index, and
- results from flood event monitoring (if conducted during the year) including pesticide sampling.

Site-specific data and additional information are presented in Appendix C and include:

- Figure C-1: Time-series of chlorophyll and turbidity measured by moored FLNTUSB instruments;
- Figure C-2: Time-series of temperature and salinity measured by moored Sea-Bird Electronics instruments;
- Table C-1: Summary statistics for each water quality variable from each monitoring location for the current water year;
- Table C-2: Annual summaries of moored FLNTUSB turbidity measurements for each monitoring location, including percentage exceedances of GVs; and
- Table C-3 to Table C-8: Summary of water quality data (collected as part of the event-based sampling) across the Reef colour classes and water types.

5.1 Cape York region

The Cape York region is divided into 4 focus regions: the Pascoe, Stewart, Normanby, and Annan-Endeavour. The monitoring results are presented separately for each.

Water quality monitoring commenced in the Cape York region as part of the MMP in January 2017. Twenty-one sites in 4 focus regions (Figure 5-1) are sampled 4 to 5 times per year during ambient conditions. Additional event samples are collected depending on the location and accessibility of flood plumes at these and additional sites (Appendix A). Ambient sampling primarily occurs between 1 November to 30 April (wet season) due to strong trade winds (>25 km h^{-1}) preventing access during the winter months.

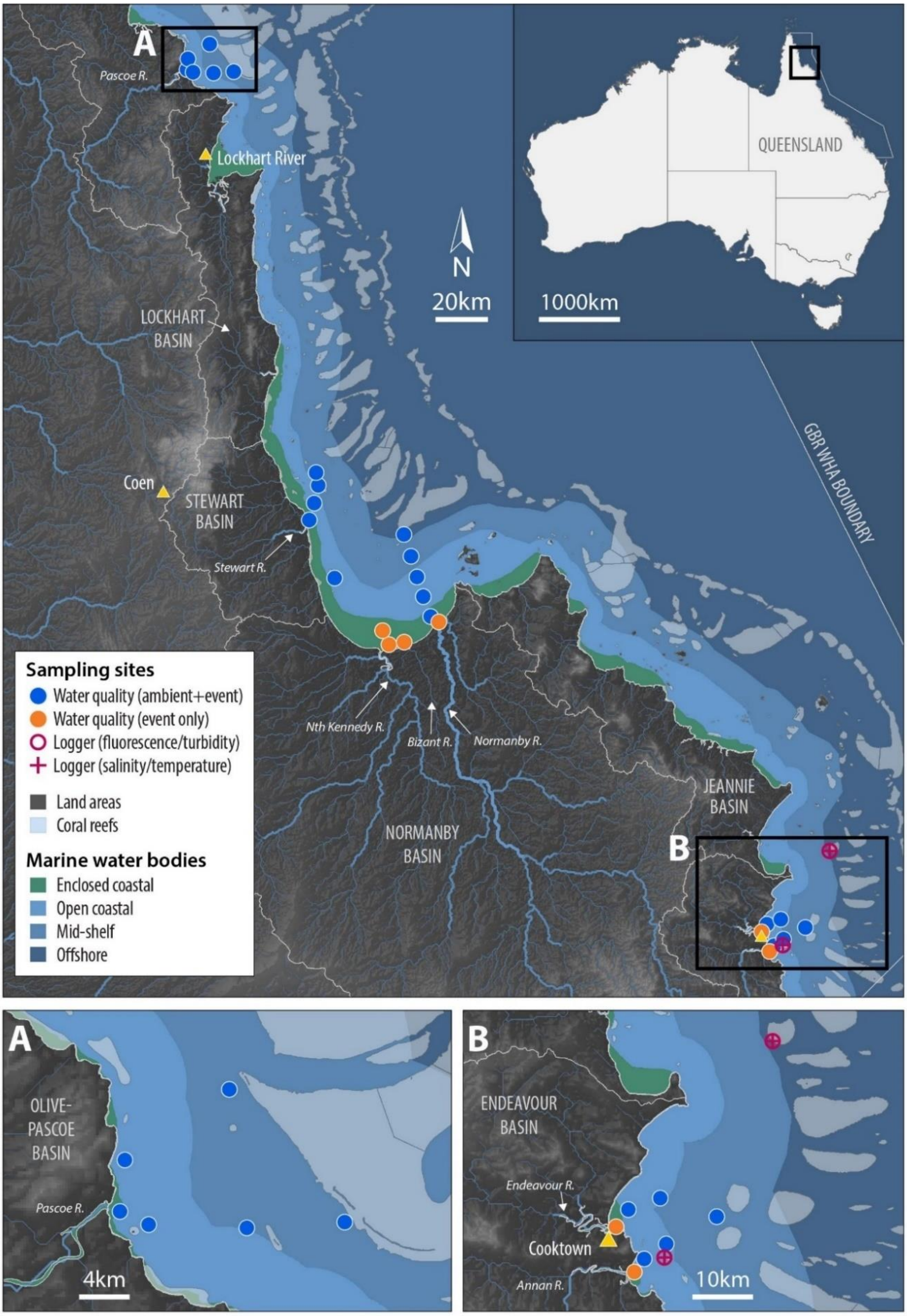


Figure 5-1: Sampling sites in the Cape York region, shown with water body boundaries. River datasets for map courtesy Grill *et al.* (2019).

The 2024–25 water year is the eighth year of sampling for the Cape York region. In consultation between CYWP, AIMS, and the Reef Authority, the laboratory analysis methods and the number of sites sampled in Cape York changed in 2020 (see Moran *et al*., 2023). Because of this change, the Water Quality Index and other trends are calculated from 2020–present. Water quality results within each focus region are assessed relative to distance from river mouths and compared against the Eastern Cape York Water Quality Guidelines (State of Queensland, 2020).

5.1.1 Pascoe

The Pascoe focus region is influenced primarily by discharge from the Pascoe and Olive Rivers. Six sampling sites (Figure 5-2) are located along 2 transects to the northeast and southeast from the Pascoe River mouth out to Eel Reef and past Middle Reef (locally known as Blue Bells). Floodwaters have been observed flowing in both directions depending on wind and other local conditions. Enclosed coastal waters near the mouth of the Pascoe and site PRS01 are highly turbid due to tidal and wind-driven resuspension of shallow sediments.

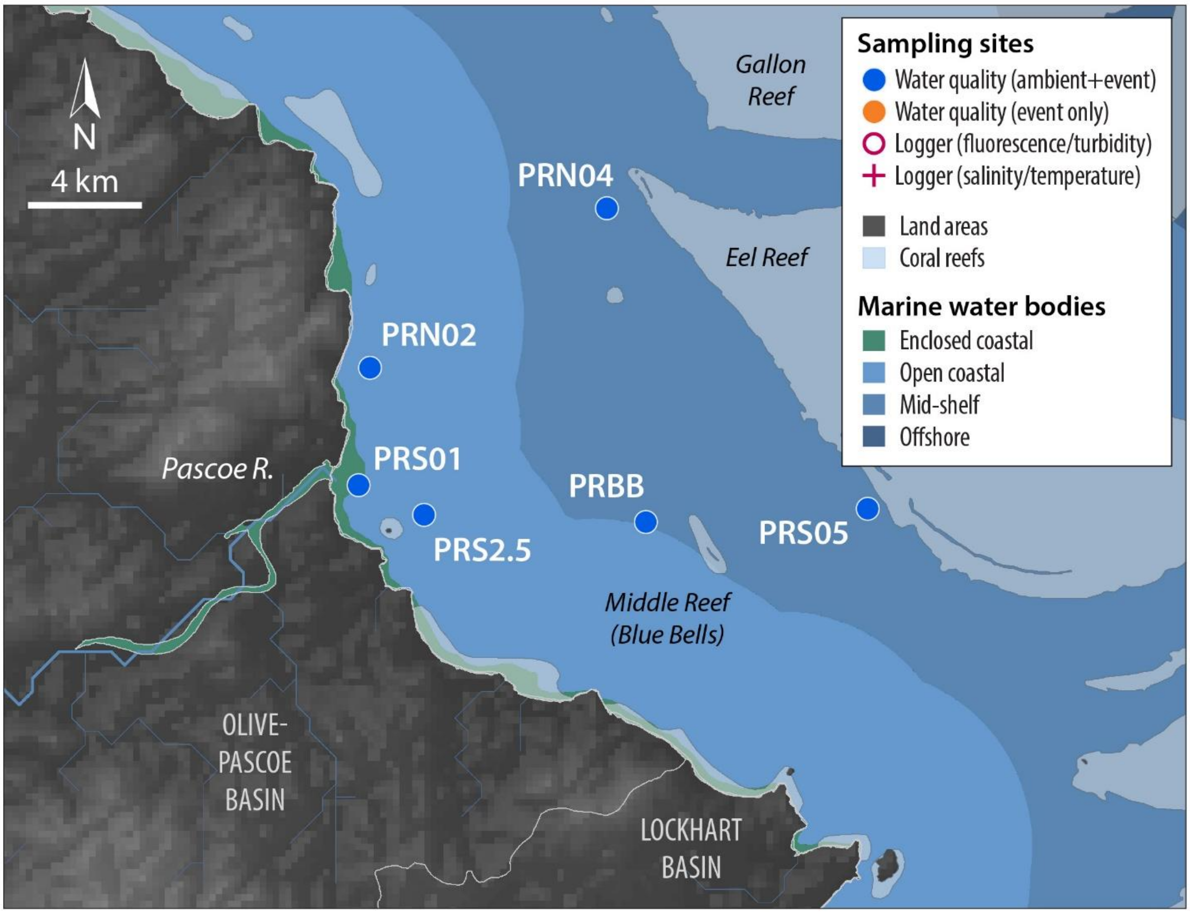


Figure 5-2: Sampling sites in the Pascoe River transect, with water body boundaries.

The Pascoe River transect was sampled 5 times under ambient wet season conditions from November 2024–April 2025 (Figure 5-3).

Total discharge for the combined Olive and Pascoe Rivers for the year was slightly above (1.2 times) the annual median discharge (Figure 5-4), with significant flows occurring throughout March and April but no above-average magnitude flood events recorded (Figure 5-3).

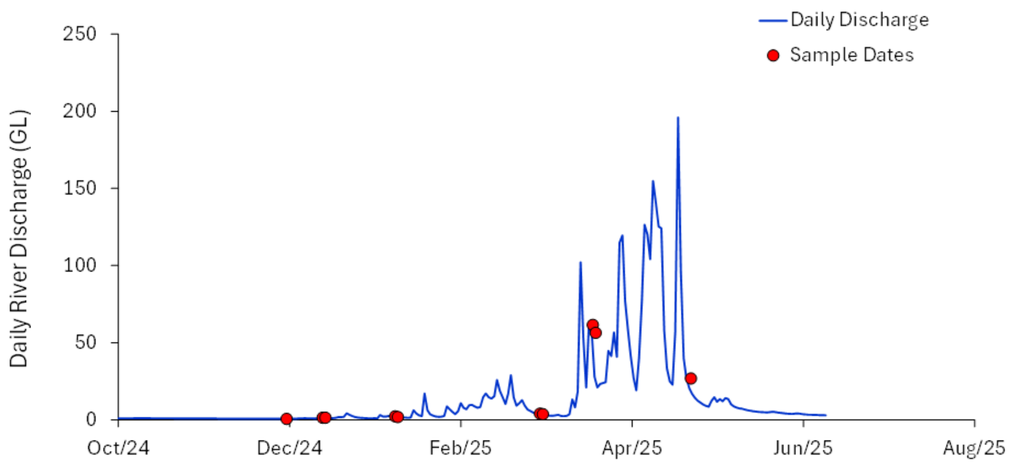


Figure 5-3: Daily discharge and sampling dates for the Pascoe River (gauge 102102A) for the 2024–25 water year. Red dots represent sampling dates. Note there is a 2 to 3-day travel time between the gauge and coastal waters, and thus April event samples were collected closer to peak flood stage than shown on the hydrograph

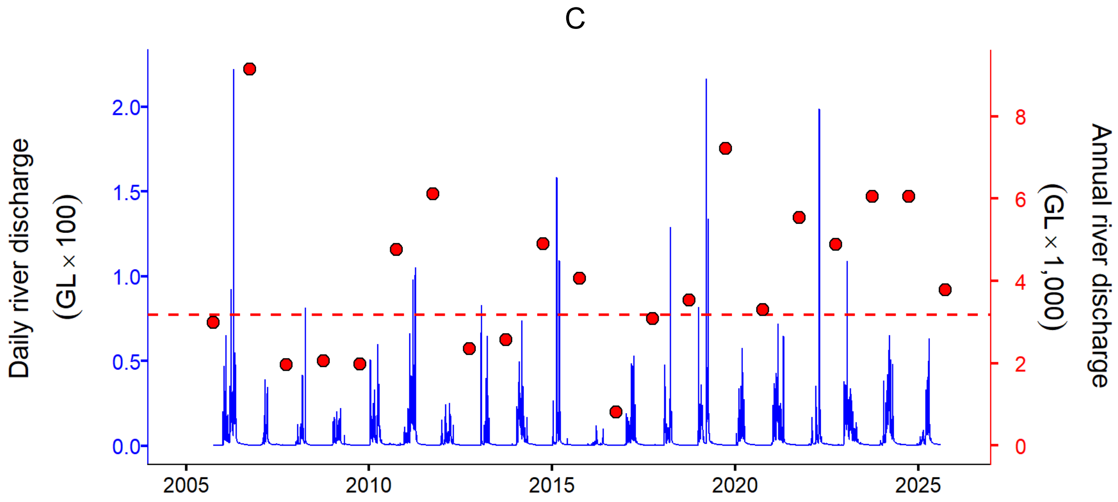


Figure 5-4: Long-term discharge for the Olive and Pascoe Rivers. Daily (blue) from Pascoe R. at Garraway Creek (gauge 102102A) and water year (1 October to 30 September, red symbols) for the combined Olive Pasce Rivers discharge volumes are shown. Red dashed line represents long-term median of the combined annual discharge.

The total discharge and modelled loads estimated for the 2024–25 water year from the Pascoe catchment (upscaled from the Garraway gauge) are shown in Figure 5-5. The discharge and loads calculated for the 2024–25 water year from the Pascoe catchment (not including the Olive catchment) were 1.4 times the long-term median. Over the 19-year period between 2006–07 and the current water year:

- discharge ranged from 425 GL (2015–16) to 3,770 GL (2018–19)
- TSS loads ranged from 19 kt (2015–16) to 194 kt (2018–19)
- DIN loads ranged from 34 t (2015–16) to 275 t (2018–19)
- PN loads ranged from 68 t (2015–16) to 1,068 t (2018–19).

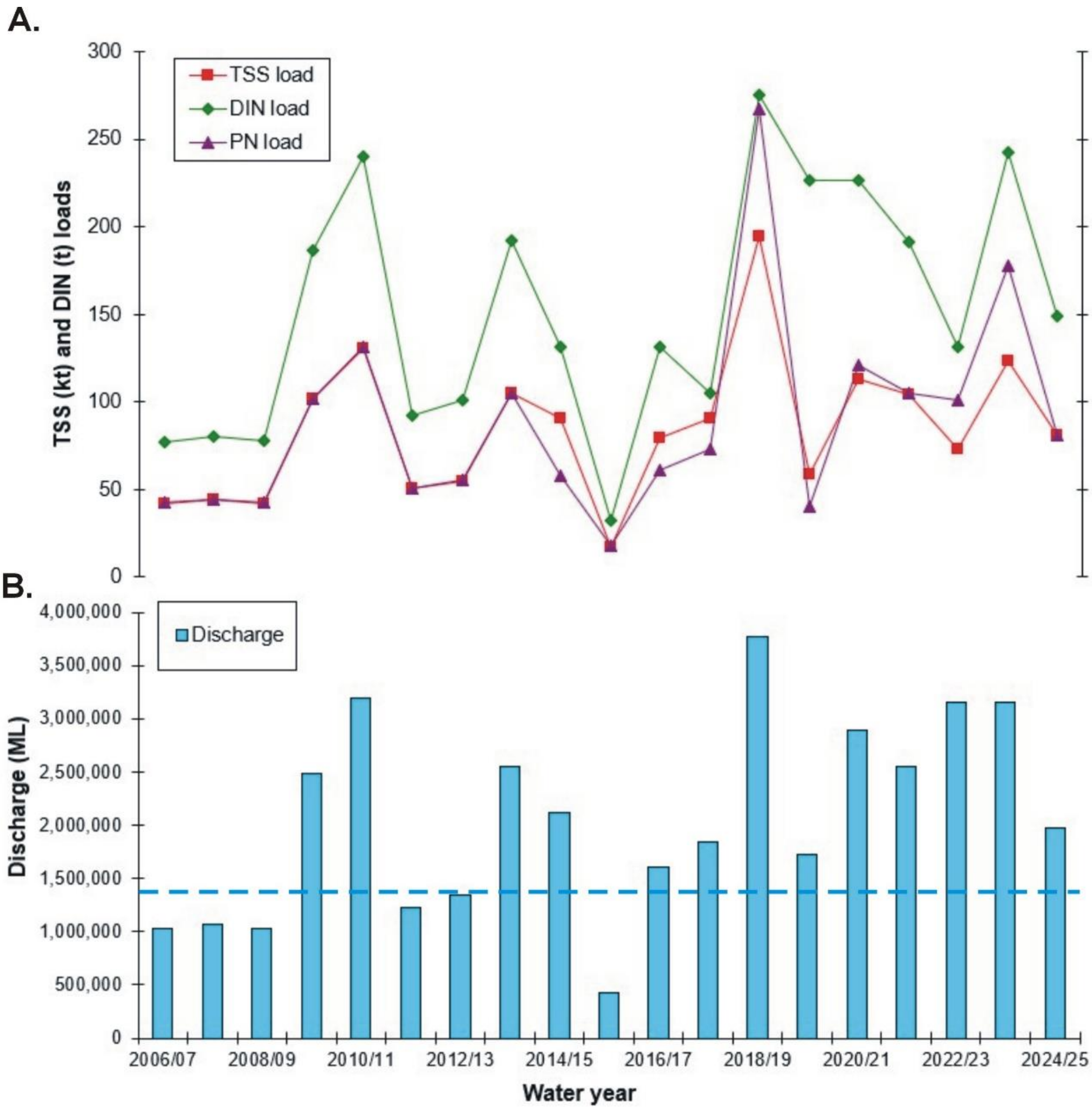


Figure 5-5: Modelled loads of (A) TSS, DIN, and PN and (B) discharge for the Pascoe catchment (note Pascoe catchment only, does not include the Olive catchment) from 2006 to 2025.The loads reported here are a combination of 'best estimates' based on 'up-scaled' discharge data from gauging stations and monitoring data for the 2014–15, 2016–17, 2017–18, 2018–19, 2019-20, 2020-21, 2022–23 and 2023–24 water years and an average of the annual mean concentrations for these 7 water years applied to the remaining dataset. Dotted line represents the long-term median for basin discharge. Note the different scales on the 2 y-axes.

Ambient water quality and the in situ *Water Quality Index*

Water quality showed trends along the 2 sampling transects (cross-shelf gradient in northeasterly and easterly directions). Sites located nearest to the river mouth (distance from river mouth = 0 km) had high concentrations of NO_x, TSS, and particulate nutrients (PN and PP), which declined with distance away from the river mouth, reaching low levels in mid-shelf waters (Figure 5-6, Table C-2). Concentrations of Chl-*a* showed high variability over the wet season sampling trips, with an overall increasing (but likely not significant) trend with distance from the river mouths. Secchi depths were low at sites near the river mouth (water clarity was poor) and increased (water clarity improved) with distance from the river mouth. These spatial patterns are generally consistent with those that are typically observed in the region.

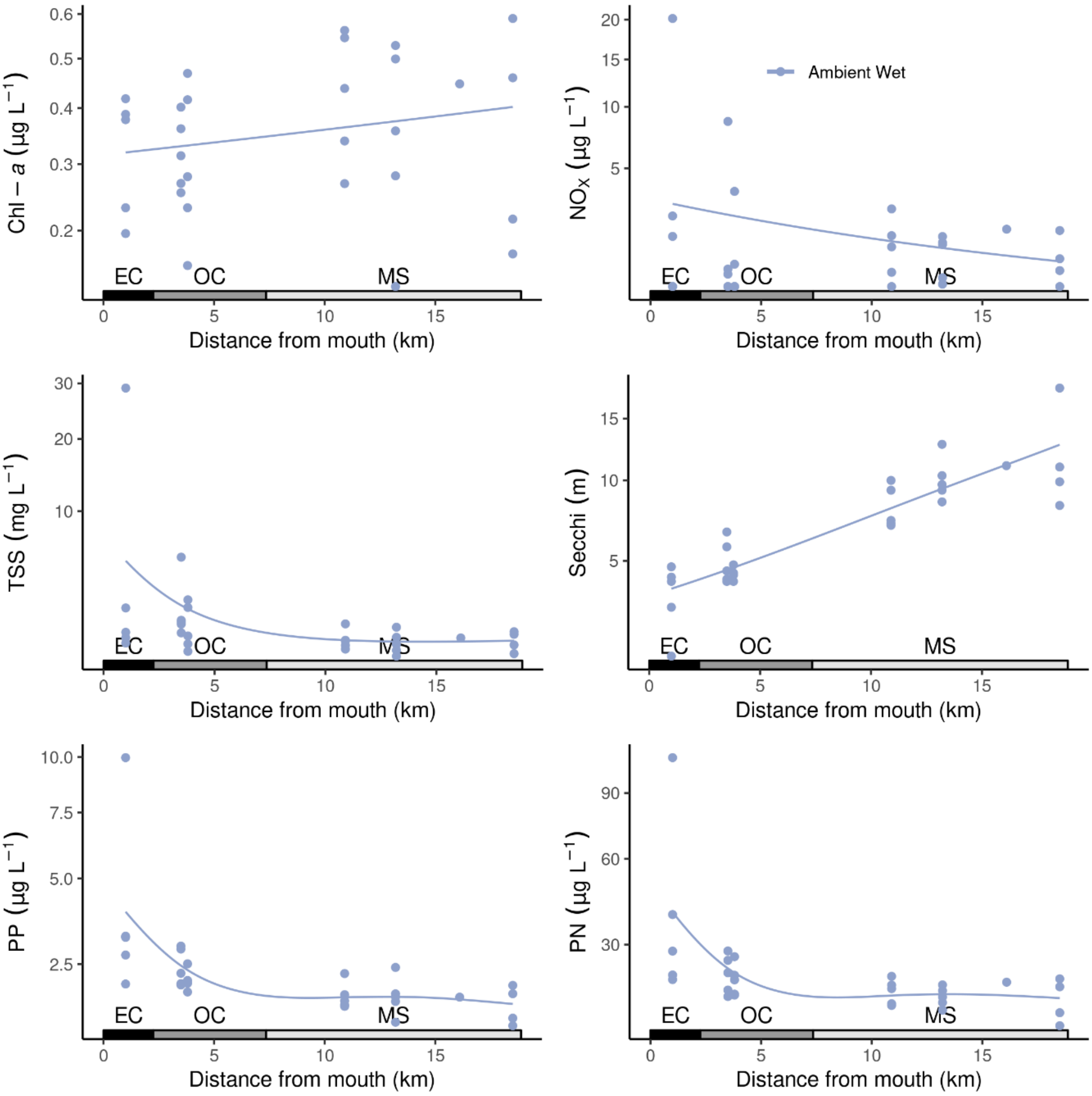


Figure 5-6: Water quality variables measured during ambient wet and dry season sampling in 2024–25 along the Pascoe focus region transect. Chlorophyll a (Chl-a), nitrate/nitrite (NO_x), total suspended solids (TSS), Secchi depth, particulate phosphorus (PP), and particulate nitrogen (PN) are shown with distance from the river mouth. Water body classifications are shown along the x-axes: enclosed coastal (EC), open coastal (OC), and mid-shelf (MS). Note the y-axes are logarithmic scales. Fitted lines are generalised additive models. Note no dry season samples were collected during this monitoring year.

Due to sampling limitations (discussed in Methods), trends in this focus region are only available since 2020 (Figure 5-7). It should be noted these trends are preliminary given only 5 years of data are available. Site-specific statistics and comparison to GVs for all variables are available in Table C-1.

Concentrations of Chl-*a* appear to have increased since 2020 (Figure 5-7a). Chl-*a* in 2024–25 was above (did not meet) the local GVs at 4 of the 7 sites sampled (Table C-1).

Secchi depth has been generally stable since 2020 (Figure 5-7b). Secchi depth in 2024–25 was below (did not meet) the local GVs at 3 of the 7 sites sampled (Table C-1).

Concentrations of TSS have fluctuated since 2020 but appear stable overall during this time period (Figure 5-7c). TSS concentrations in 2024–25 were below (met) the local water quality GVs at all sites sampled (Table C-1).

Concentrations of NO_x have fluctuated since 2020 with high inter-annual variability (Figure 5-7d). NO_x in 2024–25 was above (did not meet) the local GVs at 5 of the 7 sites sampled (Table C-1).

Concentrations of PO_4 appear to have increased from 2020–24 with a decline over the last year (Figure 5-7e). PO_4 in 2024–25 was above (did not meet) the local GVs at 4 of the 7 sites sampled (Table C-1).

Concentrations of PN appear to have declined since 2020 (Figure 5-7f). PN in 2024–25 was above (did not meet) the local GVs at 4 of the 7 sites sampled (Table C-1).

Concentrations of PP appear to be stable since 2020 (Figure 5-7g). PP in 2024–25 was below (met) the local GVs at all sites sampled (Table C-1).

Concentrations of POC and DOC appear to have declined since 2020 (Figure 5-7h,i). Guideline values are not available for these analytes.

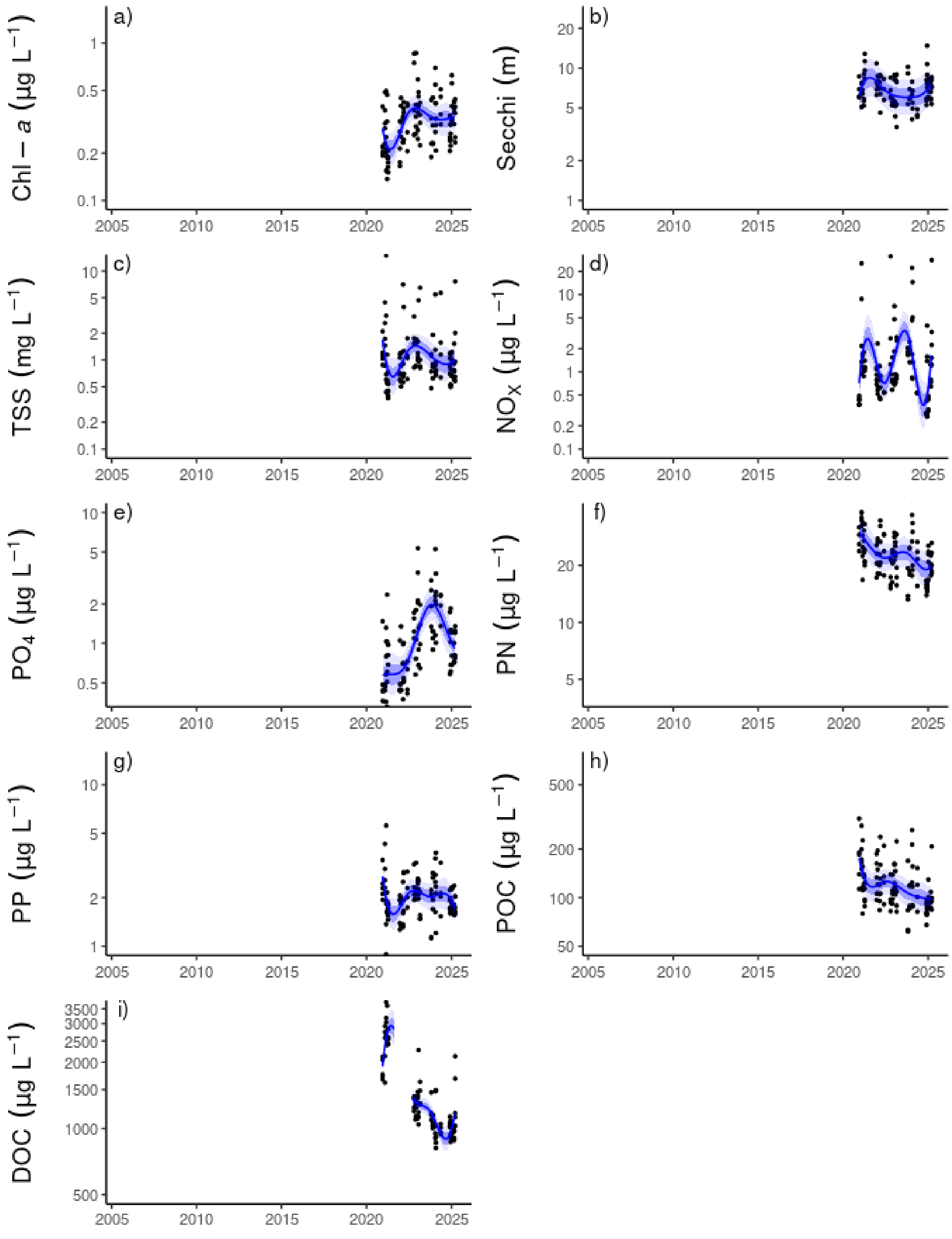


Figure 5-7: Temporal trends in water quality variables for the Pascoe focus region: a) chlorophyll *a* (Chl-*a*), b) Secchi depth, c) total suspended solids (TSS), d) nitrate/nitrite (NO_x), e) phosphate (PO_4), f) particulate nitrogen (PN), g) particulate phosphorus (PP), h) particulate organic carbon (POC) and i) dissolved organic carbon (DOC). Generalised additive mixed effect models (trends) are represented by blue lines with shaded areas defining 95% confidence intervals of those trends and black dots represent observed data (depth weighted averages). These trends and data are accounting for the effects of seasons after applying x-z detrending.

For the Pascoe region, the annual WQ Index has shown an improved score since 2020 (Figure 5-8a). The 2024–25 water year received a score of ‘good’, which was an improvement on the ‘moderate’ score from 2023–24. This improvement from last year was driven by improvements in the water clarity sub-indicator from Secchi depth and TSS.

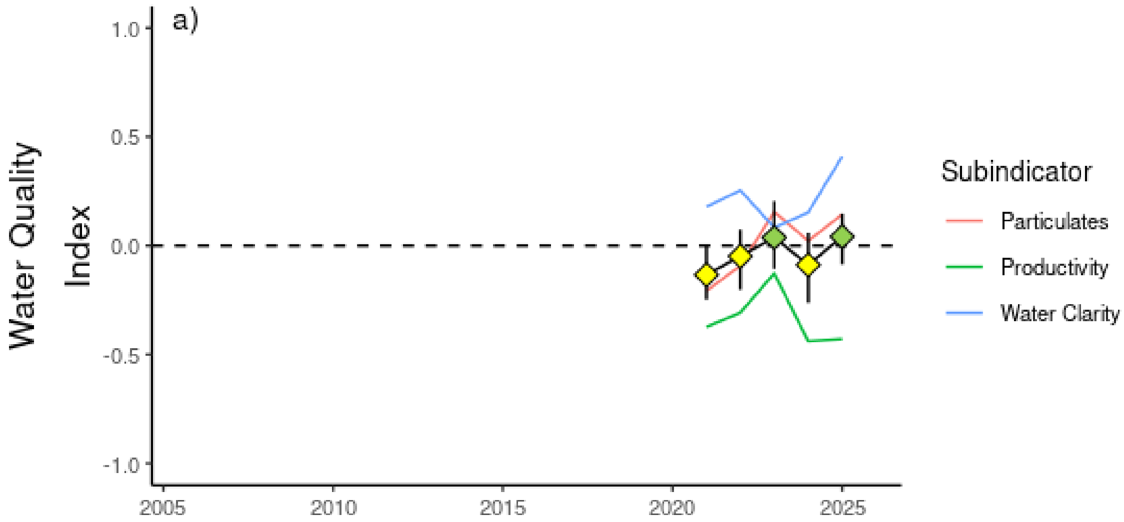


Figure 5-8: The annual condition Water Quality Index (WQ Index) for the Pascoe focus region. WQ Index colour coding: ◆– ‘very good’; ◆ – ‘good’; ◆ – ‘moderate; ◆ – ‘poor’; ◆ – ‘very poor’. Sub-indicators that are used to calculate the WQ Index are shown as coloured lines. Error bars (vertical black lines) on the WQ Index represent the 95% quantile intervals. Calculations for index formulations are described in Appendix B.

Event water quality

The largest magnitude event of the 2024–25 wet season occurred in April 2025, with peak discharge of 196 GL day^{-1} at the upstream Garraway gauge on 21 April (Figure 5-3). Event samples were collected across the Pascoe transect on 24 April 2025, when peak floodwaters had reached the coast. While this was a relatively moderate flood event in terms of total and peak discharge in the Pascoe River, satellite images from the 24 April showed turbid plume water across the whole region, from the mouth of the Pascoe River out to Eel Reef, as well as further to the north (Olive River region) and south (Lockhart River), and along the coast further south all the way to Princess Charlotte Bay (Figure 5-9). The samples collected that day likely represent a mix of influences from the Pascoe and Lockhart flood plumes, as well as rivers further south such as the Nesbit, Rocky Creek, and Chester Rivers.

TSS remained low across the flood plume (maximum 3.4 mg L^{-1} near the river mouth), and PN and PP concentrations were close to average ambient concentrations; however, Secchi depths of 2.1 m and 3.2 m showed poor water clarity in open coastal waters (Figure 5-10). DIN and DIP were elevated above the GVs and typical ambient concentrations across the transect out to Eel Reef, with maximum DIN concentrations (2.28 µg L^{-1}) measured close to the river mouth. Chl-*a* concentrations were slightly elevated above the GVs and ambient concentrations, with a maximum concentration of 1.02 µg L^{-1} near the river mouth (Figure 5-10).

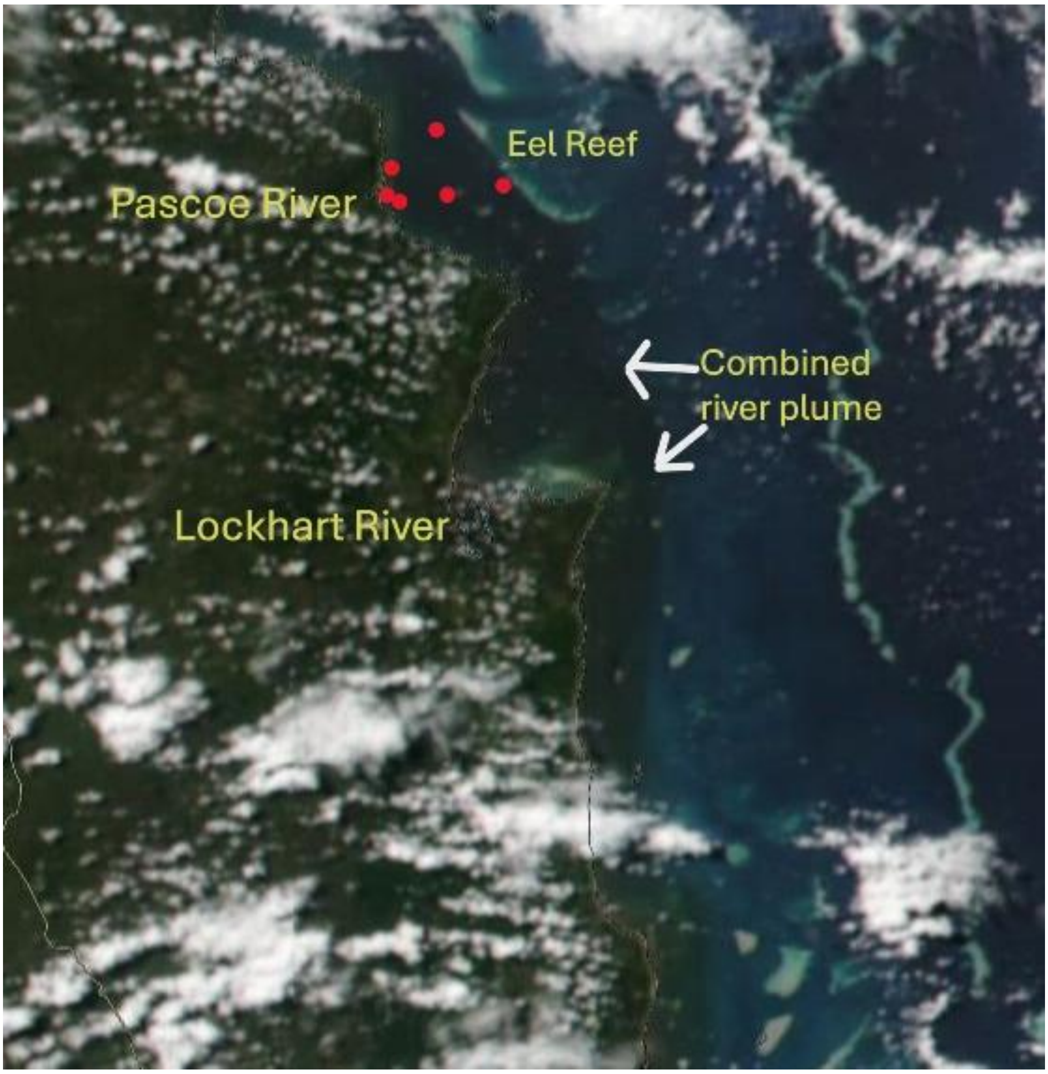


Figure 5-9: MODIS Aqua satellite images showing Pascoe River flood event sampling locations (red dots) on 24 April 2024. The band of darker coloured water close to the coast shows the combined flood plumes from the Olive, Pascoe, Lockhart, and other rivers to the south.

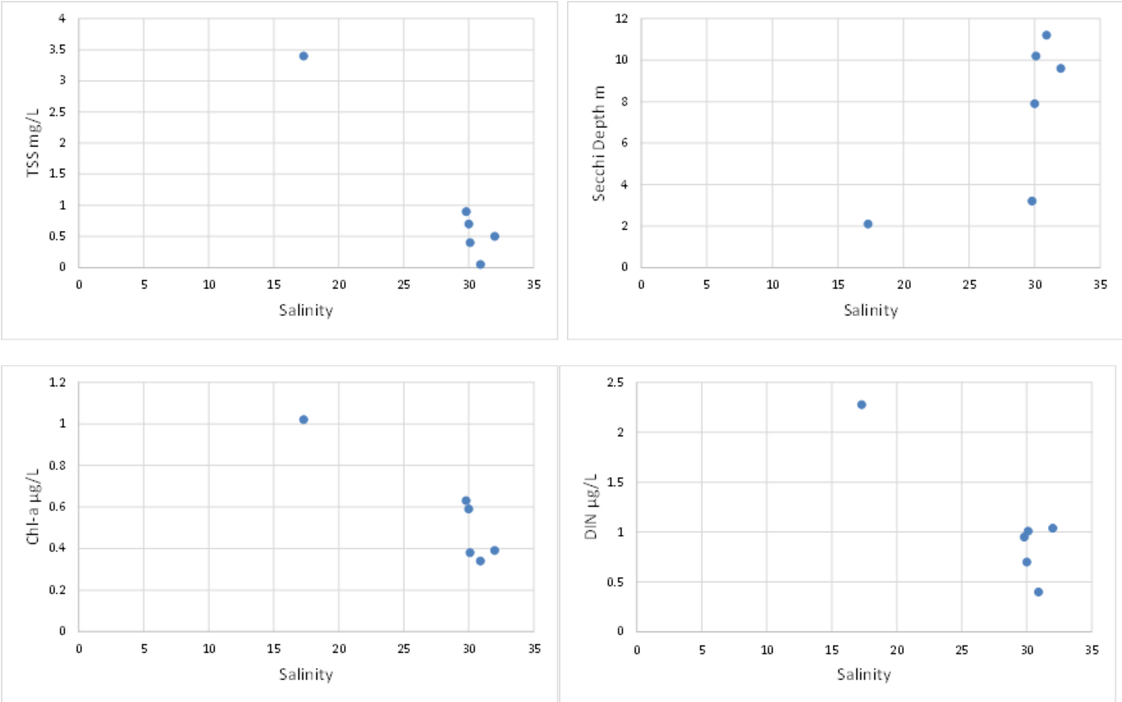


Figure 5-10: Flood event water quality data from the Pascoe transect on 24 April 2025 (blue circles)

5.1.2 Stewart

The Stewart focus region is influenced primarily by discharge from the Stewart River. However, during flood conditions it can also be influenced by floodwater from the Normanby and Kennedy Rivers and potentially by runoff from coastal creeks and mudflats.

Four sampling sites for the Stewart River are located in a transect from the river mouth to mid-shelf reefs, representing a gradient in water quality (Figure 5-11). The transect was sampled 4 times (3 times during ambient wet conditions and once during ambient dry conditions) between October 2024 and February 2025 (Figure 5-12; Table A-1). Due to access issues, a planned fifth sampling event for March/April 2025 was not possible. There were no major flood events in the Stewart River over the 2024–25 wet season. Peak discharge of 49 GL day^{-1} occurred on 16 March 2025.

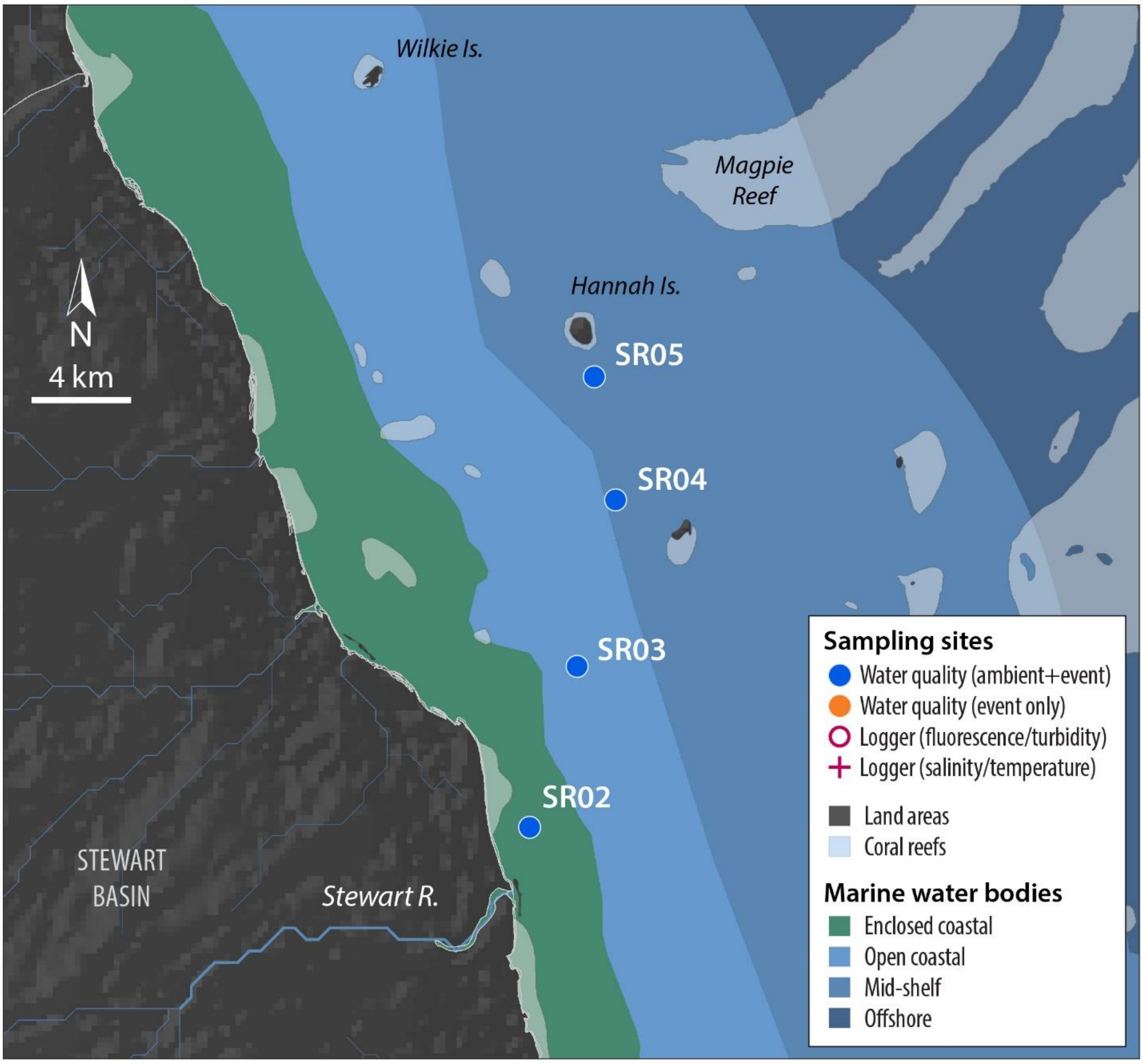


Figure 5-11: Sampling sites in the Stewart River transect, with water body boundaries.

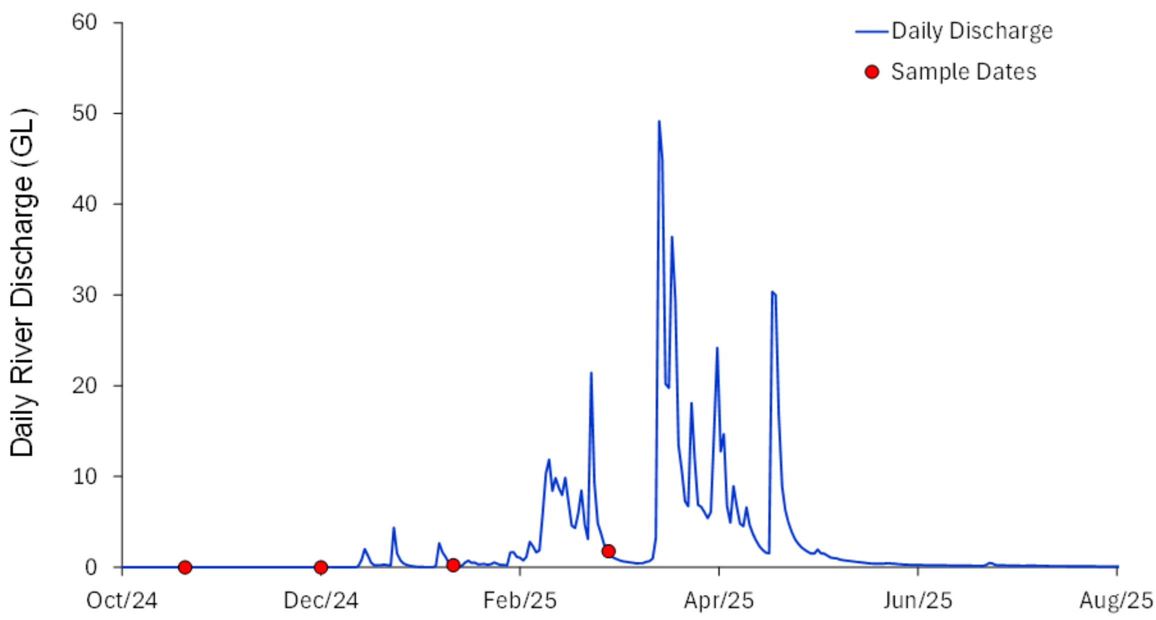


Figure 5-12: Daily discharge and sampling dates for the Stewart River (gauge 104001A) for the 2024–25 water year.

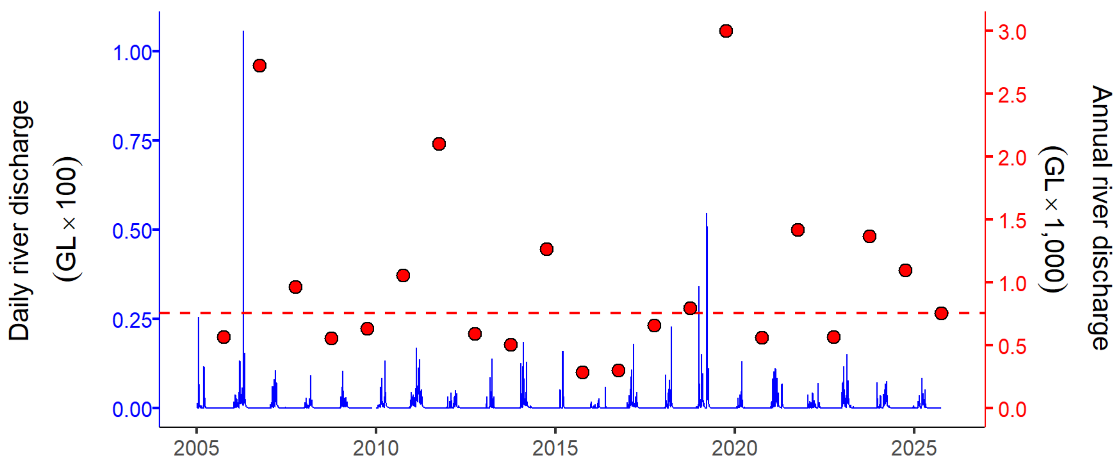


Figure 5-13: Discharge for the Stewart River (gauge 104001A – Telegraph Road).Daily (blue) and water year (1 October to 30 September, red symbols) discharge volumes shown. Red dashed line represents long-term median of the annual discharge.

The combined discharge and modelled loads estimated for the 2024–25 water year from the Stewart Basin are shown in Figure 5-14. The discharge and loads calculated for the 2024–25 water year from the Stewart Basin were close to the long-term median. Over the 19-year period between 2006–07 and the current water year:

- discharge has varied from 289 GL (2014–15) to 3,002 GL (2018–19)
- TSS loads ranged from 8.7 kt (2014–15) to 90 kt (2018–19)
- DIN loads ranged from 13 t (2014–15) to 135 t (2018–19)
- PN loads ranged from 40 t (2014–15) to 420 t (2018–19).

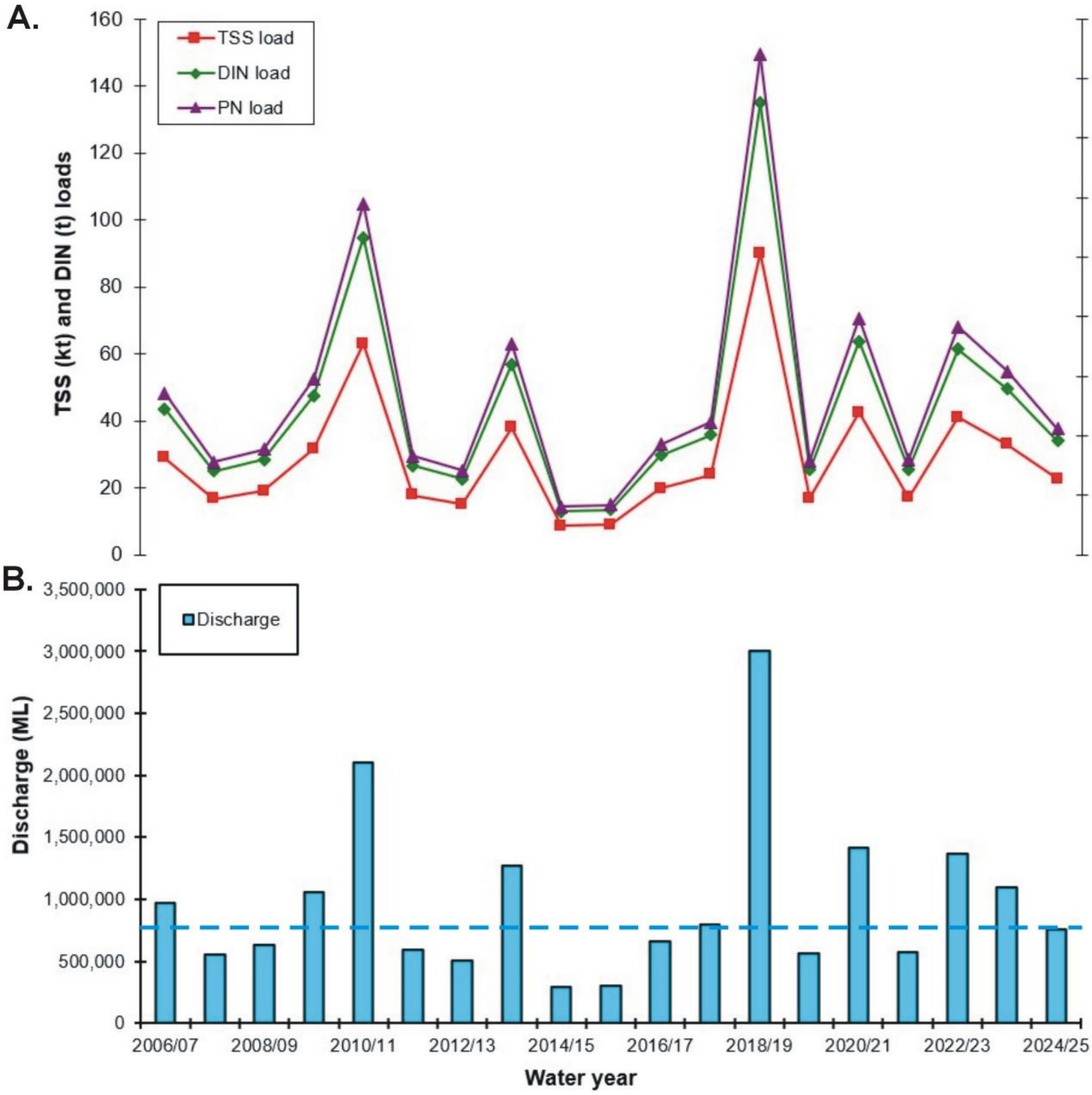


Figure 5-14: Loads of (A) TSS, DIN and PN, and (B) discharge for the Stewart Basin from 2006 to 2025.The loads reported here are based on the best estimates of annual mean concentration informed by nearest neighbour monitoring and by the Source Catchments modelling data and applied to each water year. Dotted line represents the long-term median for basin discharge. Note the different scales on the 2 y-axes.

Ambient water quality and the in situ *Water Quality Index*

Water quality showed trends along the transect (cross-shelf gradient in northerly direction). Sites located nearest to the river mouth (distance from river mouth = 0 km) generally had higher concentrations of NO_x, TSS, and particulate nutrients (PN and PP) than sites further offshore, reaching low levels in mid-shelf waters (Figure 5-15, Table C-2). Concentrations of Chl-*a* showed high variability between the wet and dry season sampling trips; however, as sites were only visited once during the late dry season, it is not possible to draw seasonal comparisons from this dataset. Secchi depths were low at sites near the river mouth (water clarity was poor) and increased (water clarity improved) with distance from the river mouth. These spatial patterns are generally consistent with those that are typically observed in the region.

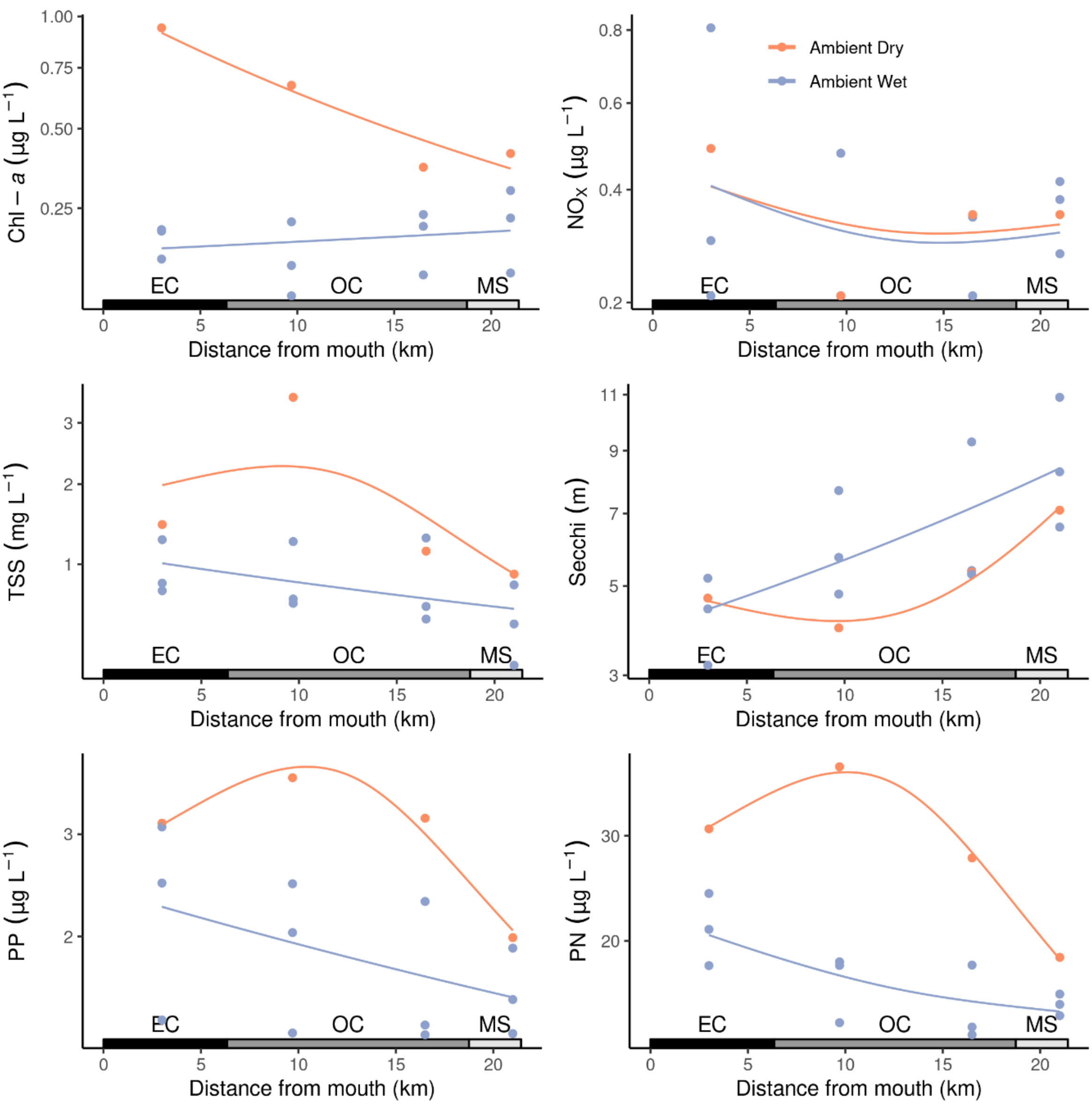


Figure 5-15: Water quality variables measured during ambient wet and dry season sampling in 2024–25 along the Stewart focus region transect. Chlorophyll *a* (Chl-*a*), nitrate/nitrite (NO_x), total suspended solids (TSS), Secchi depth, particulate phosphorus (PP), and particulate nitrogen (PN) are shown with distance from the river mouth. Water body classifications are shown along the x-axes: enclosed coastal (EC), open coastal (OC), and mid-shelf (MS). Note the y-axes are logarithmic scales. Fitted lines are generalised additive models.

Due to sampling limitations (discussed in Methods), trends in this focus region are only available since 2020 (Figure 5-16). It should be noted these trends are preliminary given only 5 years of data are available. Site-specific statistics and comparison to GVs for all variables are available in Table C-1.

Concentrations of Chl-*a* have oscillated since 2020 and are currently at a minima within the available data record (Figure 5-16a). Chl-*a* in 2024–25 was below (met) the local GVs at all sites sampled (Table C-1).

Secchi depth has been generally stable since 2020 (Figure 5-16b). Secchi depth in 2024–25 was below (did not meet) the local GVs at 3 of the 4 sites sampled (Table C-1).

Concentrations of TSS appear to have declined overall since 2020 (Figure 5-16c). TSS concentrations in 2024–25 were below (met) the local water quality GVs at all sites sampled (Table C-1).

Concentrations of NO_x have fluctuated since 2020 with high inter-annual variability and appear to currently be at a minima within the available data record (Figure 5-16d). NO_x in 2024–25 was above (did not meet) the local GVs at one of the 4 sites sampled (Table C-1).

Concentrations of PO_4 have fluctuated since 2020 with high inter-annual variability (Figure 5-16e). PO_4 in 2024–25 was above (did not meet) the local GVs at one of the 4 sites sampled (Table C-1).

Concentrations of PN have fluctuated since 2020 and appear to currently be at a minima within the available data record (Figure 5-16f). PN in 2024–25 was above (did not meet) the local GVs at one of the 4 sites sampled (Table C-1).

Concentrations of PP appear to be stable since 2020 (Figure 5-16g). PP in 2024–25 was below (met) the local GVs at all sites sampled (Table C-1).

Concentrations of POC and DOC appear to have declined since 2020 (Figure 5-16h,i). Guideline values are not available for these analytes.

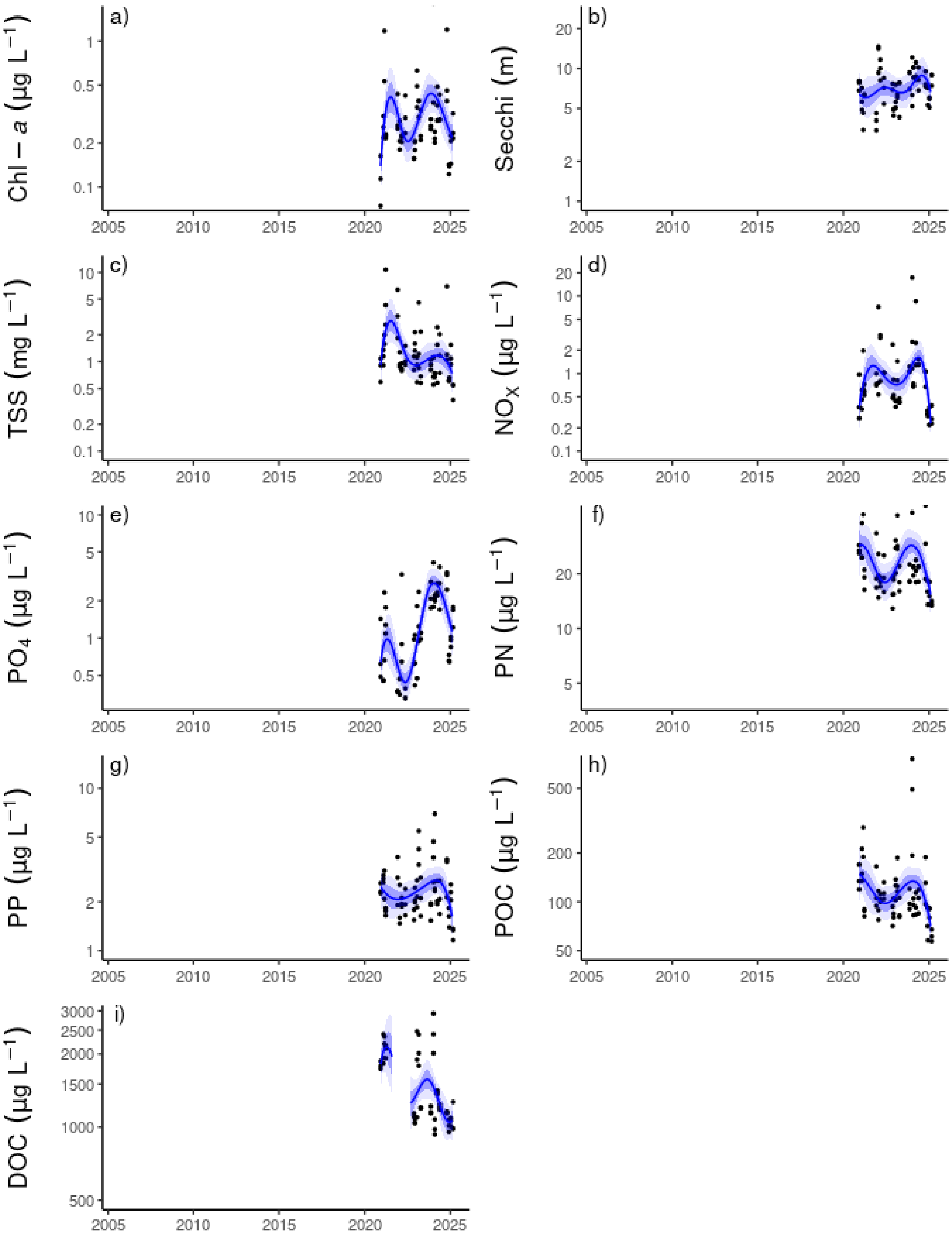


Figure 5-16: Temporal trends in water quality variables for the Stewart focus region: a) chlorophyll *a* (Chl-*a*), b) Secchi depth, c) total suspended solids (TSS), d) nitrate/nitrite (NO_x), e) phosphate (PO_4), f) particulate nitrogen (PN), g) particulate phosphorus (PP), h) particulate organic carbon (POC) and i) dissolved organic carbon (DOC). Generalised additive mixed effect models (trends) are represented by blue lines with shaded areas defining 95% confidence intervals of those trends and black dots represent observed data (depth weighted averages). These trends and data are accounting for the effects of seasons after applying x-z detrending.

For the Stewart region, the annual WQ Index has shown an overall trend of improvement since 2020 (Figure 5-17a). The 2024–25 water year received a score of ‘good’, which was a large improvement on the ‘moderate’ score from 2023–24. This improvement from last year was driven by a large improvement in the Productivity sub-indicator from NO_x.

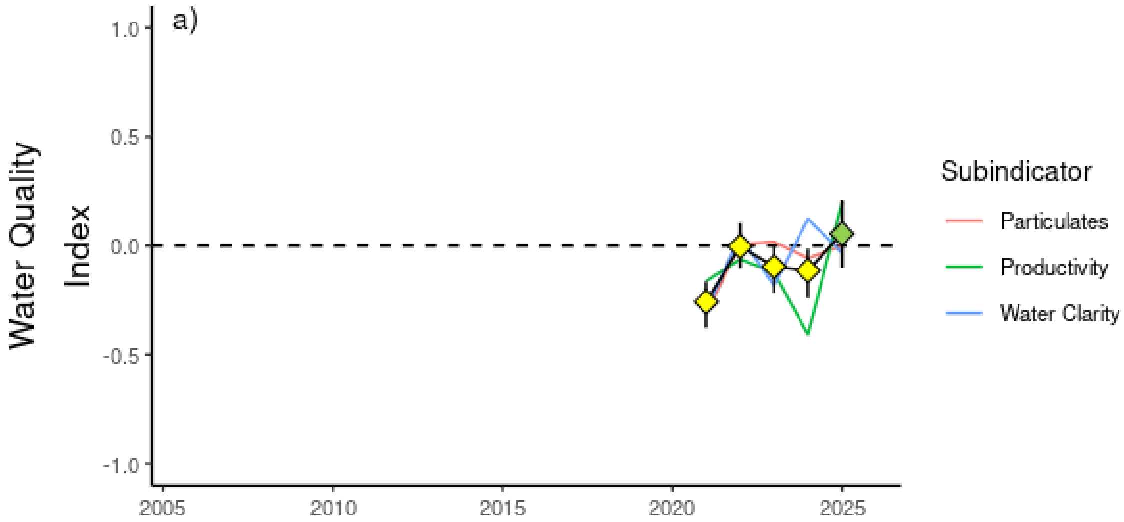


Figure 5-17: The annual condition Water Quality Index (WQ Index) for the Stewart focus region. WQ Index colour coding: ◆ – ‘very good’; ◆ – ‘good’; ◆ – ‘moderate; ◆ – ‘poor’; ◆ – ‘very poor’. Sub-indicators that are used to calculate the WQ Index are shown as coloured lines. Error bars (vertical black lines) on the WQ Index represent the 95% quantile intervals. Calculations for index formulations are described in Appendix B.

Event water quality

No event sampling was conducted in the 2024–25 wet season in the Stewart focus region.

5.1.3 Normanby

The Normanby focus region is influenced by discharge from the Normanby, Laura, Kennedy, Hann, Mossman, Morehead, and Annie Rivers via 3 distributaries: the North Kennedy, Normanby, and Bizant (the Normanby Basin). Five sampling sites are located along a transect from the Normanby River mouth to Corbett Reef in the offshore water body (Figure 5-18). Site CI01 is located near Cliff Isles (‘Marrpa’ in Lama Lama language). Four additional event-only sites are: NR01 at the Normanby River mouth, 2 sample sites located near the Kennedy River and one near the Bizant River mouth in the enclosed coastal water body.

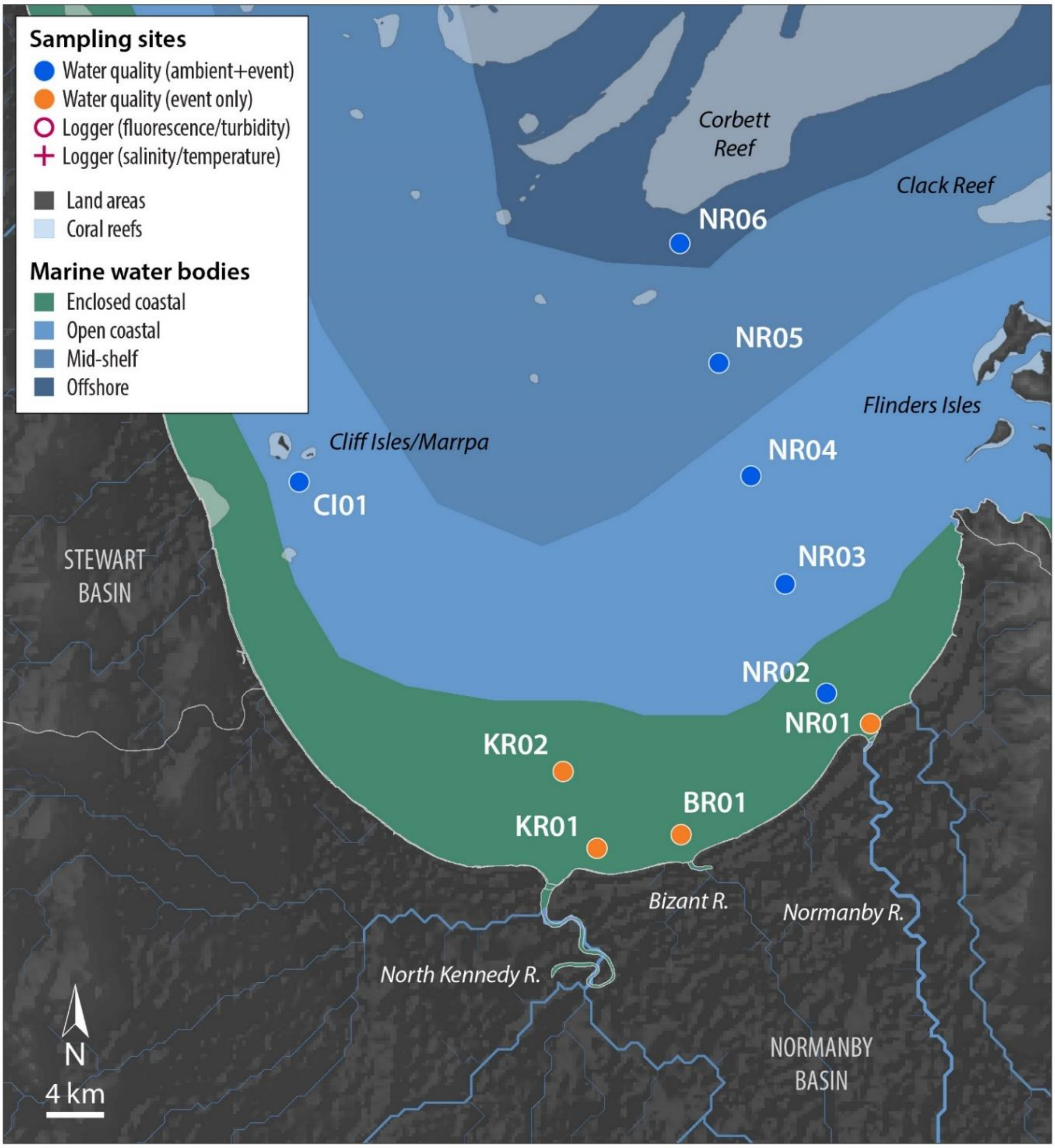


Figure 5-18: Sampling sites in the Normanby focus region, with water body boundaries.

The Normanby transect was sampled 4 times (spread over 7 days) from November 2024 to April 2025 (Figure 5-18). Significant discharge occurred through January and February and again in March, with peak discharge measured on 17 February 2025 (208 GL day^{-1}[1]).

However, there were no above average magnitude flood events (Figure 5-19), and no event sampling occurred over the wet season.

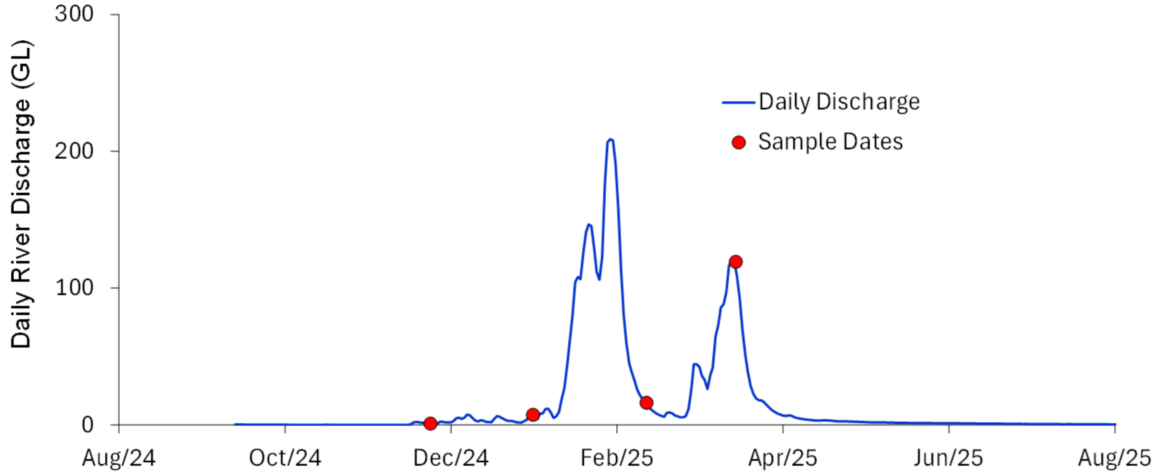


Figure 5-19: Daily discharge and sampling dates for the Normanby River (gauge 105107A) for the 2024–25 wet season.

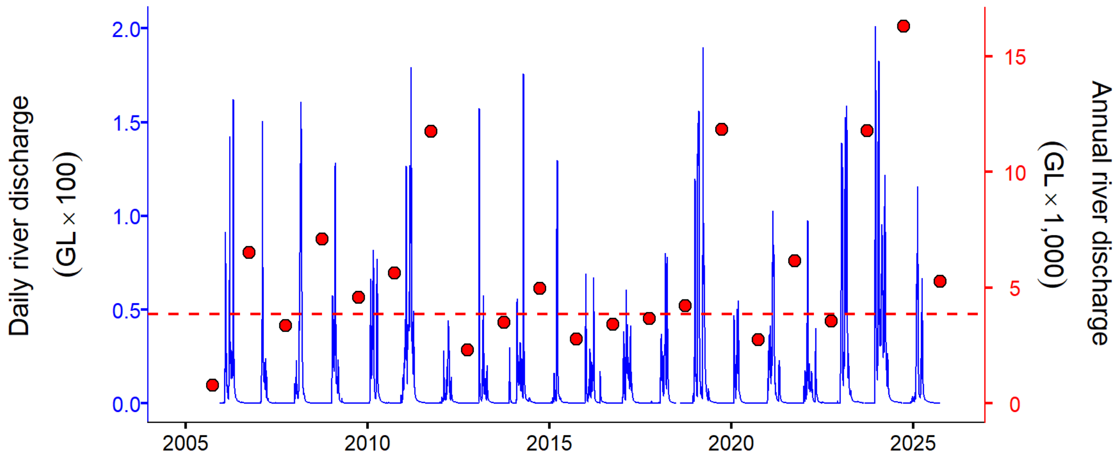


Figure 5-20: Discharge for the Normanby River (gauge 105107A – Kalpowar Crossing). Daily (blue) and water year (1 October to 30 September, red symbols) discharge volumes shown. Red dashed line represents long-term median of the annual discharge.

The discharge and modelled load estimates (Source Catchments) for the 2024–25 water year from the Normanby Basin were slightly higher than (1.4 times) the long-term median. Over the 19-year period between 2006–07 and the current water year:

- discharge ranged from 2,314 GL (2011–12) to 16,300 GL (2023–24)
- TSS loads ranged from 55 kt (2014–15) to 645 kt (2023–24)
- DIN loads ranged from 42 t (2011–12) to 520 t (2023–24)
- PN loads ranged from 124 t (2009–10) to 2,470 t (2018–19).

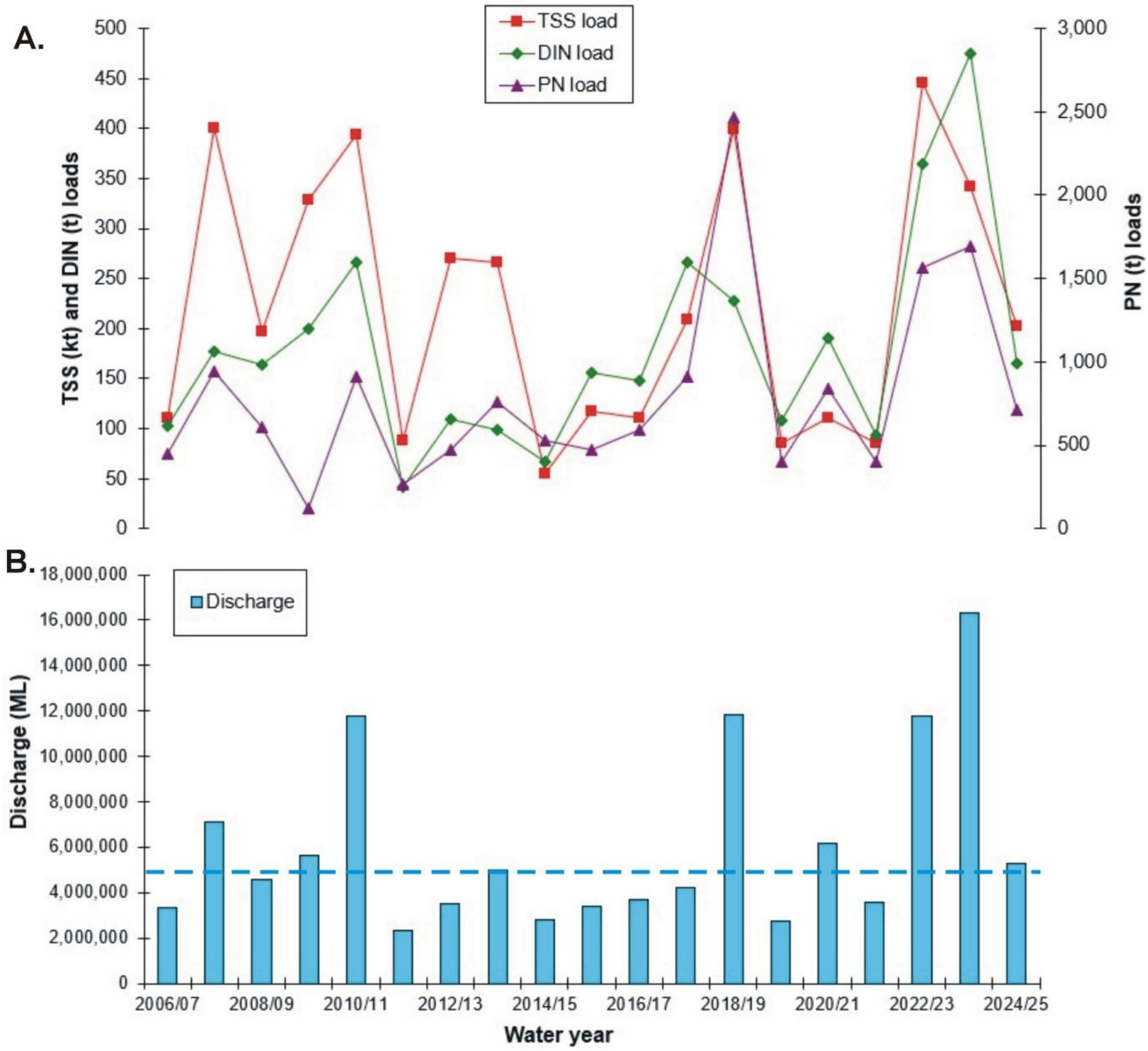


Figure 5-21: Modelled loads of (A) total suspended solids, dissolved inorganic (DIN) and particulate nitrogen (PN) and (B) discharge for the Normanby Basin. The loads reported here are a combination of 'best estimates' based on 'up-scaled' discharge and monitoring data from the Normanby River at Kalpowar gauging station (covers ~50% of the basin area). The dotted line represents the long-term median for basin discharge. Note the different scales on the 2 y-axes.

Ambient water quality and the in situ *Water Quality Index*

Water quality showed trends along the transect (cross-shelf gradient in northerly direction). Sites located nearest to the river mouth (distance from river mouth = 3.7 km) generally had higher concentrations of Chl-*a*, NO_x, TSS, and particulate nutrients (PN and PP) than sites further offshore, reaching low levels in mid-shelf and offshore waters (Figure 5-22, Table C-2). Secchi depths were low at sites near the river mouth (water clarity was poor) and increased (water clarity improved) with distance from the river mouth. These spatial patterns are generally consistent with those that are typically observed in the region.

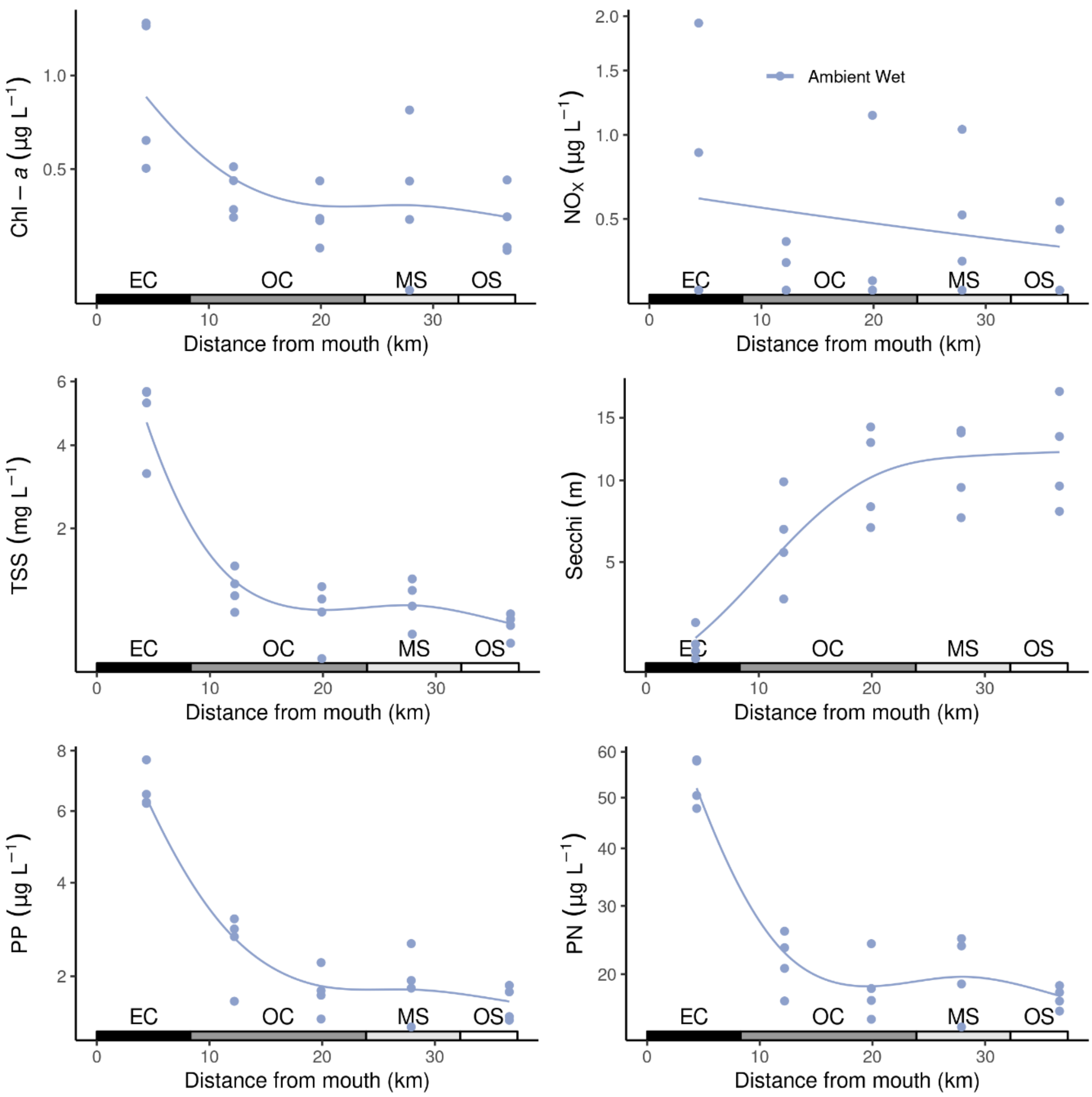


Figure 5-22: Water quality variables measured during ambient wet season sampling in 2024–25 along the Normanby focus region transect. Chlorophyll *a* (Chl-*a*), nitrate/nitrite (NO_x), total suspended solids (TSS), Secchi depth, particulate phosphorus (PP), and particulate nitrogen (PN) are shown with distance from the river mouth. Water body classifications are shown along the x-axes: enclosed coastal (EC), open coastal (OC), mid-shelf (MS), and offshore (OS). Note the y-axes are logarithmic scales. Fitted lines are generalised additive models.

Due to sampling limitations (discussed in Methods), trends in this focus region are only available since 2020 (Figure 5-23). It should be noted these trends are preliminary given only 5 years of data are available. Site-specific statistics and comparison to GVs for all variables are available in Table C-1.

Concentrations of Chl-*a* have oscillated since 2020 and are currently similar to concentrations at the start of sampling (Figure 5-23a). Chl-*a* in 2024–25 was above (did not meet) the local GVs at 3 of the 6 sites sampled (Table C-1).

Secchi depth has also oscillated since 2020 and is presently similar to observations made at the start of sampling (Figure 5-23b). Secchi depth in 2024–25 was below (did not meet) the local GVs at 3 of the 6 sites sampled (Table C-1).

Concentrations of TSS appear to have declined steadily since 2020 (Figure 5-23c). TSS concentrations in 2024–25 were above (did not meet) the local water quality GVs at one of the 6 sites sampled (Table C-1).

Concentrations of NO_x have fluctuated since 2020 with high inter-annual variability and appear to currently be at a minima within the available data record (Figure 5-23d). NO_x in 2024–25 was above (did not meet) the local GVs at 2 of the 6 sites sampled (Table C-1).

Concentrations of PO_4 have fluctuated since 2020 with a maxima occurring in 2023–24, potentially related to cyclone Jasper (Figure 5-23e). PO_4 in 2024–25 was above (did not meet) the local GVs at 2 of the 6 sites sampled (Table C-1).

Concentrations of PN have fluctuated since 2020 and are currently similar to concentrations at the start of sampling (Figure 5-23f). PN in 2024–25 was above (did not meet) the local GVs at 4 of the 6 sites sampled (Table C-1).

Concentrations of PP have fluctuated since 2020 and are currently similar to concentrations at the start of sampling (Figure 5-23g). PP in 2024–25 was above (did not meet) the local GVs at 2 of the 6 sites sampled (Table C-1).

Concentrations of POC have fluctuated since 2020 but remain similar to concentrations at the start of sampling, while DOC concentrations appear to have declined since 2020 (Figure 5-23h,i). Guideline values are not available for these analytes.

For the Normanby region, the annual WQ Index has shown a large improvement since 2020 (Figure 5-24a). The 2024–25 water year received a score of ‘good’, which was a large improvement on the ‘moderate’ score from 2023–24. This improvement from last year was driven by improvements in all sub-indicators (Figure 5-24a). Productivity and Water Clarity sub-indicators showed particularly large increases, driven by improvements in Chl-*a*, NO_x, and TSS.

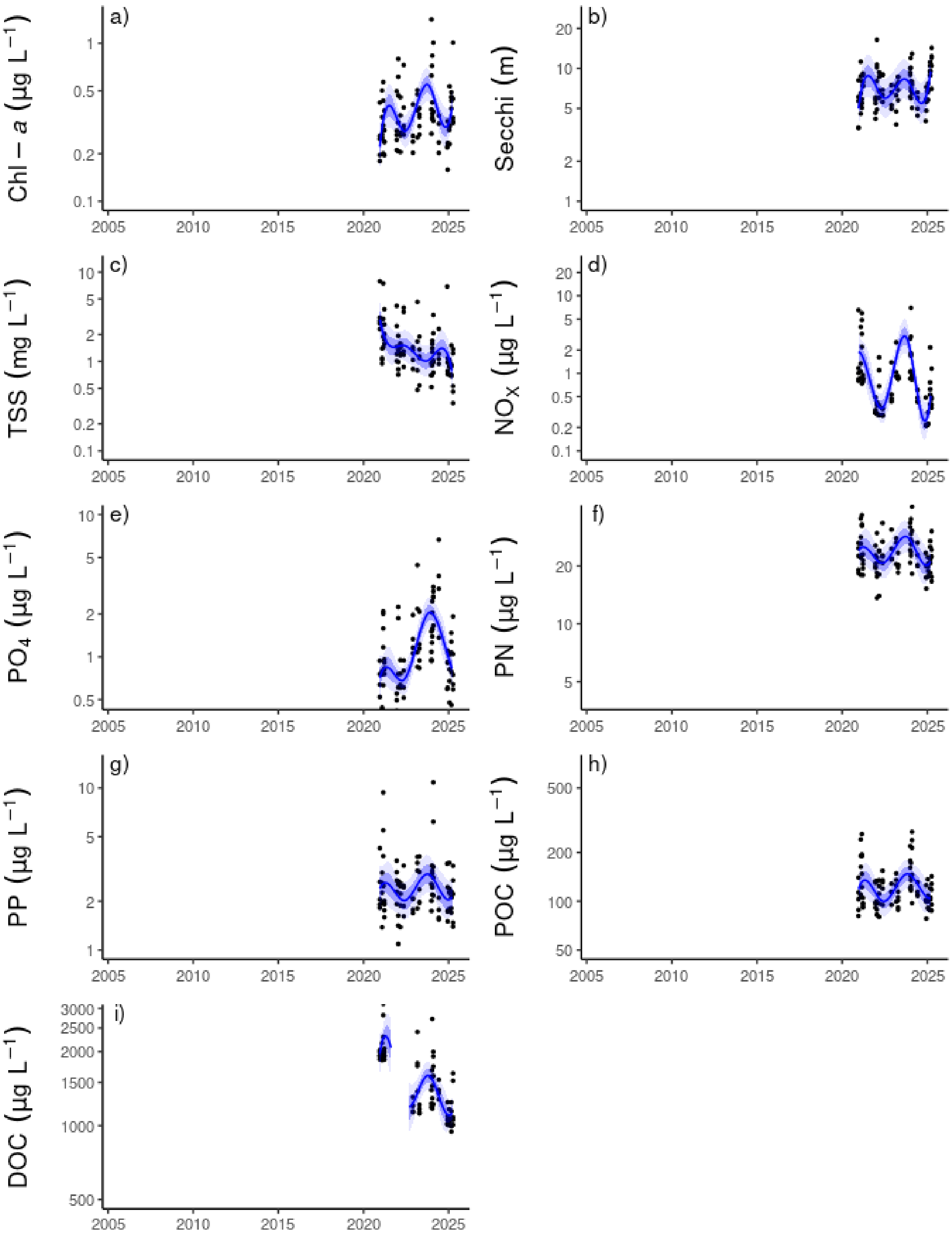


Figure 5-23: Temporal trends in water quality variables for the Normanby focus region: a) chlorophyll *a* (Chl-*a*), b) Secchi depth, c) total suspended solids (TSS), d) nitrate/nitrite (NO_x), e) phosphate (PO_4), f) particulate nitrogen (PN), g) particulate phosphorus (PP), h) particulate organic carbon (POC) and i) dissolved organic carbon (DOC). Generalised additive mixed effect models (trends) are represented by blue lines with shaded areas defining 95% confidence intervals of those trends and black dots represent observed data (depth weighted averages). These trends and data are accounting for the effects of seasons after applying x-z detrending.

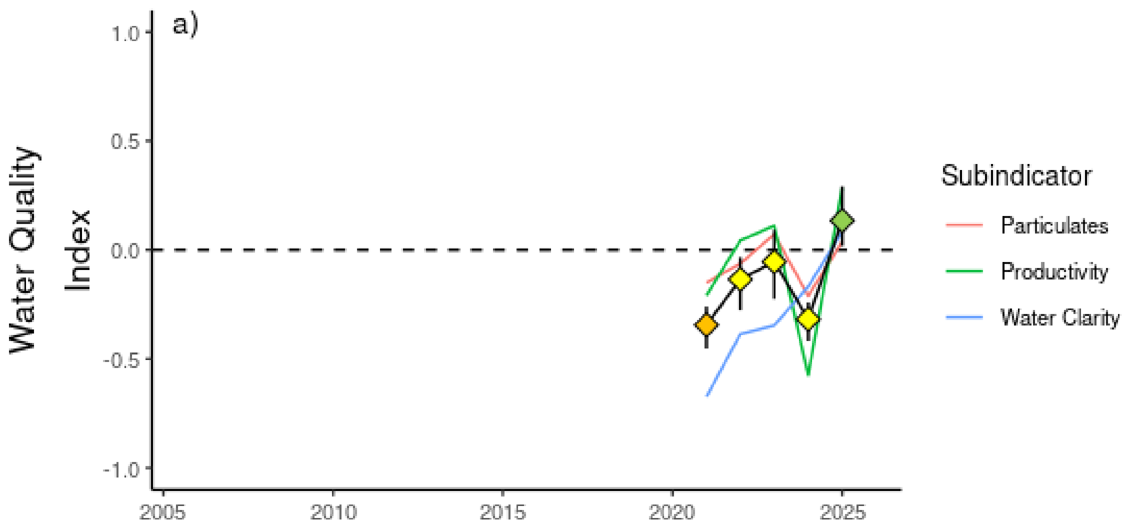


Figure 5-24: The annual condition Water Quality Index (WQ Index) for the Normanby focus region. WQ Index colour coding: – 'very good'; – 'good'; – 'moderate; – 'poor'; – 'very poor'. Sub-indicators that are used to calculate the WQ Index are shown as coloured lines. Error bars (vertical black lines) on the WQ Index represent the 95% quantile intervals. Calculations for index formulations are described in Appendix B.

Event water quality

No event sampling was conducted in the 2024–25 wet season in the Normanby focus region. However, a significant flood plume was observed in Princess Charlotte Bay satellite images from at least 13–20 February 2025, with turbid plume water from the Normanby and Kennedy estuaries inundating Corbett Reef 30 km to the north and extending over 75 km to the east past the Flinders Isles and outer reef due to westerly winds. By 20 February, winds had shifted to the south and the turbid plume footprint extended north along the coast past the Stewart River (Figure 5-25). Regular ambient sampling 2 weeks later on 3 March 2025 showed a slight freshwater influence near the river mouth (salinity 32), and Chl-*a* remained elevated (max 1.9 µg L^{-1}) across the transect, particularly in sub-surface samples.

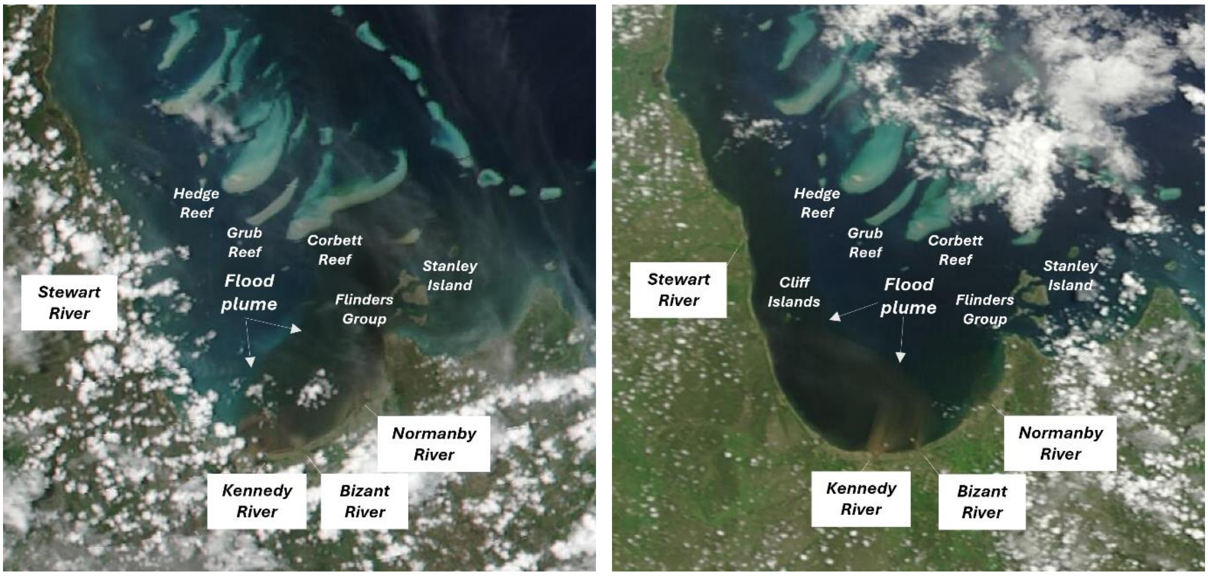


Figure 5-25: MODIS Terra satellite imagery from 13 February 2025 (left) and 20 February 2025 (right), showing Normanby and Kennedy River flood plumes flowing east towards the outer reef and to the north past Cliff Isles and the Stewart transect sites.

5.1.4 Annan-Endeavour

The Annan-Endeavour focus region is influenced primarily by discharge from the Endeavour and Annan Rivers. Five sampling sites are located along transects from the 2 river mouths to mid-shelf reefs, representing a gradient in water quality (Figure 5-26). Additional sites ER01 and AR01 are sampled during events. In addition to manual sampling, dataloggers monitor continuous chlorophyll fluorescence, turbidity, and conductivity at Dawson Reef 6 km from the mouth of the Annan River and Forrester Reef 30 km north of the Endeavour River mouth (Figure 5-26).

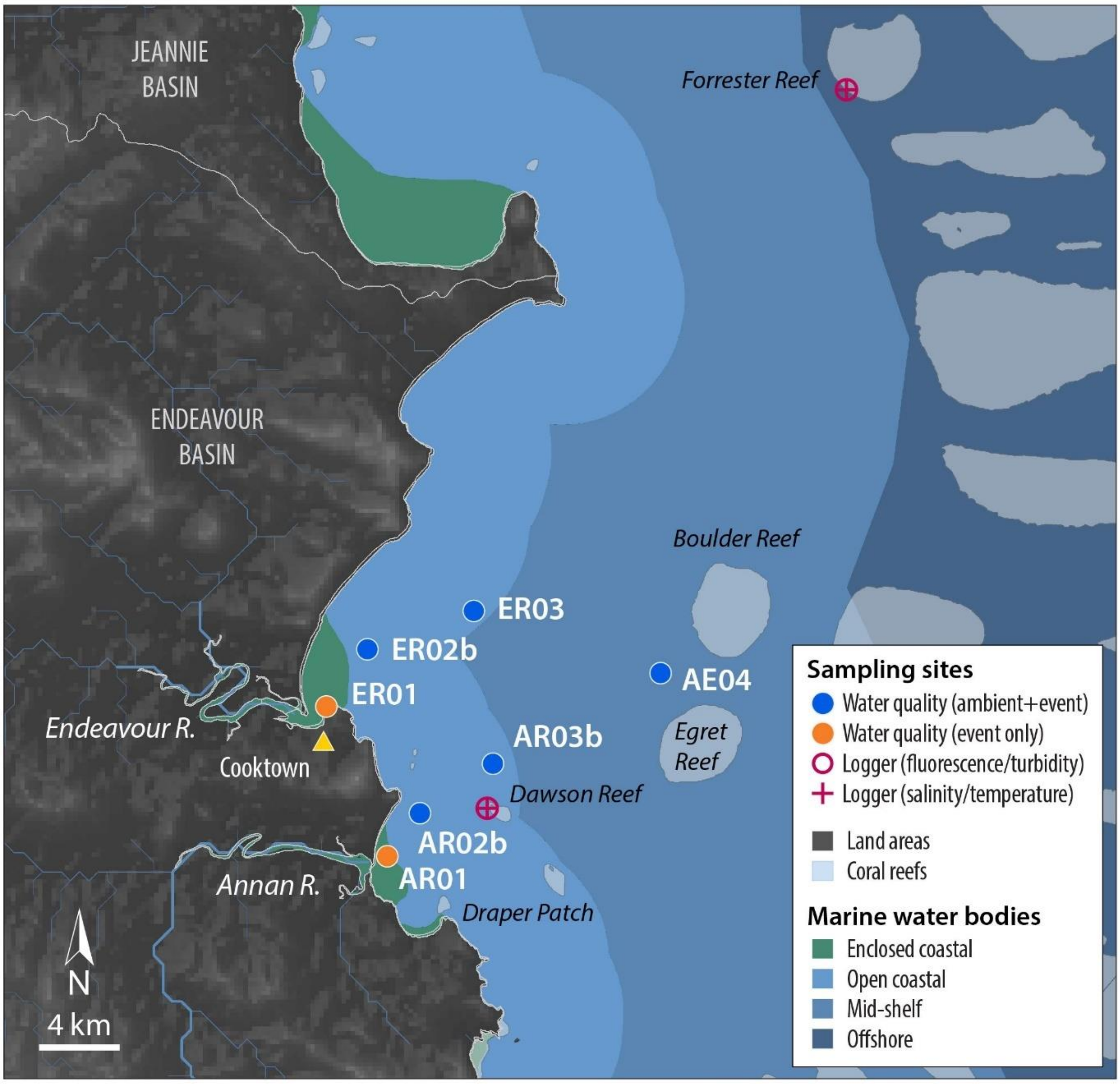


Figure 5-26: Sampling sites in the Annan-Endeavour focus region, shown with water body boundaries.

The Annan and Endeavour transect was sampled for ambient wet season conditions 5 times (spread over 7 days) between December 2024–June 2025. Additional event samples were collected on 18 and 19 March 2025 following peak discharge measured at the upstream gauges on 17 March (Figure 5-27). Five samples of TSS, salinity and Chl-*a* were collected adjacent to Dawson Reef and Forrester Reef dataloggers to estimate TSS and Chl-*a* concentrations from logger measurements of turbidity and chlorophyll fluorescence, respectively.

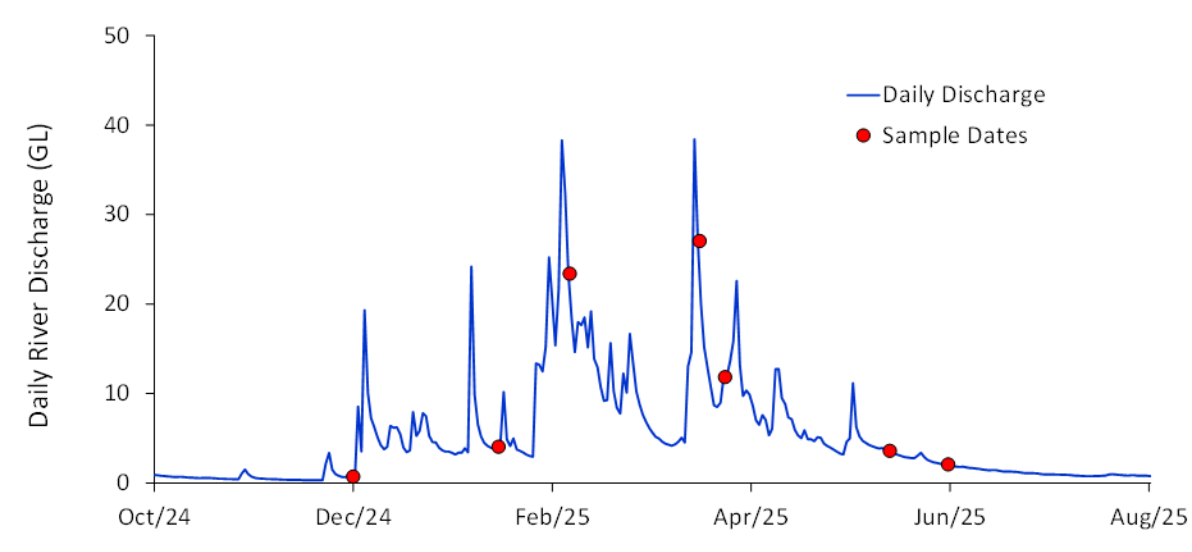


Figure 5-27: Daily discharge and sampling dates for the Endeavour Basin using combined values from the Annan River (gauge 107003A) and Endeavour River gauge (107001B) for the 2024–25 wet season. Note that final transect sampling trip was split over 2 days in May / June.

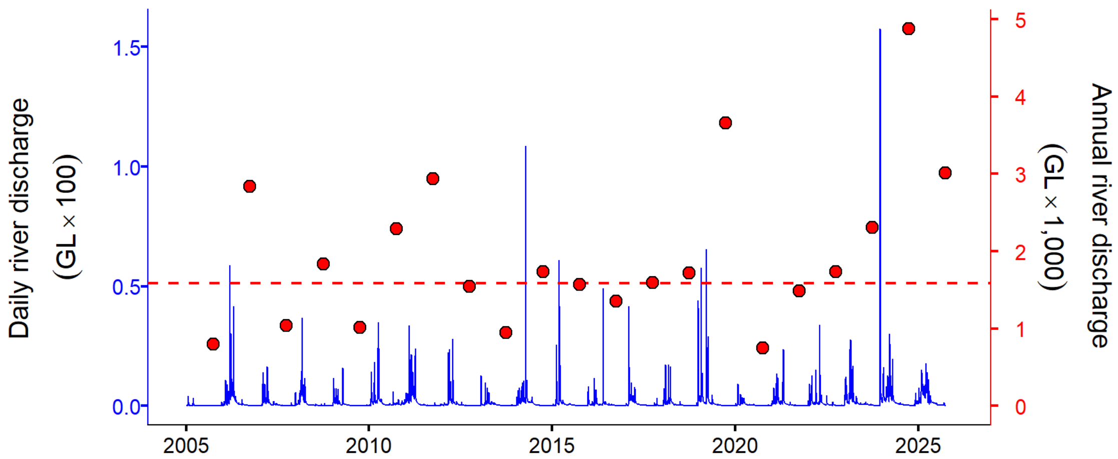


Figure 5-28: Discharge for the Endeavour Basin using combined values from the Annan River (gauge 107003A - Beesbike) and Endeavour River (gauge 107001B – Flaggy). Daily (blue) and water year (1 October to 30 September, red symbols) discharge volumes shown. Red dashed line represents long-term median of the annual discharge.

The estimated total discharge from the Endeavour Basin for the 2024–25 water year was 1.9 times the long-term median (Table 3-1, Figure 5-28). Over the 19-year period between 2006–07 and the current water year:

- discharge ranged from 753 GL (2019–20) to 4,877 GL (2023–24)
- TSS loads ranged from 38 kt (2019–20) to 244 kt (2023–24)
- DIN loads ranged from 34 t (2019–20) to 219 t (2023–24)
- PN loads ranged from 105 t (2019–20) to 683 t (2023–24).

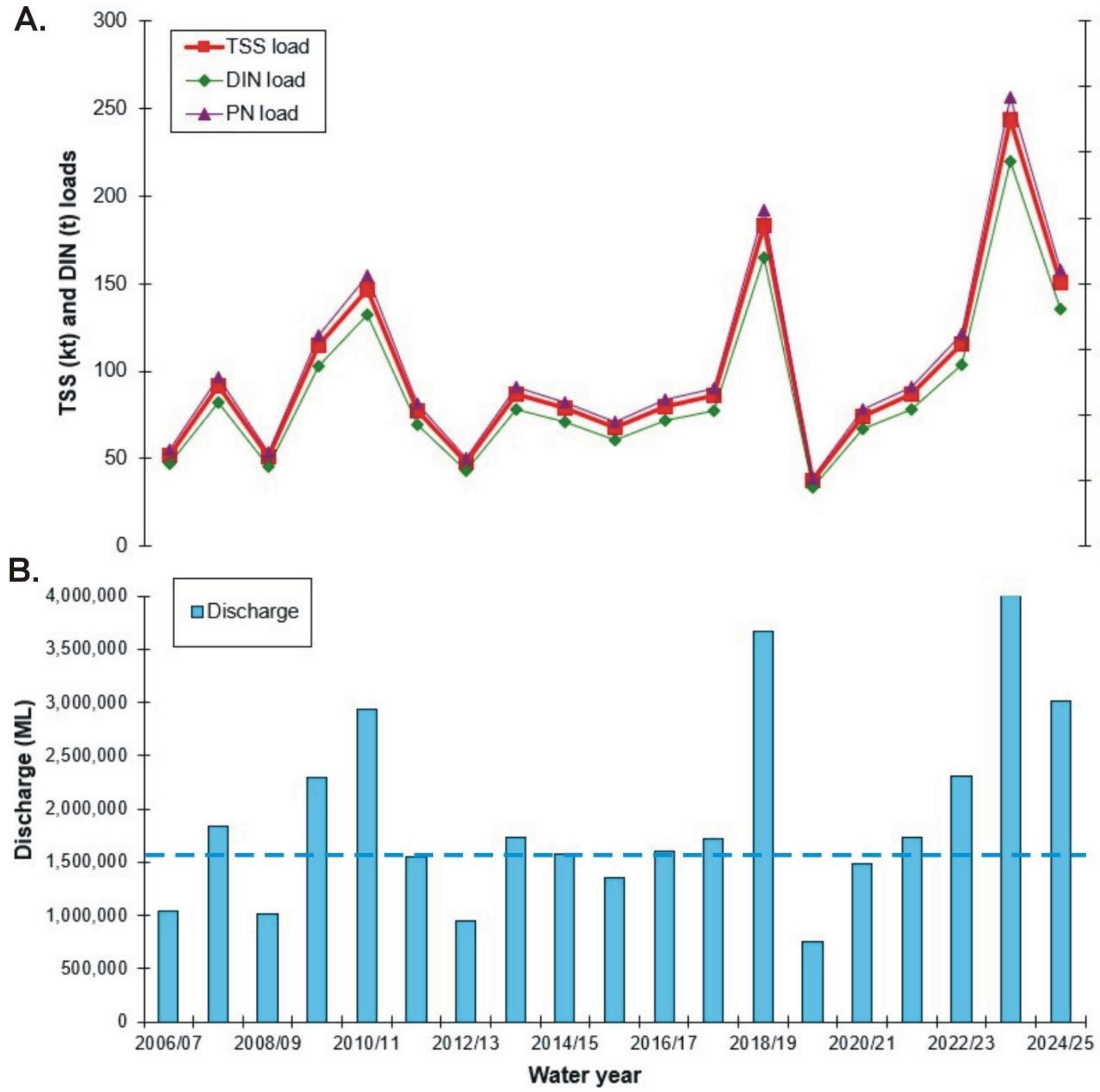


Figure 5-29: Loads of (A) total suspended solids, dissolved inorganic (DIN) and particulate nitrogen (PN) and (B) discharge for the Endeavour Basin from 2006 to 2025.The loads reported here are the best estimates of annual mean concentration informed by nearest neighbour monitoring and by the Source Catchments modelling data applied to each water year. Dotted line represents the long-term median for basin discharge. Note the different scales on the 2 y-axes.

Ambient water quality and the in situ *Water Quality Index*

Water quality showed trends along the transect (cross-shelf gradient in northeasterly direction). Sites located nearest to the river mouth (distance from river mouth = 3.6 km) generally had higher concentrations of particulate nutrients (PN and PP) than sites further offshore, reaching low levels in mid-shelf waters (Figure 5-30, Table C-2). Concentrations of Chl-*a*, NO_x, and TSS were relatively similar across the transect and showed more variability between sampling occasions than with distance from the river mouths. Secchi depths were low at sites near the river mouth (water clarity was poor) and increased (water clarity improved) with distance from the river mouth These spatial patterns are generally consistent with those that are typically observed in the region and are driven by both catchment inputs and coastal processes.

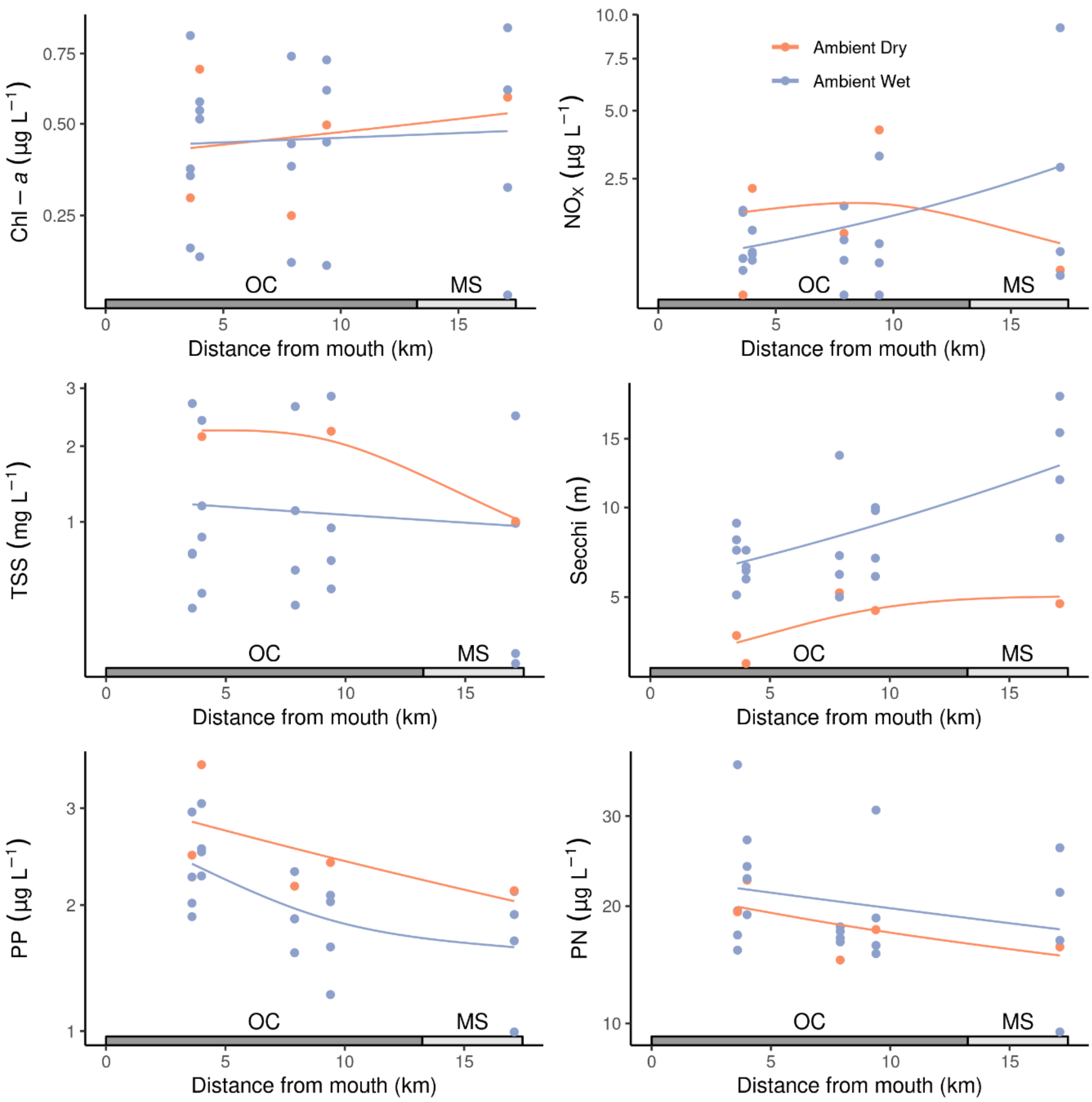


Figure 5-30: Water quality variables measured during ambient wet and dry season sampling in 2024–25 along the Annan-Endeavour focus region transect. Chlorophyll *a* (Chl-*a*), nitrate/nitrite (NO_x), total suspended solids (TSS), Secchi depth, particulate phosphorus (PP), and particulate nitrogen (PN) are shown with distance from the river mouth. Water body classifications are shown along the x-axes: open coastal (OC) and mid-shelf (MS). Note the y-axes are logarithmic scales. Fitted lines are generalised additive models.

Due to sampling limitations (discussed in Methods), trends in this focus region are only available since 2020 (Figure 5-31). It should be noted these trends are preliminary given only 5 years of data are available. Site-specific statistics and comparison to GVs for all variables are available in Table C-1.

Concentrations of Chl-*a* appear to have increased since 2020, especially over the last 2 years of sampling (Figure 5-31a). Chl-*a* in 2024–25 was above (did not meet) the local GVs at 3 of the 6 sites sampled (Table C-1).

Secchi depth has remained relatively stable since 2020 (Figure 5-31b). Secchi depth in 2024–25 was below (did not meet) the local GVs at 3 of the 6 sites sampled (Table C-1).

Concentrations of TSS appear to have declined from 2020–24 but increased in the last year of sampling (Figure 5-31c). TSS concentrations in 2024–25 were above (did not meet) the local water quality GVs at one of the 6 sites sampled (Table C-1).

Concentrations of NO_x appear to have increased since 2020, especially over the last 2 years of sampling (Figure 5-31d). NO_x in 2024–25 was above (did not meet) the local GVs at 2 of the 6 sites sampled (Table C-1).

Concentrations of PO_4 have fluctuated since 2020, showing some interannual variability, with concentrations presently similar to the start of sampling (Figure 5-31e). PO_4 in 2024–25 was above (did not meet) the local GVs at 2 of the 6 sites sampled (Table C-1).

Concentrations of PN have fluctuated since 2020 and are currently similar to concentrations at the start of sampling (Figure 5-31f). PN in 2024–25 was above (did not meet) the local GVs at 4 of the 6 sites sampled (Table C-1).

Concentrations of PP remained relatively stable since 2020 and are currently similar to concentrations at the start of sampling (Figure 5-31g). PP in 2024–25 was above (did not meet) the local GVs at 2 of the 6 sites sampled (Table C-1).

Concentrations of POC have fluctuated since 2020 but remain similar to concentrations at the start of sampling, while DOC concentrations appear to have declined since 2020 (Figure 5-31h,i). Guideline values are not available for these analytes.

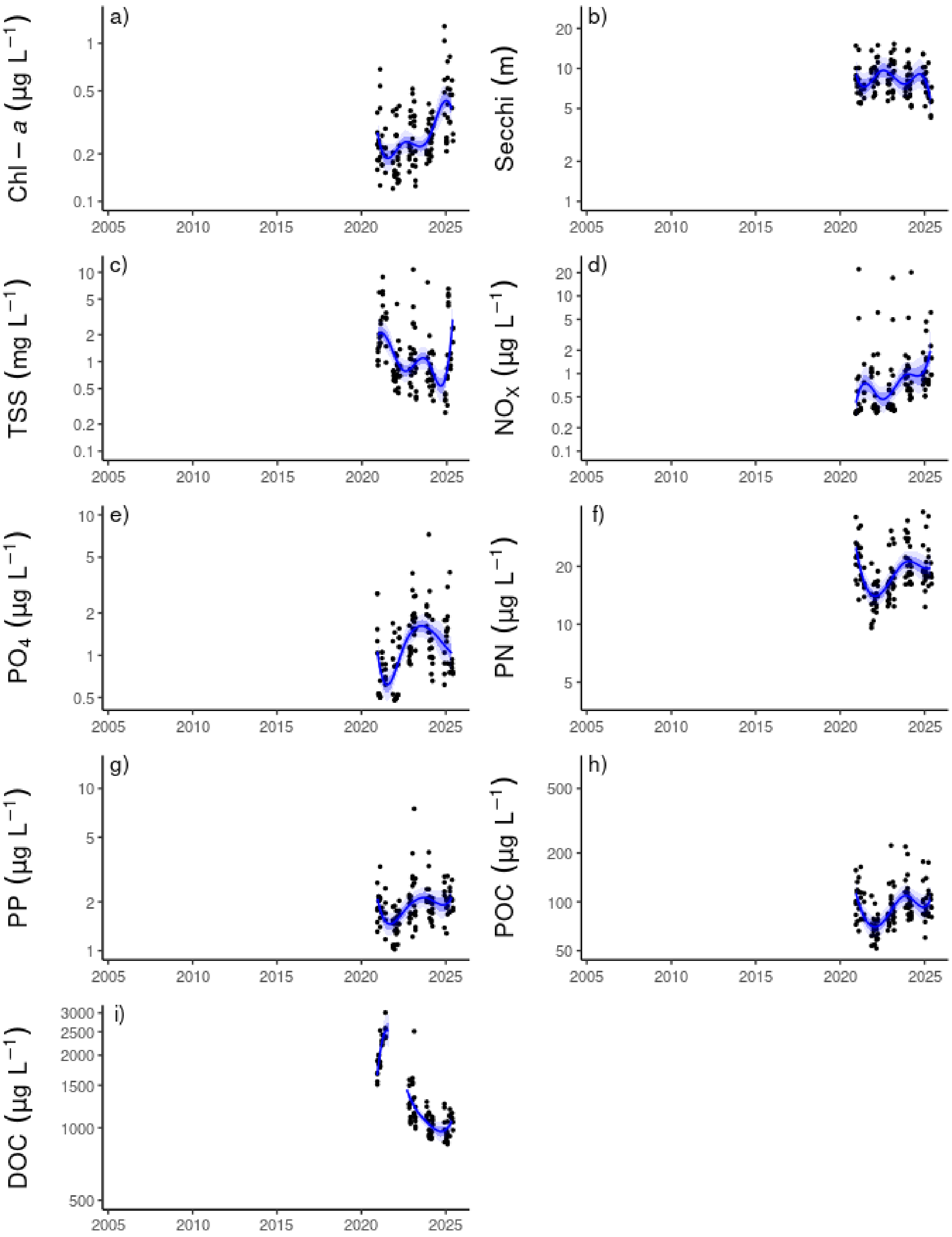


Figure 5-31: Temporal trends in water quality variables for the Annan-Endeavour focus region: a) chlorophyll *a* (Chl-*a*), b) Secchi depth, c) total suspended solids (TSS), d) nitrate/nitrite (NO_x), e) phosphate (PO_4), f) particulate nitrogen (PN), g) particulate phosphorus (PP), h) particulate organic carbon (POC) and i) dissolved organic carbon (DOC). Generalised additive mixed effect models (trends) are represented by blue lines with shaded areas defining 95% confidence intervals of those trends and black dots represent observed data (depth weighted averages). These trends and data are accounting for the effects of seasons after applying x-z detrending.

For the Annan-Endeavour region, the annual WQ Index has shown a decline since the 2021–22 water year, with values presently similar to the start of sampling (Figure 5-32a). The 2024–25 water year received a score of 'moderate', which was a large deterioration on the 'good' score from 2023–24. This deterioration from last year was driven primarily by the Productivity sub-indicator from a large deterioration in Chl-*a*. PP and TSS concentrations also increased, while Secchi depth decreased (water clarity worsened), contributing to the overall decline in condition. NO_x deteriorated (concentrations increased) in 2023–24 and remained high over the 2024–25 wet season.

The deterioration in WQ Index is likely to be related to long-term impacts from the extreme cyclone Jasper in December 2023. Multiple landslides, and the severe loss of riparian vegetation in the Annan catchment and other rivers to the south, have increased the supply of sediment and associated nutrients to the coast (Howley *et al*., 2024). As a result, the Annan river remained highly turbid throughout most of the wet season, even under ambient conditions. In contrast, the Endeavour River, which was less impacted by the cyclone, remained clear under similar discharge conditions (

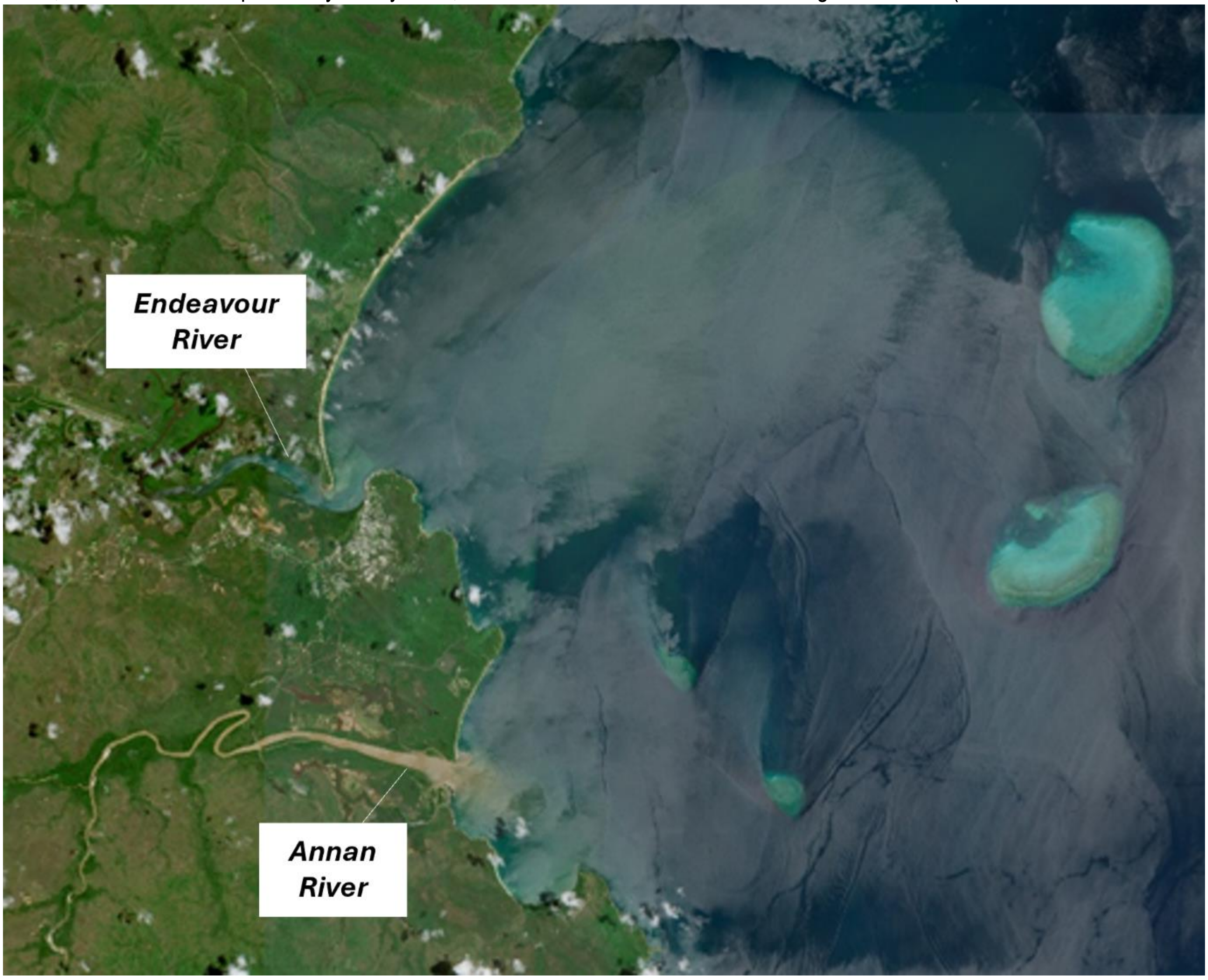


Figure 5-33).

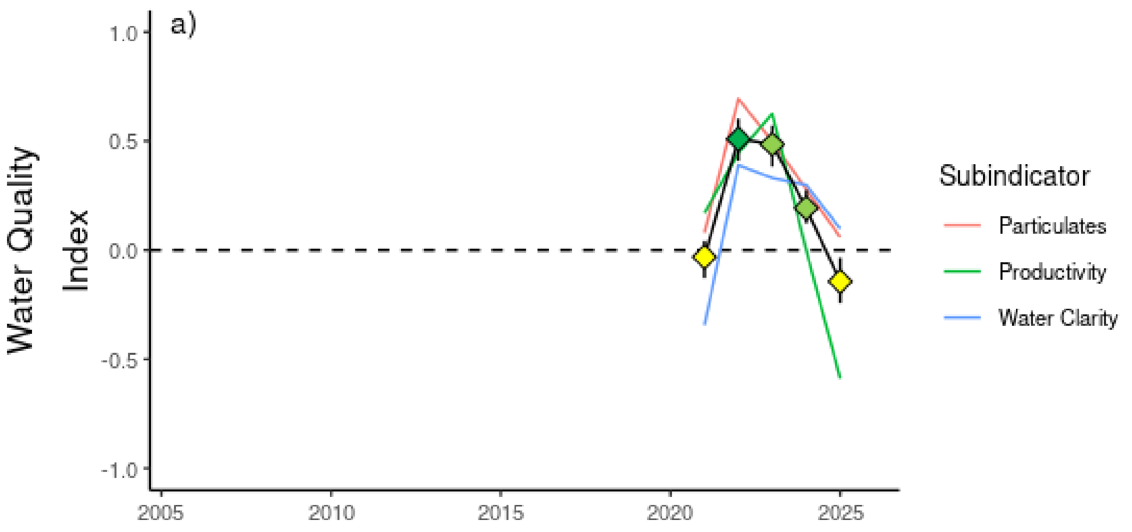


Figure 5-32: The annual condition Water Quality Index (WQ Index) for the Annan-Endeavour focus region. WQ Index colour coding: ◆– 'very good'; ◆ – 'good'; ◆ – 'moderate; ◆ – 'poor'; ◆ – 'very poor'. Sub-indicators that are used to calculate the WQ Index are shown as coloured lines. Error bars (vertical black lines) on the WQ Index represent the 95% quantile intervals. Calculations for Index formulations are described in Appendix B.

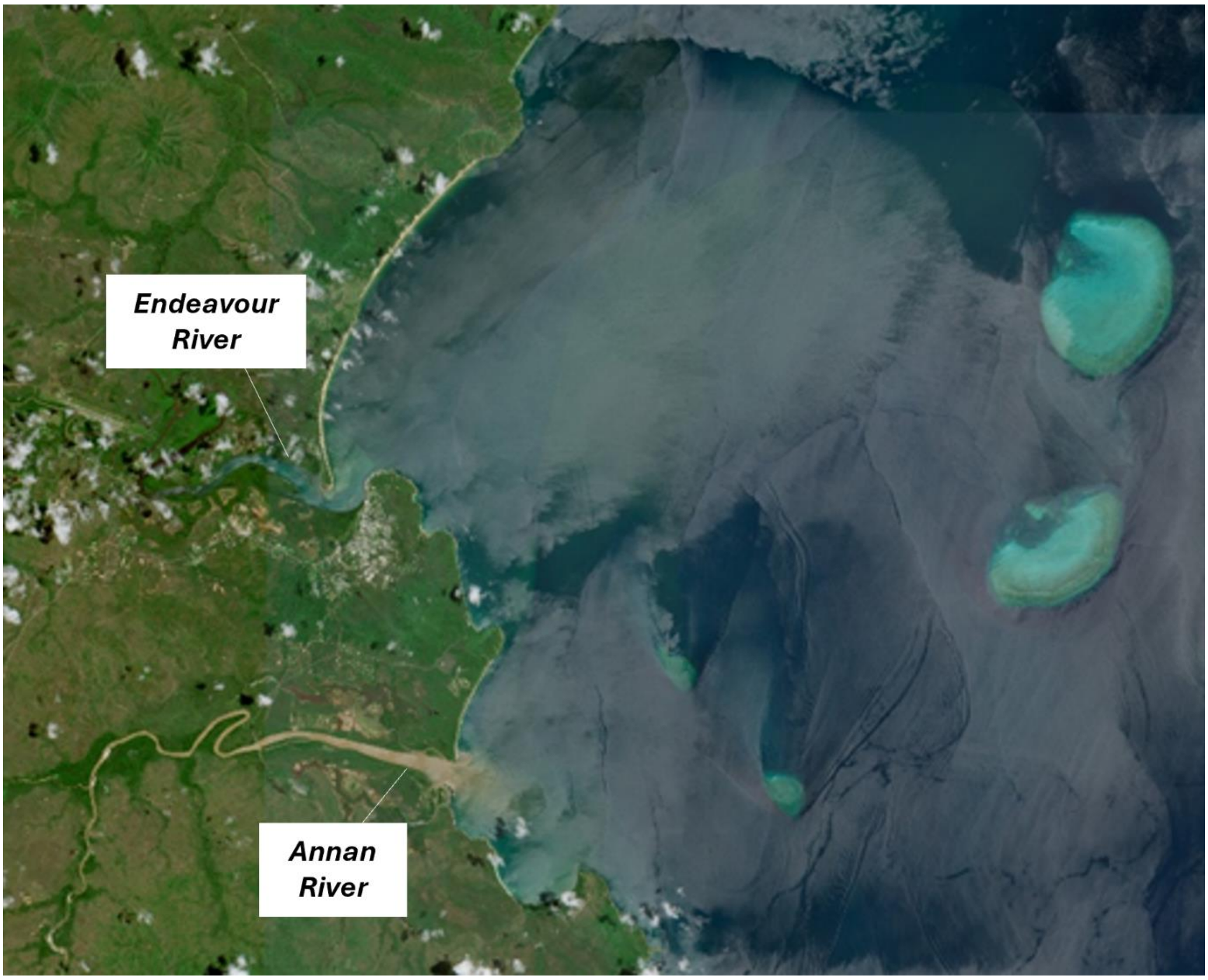


Figure 5-33: Sentinel satellite image (14 February 2025) showing highly turbid water in the Annan River under ambient wet season conditions following Tropical Cyclone Jasper. The Endeavour River to the north is clear under similar discharge conditions.

Median turbidity measured continuously at Dawson and Forrester reefs met the relevant GVs for the open coastal and mid-shelf water bodies (Table 5-1, Table 5-2). However, median turbidity exceeded the GVs for approximately 63 days at Dawson Reef and 30 days at Forrester. (Figure 5-34). Median Chl-*a* also met the GVs at both sites, however the median Chl-*a* at Forrester remained elevated above pre-cyclone Jasper (2023) median concentrations (Table 5-2). Median Chl-*a* exceeded the GVs for approximately 27 and 73 days over the wet season at Dawson and Forrester reefs respectively (Figure 5-34).

Table 5-1: Median wet season turbidity and chlorophyll concentrations from a Wetlabs FLNTU datalogger at Dawson Reef from the 2018–19 water year until present and guideline values (GV) from the open coastal water body.

Dawson Reef	**2018–19**	**2019–20**	**2020–21**	**2021–22**	**2022–23**	**2023–24**	**2024–25**	**GV**
Median turbidity wet season (NTU)	0.87	0.60	0.59	0.54	0.60	0.85	0.54	0.8
Median chlorophyll wet season (µg L^{-1})	0.31	0.20	0.20	0.11	0.15	0.27	0.13	0.46

Table 5-2: Median wet season turbidity and chlorophyll concentrations from a Wetlabs FLNTU datalogger at Forrester Reef from the 2019–20 water year until present and guideline values (GV) from the mid shelf water body.

Forrester Reef	**2019–20**	**2020–21**	**2021–22**	**2022–23**	**2023–24**	**2024–25**	**GV**
Median turbidity wet season (NTU)	0.29	0.23	0.31	0.26	0.27	0.26	0.5
Median chlorophyll wet season (µg L^{-1})	0.19	0.13	0.15	0.12	0.26	0.22	0.26

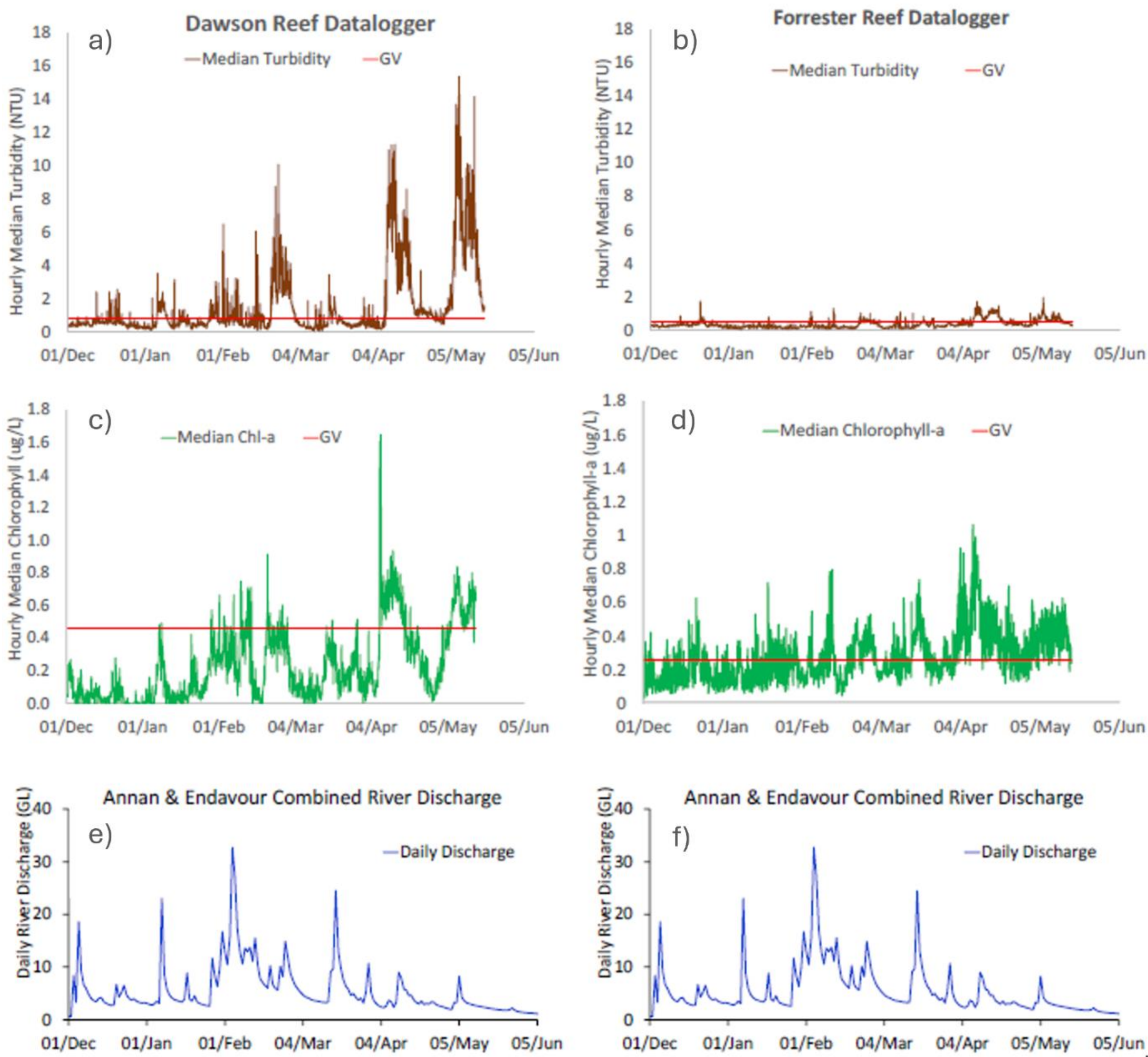


Figure 5-34: Continuous turbidity and chlorophyll measured on the FLNTU dataloggers at Dawson and Forrester Reefs over the 2024–25 wet season. Dawson Reef left column, a) turbididy and c) chl-a and Forrester Reef right column, b) turbidity and d) chl-a. The hydrographs (e and f) display combined river discharge from the Annan and Endeavour Rivers that influence Dawson and Forrester Reefs and are shown in duplicate to align with Dawson and Forrester data shown above.

Event water quality

Although river discharge for the Annan and Endeavour Rivers was 1.9 times the mean annual discharge-, there were no large magnitude flood events over the 2024–25 wet season compared to previous years (Figure 5-28). River discharge peaked at 38.3 GL/day on 4 February 2025 and 38.4 GL/day on 17 March. Event samples were collected on 18 and 19 March 2025. During this moderate magnitude event salinity ranged from 8 near the mouth of the Annan and 20 near the Endeavour mouth, to 32 in the mid-shelf water body near Egret and Boulder reefs. TSS was elevated near the river mouths (11 and 20 mg L^{-1}) and decreased along the salinity gradient while Secchi depth increased from 0.3 to 7.1 m with distance from the river mouth (Figure 5-35). DIN, PN, PP, DOC, and POC concentrations close to the river mouths were highly elevated above mean ambient concentrations and decreased along the transect. In contrast, DIP concentrations increased with increasing salinity across the plume. Maximum Chl-*a* concentrations (>1 µg L^{-1}) occurred both close to the Annan River mouth and in the mid-shelf water body, correlating to DIN uptake and increased light availability.

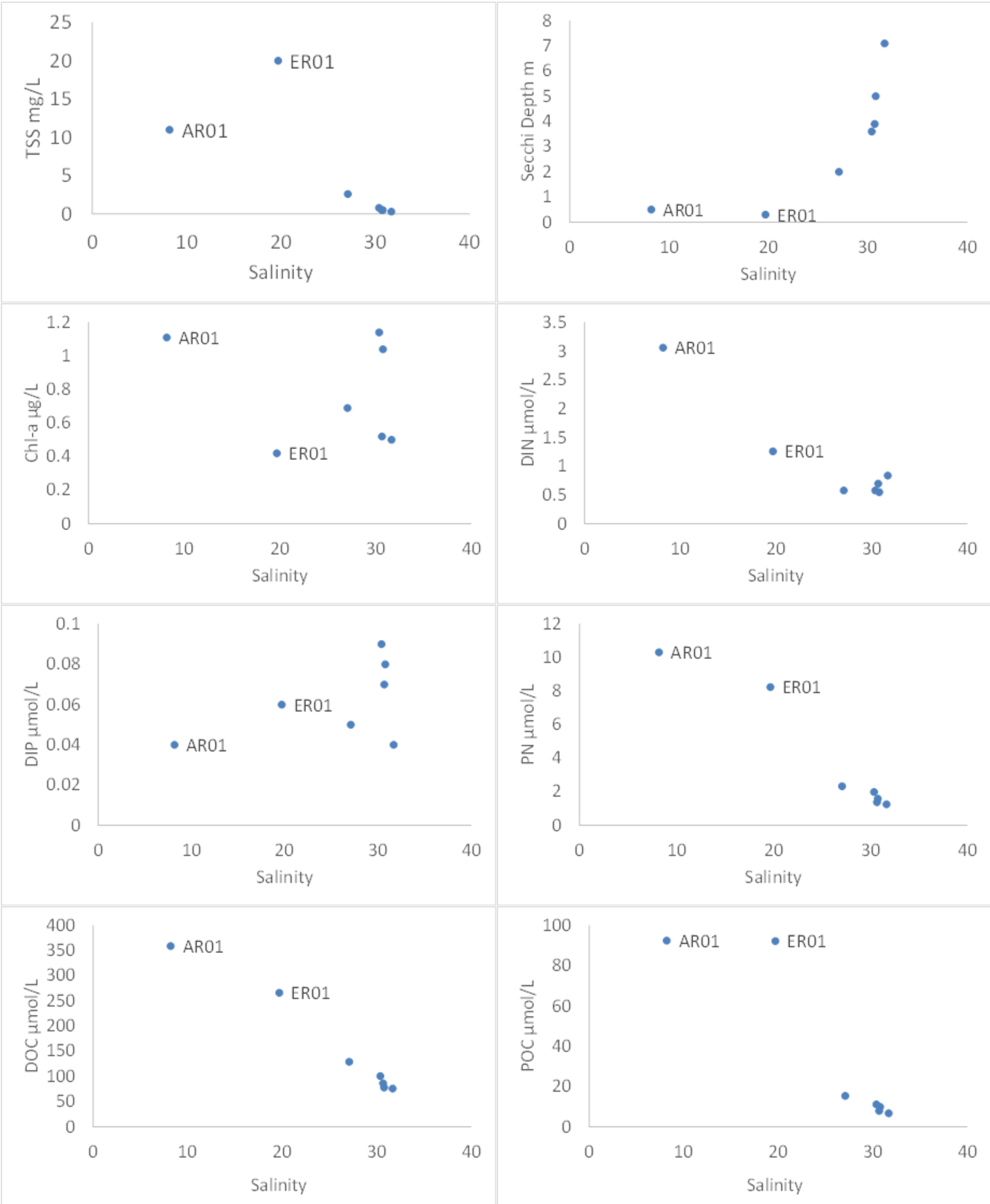


Figure 5-35: Flood event water quality data from the Annan-Endeavour transect on 18 and 19 March (blue circles) including total suspended solids (TSS), Secchi depth, chlorophyll *a* (Chl-*a*), dissolved inorganic nitrogen (DIN),dissolved inorganic phosphorus (DIP), particulate nitrogen (PN), dissolved organic carbon (DOC) and particulate organic carbon (POC) plotted over the salinity gradient.

5.2 Wet Tropics region

The Wet Tropics region is influenced by several river systems and is divided into 3 focus regions which are dominated by the Barron and Daintree Rivers (Barron-Daintree), the Russell and Mulgrave Rivers (Russell-Mulgrave) and the Tully River. The results on the pressures and monitoring findings are presented separately for each focus region.

5.2.1 Barron-Daintree

This focus region contains the 6 sites which are sampled 3 times a year (Figure 5-36). This sampling design and frequency did not change in 2015 (unlike all other focus regions).

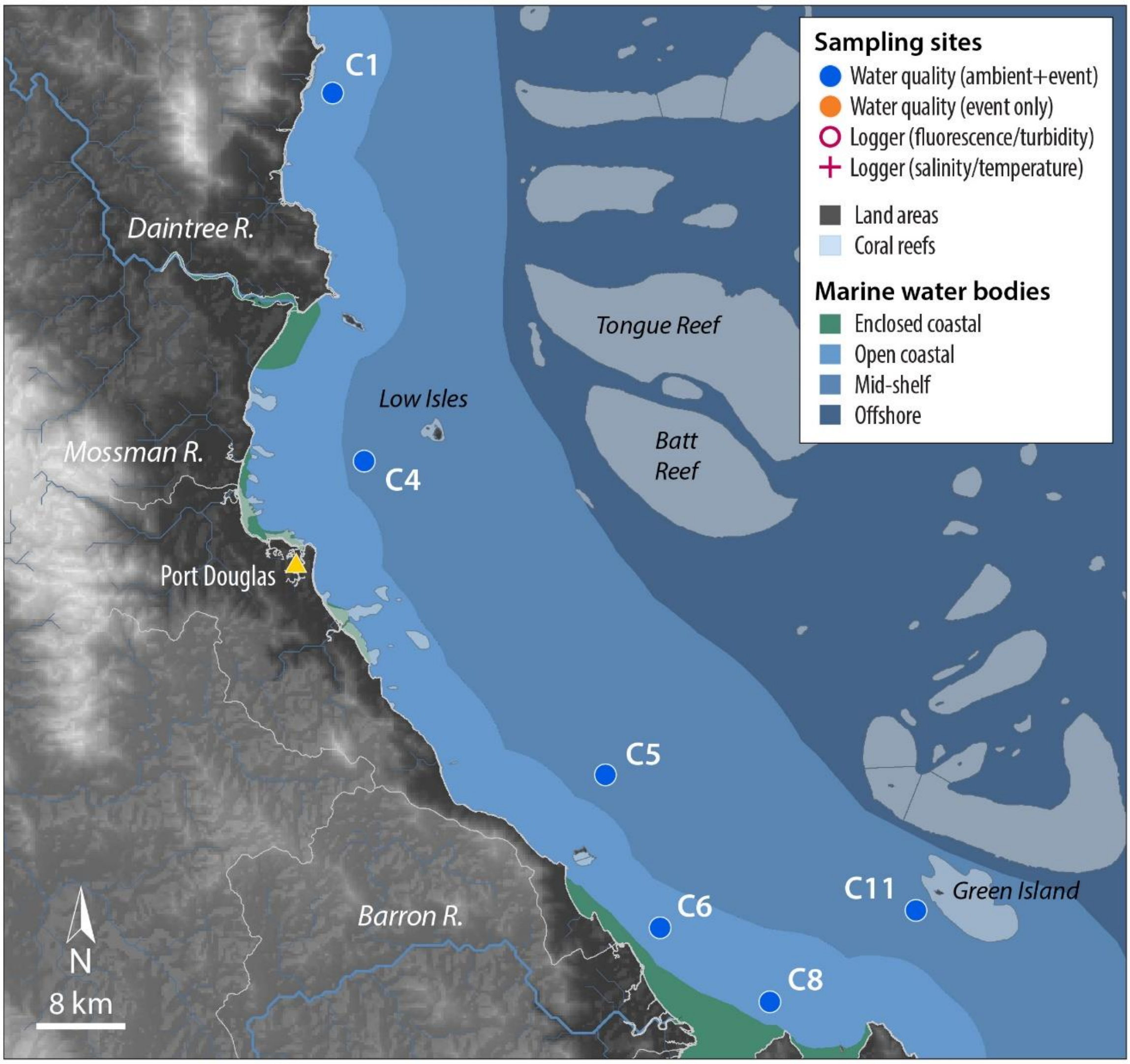


Figure 5-36: Sampling sites in the Barron-Daintree focus region shown with water body boundaries.

The combined discharge calculated for the 2024–25 water year from the Barron, Daintree, and Mossman Basins were 1.6 times greater than the long-term median values (Figure 5-37; Table 3-1). Over the 19-year period between 2006–07 and the current water year:

- discharge ranged from 1,855 GL (2019–20) to 14,527 GL (2023–24)
- TSS loads ranged from 183 kt (2019–20) to 1,546 kt (2023–24)
- DIN loads ranged from 211 t (2019–20) to 1,728 t (2023–24)
- PN loads ranged from 493 t (2019–20) to 4,079 t (2023–24).

Of the 3 focus regions within the Wet Tropics NRM region, the Barron, Daintree, and Mossman Basins commonly contribute the lowest discharge and consistent loads compared to the 2 focus regions to the south (i.e., Russell-Mulgrave and Johnstone Basins and the Tully-Murray and Herbert Basins).

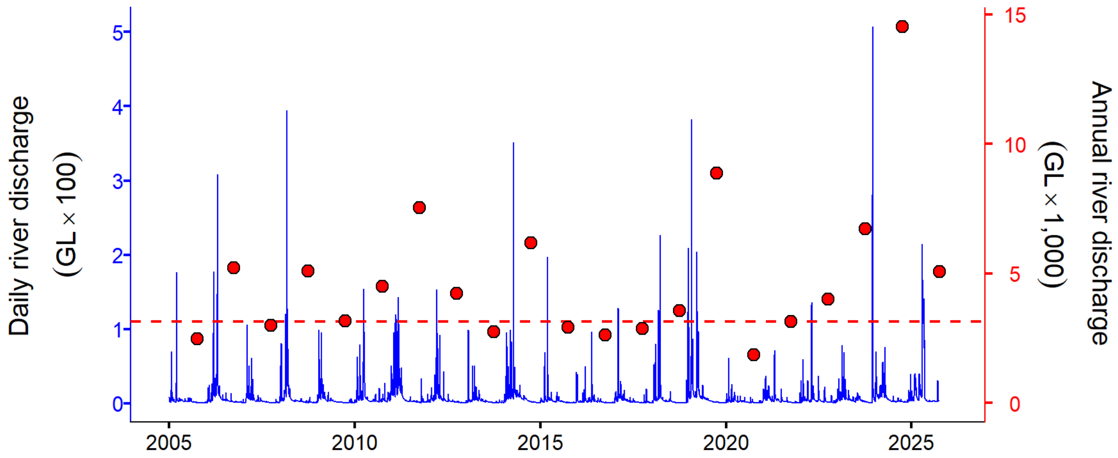


Figure 5-37: Combined discharge from rivers in the Barron-Daintree region including the Daintree River (gauge 108002A – Bairds), Bloomfield River (108003A – China Camp), Mossman River (gauge 109001A – Mossman) and Barron River (gauge 110001D – Myola). Daily (blue) and water year (1 October to 30 September, red symbols) discharge volumes shown. Red dashed line represents long-term median of the combined annual discharge.

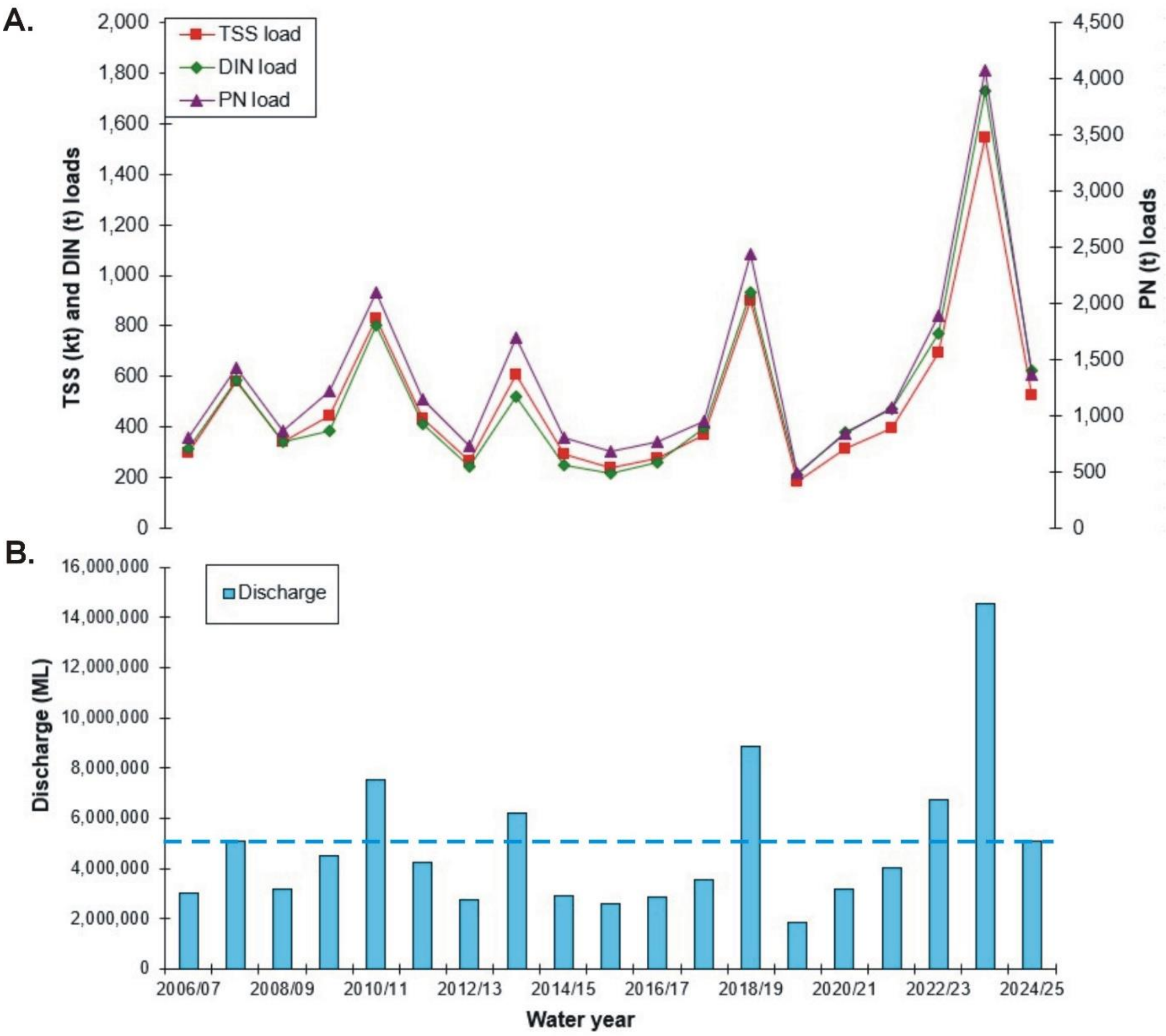


Figure 5-38: Loads of (A) TSS, DIN and PN and (B) discharge for the Barron, Daintree, and Mossman Basins from 2006–2025. The loads reported here are a combination of 'best estimates' for each basin based on 'up-scaled discharge data from gauging stations, monitoring data (Barron River), the DIN model developed in Lewis *et al.* (2014) and annual mean concentrations and discharge from monitoring data or Source Catchments modelling data. The dotted line represents the long-term median for basin discharge. Note the different scales on the 2 y-axes.

Ambient water quality and the in situ Water Quality Index

Distinct long-term trends (since 2005) were observed in some water quality variables, while others showed little change (Figure 5-39). Site-specific statistics and comparison to GVs for all variables are available in Table C-1.

Concentrations of Chl-*a* remained generally stable, fluctuating around local GVs from 2005 until 2015 (Figure 5-39a). Over the period 2015–2024, mean concentration of Chl-*a* decreased overall (conditions improved), but concentrations have increased in recent years to levels similar to the start of monitoring. Chl-*a* in 2024–25 was above (did not meet) the local GVs at 5 of the 6 sites sampled. This recent Chl-*a* increase is likely related to large flood events in the Wet Tropics during the 2023–24 (cyclone Jasper) and 2024–25 wet seasons.

Secchi depth gradually declined (i.e., water clarity deteriorated) from 2005 until 2016 (Figure 5-39b). Over the period 2015–2023, mean Secchi depth increased (water clarity improved) but has decreased (deteriorated) again since 2023. Secchi depth in 2024–25 was below (did not meet) the local GVs at any sites sampled. This recent decline in water clarity is likely related to large flood events in the Wet Tropics in the previous 2 years.

Concentrations of TSS have fluctuated above and below the GVs since monitoring began in 2005 (Figure 5-39c). Over the period 2015–2023, mean concentration of TSS decreased (conditions improved), but concentration has increased again since 2023. TSS in 2024–25 was above (did not meet) the local GVs at 3 of the 6 sites sampled. This recent increase in TSS is likely related to large flood events in the Wet Tropics in the previous 2 years.

Concentrations of NO_x appear to have increased (conditions deteriorated) from 2005 to the present; however, the confidence limits of this trend are large and indicate this trend is not statistically significant at present (Figure 5-39d). NO_x in 2024–25 was above (did not meet) the local GVs at any of the sites sampled.

Concentrations of PO_4 were generally stable and close to the local GVs from 2005 until 2015 (Figure 5-39e). Over the period 2015–25, mean concentration of PO_4 varied, decreasing until around 2023 and then increasing again in the last 2 years. Trend analysis showed that the concentration of PO_4 in 2025 was significantly greater than in 2015. PO_4 in 2024–25 was above (did not meet) the local GVs at any of the sites sampled. This recent increase in PO_4 is likely related to large flood events in the Wet Tropics in the previous 2 years.

Concentrations of PN remained relatively stable and well below the local GVs from 2005 until ~2022; over the last 3 years of monitoring, mean PN concentration increased (conditions deteriorated) (Figure 5-39f). Trend analysis showed that the concentration of PN in 2025 was significantly greater than in 2015, although concentrations generally remain below local GVs. PN in 2024–25 was above (did not meet) the local GVs at one of the 6 sites sampled. This recent increase in PN is likely related to large flood events in the Wet Tropics in the previous 2 years.

Concentrations of PP remained relatively stable and close to the local GVs from 2005 until ~2022 (Figure 5-39g). Over the last 2 years, mean concentration of PP increased (conditions deteriorated) although this trend was not significant. PP in 2024–25 was above (did not meet) the local GVs at 5 of the 6 sites sampled. This recent increase in PP is likely related to large flood events in the Wet Tropics in the previous 2 years.

Concentrations of POC remained relatively stable from 2005 until ~2022 (Figure 5-39h). Over the last 2 years, mean concentration of POC increased although this trend was not significant.

Concentrations of DOC increased substantially since 2005 (Figure 5-39i). Trend analysis showed that the concentration of DOC in 2025 was significantly greater than in 2015.

The WQ Index is calculated using 2 different formulations to communicate the a) long-term trend in water quality (based on the pre-2015 sampling design) and b) annual condition of water quality (based on the post-2015 sampling design, which increased the power to detect change). For the Barron-Daintree focus region, no additional sites were added in 2015, with sampling still conducted 3 times per year. Section 2.1.5 and Appendix B contain details of the calculations for both Index formulations.

The long-term WQ Index showed a small trend (i.e., changing by a single grade) of deterioration in water quality from 2005–2018, driven by Chl-*a* and PP indicators (Figure 5-40a). From 2018–22, this trend reversed, and water quality showed an overall trend of improvement driven by improvements in Chl-*a*, water clarity, and PP indicators. Over the last 4 years, water quality has again deteriorated.

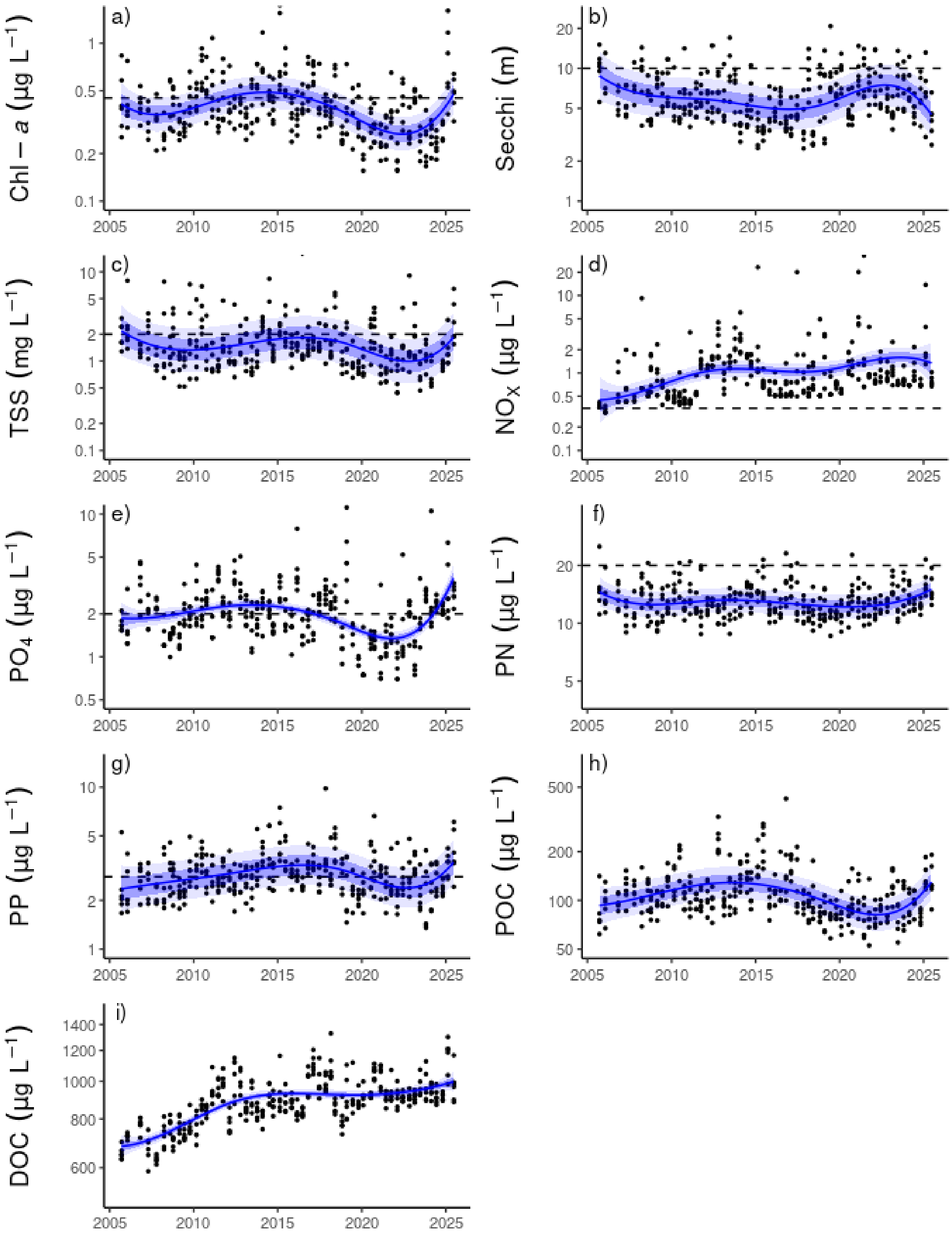


Figure 5-39: Temporal trends in water quality variables for the Barron-Daintree focus region: a) chlorophyll *a* (Chl-*a*), b) Secchi depth, c) total suspended solids (TSS), d) nitrate/nitrite (NO_x), e) phosphate (PO_4), f) particulate nitrogen (PN), g) particulate phosphorus (PP), h) particulate organic carbon (POC) and i) dissolved organic carbon (DOC). Generalised additive mixed effect models (trends) are represented by blue lines with shaded areas defining 95% confidence intervals of those trends and black dots represent observed data (depth weighted averages). These trends and data are accounting for the effects of seasons after applying x-z detrending. Dashed horizontal reference lines indicate annual guideline values for open coastal waters.

The annual condition WQ Index scored water quality as ‘moderate’ during the 2015–18 water years and ‘good’ during the following 6 water years (Figure 5-40b). The 2024–25 water year marked a large deterioration in the annual condition score, which was ‘moderate’ for the first time since 2018. This deterioration was driven by all indicators, but especially Chl-*a*, which showed a major deterioration from 2023–24. This decline in condition was likely related to large flood events in the Wet Tropics in the previous 2 years, which were not evident in Index scores in 2023–24 due to the timing of sampling relative to floods (i.e., this region is only sampled 3 times per year).

It is important to note that the 2 versions of the WQ Index are designed to answer separate questions and therefore differences in scores between the versions are expected.

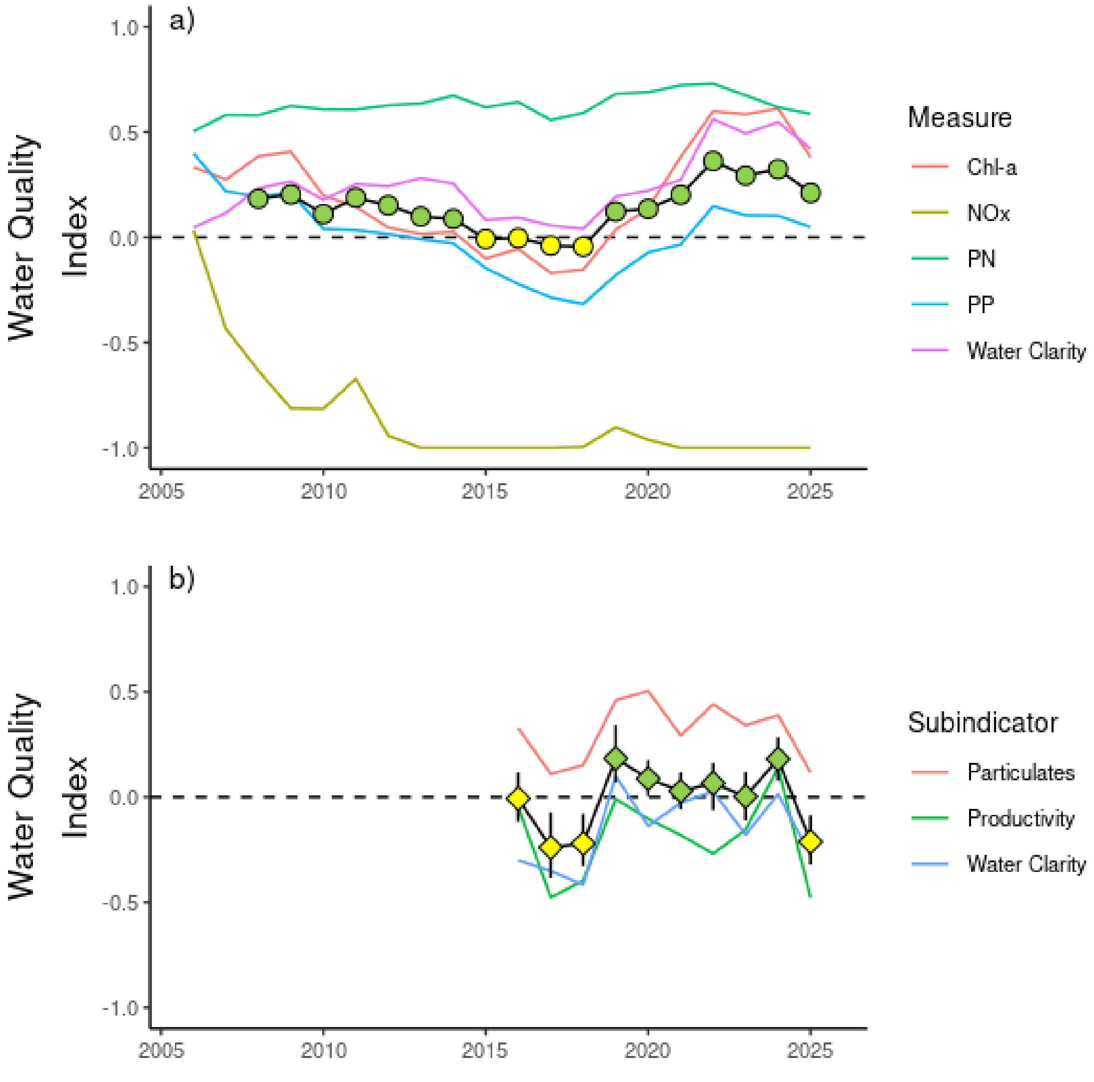


Figure 5-40: The Water Quality Index (WQ Index) for the Barron-Daintree focus region. The WQ Index uses two formulations to communicate: a) long-term trend (based on pre-2015 sampling design) and b) the annual condition (based on post-2015 sampling design). WQ Index colour coding: ● / ◆– ‘very good’; ● / ◆ – ‘good’; ● / ◆ – ‘moderate; ● / ◆ – ‘poor’; ● / ◆ – ‘very poor’. Indicators or sub-indicators that are used to calculate the WQ Index are shown as coloured lines on each plot. Error bars (vertical black lines) on the WQ Index represent the 95% quantile intervals. Calculations for both formulations are described in Appendix B.

Event water quality

No event sampling was conducted during the 2024–25 wet season in this focus region.

5.2.2 Russell-Mulgrave

The Russell-Mulgrave focus region is primarily influenced by discharge from the Russell-Mulgrave and Johnstone Basins and, to a lesser extent, by other rivers south of the focus region such as the Burdekin (Brodie *et al.*, 2013; Waterhouse *et al.*, 2017). Three sites were sampled 3 times per year in this focus region until the end of 2014. Following the implementation of the revised MMP water quality sampling design in 2015, 12 monitoring sites are sampled in this focus region up to 10 times per year, with 5 sites sampled during both the dry and wet seasons and 7 additional sites sampled during major flood events (Table A-1). The monitoring sites form a transect from the river mouth to mid-shelf waters, representing a gradient in water quality. Five sites are in the open coastal water body, 5 sites are located in the mid-shelf water body, one site is in mid-estuarine waters, and one site is in enclosed coastal waters (Figure 5-41).

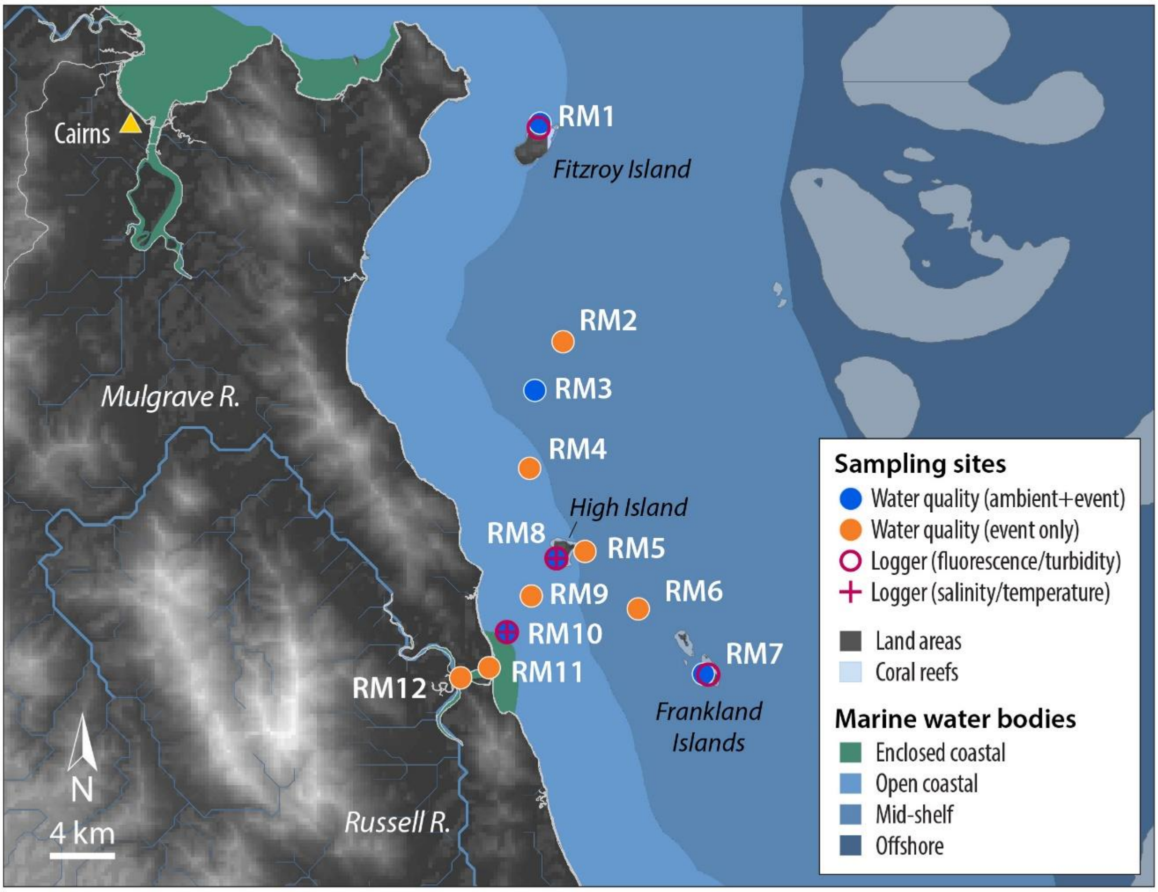


Figure 5-41: Sampling sites in the Russell-Mulgrave focus region, shown with the water body boundaries.

The combined discharge volume of the Russell-Mulgrave and Johnstone Rivers for the 2024–25 water year was 1.3 times higher than the long-term median (Figure 5-42).

The combined discharge and loads calculated for the 2024–25 water year from the Russell-Mulgrave and Johnstone Basins were in the higher range to that recorded over the past decade (Figure 5-43). Over the 19-year period between 2006–07 and the current water year:

- discharge ranged from 6,318 GL (2014–15) to 15,813 GL (2010–11)
- TSS loads ranged from 350 kt (2014–15) to 896 kt (2010–11)
- DIN loads ranged from 835 t (2014–15) to 2,722 t (2010–11)
- PN loads ranged from 1,177 t (2014–15) to 3,005 t (2010–11).

Of the 3 focus regions within the Wet Tropics NRM region, the Russell-Mulgrave and Johnstone Basins collectively contribute similar discharge and loads to the Tully-Murray and Herbert Basins during low to average discharge years, although the latter basins contribute higher values (particularly DIN) during the high discharge years such as in 2008–09 and 2010–11 water years.

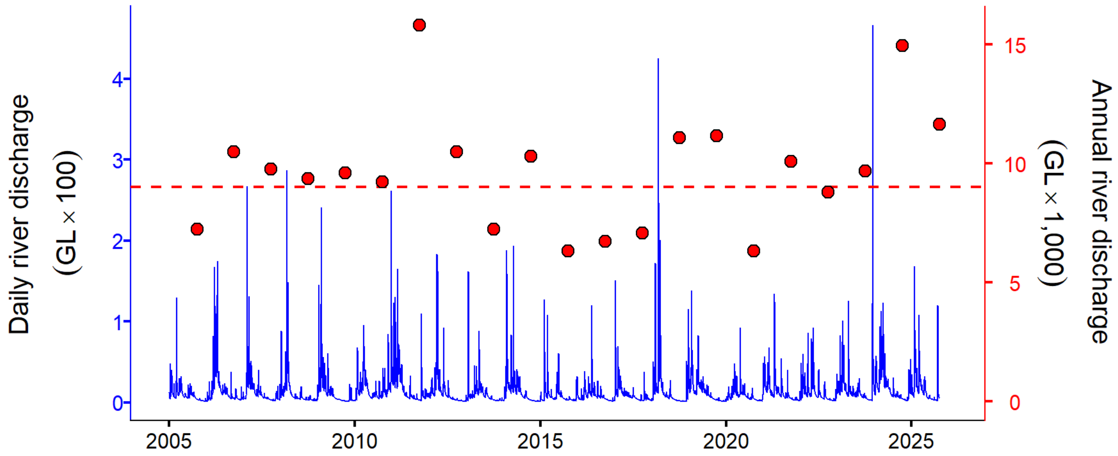


Figure 5-42: Combined discharge for rivers in the Russell-Mulgrave region including the North Johnstone (gauge 112004A – Tung Oil) and South Johnstone gauge 112101B – Central Mill), Russell (gauge 111101D – Bucklands) and Mulgrave (gauge 111007A – Peets Bridge) Rivers. Daily (blue) and water year (1 October to 30 September, red symbols) discharge is shown. Red dashed line represents the long-term median of the combined annual discharge.

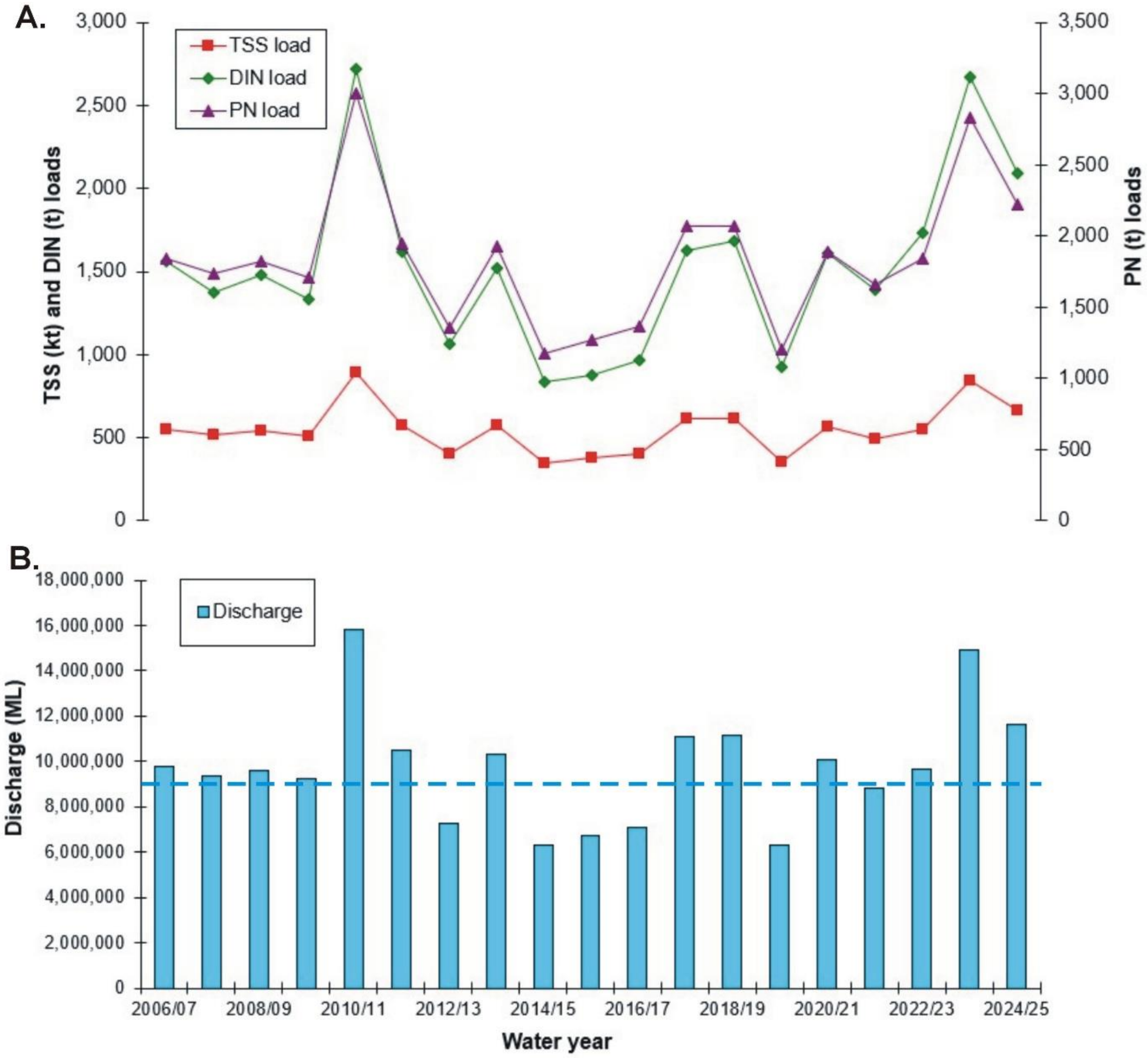


Figure 5-43: Loads of (A) TSS, DIN and PN and (B) discharge for the Russell, Mulgrave and Johnstone Basins from 2006 to 2025. The loads reported here are a combination of 'best estimates' for each basin based on 'up-scaled discharge data from gauging stations, monitoring data (Johnstone River), the DIN model developed in Lewis *et al.* (2014) and annual mean concentrations and discharge from monitoring data or Source Catchments modelling data. Dotted line represents the long-term median for basin discharge. Note the different scales on the 2 y-axes.

Ambient water quality and the in situ *Water Quality Index*

Water quality showed trends along the sampling transect (cross-shelf gradient in north and easterly directions). Sites located nearest to the river mouth (distance from river mouth = 0 km) had high concentrations of NO_x and particulate nutrients (PN and PP), which declined with distance away from the river mouth, reaching low levels in mid-shelf waters (Figure 5-44, Table C-2). Concentrations of Chl-*a* and TSS showed a similar pattern to nutrient concentrations and tended to decline with distance from the river mouth. Secchi depths were low at sites near the river mouth (water clarity was poor) and increased (water clarity improved) with distance from the river mouth. These spatial patterns were generally consistent with those that are typically observed in the region.

Seasonal differences in NO_x, Chl-*a*, PP, and PN were also typical, where concentrations were higher during the wet than the dry season. For Chl-*a*, NO_x, and PN, these seasonal differences persisted even in mid-shelf waters, which is not typical for this region and may be a reflection of the relatively long-lived and widespread flooding throughout the Wet Tropics during 2024–25. TSS concentrations were similar between wet and dry seasons along the transect, while Secchi depths were greater (water was clearer) during the wet season than the dry (Figure 5-44).

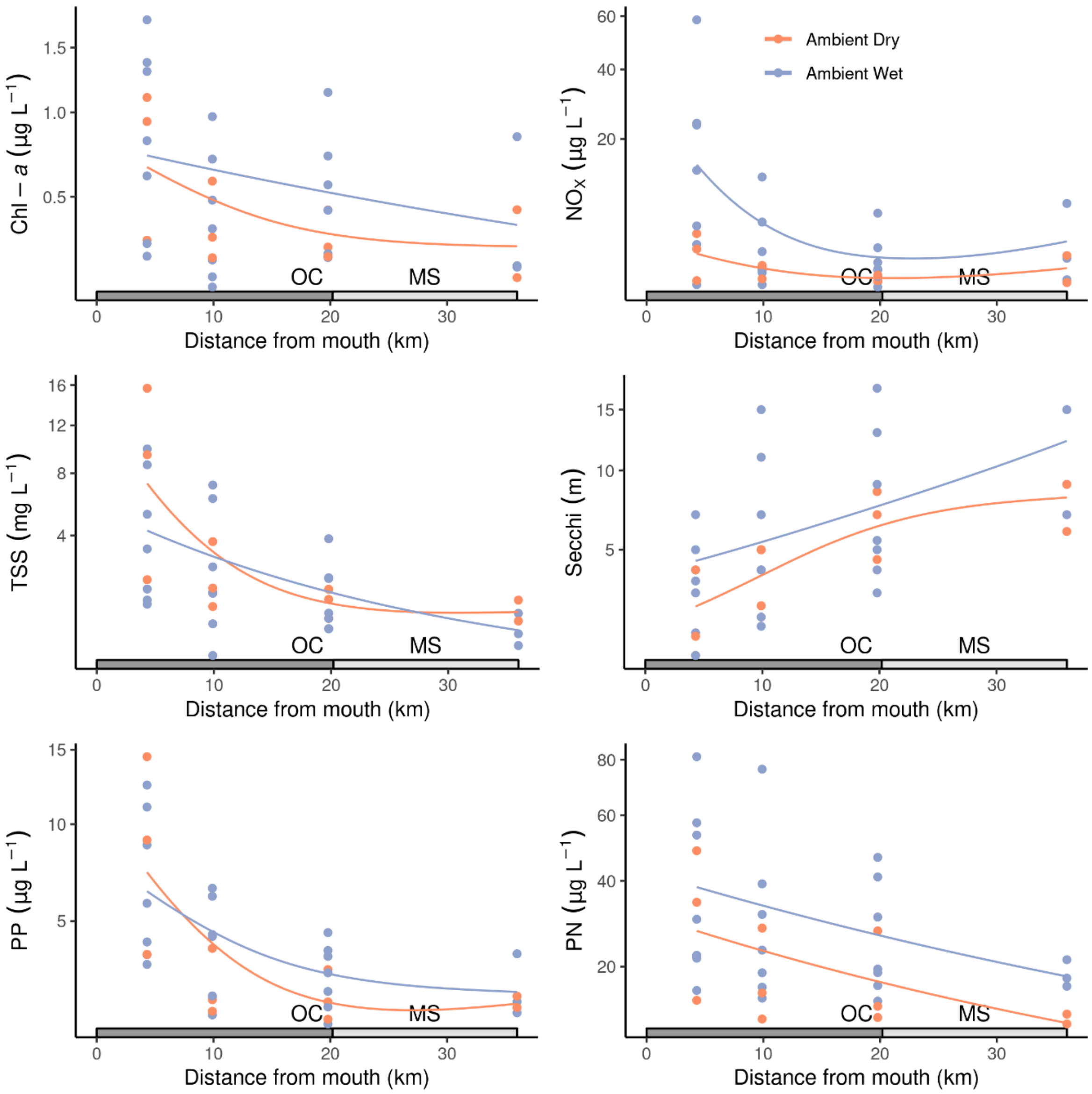


Figure 5-44: Water quality variables measured during ambient wet and dry season sampling in 2024–25 along the Russell-Mulgrave focus region transect. Chlorophyll *a* (Chl-*a*), nitrate/nitrite (NO_x), total suspended solids (TSS), Secchi depth, particulate nitrogen (PN), and particulate phosphorus (PP) are shown with distance from the Russell-Mulgrave River mouth. Water body classifications are shown along the x-axes: open coastal (OC) and mid-shelf (MS). Note the y-axes are logarithmic scales. Fitted lines are generalised additive models.

Distinct long-term trends (since 2005) were observed in some water quality variables, while others showed little change (Figure 5-45). Site-specific statistics and comparison to GVs for all variables are available in Table C-1.

Concentrations of Chl-*a* fluctuated above and below the GVs since monitoring began in 2005 (Figure 5-45a). Over the period 2015–2023, mean concentration of Chl-*a* decreased (conditions improved) to a minima. Over the last 2 years, Chl-*a* rapidly increased (conditions deteriorated) to levels similar to 2015. Chl-*a* in 2024–25 was above (did not meet) the local GVs at 3 of the 5 sites sampled. Chlorophyll fluorescence measured by FLNTU instruments (Figure 5-45a) likewise fluctuated around GVs since monitoring began in 2007 and is currently not meeting local GVs (Table C-2). The differences between FLNTU chlorophyll fluorescence and Chl-*a* concentration reflect differences in sampling location and frequency (e.g., FLNTUs are only present at a subset of sites and monitor year-round). This recent Chl-*a* increase is likely related to large flood events in the Wet Tropics during the 2023–24 (cyclone Jasper) and 2024–25 wet seasons.

Secchi depth gradually declined (water clarity deteriorated) from 2005 until 2015 before it increased (water clarity improved) until 2023. (Figure 5-45b). Over the last 2 years, Secchi depth rapidly decreased (water clarity deteriorated), and trend analysis showed that measurements in 2025 were significantly lower (worsened) than in 2015. Secchi depth in 2024–25 was below (did not meet) the local GVs at any site sampled. This recent decline in water clarity is likely related to large flood events in the Wet Tropics in the previous 2 years.

Concentrations of TSS fluctuated above and below the GVs between 2005 and 2022. Over the last 2 years, TSS increased (conditions deteriorated) to levels similar to 2015 (Figure 5-45c). TSS in 2024–25 was above (did not meet) the local water quality GVs at 2 of the 5 sites sampled. This recent increase in TSS is likely related to large flood events in the Wet Tropics in the previous 2 years.

Turbidity remained relatively stable and close to the GVs since monitoring began in 2005 (Figure 5-45d). Over the period 2015–2025, turbidity remained stable with small oscillations. Turbidity in 2024–25 was above (did not meet) the GVs at 2 sites (RM10 and RM7) of the 4 sites monitored.

Concentrations of NO_x steadily increased (conditions deteriorated) and remained above the local GVs from 2005 until ~2018 (Figure 5-45e). Over the period ~2018–2025, mean concentrations of NO_x steadily decreased (conditions improved), although this trend is not statistically significant at present. NO_x in 2024–25 was above (did not meet) the local GVs at any of the 5 sites sampled.

Concentrations of PO_4 remained relatively stable and above the local GVs from 2005 until ~2017 (Figure 5-45f). Over the period ~2017–2023, mean concentration of PO_4 decreased (conditions improved). Over the last 2 years, PO_4 increased (conditions deteriorated) and trend analysis showed that concentrations in 2025 were significantly greater (worsened) than in 2015. PO_4 in 2024–25 was above (did not meet) the local GVs at 4 of the 5 sites sampled. This recent increase in PO_4 is likely related to large flood events in the Wet Tropics in the previous 2 years.

Concentrations of PN were below (met) local GVs from 2005–2015 (Figure 5-45g). Over the period 2015–2025, mean PN concentration showed a nonlinear increase, and trend analysis showed that concentrations in 2025 were significantly greater (worsened) than in 2015. PN in 2024–25 was above (did not meet) the local GVs at 4 of the 5 sites sampled.

Concentrations of PP remained relatively stable and close to the local GVs since monitoring began in 2005 (Figure 5-45h). Over the period 2015–2025, a small increase in mean PP concentration occurred, and trend analysis showed that concentrations in 2025 were significantly greater (worsened) than in 2015. PP in 2024–25 was above (did not meet) the local GVs at 4 of the 5 sites sampled.

Concentrations of POC and DOC increased dramatically over the period 2005–2017 (Figure 5-45i,j). Over the period 2017–2025, mean concentration of POC fluctuated, while mean concentration of DOC was more stable (Figure 5-45j).

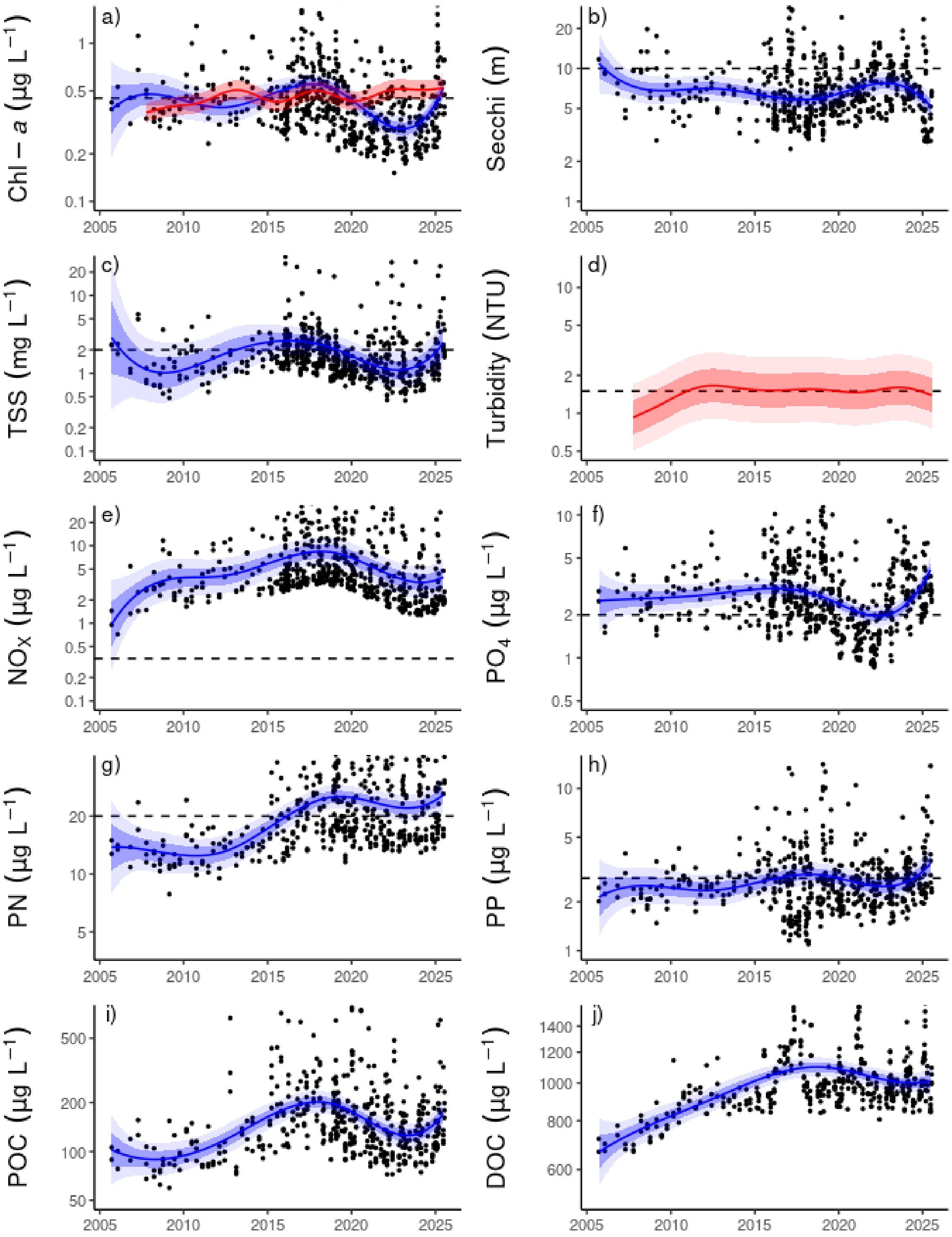


Figure 5-45: Temporal trends in water quality variables for the Russell-Mulgrave focus region: a) chlorophyll *a* (Chl-*a*), b) Secchi depth, c) total suspended solids (TSS), d) turbidity, e) nitrate/nitrite (NO_x), f) phosphate (PO_4), g) particulate nitrogen (PN), h) particulate phosphorus (PP), i) particulate organic carbon (POC) and j) dissolved organic carbon (DOC). Generalised additive mixed effect models (trends) are represented by blue lines with shaded areas defining 95% confidence intervals of those trends and black dots represent observed data (depth weighted averages). These trends and data are accounting for the effects of seasons after applying x-z detrending. Trends of records from ECO FLNTUSB instruments are represented in red, and individual records can be found in Figure C-1. Dashed horizontal reference lines indicate annual guidelines for open coastal waters.

The WQ Index is calculated using 2 different formulations to communicate the a) long-term trend in water quality (based on the pre-2015 sampling design) and b) annual condition of water quality (based on the post-2015 sampling design, which increased the power to detect change). Section 2.1.5 and Appendix B contain details of the calculations for both Index formulations.

The long-term WQ Index showed a small trend (i.e., changing within a grade) of deterioration in water quality from 2009–2019, which stabilised around 2020 (Figure 5-46a). This deteriorating trend was generally driven by PN, PP, and Chl-*a* indicators. Between 2020–24, this trend reversed and water quality improved back to conditions ~2009. The long-term WQ Index for 2024–25 shows a slight deterioration driven by a deterioration in the Chl-*a* indicator.

The annual condition WQ Index scored water quality as ‘moderate’ since its inception (2015–present) (Figure 5-46b). Scores were relatively stable from 2019–2024, and the 2024–25 water year marked a small downward trend in annual condition score. This trend was driven by all indicators, but especially Chl-*a*, which showed a major deterioration in condition from 2023–24. This decline in condition was likely related to large flood events in the Wet Tropics in the previous 2 years.

It is important to note that the 2 versions of the WQ Index are designed to answer separate questions and therefore differences in scores between the versions are expected.

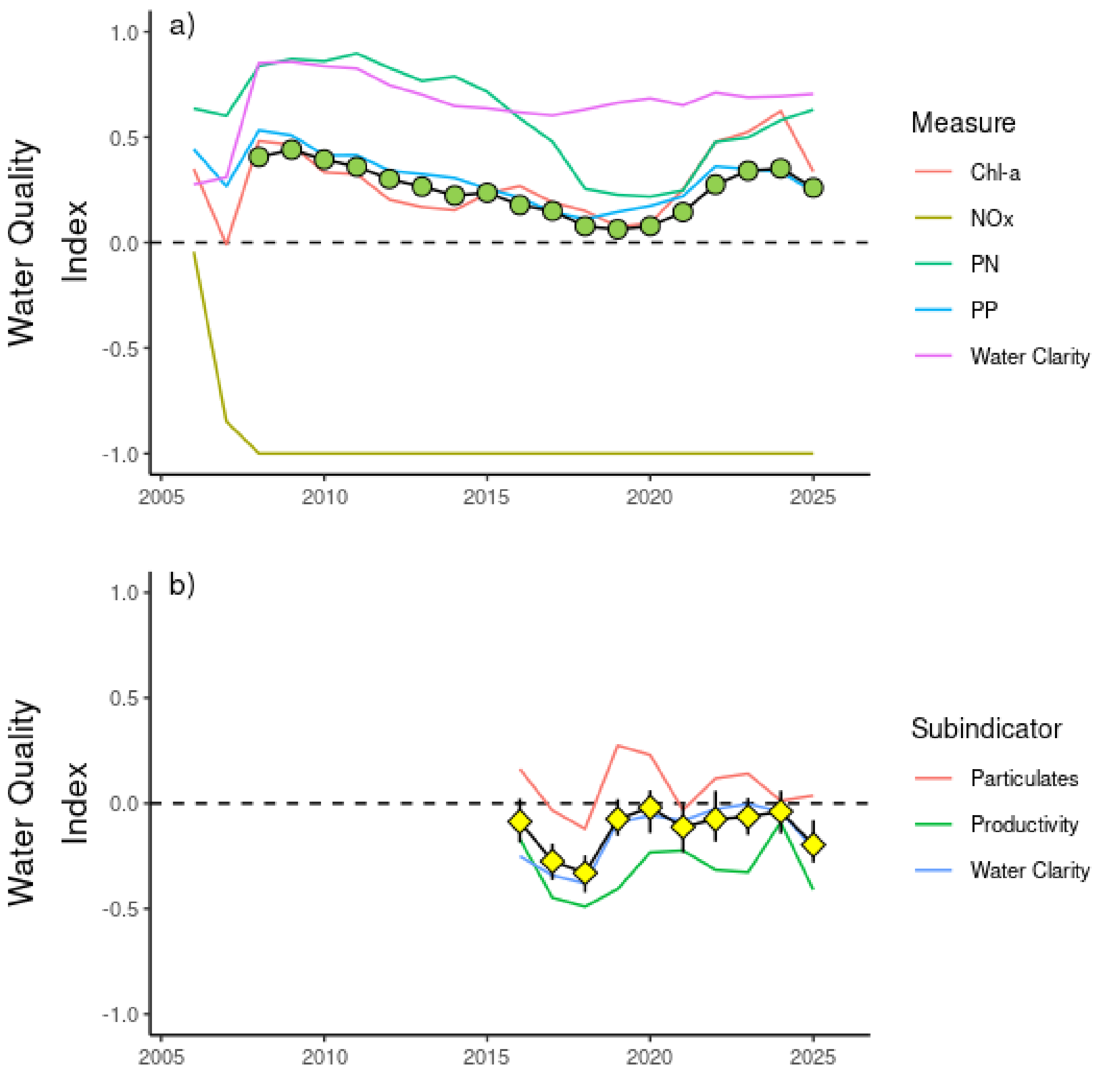


Figure 5-46: The Water Quality Index (WQ Index) for the Russell-Mulgrave focus region. The WQ Index uses 2 formulations to communicate the a) long-term trend (based on pre-2015 sampling design) and b) annual condition (based on post-2015 sampling design). WQ Index colour coding: ● / ◆– 'very good'; ● / ◆ – 'good'; ● / ◆ – 'moderate; ● / ◆ – 'poor'; ● / ◆ – 'very poor'. Indicators or sub-indicators that are used to calculate the WQ Index are shown as coloured lines on each plot. Error bars (vertical black lines) on the WQ Index represent the 95% quantile intervals. Calculations for both formulations are described in Appendix B.

Event water quality

No event samples were collected in the Russell-Mulgrave focus area in 2024–25.

5.2.3 Tully

The Tully focus region is primarily influenced by discharge from the Tully-Murray River, the Herbert River (to the south) and, to a lesser extent, by the Burdekin River (to the south) in large flow years (Brodie *et al.*, 2013).

One site was sampled in this focus region 3 times per year until the end of 2014. Following the implementation of the revised MMP water quality sampling design in 2015, 11 monitoring sites are sampled in this focus region up to 10 times per year, with 6 sites sampled during both the dry and wet seasons and 5 additional sites sampled during major flood events (Table A-1). The monitoring sites form a northeasterly transect from the river to mid-shelf waters, representing a gradient in water quality. Seven sites are in the open coastal water body, one is located in the mid-shelf water body, one site is in mid-estuarine waters, and 2 sites are in lower estuarine waters (Figure 5-47).

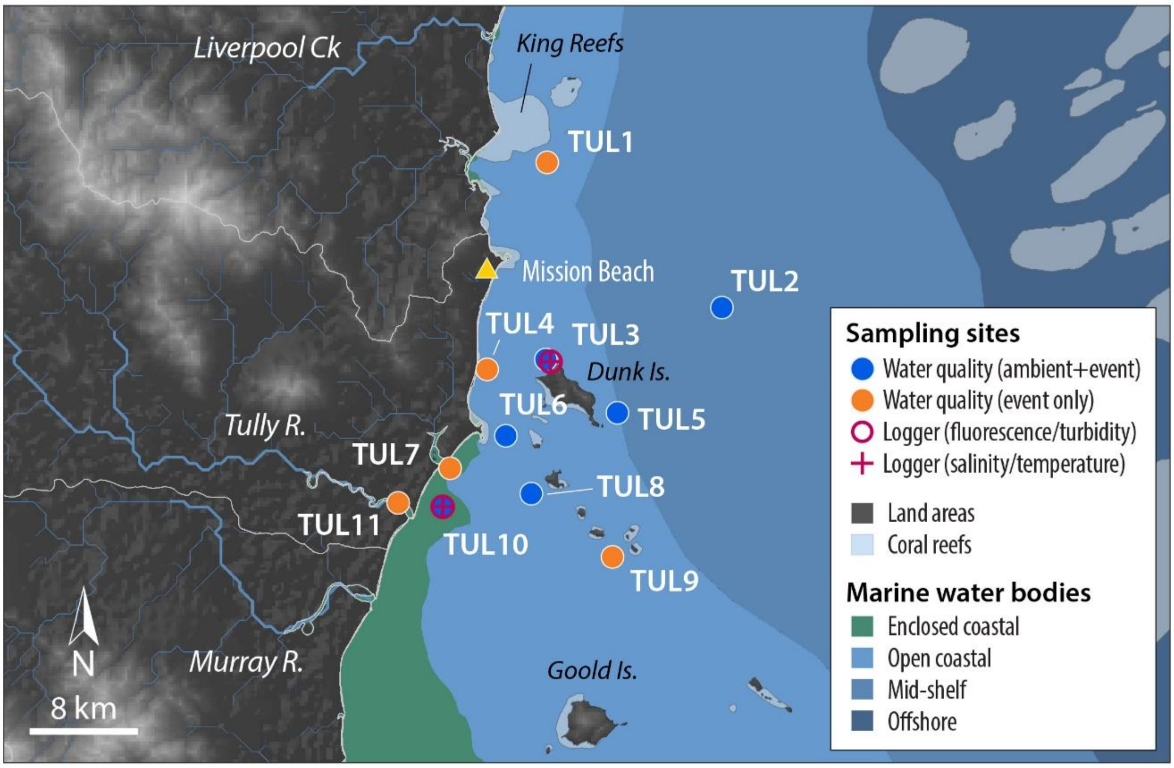


Figure 5-47: Sampling sites in the Tully focus region, shown with the water body boundaries.

The combined discharge (Figure 5-48) and loads calculated for the 2024–25 water year from the Tully, Murray, and Herbert Basins were around 2.0 times higher than the long-term median (Figure 5-49). Over the 19-year period between 2006–07 and the current water year: :

- discharge ranged from 4,491 GL (2014–15) to 24,166 GL (2010–11)
- TSS loads ranged from 260 kt (2014–15) to 1,827 kt (2010–11)
- DIN loads ranged from 1,082 t (2014–15) to 5,875 t (2010–11)
- PN loads ranged from 796 t (2014–15) to 5,307 t (2010–11).

Of the 3 focus regions within the Wet Tropics NRM region, the Tully, Murray, and Herbert Basins collectively contribute similar discharge and TSS and PN loads to the Russell, Mulgrave, and Johnstone Basins during low-to-moderate discharge years. However, the Tully, Murray, and Herbert Basins contribute higher values during the high discharge years such as in 2008–09 and 2010–11 as well as generally higher DIN loads in the average to above-average discharge years.

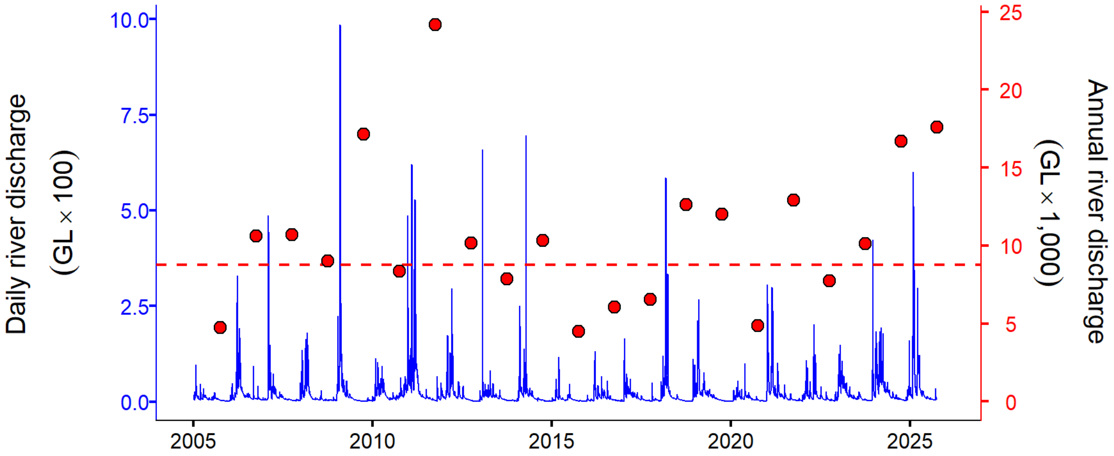


Figure 5-48: Combined discharge from rivers in the Tully region including the Tully (gauge 113006A – Euramo), Murray (gauge 114001A – Upper Murray) and Herbert (gauge 116001F – Ingham) Rivers. Daily (blue) and water year (1 October to 30 September, red) discharge is shown. Red dashed line represents the long-term median of the combined annual discharge. Please note as this is the combined discharge, high flows in one river will not necessarily be visible in the graph.

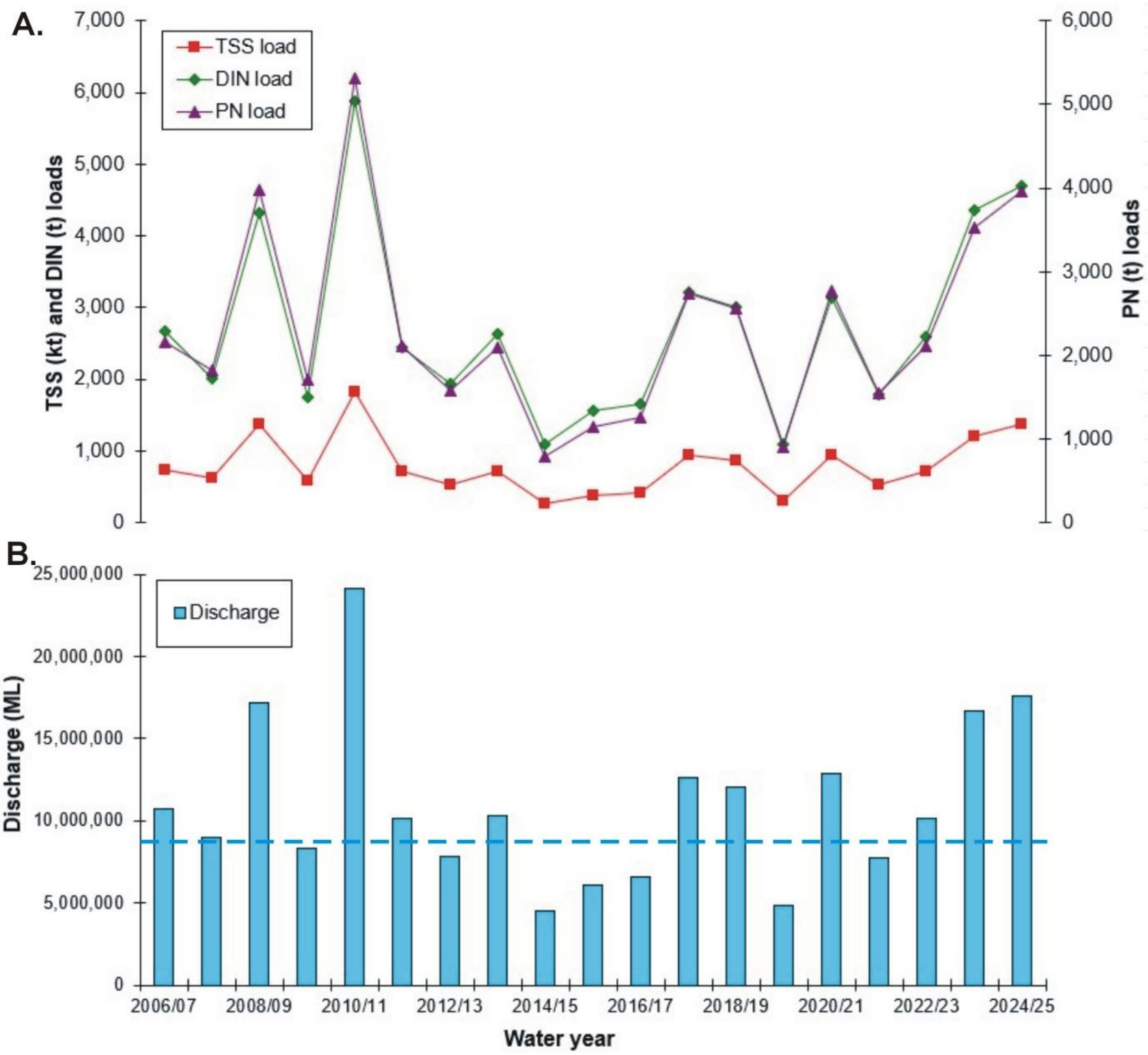


Figure 5-49: Loads of (A) TSS, DIN and PN and (B) discharge for the Tully, Murray, and Herbert Basins from 2006 to 2025.The loads reported here are a combination of 'best estimates' for each basin based on 'up-scaled discharge data from gauging stations, monitoring data (Tully and Herbert Rivers), the DIN model developed in Lewis *et al.* (2014) and annual mean concentrations and discharge from monitoring data or Source Catchments modelling data. The dotted line represents the long-term median for basin discharge. Note the different scales on the 2 y-axes.

Ambient water quality and the in situ *Water Quality Index*

Water quality showed trends along the sampling transect (cross-shelf gradient in northeasterly direction). Sites located nearest to the river mouth (distance from river mouth = 0 km) had high concentrations of Chl-*a*, TSS, NO_x and particulate nutrients (PN and PP), which declined with distance away from the river mouth, reaching low levels in mid-shelf waters (Figure 5-50, Table C-2). Secchi depths were low at sites near the river mouth (water clarity was poor) and increased (water clarity improved) with distance from the river mouth. These spatial patterns are generally consistent with those that are typically observed in the region.

This year, clear seasonal differences were observed, where concentrations (especially near the river mouth) were higher during the wet than the dry season. Concentrations of Chl-*a* and particulate nutrients (PP and PN) showed generally similar trends between wet and dry seasons with higher concentration inshore compared with offshore and higher concentrations in the wet season compared with the dry season. Concentrations of NO_x and TSS were higher in the wet season at enclosed coastal sites but were similar between the wet and dry seasons at sites in mid-shelf waters. Secchi depths were lower (water clarity was worse) over the entire transect during the wet season as compared to the dry (Figure 5-50).

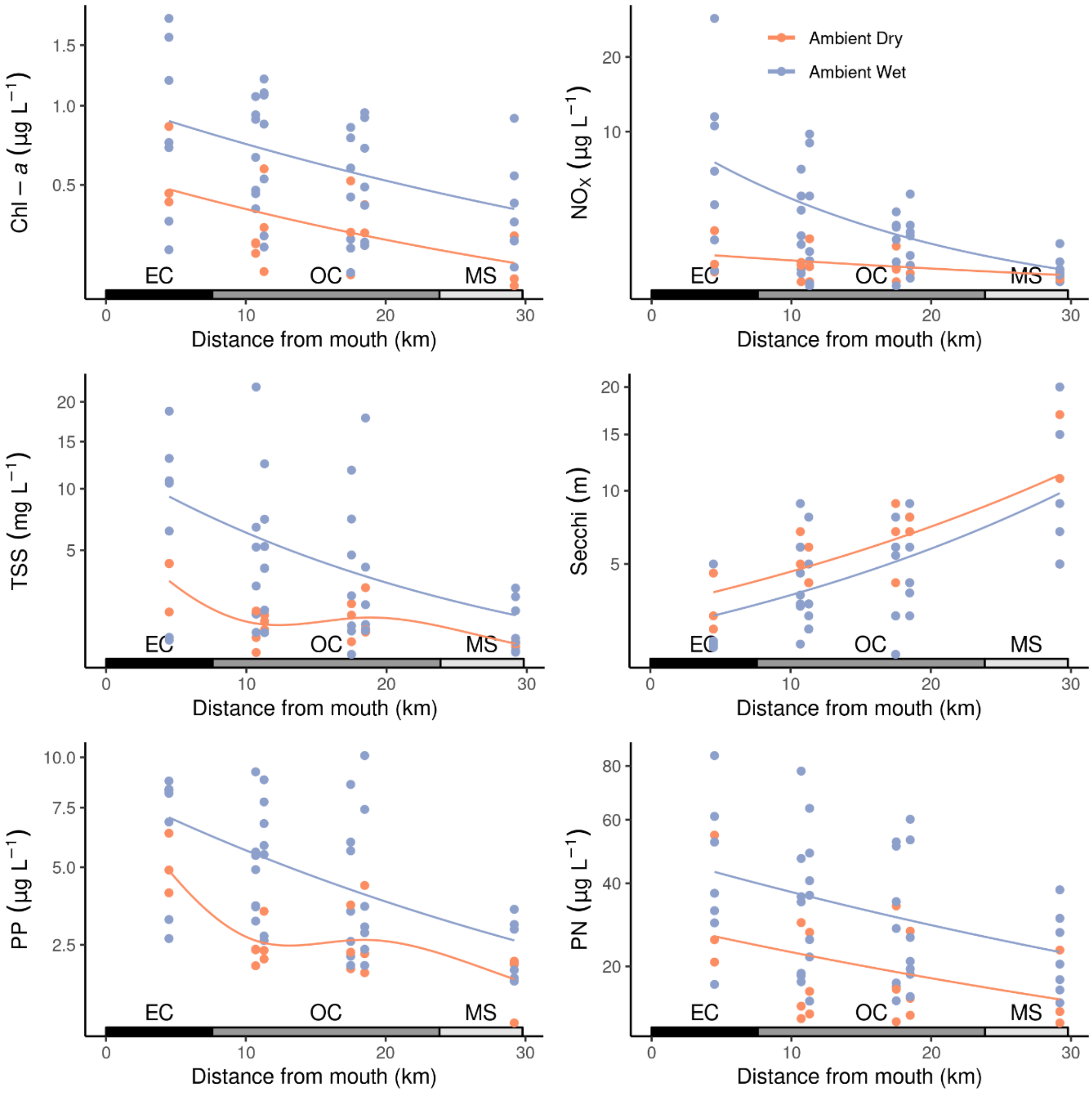


Figure 5-50: Water quality variables measured during ambient and event sampling in 2024–25 along the Tully focus region transect. Chlorophyll *a* (Chl-*a*), nitrate/nitrite (NO_x), total suspended solids (TSS), Secchi depth, particulate nitrogen (PN), and particulate phosphorus (PP) are shown with distance from the Tully River mouth. Water body classifications are shown along the x-axes: open coastal (OC) and mid-shelf (MS). Note the y-axes are logarithmic scales. Fitted lines are generalised additive models.

Distinct long-term trends (since 2005) were observed in some water quality variables, while others showed little change (Figure 5-51). Site-specific statistics and comparison to GVs for all variables are available in Table C-1.

Concentrations of Chl-*a* fluctuated above the GVs since monitoring began until ~2017 (Figure 5-51a). Over the period 2017–2023, mean concentration of Chl-*a* decreased (conditions improved) to a minima. Over the last 2 years, Chl-*a* rapidly increased (conditions deteriorated) to levels similar to 2015. Chl-*a* in 2024–25 was above (did not meet) the local GVs at 3 of the

6 sites sampled. Chlorophyll fluorescence measured by FLNTU instruments (Figure 5-51a) was generally stable and above (did not meet) GVs since monitoring began in 2007 (Table C-2). The differences between FLNTU chlorophyll fluorescence and Chl-*a* concentration reflect differences in sampling location and frequency (e.g., FLNTUs are only present at a subset of sites and monitor year-round). This recent Chl-*a* increase is likely related to large flood events in the Wet Tropics during the 2023–24 and 2024–25 wet seasons.

Secchi depth gradually declined (water clarity deteriorated) from 2005 until ~2017 before it increased (water clarity improved) until 2023 (Figure 5-51b). Over the last 2 years, Secchi depth decreased (water clarity deteriorated), although this trend was not significant. Secchi depth in 2024–25 was below (did not meet) the local GVs at 5 of the 6 sites sampled. This recent decline in water clarity is likely related to large flood events in the Wet Tropics in 2024–25 and the previous year.

Concentrations of TSS fluctuated generally above the GVs between 2005–2025 and reached a minima in 2022. Over the last 2 years, TSS increased (conditions deteriorated) to levels similar to 2015 (Figure 5-51c). TSS in 2024–25 was above (did not meet) the local water quality GVs at 5 of the 6 sites sampled. This recent increase in TSS is likely related to large flood events in the Wet Tropics in 2024–25 and the previous year.

Turbidity varied above the GVs since monitoring began in 2007 (Figure 5-51d). Over the period 2015–2025, turbidity remained generally stable with small oscillations. Turbidity in 2024–25 was above (did not meet) the GVs at one site (TUL3) of the 2 sites monitored.

Concentrations of NO_x markedly increased (conditions deteriorated) and remained above the local GVs from 2007 until ~2017 (Figure 5-51e). Over the period ~2018–2025, mean concentrations of NO_x steadily decreased (conditions improved) to levels similar to the start of monitoring, and trend analysis showed that concentrations in 2025 were significantly lower (improved) than in 2015. NO_x in 2024–25 was above (did not meet) the local GVs at 5 of the 6 sites sampled.

Concentrations of PO_4 remained relatively stable and above the local GVs from 2007 until ~2017 (Figure 5-51f). Over the period ~2017–2023, mean concentration of PO_4 decreased (conditions improved). Over the last 2 years, PO_4 increased (conditions deteriorated) to levels similar to 2015. PO_4 in 2024–25 was above (did not meet) the local GVs at 5 of the 6 sites sampled. This recent increase in PO_4 is likely related to large flood events in the Wet Tropics in 2024–25 and the previous year.

Concentrations of PN were below (met) local GVs from 2005–2015 (Figure 5-51g). Over the period 2015–2025, mean PN concentration increased and then stabilised. Trend analysis showed that concentrations in 2025 were significantly greater (worsened) than in 2015. PN in 2024–25 was above (did not meet) the local GVs at 5 of the 6 sites sampled.

Concentrations of PP remained relatively stable and close to the local GVs since monitoring began (Figure 5-51h). Over the period 2015–2025, mean PP concentration showed minor variability with a potential small increase over the last year. PP in 2024–25 was above (did not meet) the local GVs at 5 of the 6 sites sampled.

Concentrations of POC and DOC increased over the period 2007–2017 (Figure 5-51i,j). Over the period 2017–2025, mean concentration of DOC stabilised (Figure 5-51j), while mean concentration of POC declined to a minima around 2023 (Figure 5-51i). Trend analysis showed that POC concentrations were significantly lower in 2025 than in 2015.

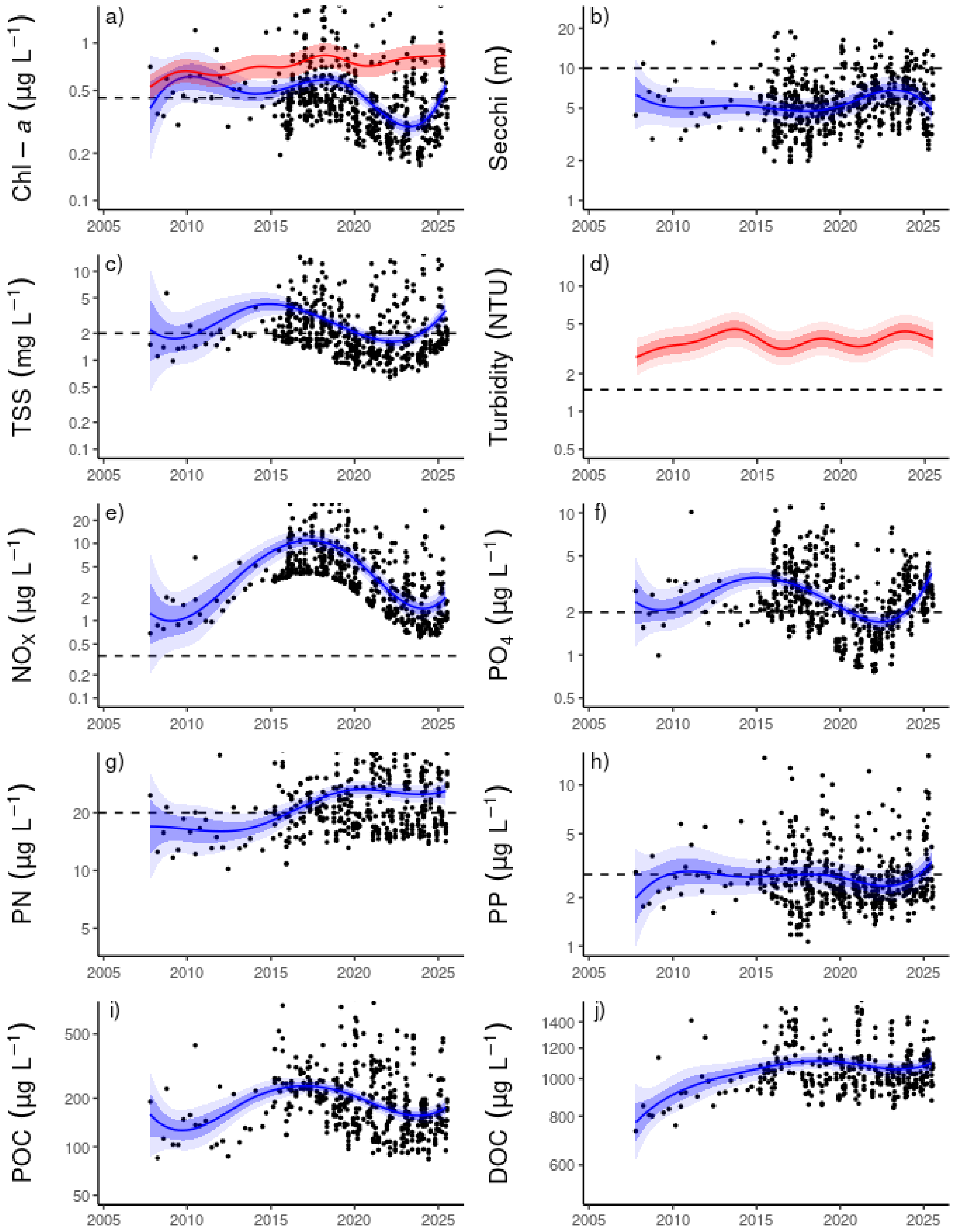


Figure 5-51: Temporal trends in water quality variables for the Tully focus region: a) chlorophyll *a* (Chl-*a*), b) Secchi depth, c) total suspended solids (TSS), d) turbidity, e) nitrate/nitrite (NO_x), f) phosphate (PO_4), g) particulate nitrogen (PN), h) particulate phosphorus (PP), i) particulate organic carbon (POC) and j) dissolved organic carbon (DOC). Generalised additive mixed effect models (trends) are represented by blue lines with shaded areas defining 95% confidence intervals of those trends and black dots represent observed data (depth weighted averages). These trends and data are accounting for the effects of seasons after applying x-z detrending. Trends of records from ECO FLNTUSB instruments are represented in red, and individual records can be found in Figure C-1. Dashed horizontal reference lines indicate annual guidelines for open coastal waters.

The WQ Index is calculated using 2 different formulations to communicate the a) long-term trend in water quality (based on the pre-2015 sampling design) and b) annual condition of water quality (based on the post-2015 sampling design, which increased the power to detect change). Section 2.1.5 and Appendix B contain details of the calculations for both Index formulations.

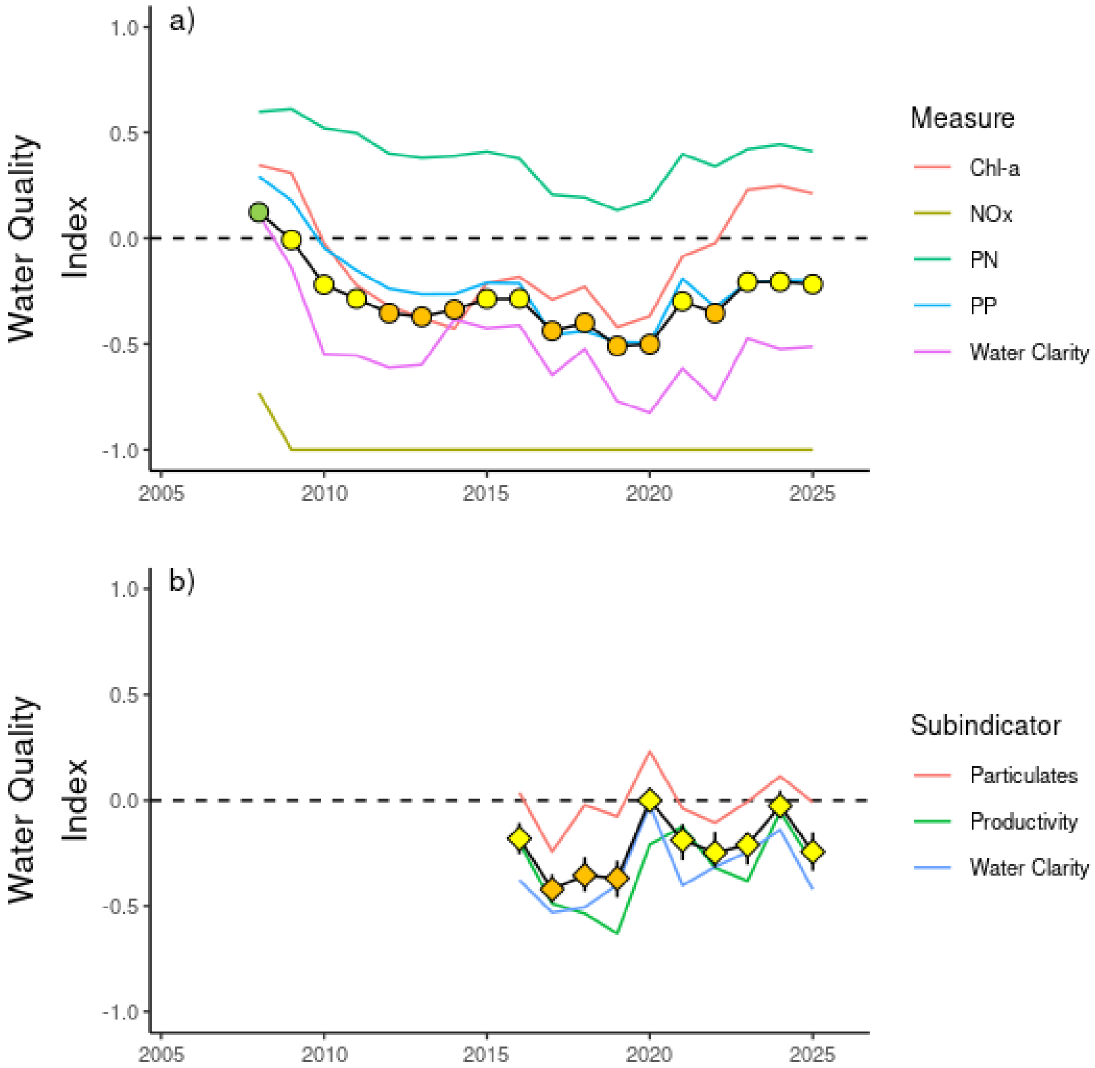


Figure 5-52: The Water Quality Index (WQ Index) for the Tully focus region. The WQ Index uses 2 formulations to communicate: a) long-term trend (based on pre-2015 sampling design) and b) the annual condition (based on post-2015 sampling design). WQ Index colour coding: ● / ◆– 'very good'; ● / ◆ – 'good'; ● / ◆ – 'moderate; ● / ◆ – 'poor'; ● / ◆ – 'very poor'. Indicators or sub-indicators that are used to calculate the WQ Index are shown as coloured lines on each plot. Error bars (vertical black lines) on the WQ Index represent the 95% quantile intervals. Calculations for both formulations are described in Appendix B.

The long-term WQ Index for the Tully region has shown the most variability of any focus region since the inception of the MMP. The period 2007–2020 was characterised by a large (i.e., changing over 2 grades) decline in water quality, driven by declines in all indicators with the exception of NO_x (Figure 5-52a). Since 2019, water quality improved by a grade, although improvement appears to have slowed in recent years. (Figure 5-52a). This improving trend was driven by improvements in Chl-*a*, PN, PP, and water clarity indicators.

The annual condition WQ Index scored water quality as 'poor' for the period 2016–2019 and 'moderate' otherwise (2015–present). For the 2024–25 year, the Tully region received a 'moderate' score (Figure 5-52b), which was lower (deteriorated) compared to the previous year. This deterioration was driven by Chl-*a*, TSS, and Secchi depth indicators, which showed a worsening in condition from 2023–24. This decline in condition was likely related to large flood events in the Wet Tropics in 2024–25 and the previous water year.

It is important to note that the 2 versions of the WQ Index are designed to answer separate questions and therefore differences in scores between the versions are expected.

Event water quality

The Tully River at Euramo gauge recorded 2 flow events over the 2024–25 water year with the first event peaking above the moderate flood level (8.0 m) at 8.7 m on 2 February 2025 and the second event peaking above the minor flood level (6.0 m) at 7.8 m on 17 March 2025. Other flows of note over the season that were just below the minor flood level include peaks in discharge on 7 December 2024 (5.0 m), 22 December (5.7 m), 7 January 2025 (5.0 m) and 17 September 2025 (5.8 m). The peak daily discharge on 2 February equated to 85,000 ML d^{-1} (Figure 5-53). The total discharge measured at the Tully at Euramo gauge for the 2024–25 water year was 4.2 million ML (~1.35 times the long-term median).

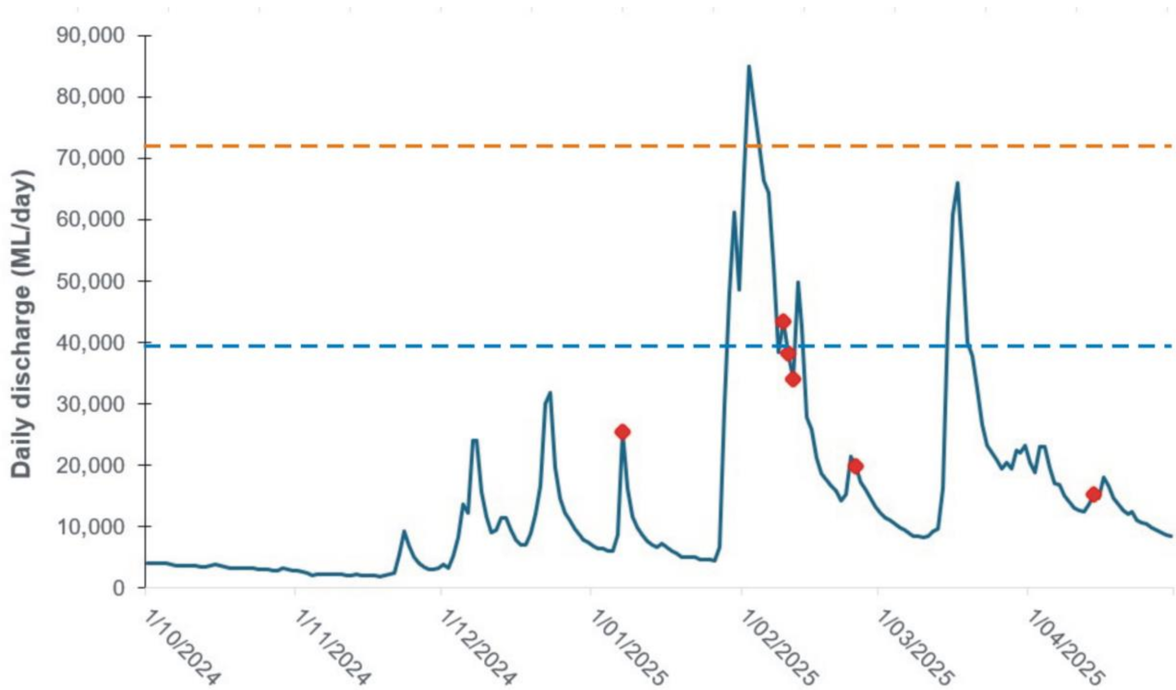


Figure 5-53: Tully River daily discharge for the 2024–25 wet season as recorded by the Euramo gauge. The dates of offshore sampling by JCU and AIMS are marked as red dots. Blue dotted line represents the minor flood level and orange dotted line represents the moderate flood level.

The MMP focussed primarily on sampling and documenting the large flood plumes generated from the Burdekin and Herbert Rivers over the 2024–25 water year due to the significance of these floods. However, sampling was conducted by the JCU and AIMS teams for the Tully transect during and close to several discharge peaks, including the collection of pesticide samples. Satellite images show the extensive plume from the southern Wet Tropics region including from the Tully River. For example, the Sentinel-2 image from 6 February 2025 shows a large turbid plume within Rockingham Bay, along with distinct “island wakes” occurring where there is clearer water on the back (side facing away from the major flooding influence) of several islands (Figure 5-54).

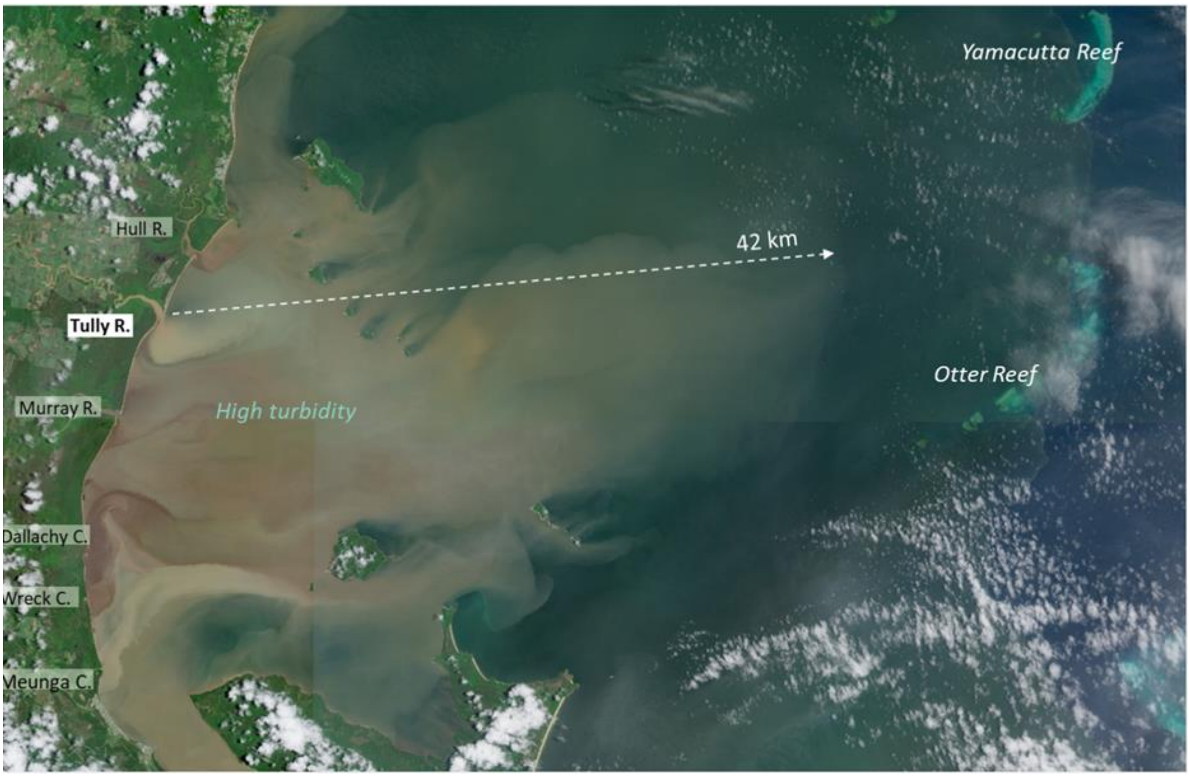


Figure 5-54: Sentinel satellite image of the Tully-Herbert flood plumes on 6 February 2025.

As flood plumes from the Tully River were not specifically targeted, the event sites were not sampled in 2025. The resulting water quality data are thus concentrated in the 15 to 35 salinity zone with only one sample in the <15 salinity zone. TSS concentrations in the surface were generally <10 mg L^{-1} with either similar or higher concentrations measured in the depth samples (Figure 5-55a). The sampling highlighted the depletion of nitrate (NO_x) in the 15 to 25 salinity range with a corresponding increase in Chl-*a* concentrations (Figure 5-55B,C). The concentrations of DIP, PN, and PP showed no obvious mixing patterns in the 15 to 35 salinity zone with similar concentrations across the surface and depth samples (Figure 5-5-56).

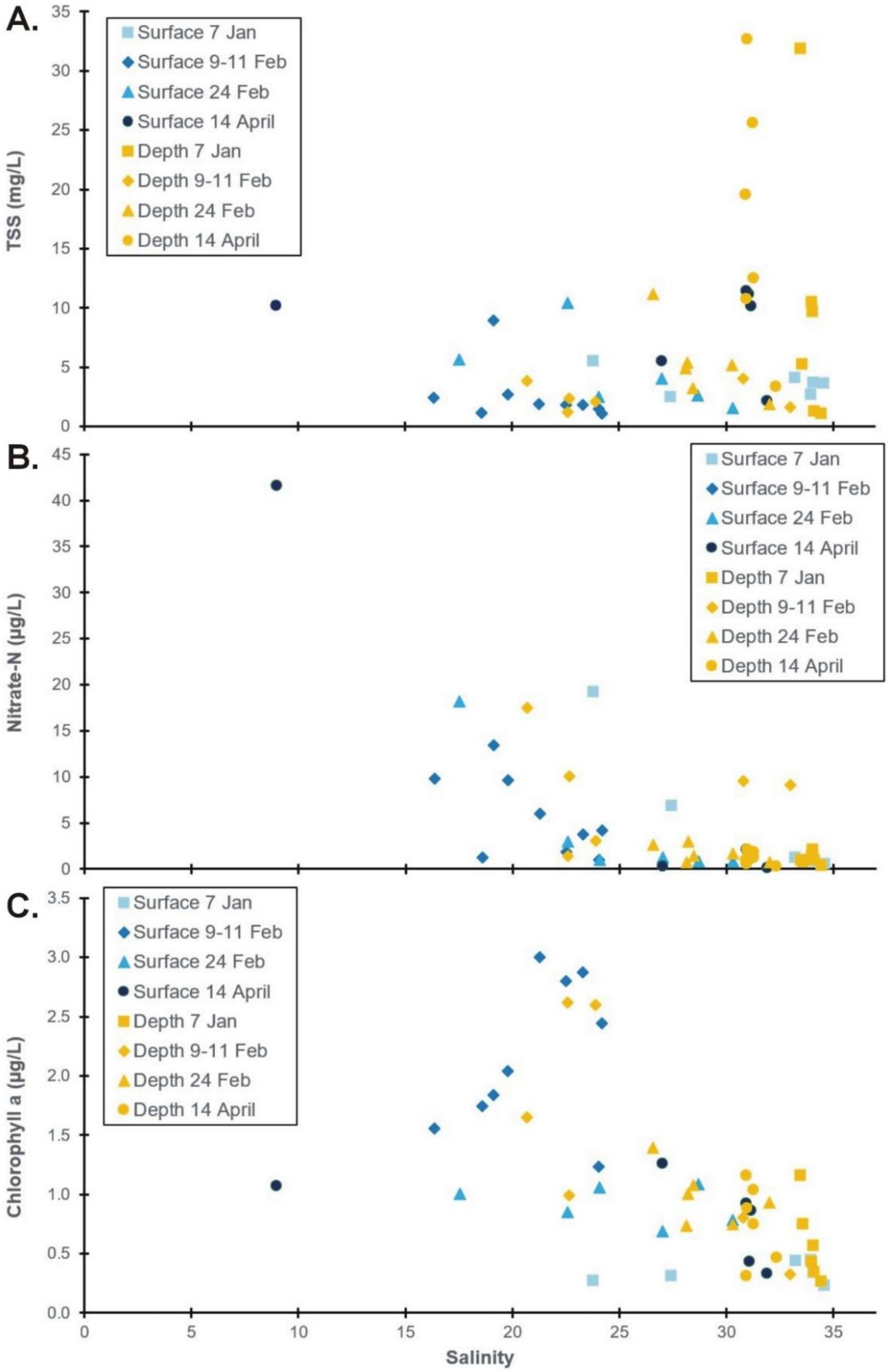


Figure 5-55: Water quality data from the Tully River plume over the 2024–25 wet season including: A) total suspended solids (TSS), B) nitrate (NO_3), and C) chlorophyll *a* (Chl-*a*) plotted over the salinity gradient. Surface samples are plotted in blue and depth samples in orange with the different shapes representing different times of sampling.

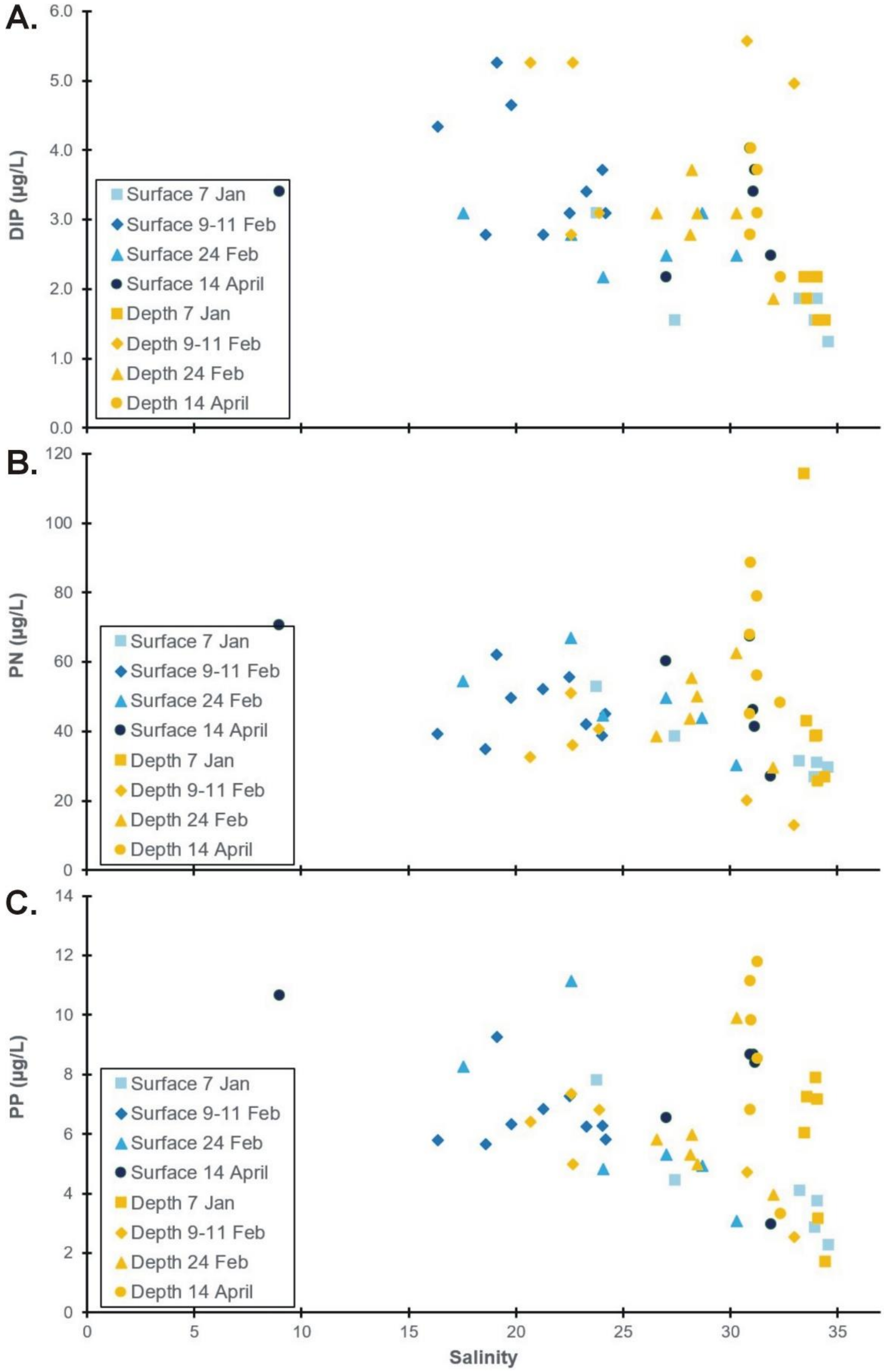


Figure 5-5-56: Water quality data from the Tully River plume over the 2024–25 wet season including: A) dissolved inorganic phosphorus (DIP), B) particulate nitrogen (PN), and C) particulate phosphorus (PP) plotted over the salinity gradient. Surface samples are plotted in blue and depth samples in orange with the different shapes representing different times of sampling.

Passive samplers were deployed at Dunk Island throughout the wet season and pesticide grab samples are also collected during deployment and retrieval of the instruments. These results are described in Section 6, however it is noteworthy that the Dunk Island grab sample on 10 February 2025 had a calculated PRM of 2.5% species affected. Additional grab samples were also collected opportunistically for pesticide analysis during routine sampling from 9 to 11 February 2025 which was close to high river discharge. A PRM >1% was calculated for all samples (n=9) during this period, including those located further offshore (e.g. offshore from Dunk Island - TUL2, Dunk Island south east - TUL5; see Figure 5-47 for locations). Two samples collected at coastal sites (Tam O'Shanter and the Tully River mouth) on 24 February 2025, outside of the peak flow period, had PRMs of 0.64% and 0.59%, respectively.

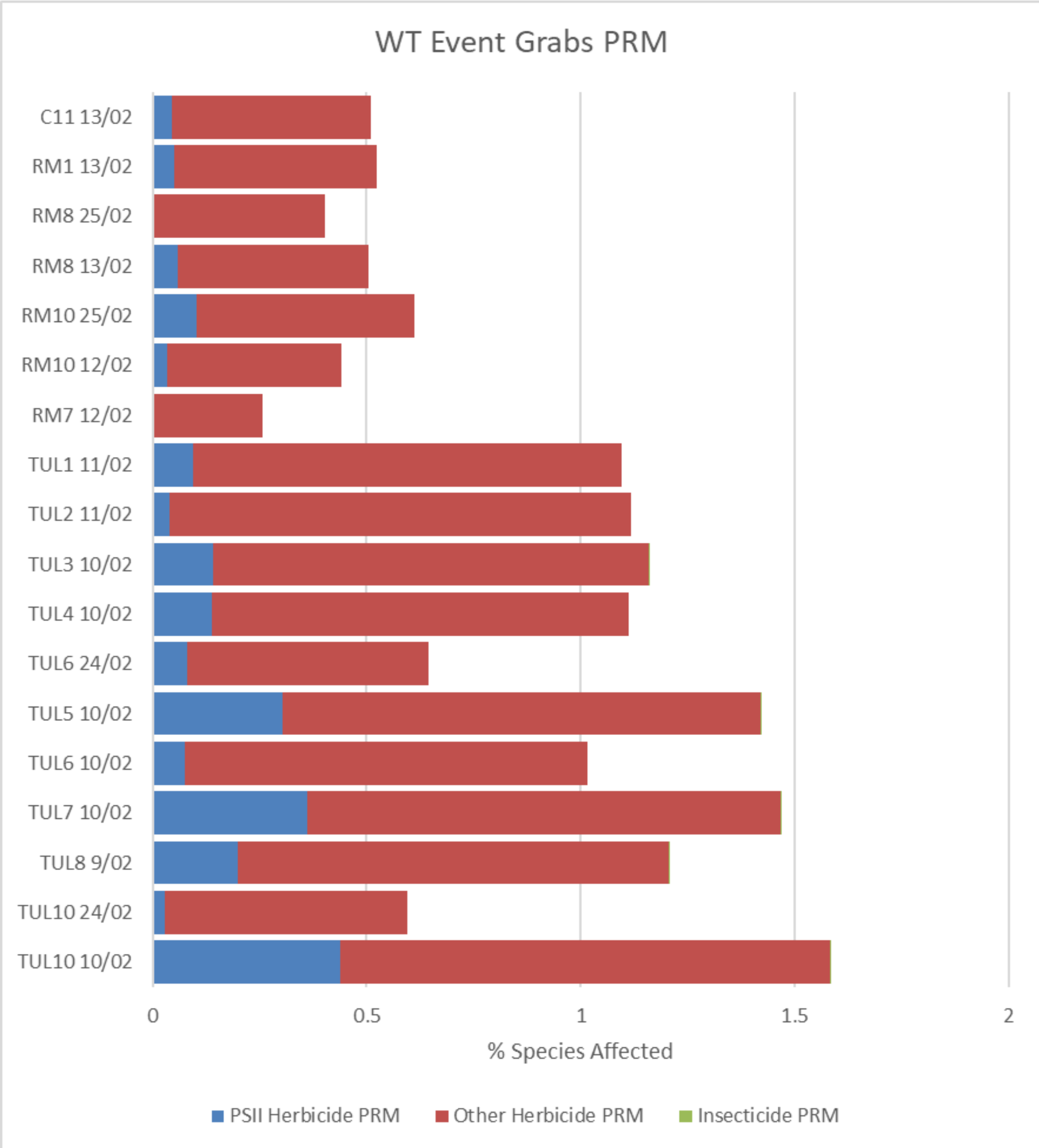


Figure 5-57: Results of the Pesticide Risk Metric for PSII Herbicides, other herbicides and insecticides for additional grab samples taken during high flow events in the Wet Tropics transects from 9 to 24 February 2025.

Additional sampling of the Herbert River

The Herbert River at Ingham gauge measured 3 sizable flow events over the 2024–25 water year (Figure 5-58). The first event peaked on 21 December 2024 at 7.6 m below the minor flood level (10.0 m). The second event which peaked at 14.9 m on 2 February 2025 caused major flooding in the Ingham district and was well above the major flood level (12.0 m); this event was one of the highest peaks measured in the 110 year record at comparable or slightly lower levels than the 1991, 1977, and 1967 floods. The third event peaked above the moderate flood level (11.0 m) at 11.8 m on 20 March 2025. The peak flows on 2–3 February 2025 equated to a volume of around 495,000 ML d^{-1}. The total discharge measured at the Herbert River at Ingham gauge was 8.95 million ML making it the third largest discharge on the 110 year record, only behind the 2010–11 and 1990–91 water years. During the largest event in February, the river exceeded the flood level for a considerable period approaching ~10–14 days.

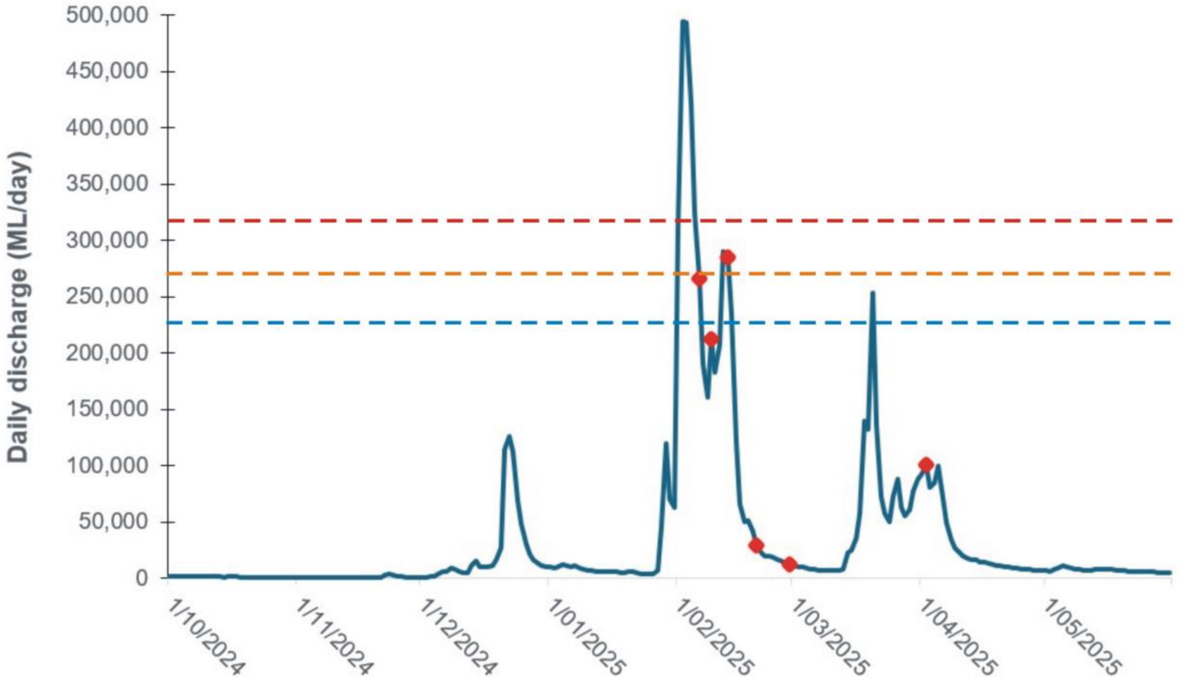


Figure 5-58: Herbert River daily discharge for the 2024–25 wet season as recorded by the Ingham gauge. The dates of offshore sampling by JCU and AIMS are marked as red dots. Blue dotted line represents the minor flood level, orange dotted line represents the moderate flood level and red dotted line represents the major flood level.

The major flooding in the Herbert River and satellite images showing the influence of this flood plume at the northernmost Burdekin transect sites (Figure 5-59), triggered water quality sampling in this region from 6 to 9 February 2025. Pandora Reef (BUR2) and Palms West (BUR1) sites were sampled (surface upper water column ~0.3 m below the surface and depth ~1 m above the seafloor) in addition to collection at several opportunistic sites (surface only) in Halifax Bay and the Palm Island group including Havannah Island and Orpheus Island, and then on 9 February, further offshore at Britomart Reef, and around Brook and Gould Islands (Figure 5-59). Collectively, there were 17 surface and 3 depth samples of relevance to the Herbert River flood plume where TSS, Chl-*a* and nutrient concentrations were analysed. We note that the BUR1 and BUR2 sites (as well as Havannah Island) continued to be sampled as part of the Burdekin transect (and Burdekin flood plume) throughout February. These results are included in the Burdekin event section as the sites were predominately under the influence of the Burdekin plume at this time..

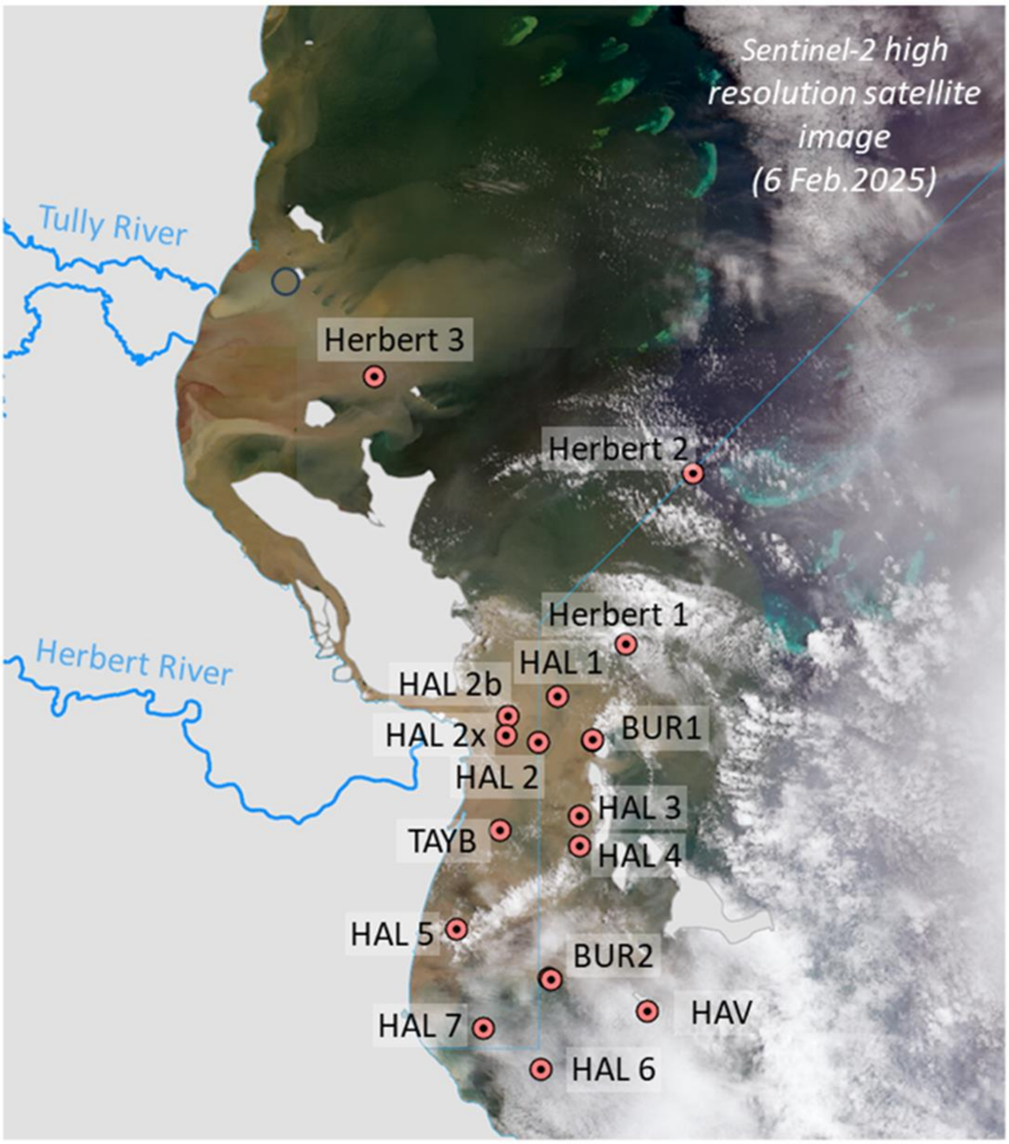


Figure 5-59: Sentinel-2 map showing the Tully and Herbert plume extent on 6 February 2025. The MMP field data collected on the 6 to 9 of Feb are overlaid on the map. Background image: Sentinel-2 true colour image.

The first sample collection on 6 February 2025 was conducted 4 days after the flood peak (earlier sampling was prevented by limited site access due to a bridge collapse on the Bruce Highway and poor weather). Observations and satellite imagery show that the plume was extensive throughout the Halifax Bay region including the Palm Islands and extending out to the mid-shelf reefs (Figure 5-59). There was still considerable discharge from the river during this period (Figure 5-58) and the sampling captured the large salinity gradient from the freshwater (2.3 salinity) to seawater (~33 salinity) endmembers. The TSS concentrations were highest in the lower salinity zone (<10) of the flood plume ranging from 6.5 to 52 mg L^{-1} (Figure 5-60A). This is the zone where most sediment falls out of suspension in the water column, although the variable concentrations in this area under similar salinities (e.g., 52 mg L^{-1} at 4.3 salinity and 7.5 mg L^{-1} at 3.7 salinity) likely reflect either different river/creek sources or different timings of river inputs. Beyond this zone, the TSS concentrations were 2 mg L^{-1} or lower (Figure 5-60A).

Similarly to TSS, the nitrate concentrations were also highly variable in this lower salinity zone (<10 salinity), again likely reflective of different river/creek sources or timing of river inputs. The nitrate concentrations were all at the lower end of what would be expected from end-of-river inputs with the highest concentration of 31 µg L^{-1} at 2.6 salinity (Figure 5-60B). These results suggest that the end-of-river concentrations at that time were below 50 µg L^{-1} which is indicative of what would be expected from natural landscapes (Lewis *et al*., 2023). Chl-*a* concentrations typically followed previous observations of river plumes whereby lower concentrations (mostly, but not exclusively below 0.5 µg L^{-1}) occurred in the 0 to ~15 salinity zone, elevated concentrations (above 1.5 µg L^{-1}) in the 15 to 27 salinity zone, returning to lower values thereafter (Figure 5-60C). The elevated concentrations in the 15 to 27 salinity zone reflect the combination of higher and available nutrient concentrations and increased light for primary productivity to thrive. Concentrations of DIP, PN, and PP all followed similar patterns to nitrate and TSS with generally elevated but variable concentrations in the 0 to 10 salinity zone and reducing thereafter (Figure 5-61).

Depth samples were also collected at the 2 northern-most sites of the Burdekin transect with salinities reflecting marine conditions, and concentrations of all parameters similar to the surface samples with similar salinities.

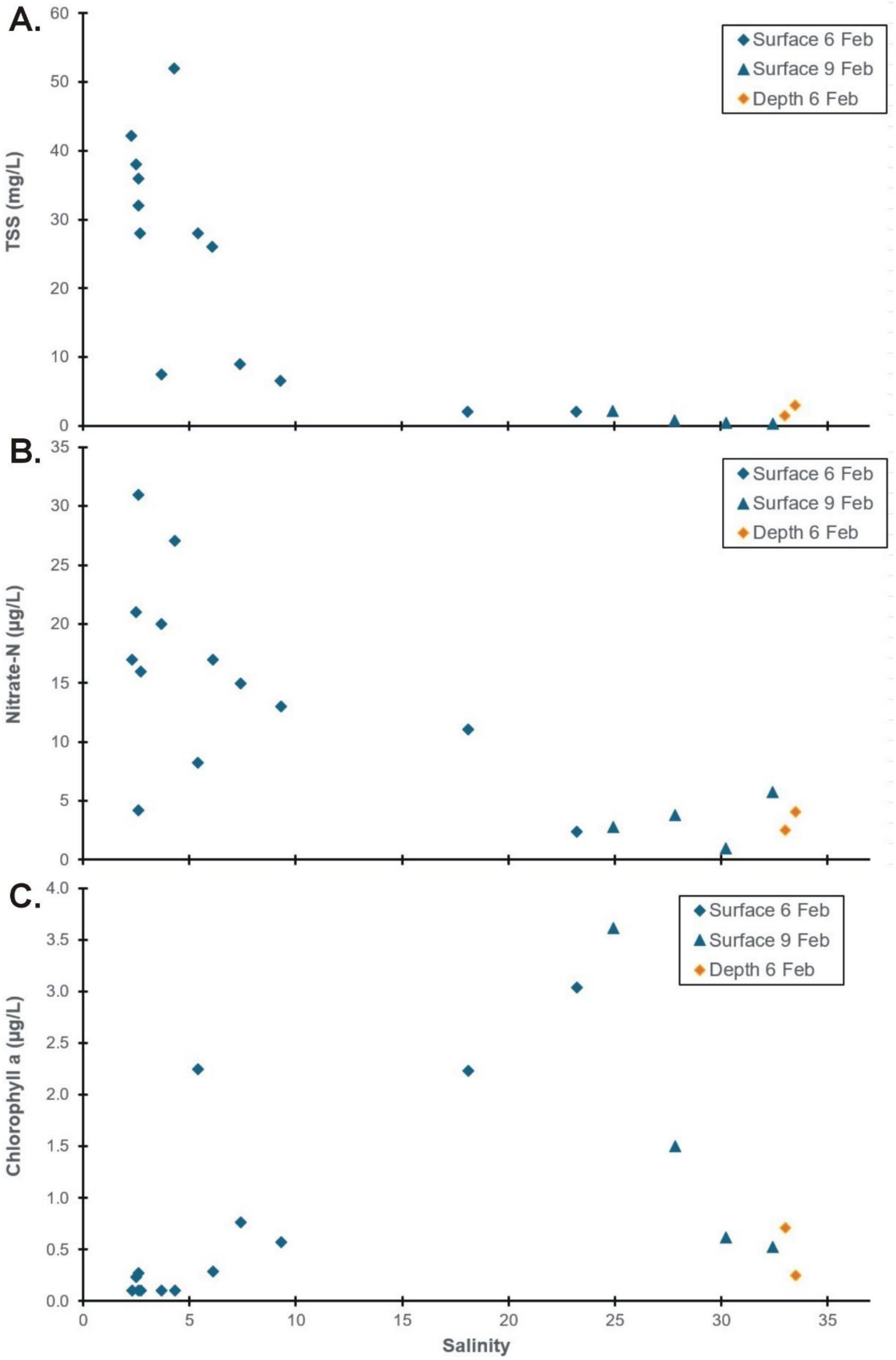


Figure 5-60: Water quality data from the Herbert region under the influence of flood plumes in February 2025. including: A) total suspended solids (TSS), B) nitrate (NO_3), and C) chlorophyll *a* plotted over the salinity gradient. Surface samples are plotted in blue and depth samples in orange.

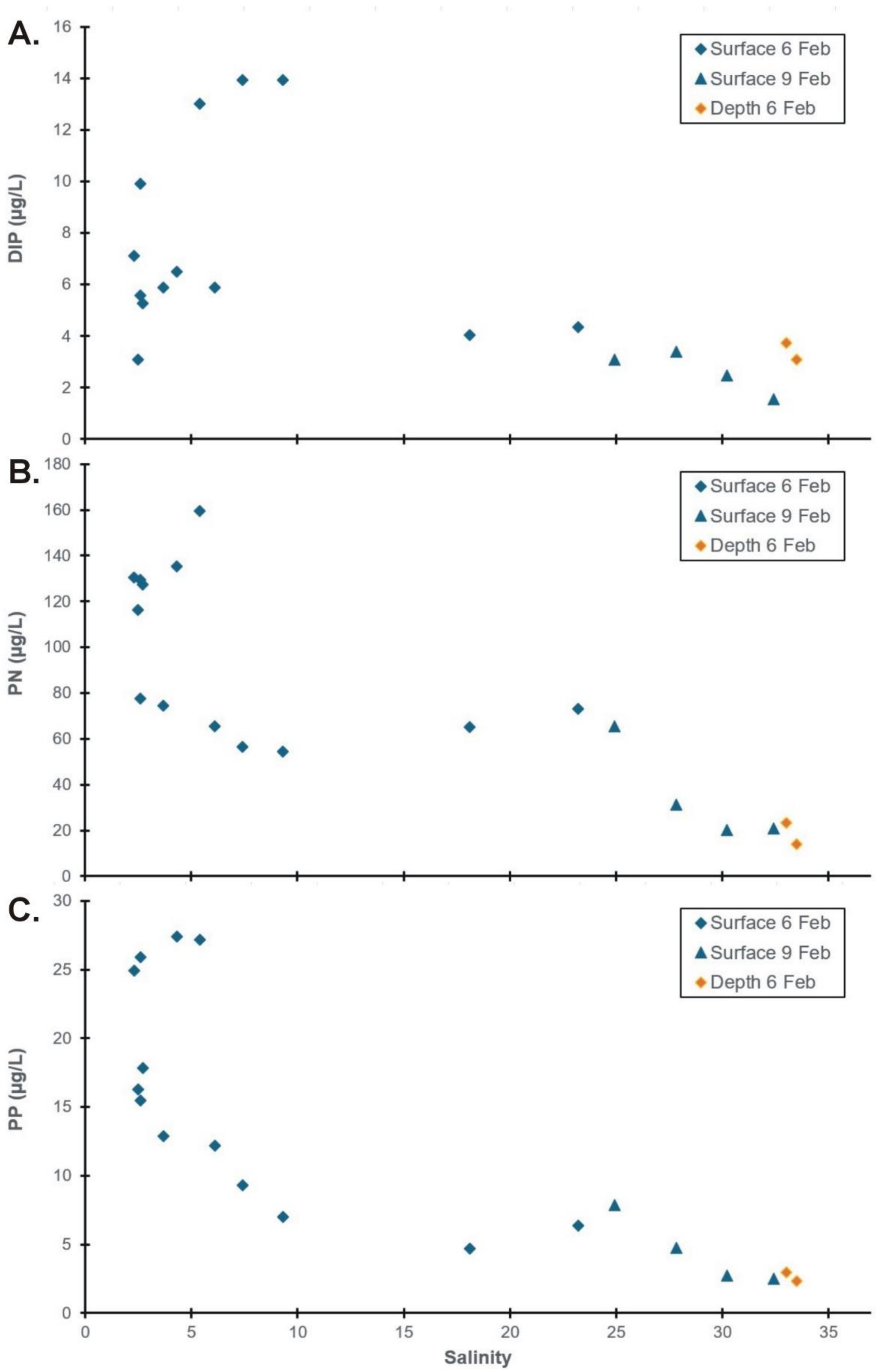


Figure 5-61: Water quality data from the Herbert region under the influence of flood plumes in February 2025 including: A) dissolved inorganic phosphorus (DIP), B) particulate nitrogen, and C) particulate phosphorus plotted over the salinity gradient. Surface samples are plotted in blue and depth samples in orange.

Grab samples were collected for pesticide analysis at 13 sites on 6 February 2025 and 3 sites on 9 February 2025. The herbicides atrazine, diuron, and 2,4-D are in common use in the sugarcane industry in the Ingham district and provide a good indication of the pesticide inputs from the Herbert River (Figure 5-62). Similarly to the other water quality parameters, the concentrations of atrazine, diuron and 2,4-D were highly variable in the 0 to 10 salinity zone and also reflect either different river sources or timing of riverine inputs relative to pesticide application. Importantly, while diuron values approached 250 ng L^{-1} (Figure 5-62) they remained slightly below the marine guideline (270 ng L^{-1}; ANZG, 2018).

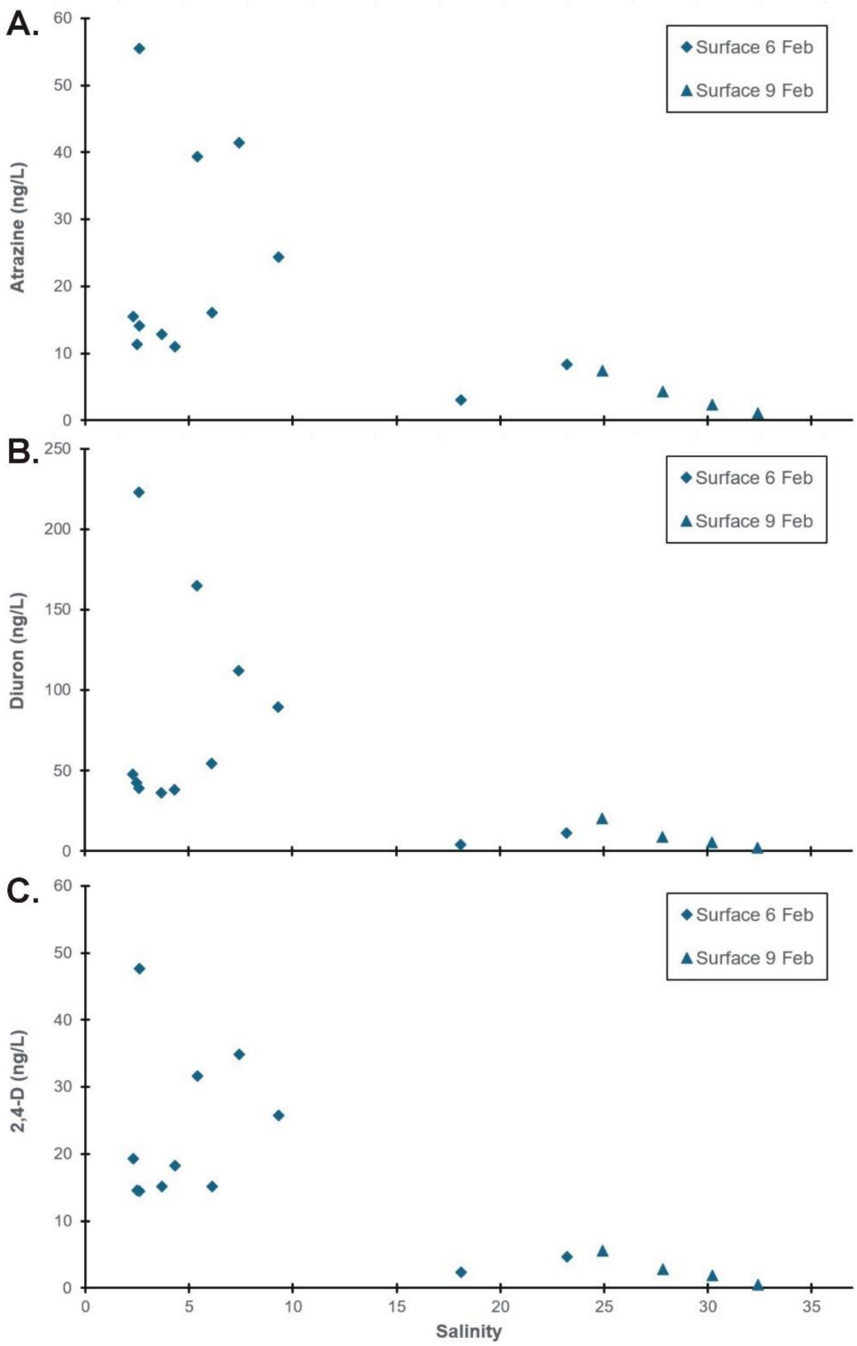


Figure 5-62: Herbicide concentration data from the Herbert region over the 2024–25 monitoring seasonwith a focus on the flood plumes in February 2025 including A) atrazine, B) diuron, and C) 2,4-D plotted over the salinity gradient.

The PRM was assessed for all pesticide grab samples collected during the Herbert event (Figure 5-63). A PRM >1% species affected was calculated for all samples (n=13) collected on 6 February 2025, with Pandora Reef (BUR2) with a PRM of 7.8% species affected (92.2%

species protected), primarily from PSII herbicides but with contributions from other herbicides and insecticides, and the coastal site off Forest Beach (HAL5) with a PRM of 5.4% species affected (94.6% species protected), primarily from PSII herbicides. These results indicate moderate risk to the aquatic species exposed, based on classification by Warne *et. al* (2023). Plant species are likely to be primarily affected, compared to other aquatic species, due to the presence of herbicide mixtures (Beggs *et. al* 2025). Herbicides such as diuron have been shown to have negative effects on microalgae and seagrass (Magnusson *et. al.* 2008; Negri *et. al.* 2015). The PRM at Havannah Island (HAV) was 3.8%, and sites close to Orpheus Island (HAL3, HAL4) ranging from 2.2% to 3%. The samples collected on 9 February were further offshore but still had a calculated PRM of 1.1% at Herbert 3, while the other sites were <1%.

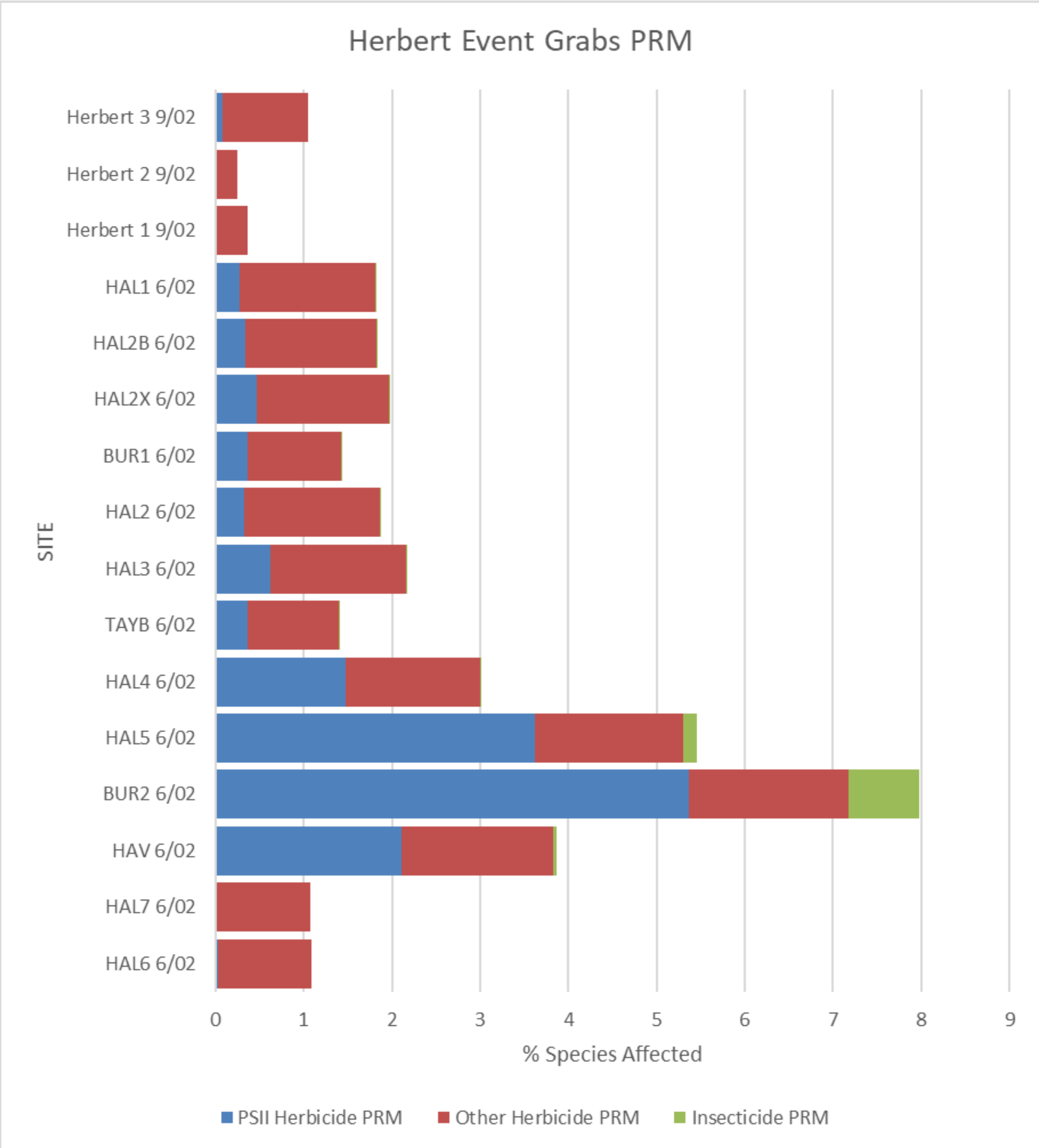


Figure 5-63: Results of the Pesticide Risk Metric for PSII Herbicides, other herbicides and insecticides for grab samples taken during high flow events in the Herbert River region from 6 to 9 February 2025.

5.3 Burdekin region

Three sites were sampled in this focus region 3 times per year until the end of 2014. Following the implementation of the revised MMP water quality sampling design in 2015, 15 sites are now sampled in this focus region up to 9 times per year. Six sites are sampled during both the dry and wet season and 9 additional sites are sampled during major flood events (Table A-1). The monitoring sites are located along a transect away from the river mouth in a north-westerly direction, representing a gradient in water quality. Eight sites are in open coastal waters, 2 sites are in the mid-shelf water body, and 5 sites are in enclosed coastal waters (Figure 5-64).

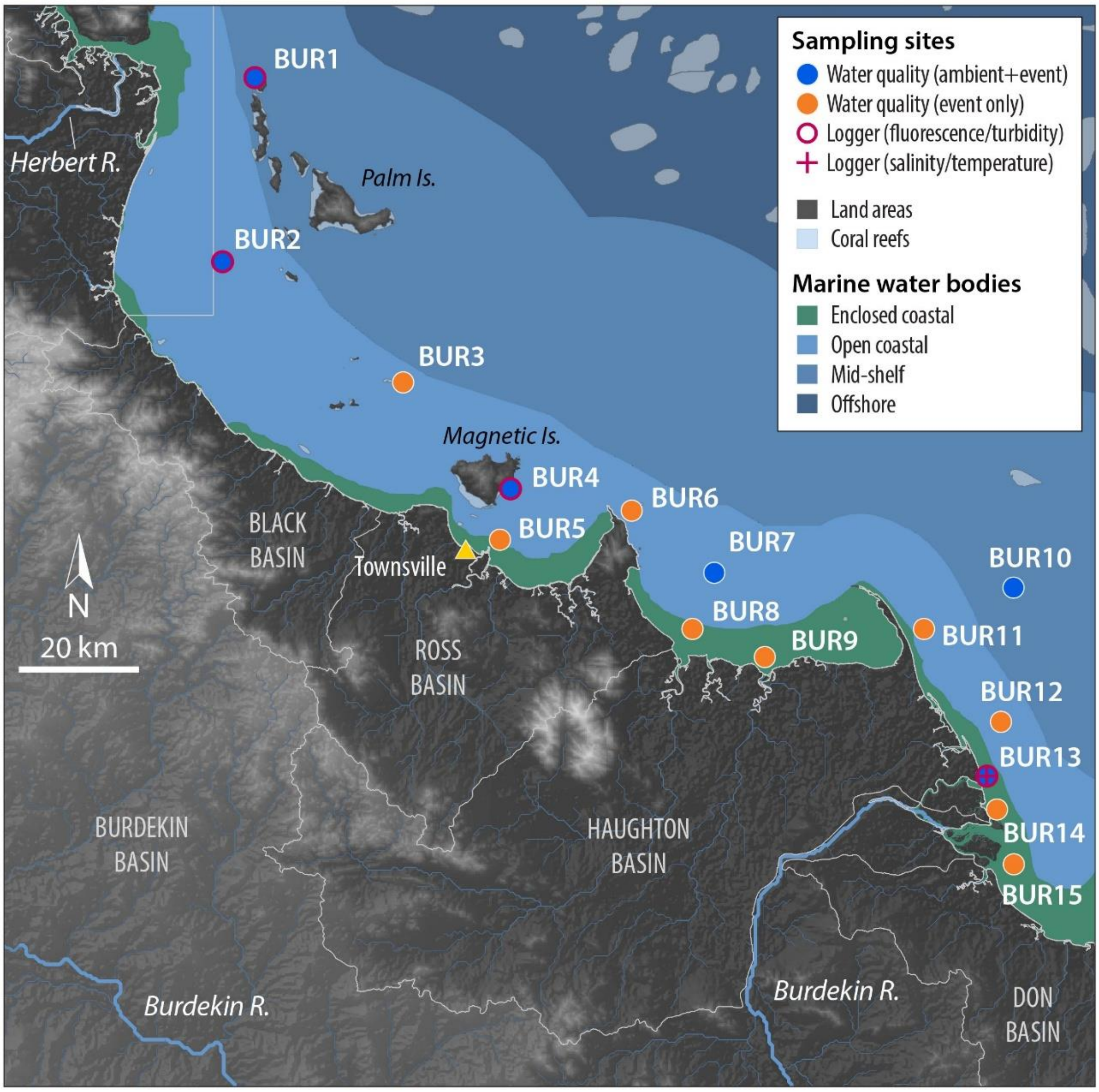


Figure 5-64: Sampling sites in the Burdekin focus region, shown with the water body boundaries.

The total discharge for the Burdekin region (Burdekin + Haughton Basins) in 2024–25 was 6.9 times the long-term median (Figure 5-65; Table 3-1). The combined discharge and loads calculated for the 2024–25 water year from the Burdekin and Haughton Basins were the highest since either 2010–11 or 2008–09 (Figure 5-66). Over the 19-year period between 2006–07 and the current water year:

- discharge ranged from 1,036 GL (2014–15) to 37,470 GL (2010–11)
- TSS loads ranged from 290 kt (2013–14) to 15,024 kt (2007–08)

- DIN loads ranged from 275 t (2014–15) to 4,019 t (2010–11)
- PN loads ranged from 586 t (2013–14) to 22,083 t (2007–08).

During the very large discharge years (2007–08, 2008–09, 2010–11, 2018–19 and 2024–25), the Burdekin and Haughton Basins (dominated by the Burdekin Basin) produced by far the highest loads of TSS, DIN, and PN compared to any of the other focus regions. In contrast, the DIN loads are either similar to or much lower than the basins of the Wet Tropics and Mackay-Whitsunday regions during the lower discharge years.

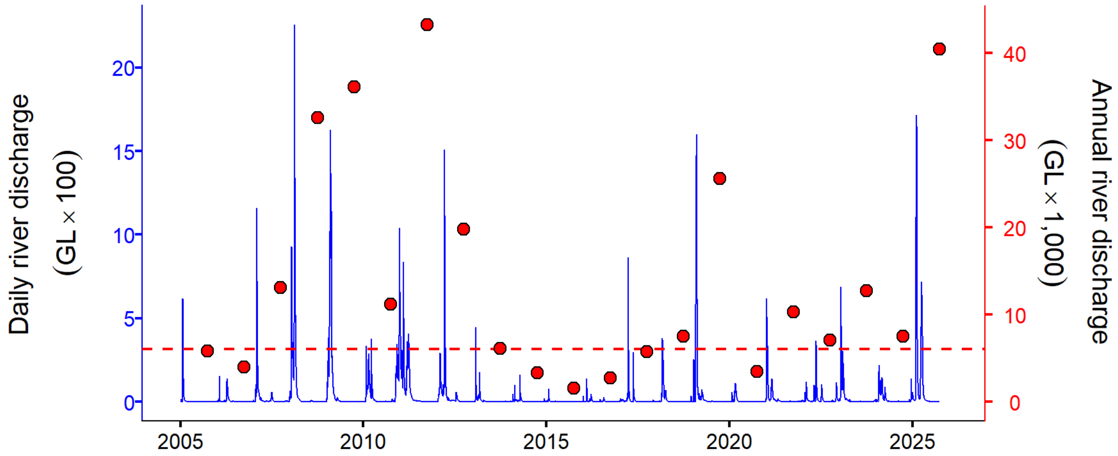


Figure 5-65: Total discharge from rivers in the Burdekin region including the Black (gauge 117002A – Bruce Highway), Haughton (gauge 119003A – Powerline), Burdekin (gauge 120006B – Clare), Elliot (gauge 121002A – Guthalungra) and Don (gauge 121003A –Reeves) Rivers and Bluewater (gauge 117003A – Bluewater), Barratta (gauge 119101A – Northcote) and Euri (gauge 121004A – Koonandah) Creeks. Daily (blue) and water year (1 October to 30 September, red) discharge is shown. Red dashed line represents the long-term median annual discharge.

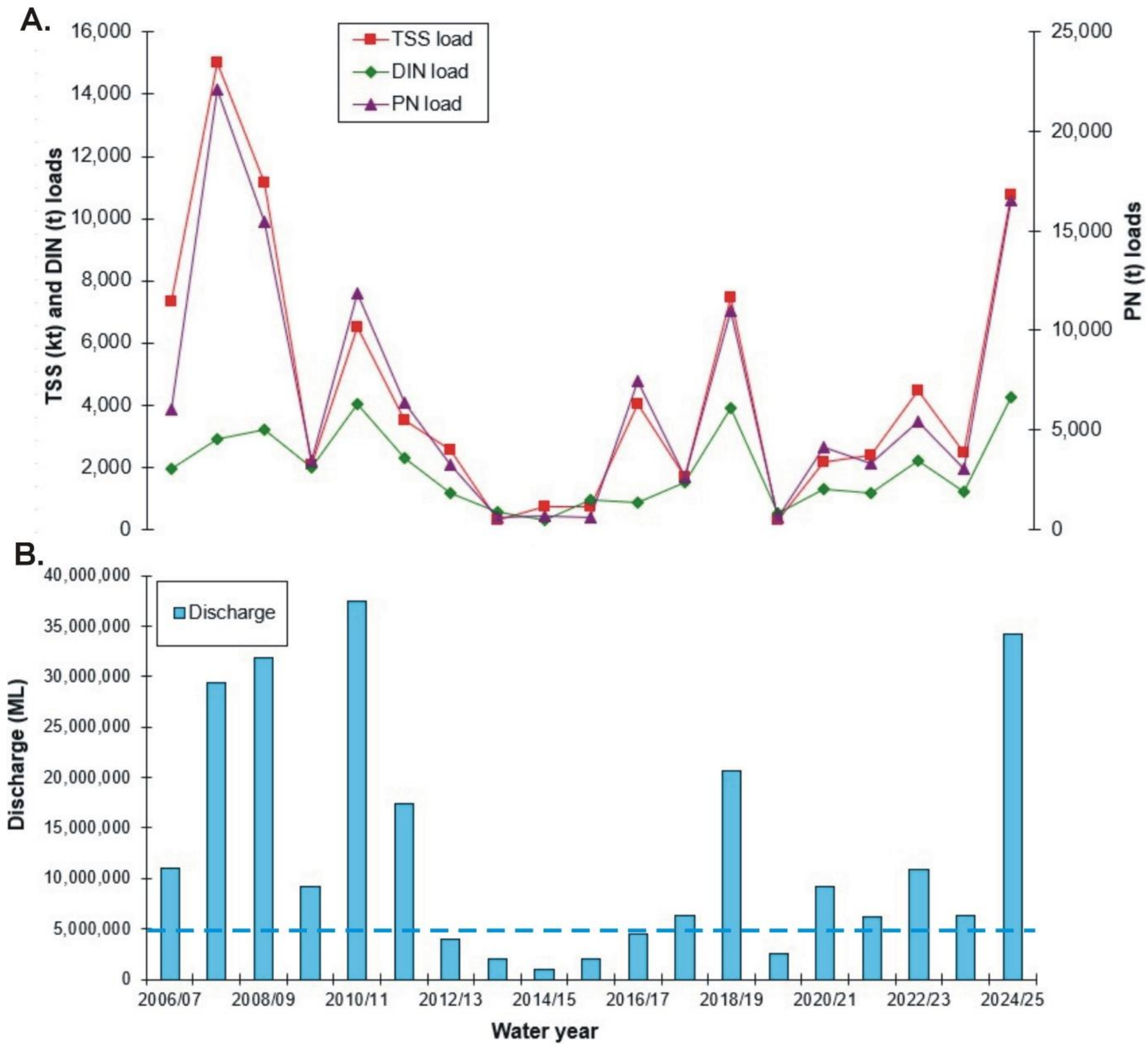


Figure 5-66: Loads of (A) TSS, DIN and PN and (B) discharge for the Burdekin and Haughton Basins from 2006 to 2025.The loads reported here are a combination of 'best estimates' for each basin based on 'up-scaled discharge data from gauging stations, monitoring data (Burdekin River), and annual mean concentrations and discharge from monitoring data or Source Catchments modelling data. Dotted line represents the long-term median for basin discharge. Note the different scales on the 2 y-axes.

Ambient water quality and the in situ *Water Quality Index*

Water quality showed trends along the sampling transect (cross-shelf gradient in north-westerly direction). Sites located nearest to the river mouth (distance from river mouth = 0 km) had high concentrations of Chl-*a*, TSS, NO_x and particulate nutrients (PN and PP), which declined with distance away from the river mouth, reaching low levels at sites furthest from the river mouth (Figure 5-67, Table C-2). Secchi depths were low at sites near the river mouth (water clarity was poor) and increased (water clarity improved) with distance from the river mouth. These spatial patterns are generally consistent with those that are typically observed in the region.

This year, clear seasonal differences in Chl-*a*, TSS, NO_x, PN, and PP were observed, where concentrations (especially near the river mouth) were higher during the wet than the dry season. For TSS and PP, these seasonal differences tended to become less pronounced further offshore (e.g., concentrations during wet and dry seasons converged at sites furthest from the river mouth). Large concentrations of NO_x and PN were measured at the furthest site along the transect (BUR1) during the wet season due to the influence of discharge from the Herbert River. Secchi depth was marginally lower during the wet season (water clarity was worse) than the dry season along the entire transect (Figure 5-67).

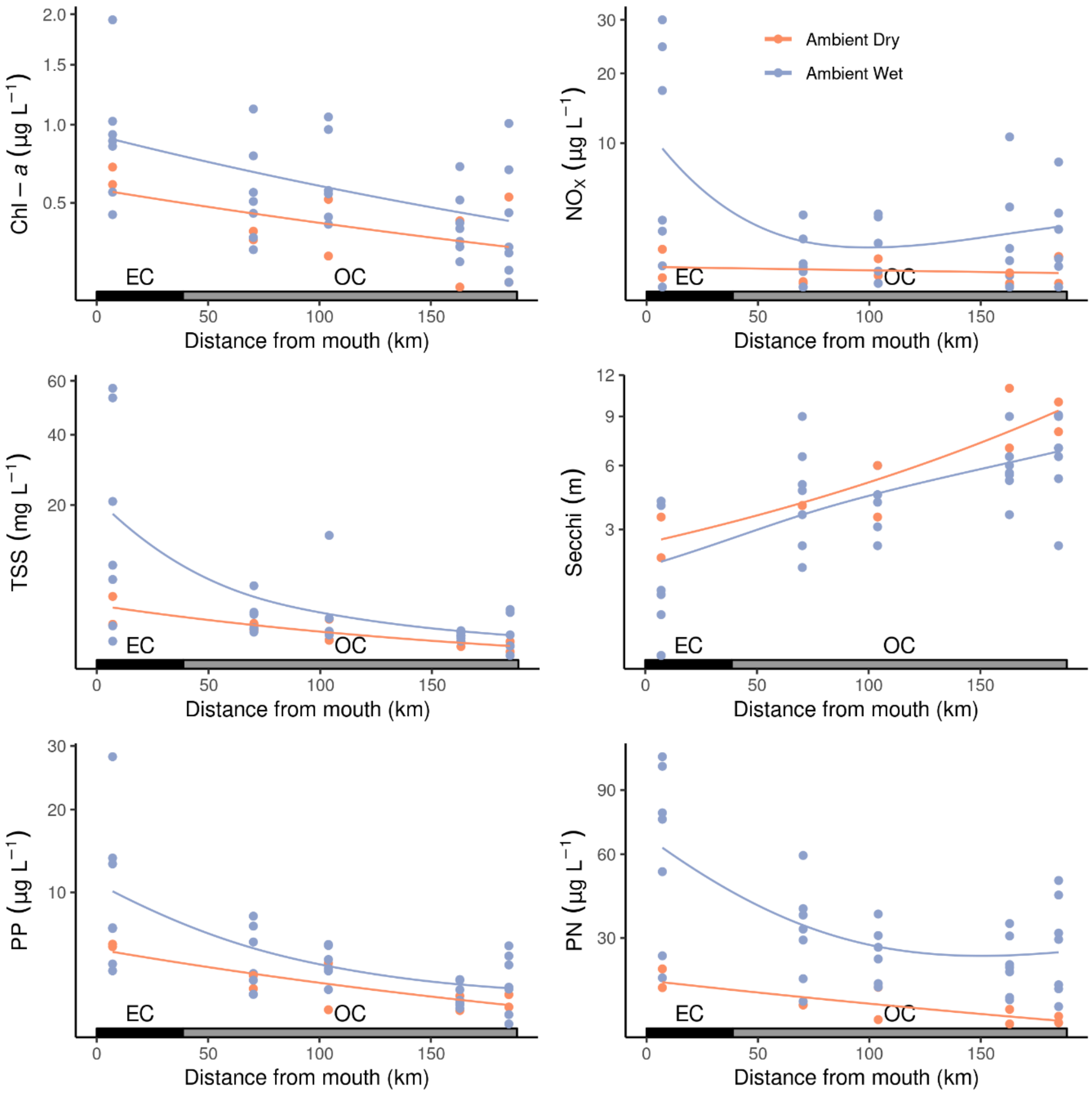


Figure 5-67: Water quality variables measured during ambient and event sampling in 2024–25 along the Burdekin focus region transect. Chlorophyll *a* (Chl-*a*), nitrate/nitrite (NO_x), total suspended solids (TSS), Secchi depth, particulate nitrogen (PN), and particulate phosphorus (PP) are shown with distance from the Burdekin River mouth. Water body classifications are shown along the x-axes: Enclosed coastal (EC) and open coastal (OC). Note the y-axes are logarithmic scales. Fitted lines are generalised additive models.

Distinct long-term trends (since 2005) were observed in some water quality variables, while others showed little change (Figure 5-68). Site-specific statistics and comparison to GVs for all variables are available in Table C-1.

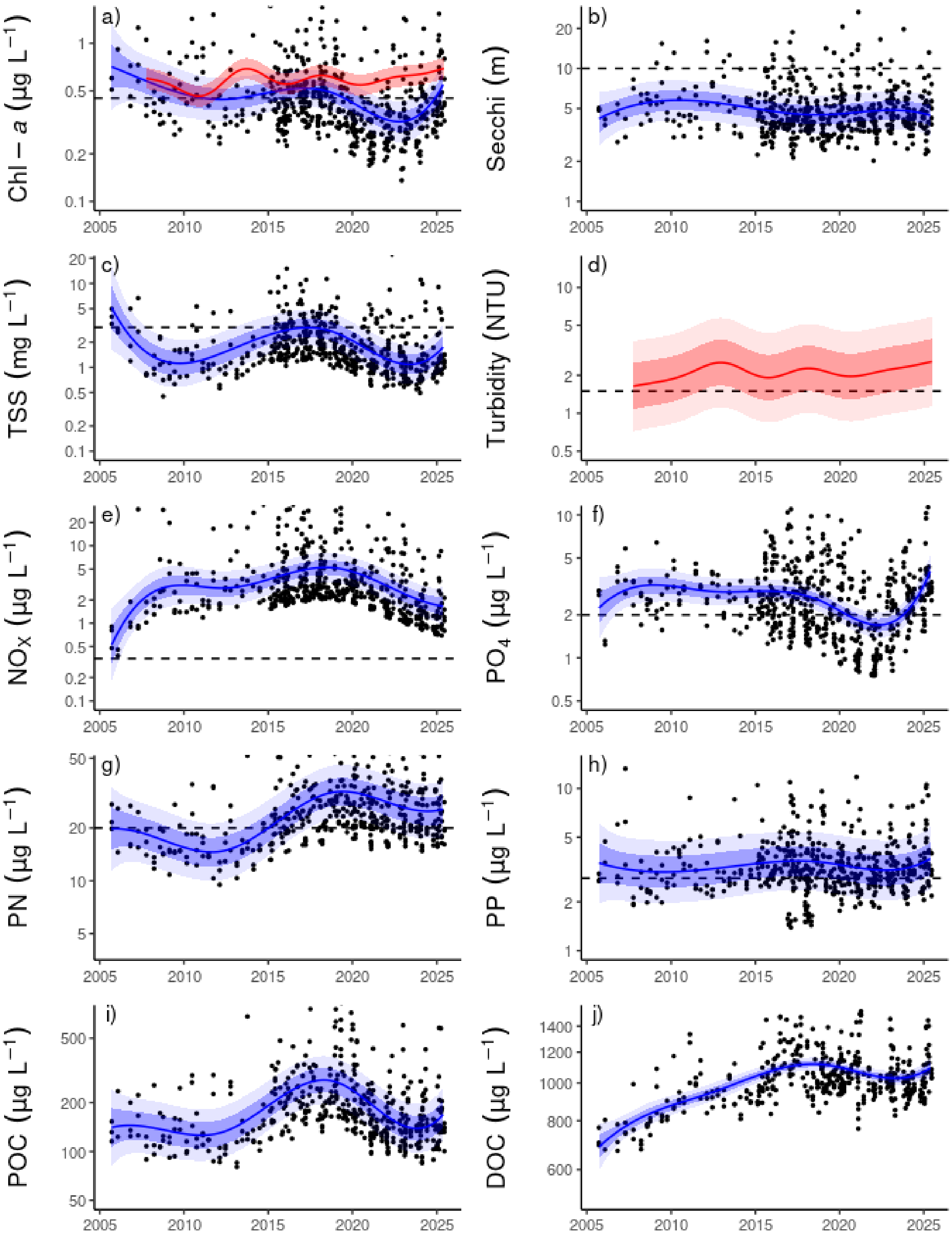


Figure 5-68: Temporal trends in water quality variables for the Burdekin focus region: a) chlorophyll *a* (Chl-*a*), b) Secchi depth, c) total suspended solids (TSS), d) turbidity, e) nitrate/nitrite (NO_x), f) phosphate (PO_4), g) particulate nitrogen (PN), h) particulate phosphorus (PP), i) particulate organic carbon (POC) and j) dissolved organic carbon (DOC). Generalised additive mixed effect models (trends) are represented by blue lines with shaded areas defining 95% confidence intervals of those trends and black dots represent observed data (depth weighted averages). These trends and data are accounting for the effects of seasons after applying x-z detrending. Trends of records from ECO FLNTUSB instruments are represented in red, and individual records can be found in Figure C-1. Dashed horizontal reference lines indicate annual guidelines for open coastal waters.

Concentrations of Chl-*a* fluctuated near the GVs from 2005 to ~2017 (Figure 5-68a). Over the period 2017–2023, mean concentration of Chl-*a* decreased (conditions improved) to a minima. Over the last 2 years, Chl-*a* increased (conditions deteriorated) to levels similar to 2015. Chl-*a* in 2024–25 was above (did not meet) the local GVs at 3 of the 6 sites sampled. Chlorophyll fluorescence measured by FLNTU instruments (Figure 5-68a) fluctuated above (did not meet) GVs since monitoring began in 2007 (Table C-2). The differences between FLNTU chlorophyll fluorescence and Chl-*a* concentration reflect differences in sampling location and frequency (e.g., FLNTUs are only present at a subset of sites and monitor year-round). This recent Chl-*a* increase is likely related to the large flood event in the Burdekin during the 2024–25 wet season.

Secchi depth remained relatively stable and below (did not meet) the GVs since monitoring began in 2005 (Figure 5-68b). Over the period 2015–2025, mean Secchi depth remained stable (not improved or declined overall) despite small fluctuations. Secchi depth in 2024–25 was below (did not meet) the local GVs at 4 of the 6 sites sampled.

Concentrations of TSS fluctuated generally below the GVs between 2005–2025 and reached a minima in 2022. In 2024–25, TSS increased (conditions deteriorated) slightly (Figure 5-68c). TSS in 2024–25 was above (did not meet) the local water quality GVs at 2 of the 6 sites sampled. This recent increase in TSS may be related to large flood event in the Burdekin during the 2024–25 wet season.

Turbidity varied above the GVs since monitoring began in 2007 (Figure 5-68d). Over the period 2015–2025, turbidity slightly increased, and trend analysis showed that levels in 2025 were significantly greater (worsened) than in 2015. Turbidity in 2024–25 was above (did not meet) the GVs at 3 sites (BUR1, BUR2, BUR10) of the 4 sites monitored (Table C-2).

Concentrations of NO_x markedly increased (conditions deteriorated) and remained above the local GVs from 2005 until ~2017 (Figure 5-68e). Over the period ~2018–2025, mean concentrations of NO_x steadily decreased (conditions improved) to levels similar to the start of monitoring, and trend analysis showed that concentrations in 2025 were significantly lower (improved) than in 2015. NO_x in 2024–25 was above (did not meet) the local GVs at 4 of the 6 sites sampled.

Concentrations of PO_4 remained relatively stable and above the local GVs from 2005 until ~2017 (Figure 5-68f). Over the period ~2017–2022, mean concentration of PO_4 decreased (conditions improved). Over the last 3 years, PO_4 increased (conditions deteriorated), and trend analysis showed that concentrations in 2025 were significantly greater (worsened) than in 2015. PO_4 in 2024–25 was above (did not meet) the local GVs at all of the 6 sites sampled.

Concentrations of PN were generally below (met) local GVs from 2005–2015 (Figure 5-68g). Over the period 2015–2025, mean PN concentration increased and then stabilised at levels similar to 2015. PN in 2024–25 was above (did not meet) the local GVs at 4 of the 6 sites sampled.

Concentrations of PP remained relatively stable and close to the local GVs since monitoring began in 2005 (Figure 5-68h). Over the period 2015–2025, mean PP concentration showed minor variability with a potential small increase over the last year. PP in 2024–25 was above (did not meet) the local GVs at 3 of the 6 sites sampled.

Concentrations of POC showed a major oscillation since monitoring began in 2005 (Figure 5-68i), and reached a minima in 2023. Concentrations of DOC increased from 2005–2018 and have stabilised in recent years (Figure 5-68j).

The WQ Index is calculated using 2 different formulations to communicate the a) long-term trend in water quality (based on the pre-2015 sampling design) and b) annual condition of water quality (based on the post-2015 sampling design, which increased the power to detect change). Section 2.1.5 and Appendix B contain details of the calculations for both Index formulations.

The long-term WQ Index showed a small (i.e., changing by a single grade) overall decline in water quality from the period 2010–2018, driven by PN and PP indicators (Figure 5-69a). The Index then stabilised for 3 years from 2018–2020 and showed a trend of improvement over the period 2021–2023 from Chl-*a* and PN indicators (Figure 5-69a). The long-term Index has shown stability over the last 3 years and is similar to conditions in 2007.

The annual condition WQ Index scored water quality as ‘moderate’ for 7 of the last 10 years, with 2023–25 receiving ‘good’ scores (Figure 5-69b). The annual condition Index has shown a general trend of improvement since 2015, and the 2024–25 score was a slight improvement over the previous years’ score driven by improvements in most indicators.

It is important to note that the 2 versions of the WQ Index are designed to answer separate questions and therefore differences in scores between the versions are expected.

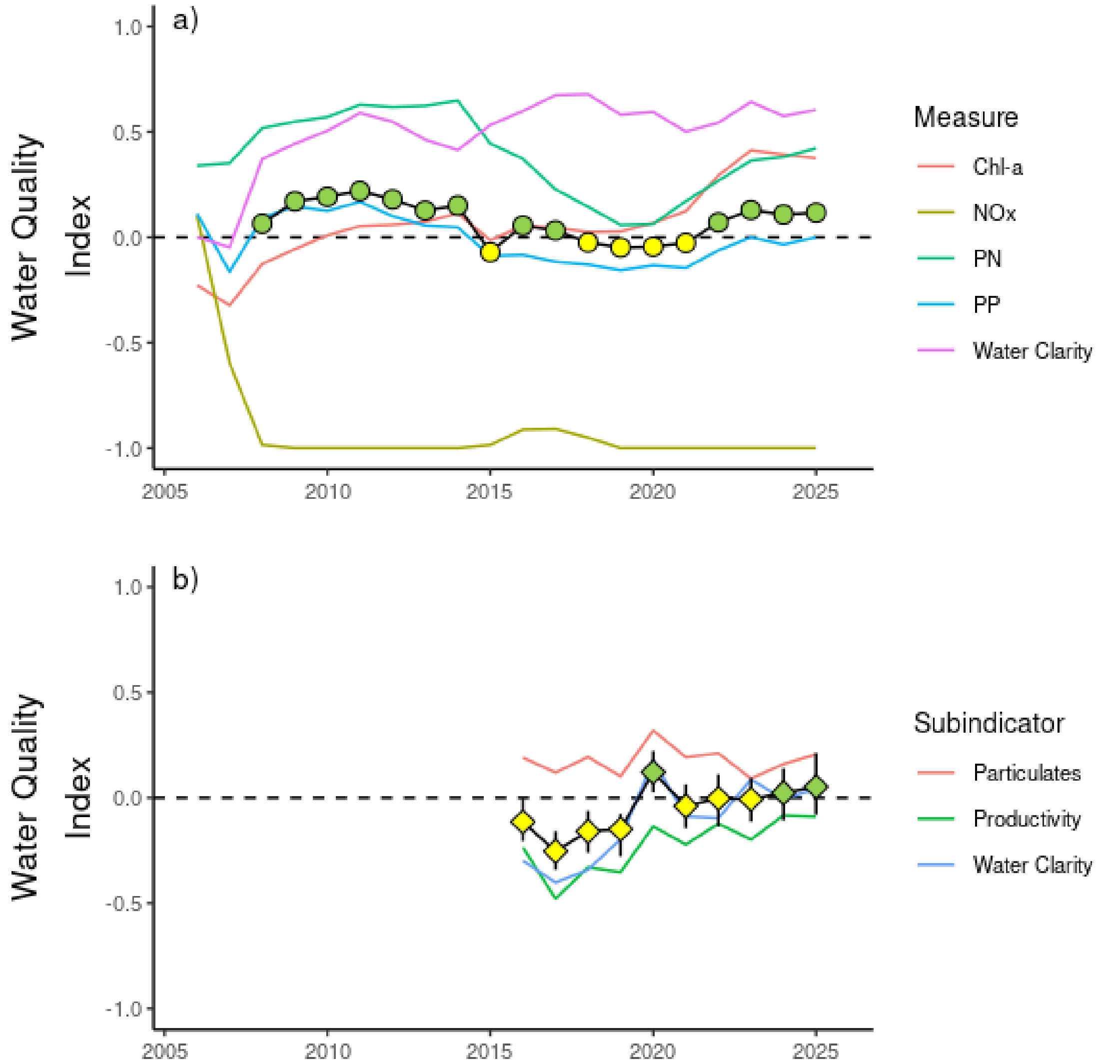


Figure 5-69: The Water Quality Index (WQ Index) for the Burdekin focus region. The WQ Index uses 2 formulations to communicate: a) long-term trend (based on pre-2015 sampling design) and b) the annual condition (based on post-2015 sampling design). WQ Index colour coding: ● / ◆– ‘very good’; ● / ◆ – ‘good’; ● / ◆ – ‘moderate; ● / ◆ – ‘poor’; ● / ◆ – ‘very poor’. Indicators or sub-indicators that are used to calculate the WQ Index are shown as coloured lines on each plot. Error bars (vertical black lines) on the WQ Index represent the 95% quantile intervals. Calculations for both formulations are described in Appendix B.

Event water quality

The Burdekin River had 2 considerable flow events in the 2024–25 water year during February and April 2025 (Figure 5-70). The February event was the largest with the Burdekin River at Clare gauge peaking above the moderate flood level (13.0 m) at 15.04 m on 11 February 2025 while the second event peaked above the minor flood level (9.0 m) at 10.09 m on 2 April. The peak daily flow volume for the February event peaked just over 1,600,000 ML d^{-1} which is the largest daily peak since the 2008–09 event while the total discharge for the water year (30.6 million ML) is the fourth largest in the 104 year gauge record and the biggest annual discharge since the extreme 2010–11 season. Of particular note was the length of the discharge event where the Burdekin River remained above the moderate flood level for 7 consecutive days and above the minor flood level for 13 consecutive days.

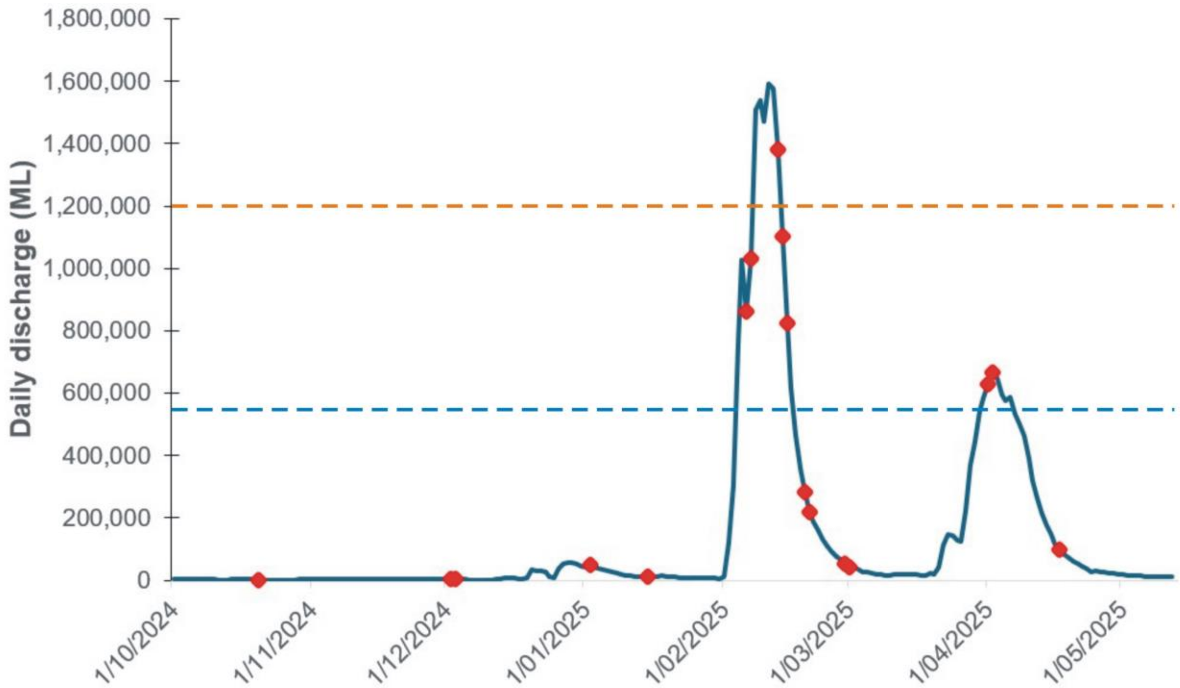


Figure 5-70: Burdekin River daily discharge for the 2024–25 wet season as recorded by the Clare gauge. The dates of offshore sampling by JCU and AIMS are marked as red dots. Blue dotted line represents the minor flood level and orange dotted line represents the moderate flood level.

The very large Burdekin discharge event resulted in a large flood plume that extended along the inshore Reef from the Burdekin mouth to the Palm Islands but at times, also reached further offshore to the mid- and outer shelf reefs (Figure 5-71). The collection of satellite images shows the development of an extensive and persistent Burdekin flood plume that extended for several weeks during the 2025 wet season.

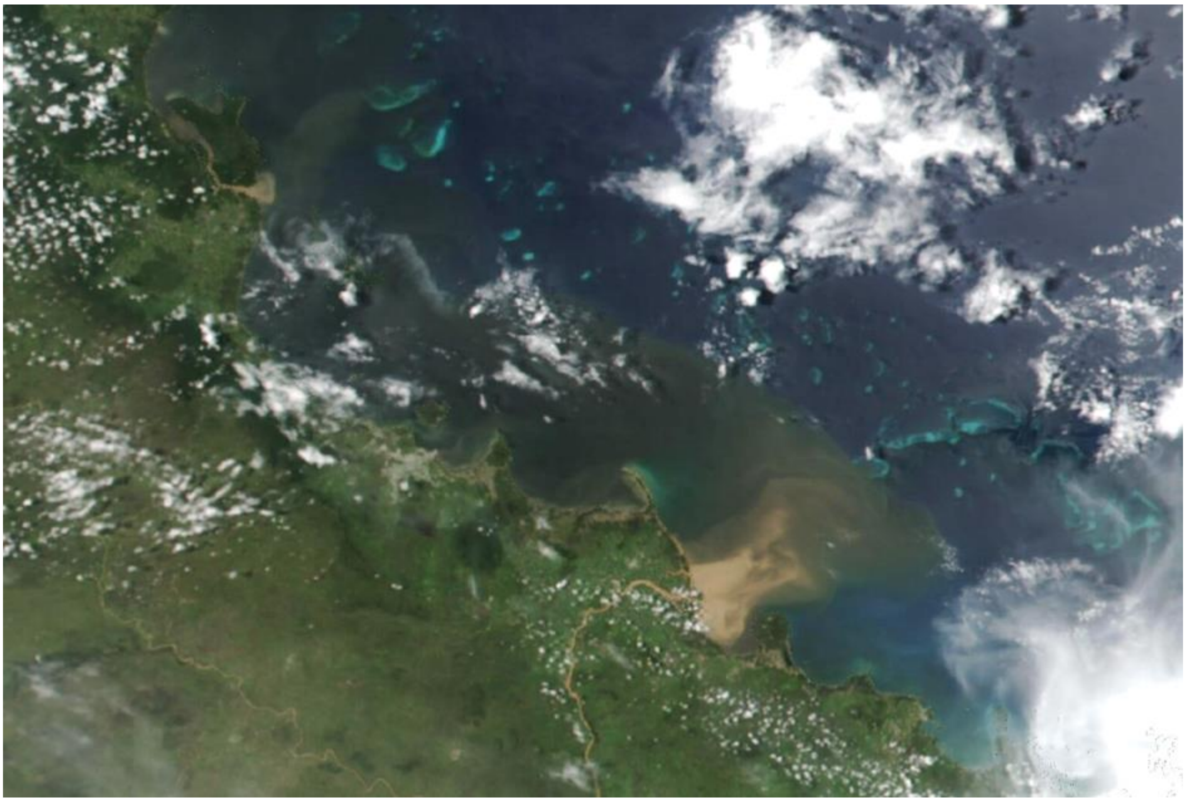


Figure 5-71: VIRSS (Suomi NPP) satellite image showing the turbid plume from the Burdekin River on 15 February 2025.

The sampling campaign was extensive (Figure 5-72) and captured the rise, peak and fall of the very large Burdekin River flood in February 2025 and the peak of a second flow event in April (Figure 5-70). The first sample collection offshore from the river mouth on 7 February was conducted 4 days before the flood peak. The sampling of this February event captured the salinity gradient from the freshwater (0 salinity) to seawater (~33 salinity) endmembers. The highest TSS concentrations (200 and 210 mg L^{-1}) were measured on 15 February at the Burdekin River mouth sites with a salinity of 0.1. Consistent with observations from previous Burdekin flood plumes, the TSS concentrations rapidly declined to <10 mg L^{-1} by the 10 salinity zone, although elevated concentrations >10 mg L^{-1} remained at times in the depth samples. In that regard, there are interesting variations between the TSS concentrations between the paired surface and depth samples at individual sampling sites. For example, the surface samples from the BUR13 site near the Burdekin mouth recorded 28.5, 56, and 106 mg L^{-1} on 7, 13, and 19 February, respectively, while the corresponding depth samples recorded 12.6, 33, and 8.4 mg L^{-1} on 7, 15, and 20 February, respectively. In comparison, the sampling at the same site from the intermediate period between the 2 flood events on 1 March recorded 16.7 mg L^{-1} at the surface and 25.6 mg L^{-1} in the depth sample. Further offshore at the Geoffrey Bay site (BUR4), the TSS concentrations were either comparable between surface and depth samples or elevated in the depth samples compared to the corresponding surface samples. Overall, the data indicate a combined influence of the newly delivered suspended sediment and the resuspension of the newly delivered or existing sediment on the seafloor. Tellingly, the depth samples at the Palms West site (BUR1), which sits beyond the zone of wave resuspension at >22 m water depth, regularly recorded concentrations >2 mg L^{-1} (with a peak value of 6.5 mg L^{-1} on 9 February). This result indicates that either the TSS is settling through the water column at this site or that bottom currents are moving sediments through this location.

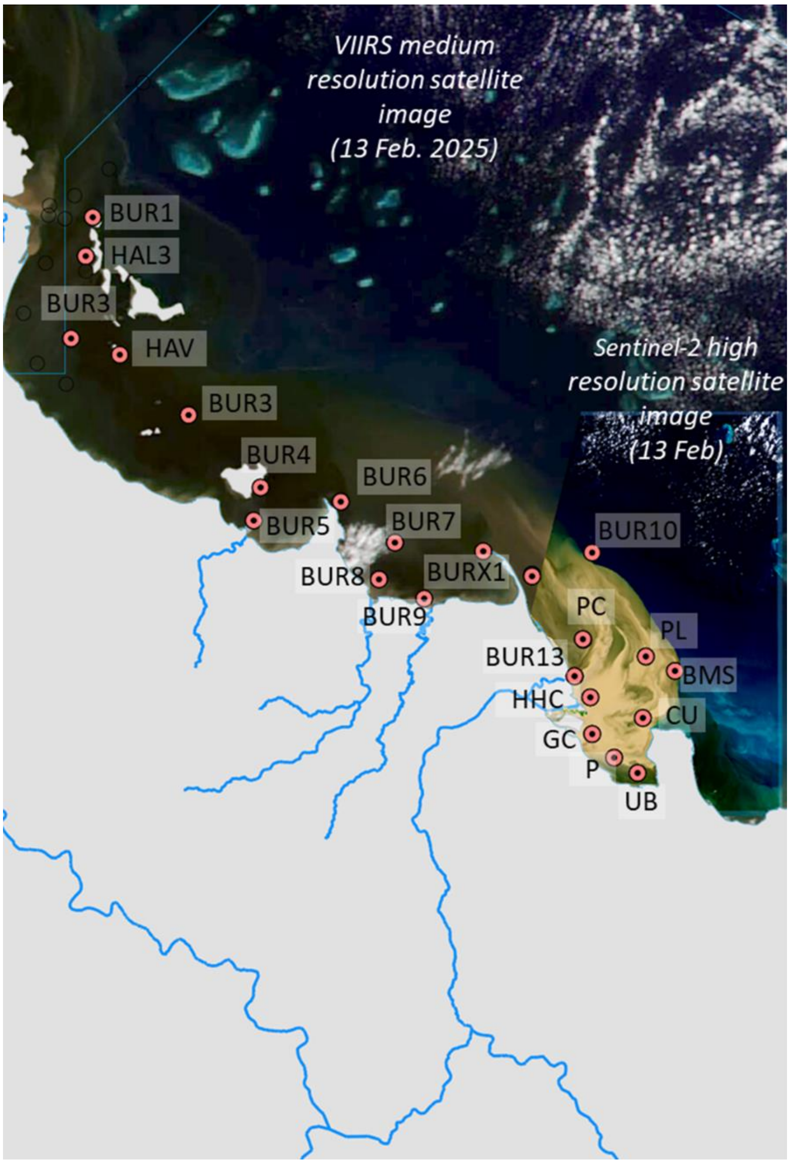


Figure 5-72: Satellite composite map showing the Burdekin plume extent measured the 13 of February 2025. The MMP field

data collected on the 6 and 7 February, and the from the 10 to the 19 February are overlaid on the map. Background image: VIRRS true colour image; Plume image: Sentinel-2 true colour image.

The nitrate concentrations in the low salinity reaches of the Burdekin plume were all at the lower end of what would be expected from end-of-river inputs with the highest concentration of 59 µg L^{-1} at 1.6 salinity (Figure 5-73B). These concentrations suggest that the end-of-river concentrations at that time were in the order of 60–70 µg L^{-1} which is indicative of what would be expected from natural landscapes in this region (Lewis *et al*., 2023). However, unlike previous sampling, the nitrate concentrations do not follow a conservative mixing pattern in the 0 to 20 salinity zone; this may reflect the contributions from different stream sources such as the main Burdekin River channel and localised Burdekin Delta streams. Elevated nitrate concentrations relative to the salinities were also measured in the depth samples during the February flood plume event (Figure 5-73B). This suggests possible inputs from submarine groundwater seeps in the area, rates of high remineralisation of flood-borne material, or an earlier discharge of higher riverine nitrate loads.

Chl-*a* concentrations typically follow previous observations of river plumes whereby lower concentrations (mostly but not exclusively <0.8 µg L^{-1}) occur in the 0 to ~15 salinity zone, elevated concentrations (>1.5 µg L^{-1}) in the 15 to 28 salinity zone and then returning to lower values thereafter (Figure 5-73C). The elevated concentrations in the 15 to 28 salinity zone reflect the combination of higher available nutrient concentrations and increased light for primary production to thrive. Concentrations of DIP, PN, and PP all follow similar patterns to nitrate and TSS with generally elevated but variable concentrations in the 0 to 10–15 salinity zone and reducing thereafter (Figure 5-74).

Multiple water quality profiles of the water column were conducted during the Burdekin River flood plume along a transect from the Burdekin River mouth (BUR13) to the Palms West site (BUR1). The salinity profiles highlight the evolution of the flood plume with the plume generally mixing deeper within the water column with increasing distance offshore and over time since the Burdekin flood peak (Figure 5-75). The salinities in the plume are lowest in the upper 5–10 m of the water column, although the sampling at the majority of sites from 28 February to 1 March showed a well-mixed water column. The profiles show the influence of the plume throughout the whole water column with salinities never reaching the ambient seawater salinity even in the deepest sections (Figure 5-75). The light (PAR) profiles of the water column show that throughout the sampling period (month of February) there was little to no light reaching beyond 5–10 m depth at any of the sampling sites along the plume transect (Figure 5-76).

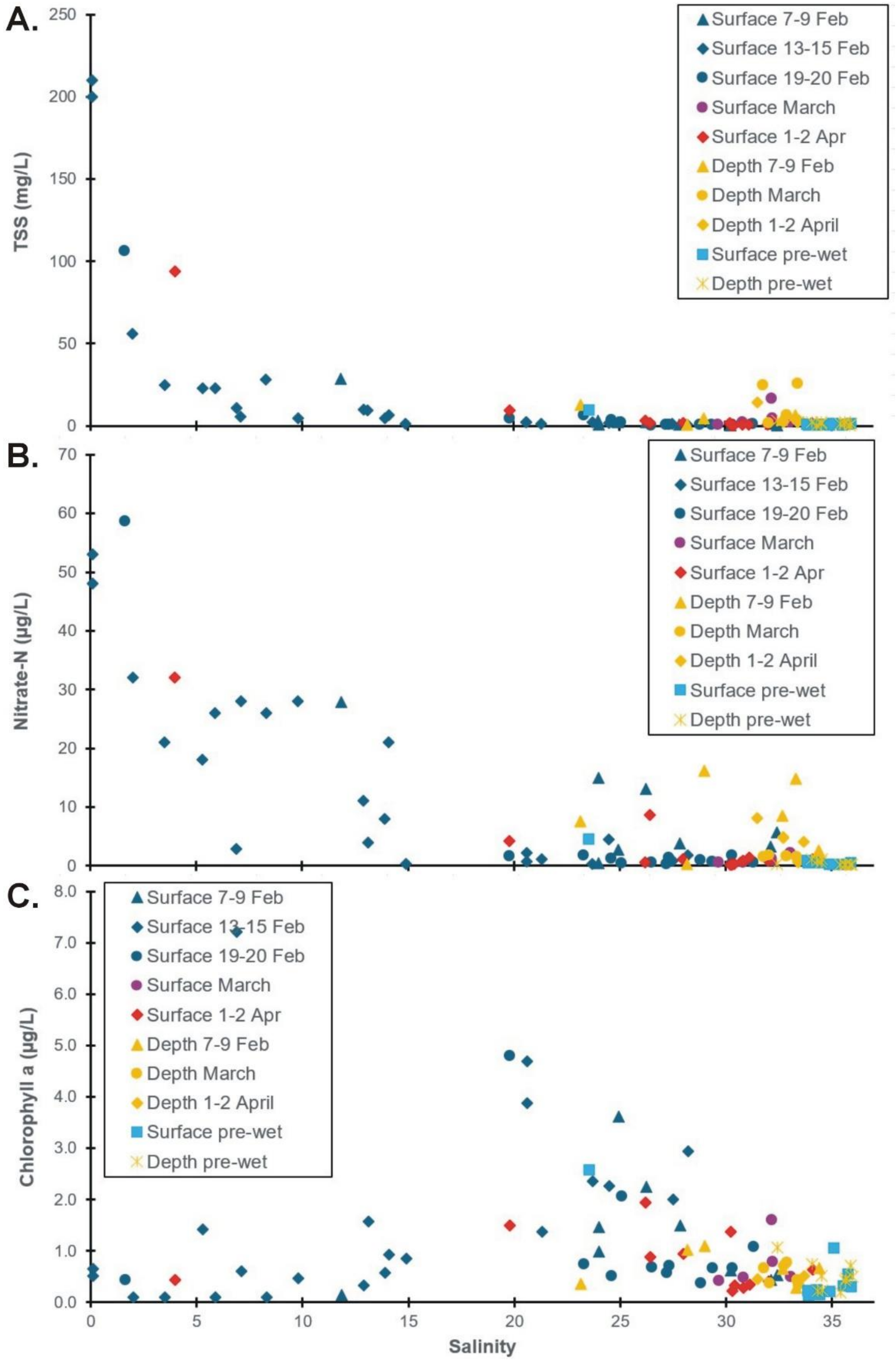


Figure 5-73: Water quality data from the Burdekin region over the 2024–25 monitoring season with a focus on the flood plumes in February and April 2025 including A) total suspended solids (TSS), B) nitrate (NO_3), and C) chlorophyll *a* plotted over the salinity gradient. Surface samples are plotted as different shapes and colours to signify different sampling periods while depth samples are plotted in orange with different symbols to represent different sampling periods.

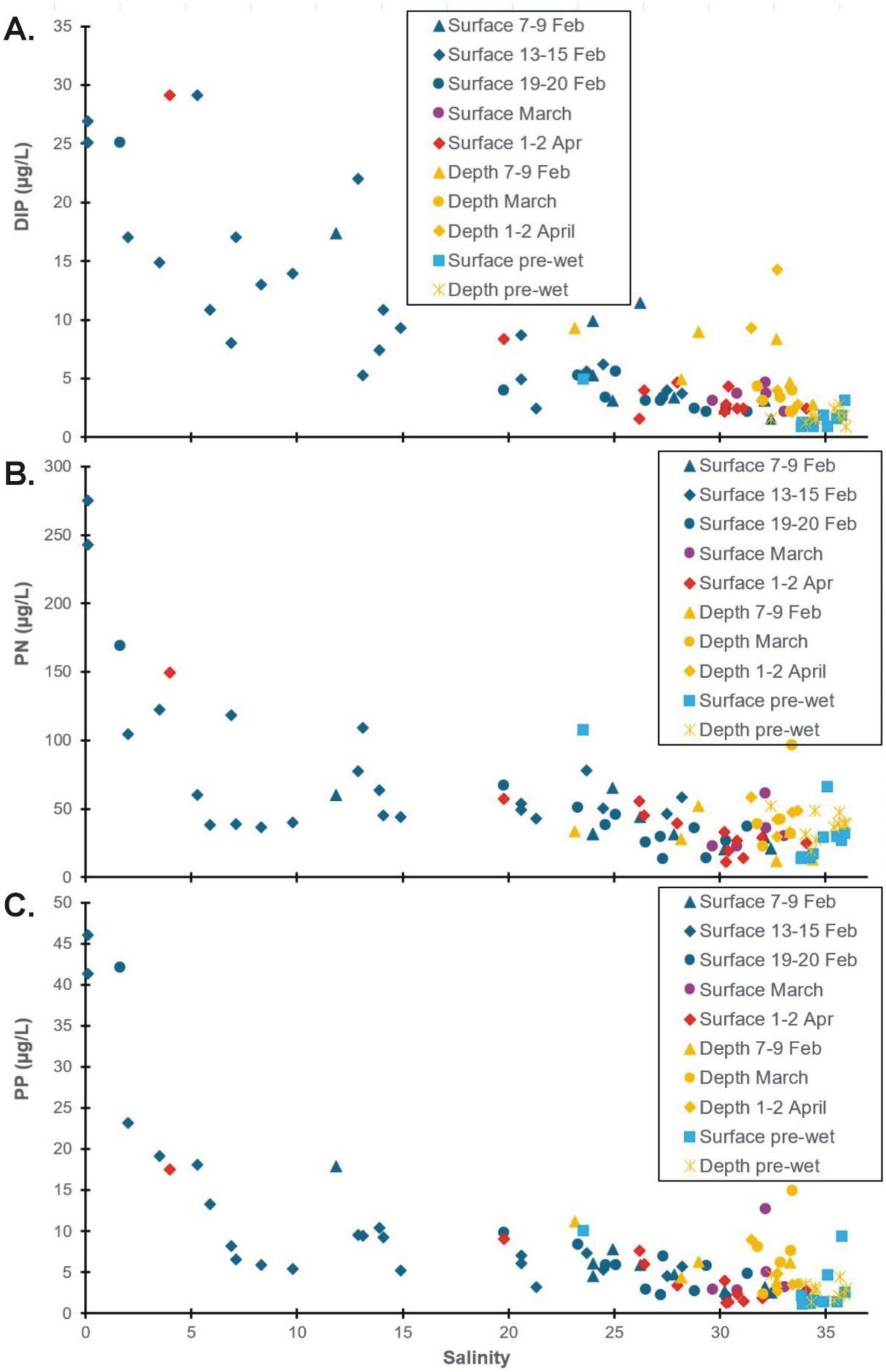


Figure 5-74: Water quality data from the Burdekin region over the 2024–25 monitoring season with a focus on the flood plumes in February and April 2025 including A) dissolved Inorganic phosphorus (DIP), B) particulate nitrogen (PN), and C) particulate phosphorus (PP) plotted over the salinity gradient. Surface samples are plotted as different shapes and colours to signify different sampling periods while depth samples are plotted in orange with different symbols to represent different sampling periods.

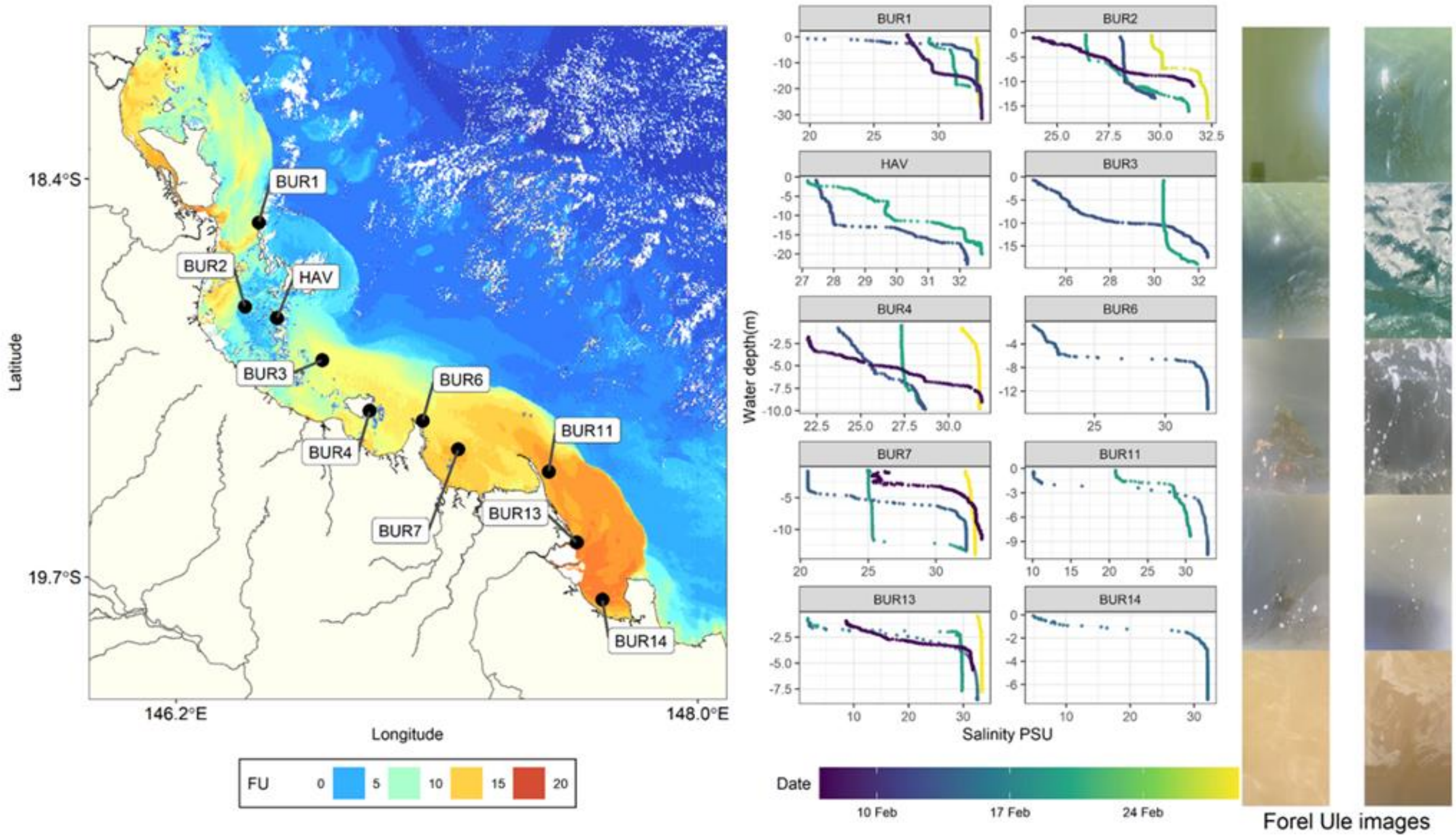


Figure 5-75: Left panel: Map of the offshore Burdekin standard event sampling sites with the addition of Havannah Island site on the Forel Ule colours based on the satellite image from 13 February 2025; middle panel: plots of the water column profiles of **salinity** taken over different times during the February flood plume at the selected sites shown on the map; right panel of the corresponding Forel Ule images taken during sampling from 13–15 February.

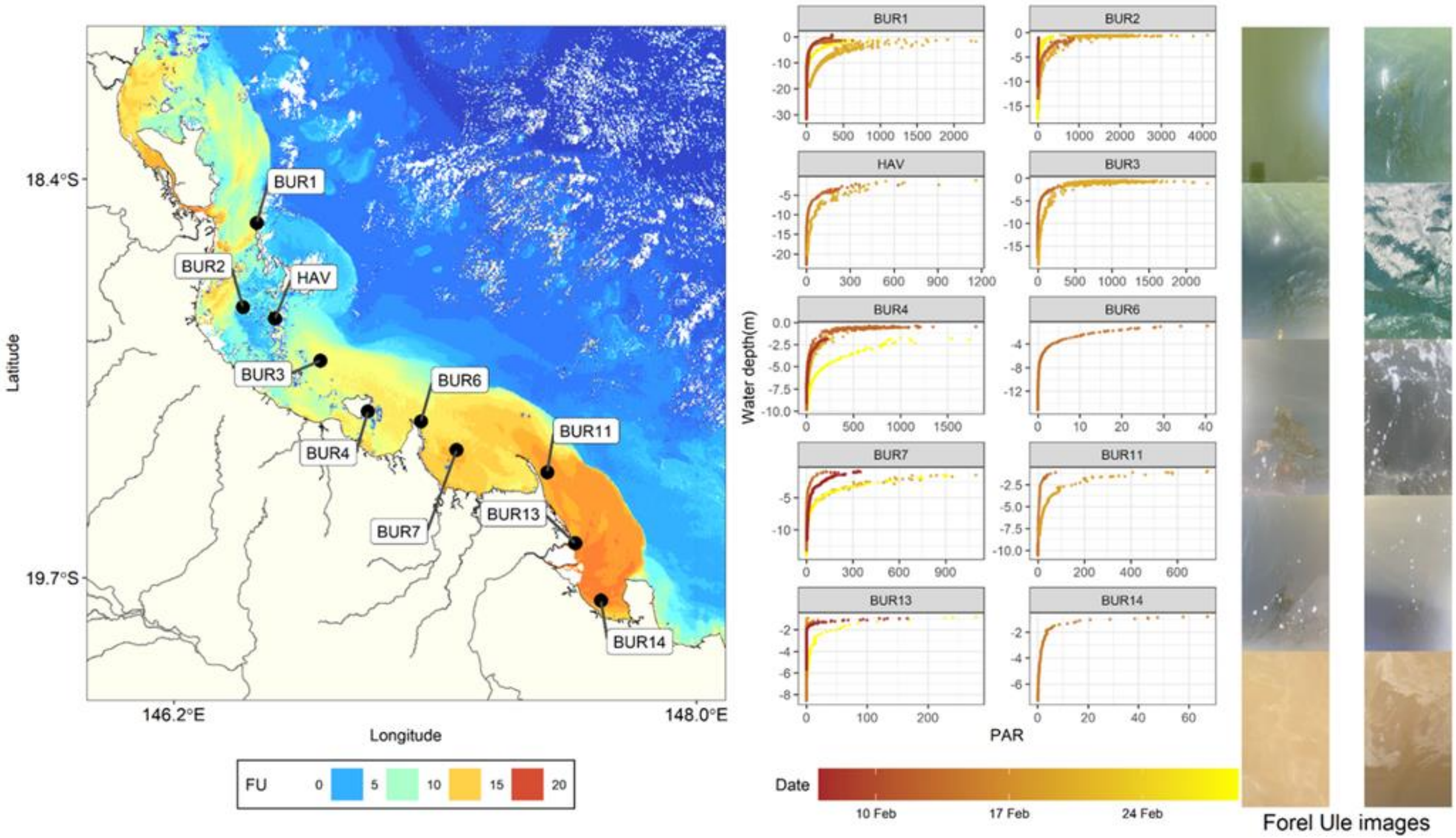


Figure 5-76: Left panel: map of the offshore Burdekin standard event sampling sites with the addition of Havannah Island site on the Forel Ule colours based on the satellite image from 13 February 2025; middle panel: plots of the water column profiles of **photosynthetically active radiation** (PAR: light) taken over different times during the February flood plume at the selected sites shown on the map; right panel of the corresponding Forel Ule images taken during sampling from 13–15 February.

The water quality loggers deployed by AIMS for the Geoffrey Bay (Figure 5-77) and Pandora Reef (Figure 5-78) sites also highlight the extensive influence of the Burdekin flood plume from February to April 2025. Both loggers highlight that the Chl-*a* concentrations are by far the greatest of the timeseries during the large Burdekin River flood in April with the peak values occurring once the turbidity concentrations reduced (thereby allowing light for primary production). This is consistent with previous logger data from these sites as well as at other sites throughout the monitoring network.

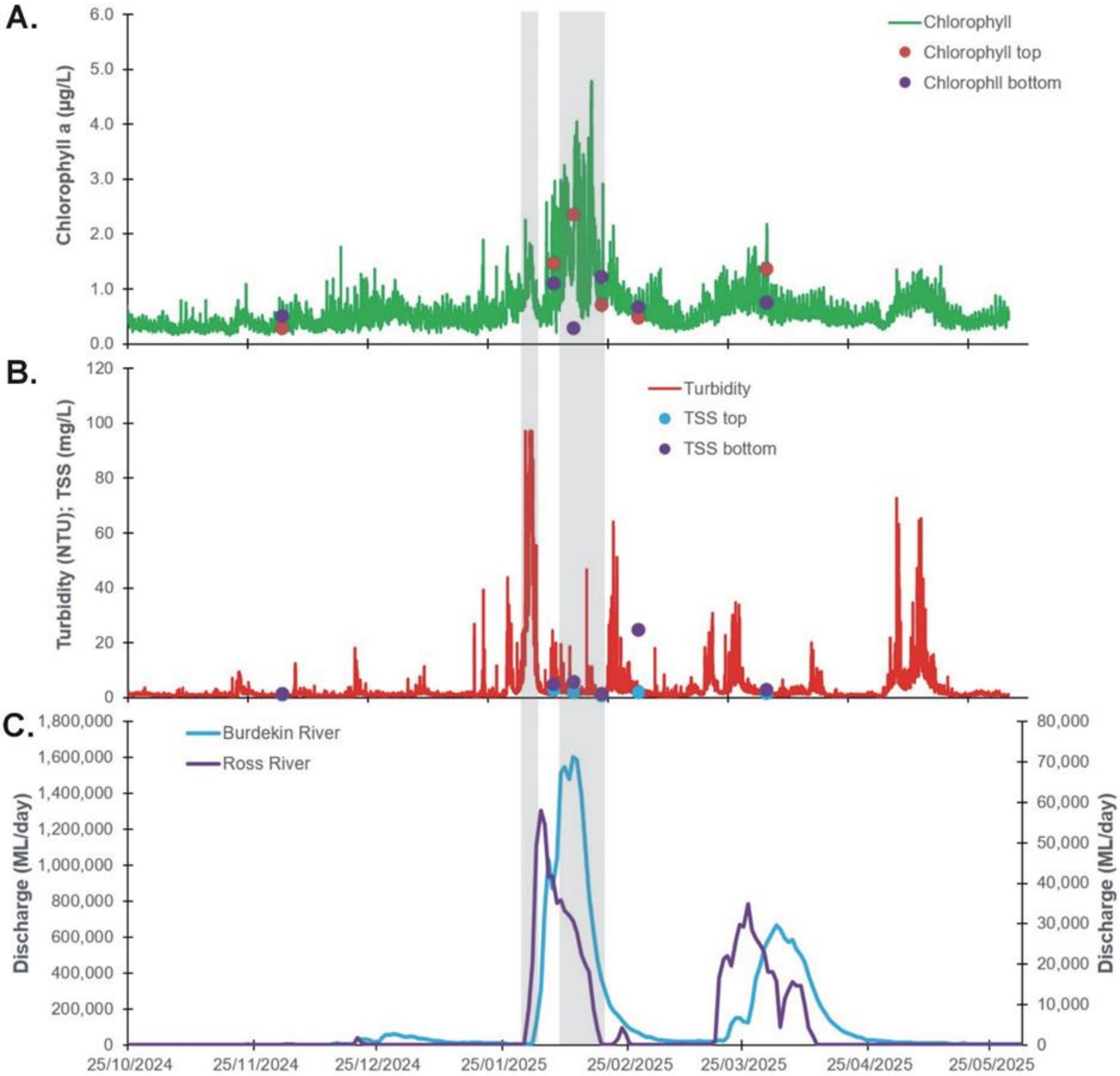


Figure 5-77: AIMS logger timeseries data for A) chlorophyll and B) turbidity at the Geoffrey Bay, Magnetic Island site along with C) daily river discharge from the Burdekin and Ross Rivers (note different scales). The gray shading highlights the periods of either peak turbidity levels or peak chlorophyll concentrations as recorded by the loggers.

Similarly, the peak turbidity often coincided with river discharge events and the timing for these peaks appeared to be more associated with discharge from the local waterways in the region such as the Ross River (and likely the local waterways on Magnetic Island) at the Geoffrey Bay site, and the Herbert River influence on Pandora Reef rather than discharge from the Burdekin River. However, turbidity spikes that occurred after the major Burdekin discharge event were likely associated with the resuspension of newly delivered and existing sediment on the seafloor. For example, the large turbidity spikes in May 2025 in the Geoffrey Bay timeseries (Figure 5-77) occurred in the absence of river discharge inputs and were therefore possibly associated with sediment resuspension of the newly-delivered and existing sediment. Comparison of the surface and depth water quality grab samples for Chl-*a* and TSS with the logger plots (as shown in the points in Figure 5-77 and Figure 5-78) showed good agreement between the *in situ* samples and the logger data in most cases.

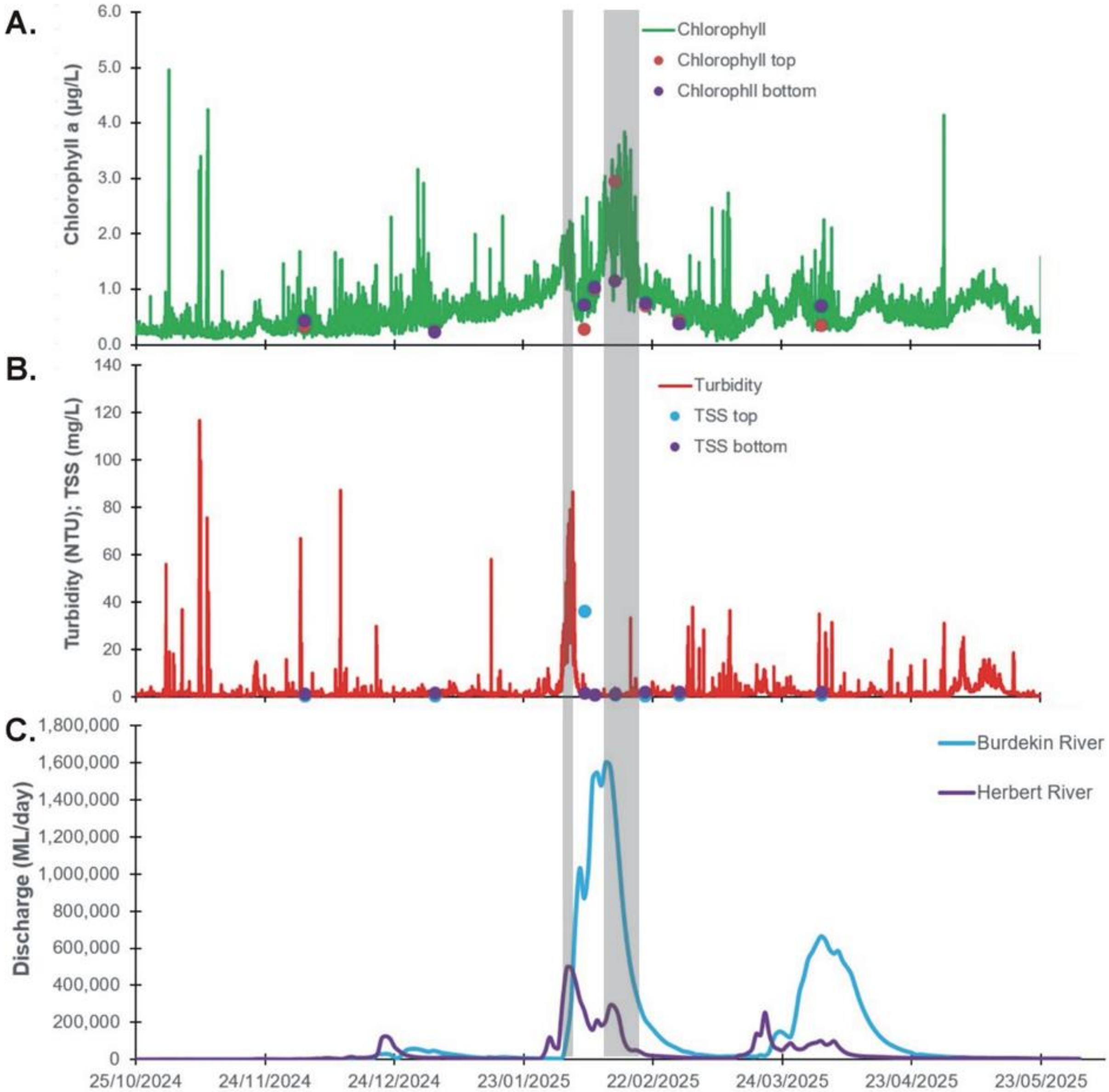


Figure 5-78: AIMS logger timeseries data for A) chlorophyll and B) turbidity at the Pandora Reef site along with C) daily river discharge data from the Burdekin and Herbert Rivers. The gray shading highlights the periods of either peak turbidity levels or peak chlorophyll concentrations as recorded by the loggers.

Figure 5-79 shows the concentration of the herbicides atrazine, diuron, and tebuthiuron plotted over the salinity gradient for the Burdekin flood plume samples in the February event. As these pesticides are primarily derived from the runoff of waters from cropping lands the highest concentrations will be expected at 0 salinity (i.e. freshwater endmember) as the seawater endmember (35 salinity) will effectively have no detectable pesticides. Atrazine is commonly used in sugarcane and grain cropping, while diuron is primarily applied in sugarcane, and tebuthiuron is mainly used in grazing lands. Monitoring showed that concentrations of atrazine and diuron peaked within the 10 to 25 salinity zone, indicating that they did not follow conservative mixing patterns (whereby concentrations are highest at the river mouth) (Figure 5-79). These elevated concentrations are most likely sourced from the sugarcane-dominated areas in the Lower Burdekin floodplain, particularly from waterways such as the Haughton River, Barratta Creek, and Plantation Creek. The highest herbicide concentrations were recorded at the sampling sites closest to these streams, reinforcing the link between land use and pesticide distribution. In contrast to other herbicides, the tebuthiuron concentrations were highest at the Burdekin River mouth, displaying a behaviour more consistent with conservative mixing along the salinity gradient (Figure 5-79C). This aligns with previous sampling that linked tebuthiuron to grazing lands, confirming the Burdekin River as its primary source. Importantly, all pesticides measured in the Burdekin flood plume remained below the established marine guideline values.

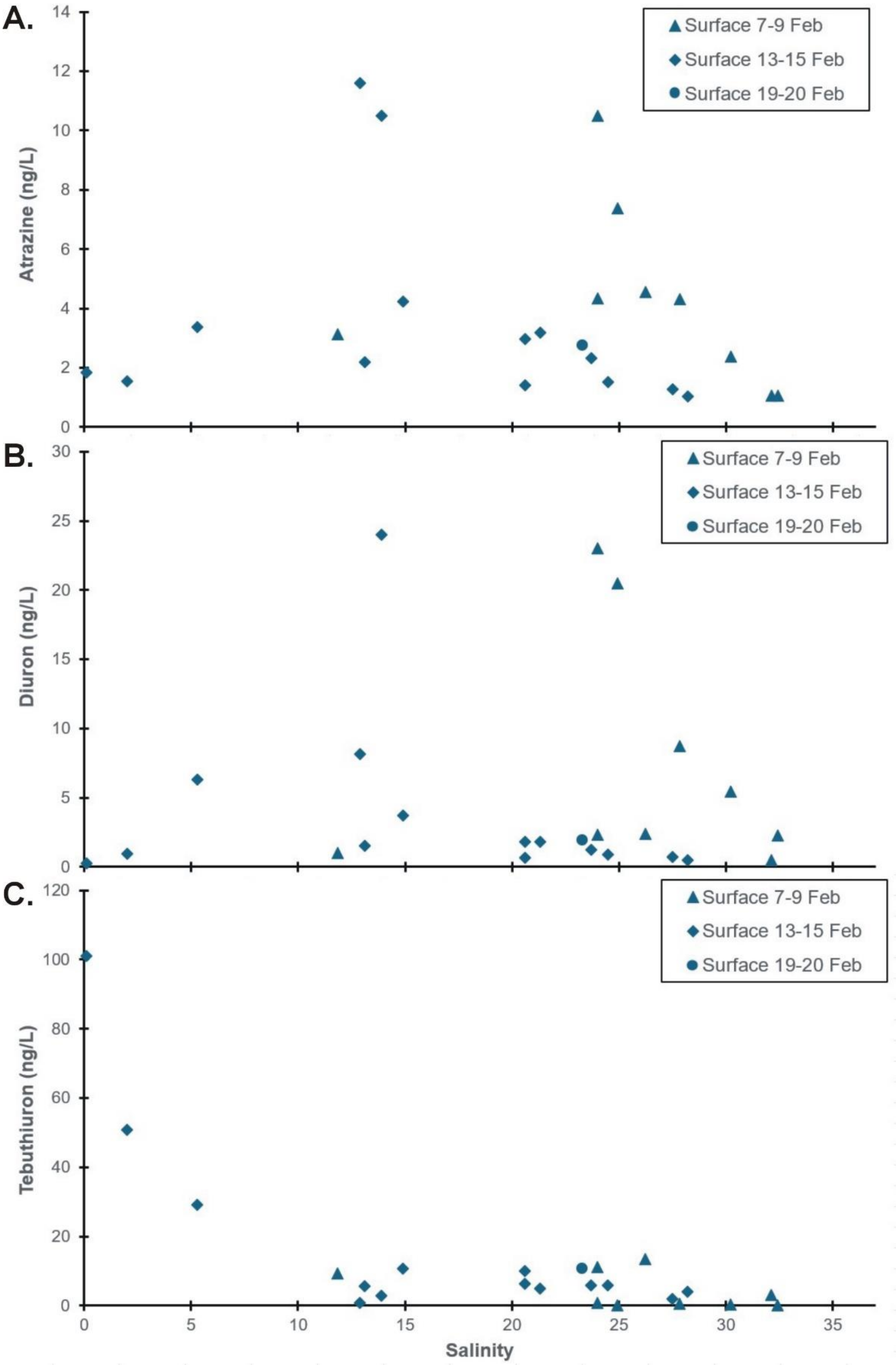


Figure 5-79: Herbicide concentration data from the Burdekin region over the 2024–25 monitoring season with a focus on the flood plumes in February 2025 including A) atrazine, B) diuron, and C) tebuthiuron plotted over the salinity gradient.

The PRM was assessed for all pesticide grab samples collected during the Burdekin event (Figure 5-80). Six sites exceeded the 1% species affected threshold, therefore not meeting the 99% species protection target. The Burdekin event BUR9 sample had the highest PRM of

1.7% species affected, followed by BUR12 with 1.6% species affected. Pelorus (BUR1) showed 0.4% species affected in the sample taken 9 Feb 2025, which increased to 1.5% species affected in the sample from 13 Feb 2025, indicating influence from the Burdekin River as the plume moved further north. This is also observed at Haughton 2 (BUR7), where the sample taken 7 Feb 2025 had a calculated PRM of 1.2% species affected, which later decreased to 0.6% species affected in the 14 Feb 2025 sample. PRM calculated for the Burdekin event sites was mainly influenced by non-PSII herbicides, such as 2,4-D and metolachlor, with lesser contribution from PSII herbicides.

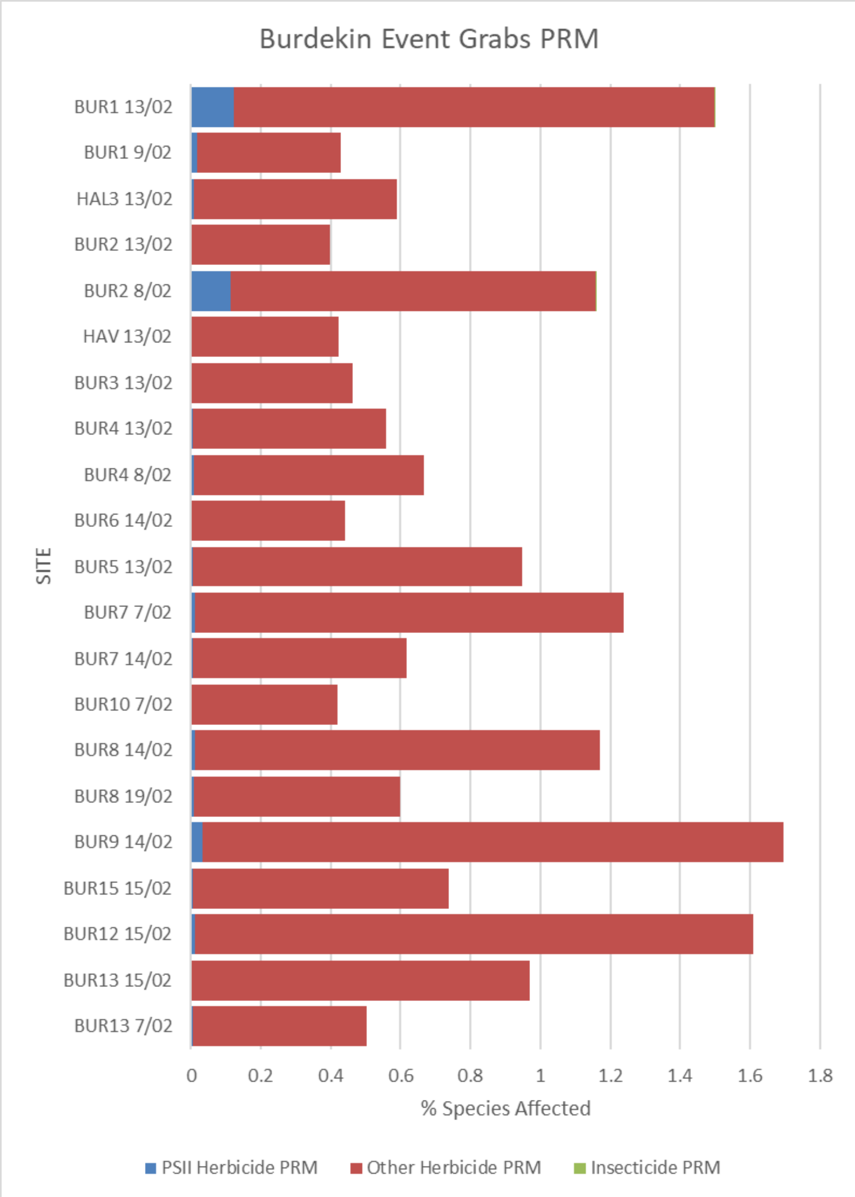


Figure 5-80: Results of the Pesticide Risk Metric for PSII Herbicides, other herbicides and insecticides for additional grab samples taken during high flow events in the Burdekin transects from 8 to 15 February 2025.

5.4 Mackay-Whitsunday region

The Mackay-Whitsunday region comprises 4 major river basins: the Proserpine, O'Connell, Pioneer Basins (Figure 5-81), and the Plane Basin further to the south. The region may also be influenced by runoff from the Fitzroy River which can be transported north during extreme events or through longer-term transport and mixing.

Three sites were sampled in this focus region 3 times per year until the end of 2014. From 2015, 11 sites have been sampled in this focus region up to 5 times per year, with 5 sites sampled during both the dry and wet seasons and 6 additional sites sampled during major flood events (Table A-1). The sites are located along a north westerly transect from the O'Connell River mouth to open coastal waters, representing a gradient in water quality. Ten sites are within open coastal waters and one site is in enclosed coastal waters (Figure 5-81).

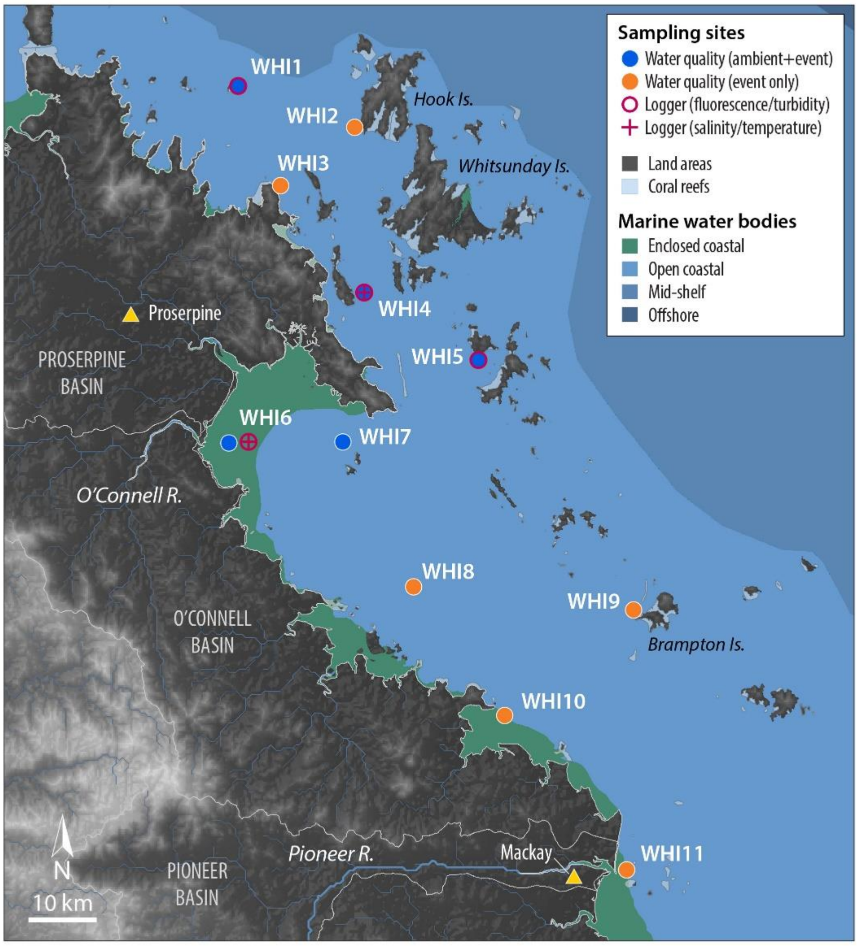


Figure 5-81: Sampling sites in the Mackay-Whitsunday focus region, shown with the water body boundaries.

Annual discharge for the Mackay-Whitsunday region in the 2024–25 water year was 2.5 times the long-term median levels (Figure 5-82).

The combined discharge and loads calculated for the 2024–25 water year from the Proserpine, O'Connell, Pioneer and Plane Basins (Figure 5-83) were in the higher range of values recorded over the past decade. Over the 19-year period between 2006–07 and the current water year:

- discharge ranged from 919 GL (2014–15) to 17,425 GL (2010–11)
- TSS loads ranged from 120 kt (2014–15) to 3,163 kt (2010–11)
- DIN loads ranged from 242 t (2014–15) to 3,814 t (2010–11)
- PN loads ranged from 356 t (2014–15) to 8,564 t (2010–11).

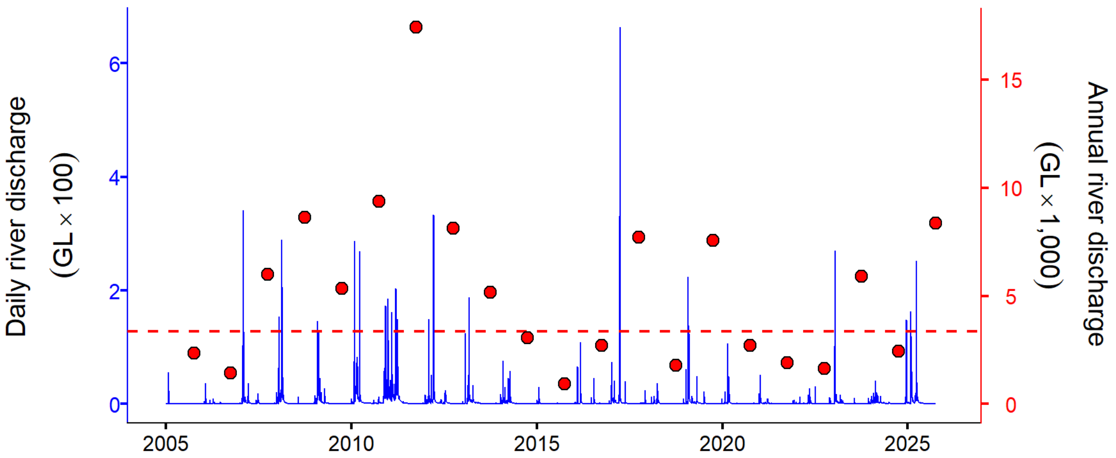


Figure 5-82: Combined discharge from rivers in the Mackay-Whitsunday region including the O'Connell (gauge 124001B – Stafford's Crossing), Andromache (gauge 124003A – Jochheims) and Pioneer (gauge 125016A – Dumbleton Weir T/W) Rivers and St. Helens (gauge 124002A – Calen), Sandy (gauge 126001A – Homebush) and Carmila (gauge 126003A – Carmila) Creeks. Daily (blue) and water year (1 October to 30 September, red) discharge is shown. Red dashed line represents the long-term median of the combined annual discharges. See Table 2-3 for a list of flow gauge data used. Please note as this is the combined discharge, high flows in one river will not necessarily be visible in the graph.

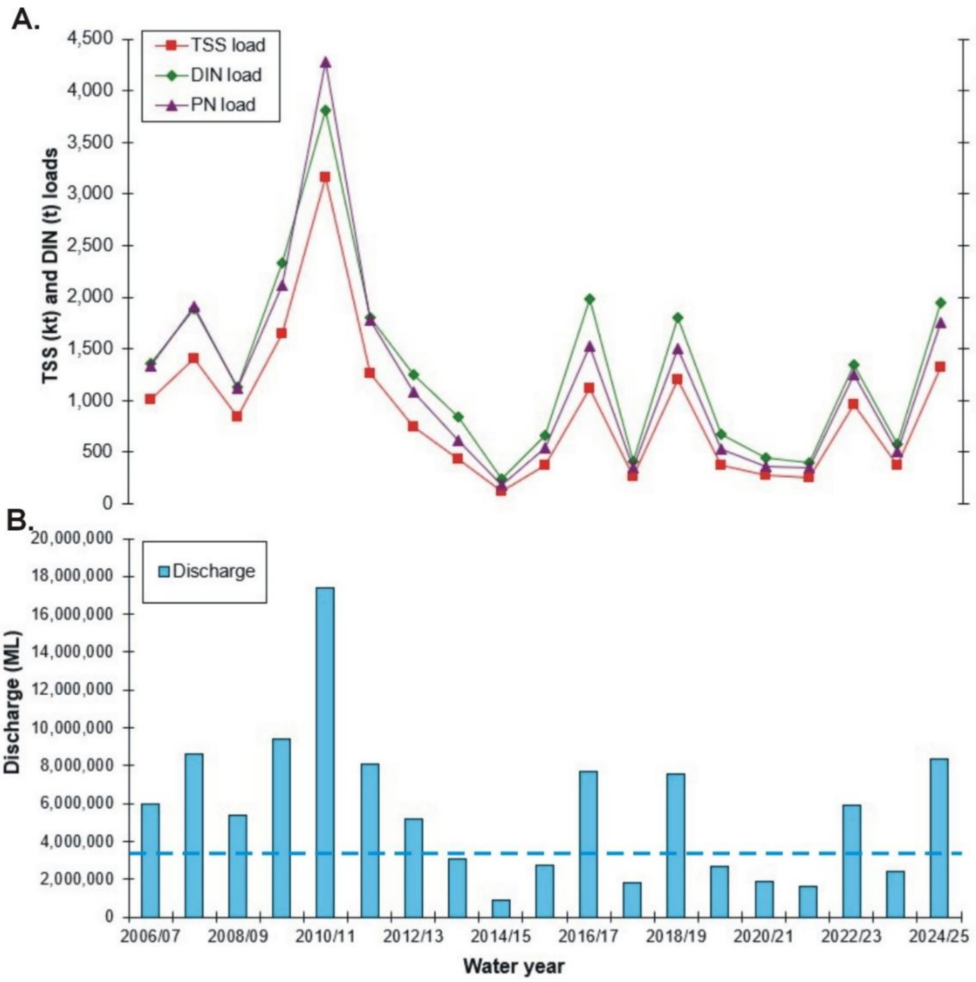


Figure 5-83: Loads of (A) TSS, DIN and PN and (B) discharge for the Proserpine, O'Connell, Pioneer, and Plane Basins from 2006 to 2025.The loads reported here are a combination of 'best estimates' for each basin based on 'up-scaled discharge data from gauging stations, monitoring data (O'Connell and Pioneer Rivers and Sandy Creek), and annual mean concentrations and discharge from monitoring data or Source Catchments modelling data. Dotted line represents the long-term median for basin discharge. Note the different scales on the 2 y-axes.

Ambient water quality and the in situ *Water Quality Index*

Water quality showed trends along the sampling transect (O'Connell River mouth to open coastal waters). The site located in the enclosed coastal water body (WHI6 O'Connell River mouth distance from river mouth = 0 km) had high concentrations of Chl-*a*, TSS, and particulate nutrients (PN and PP), which declined with distance away from the river mouth (Figure 5-84, Table C-2). Secchi depths were low at sites near the river mouth (water clarity was poor) and increased (water clarity improved) with distance from the river mouth. NO_x was variable across the transect. These spatial patterns are generally consistent with those that are typically observed in the region.

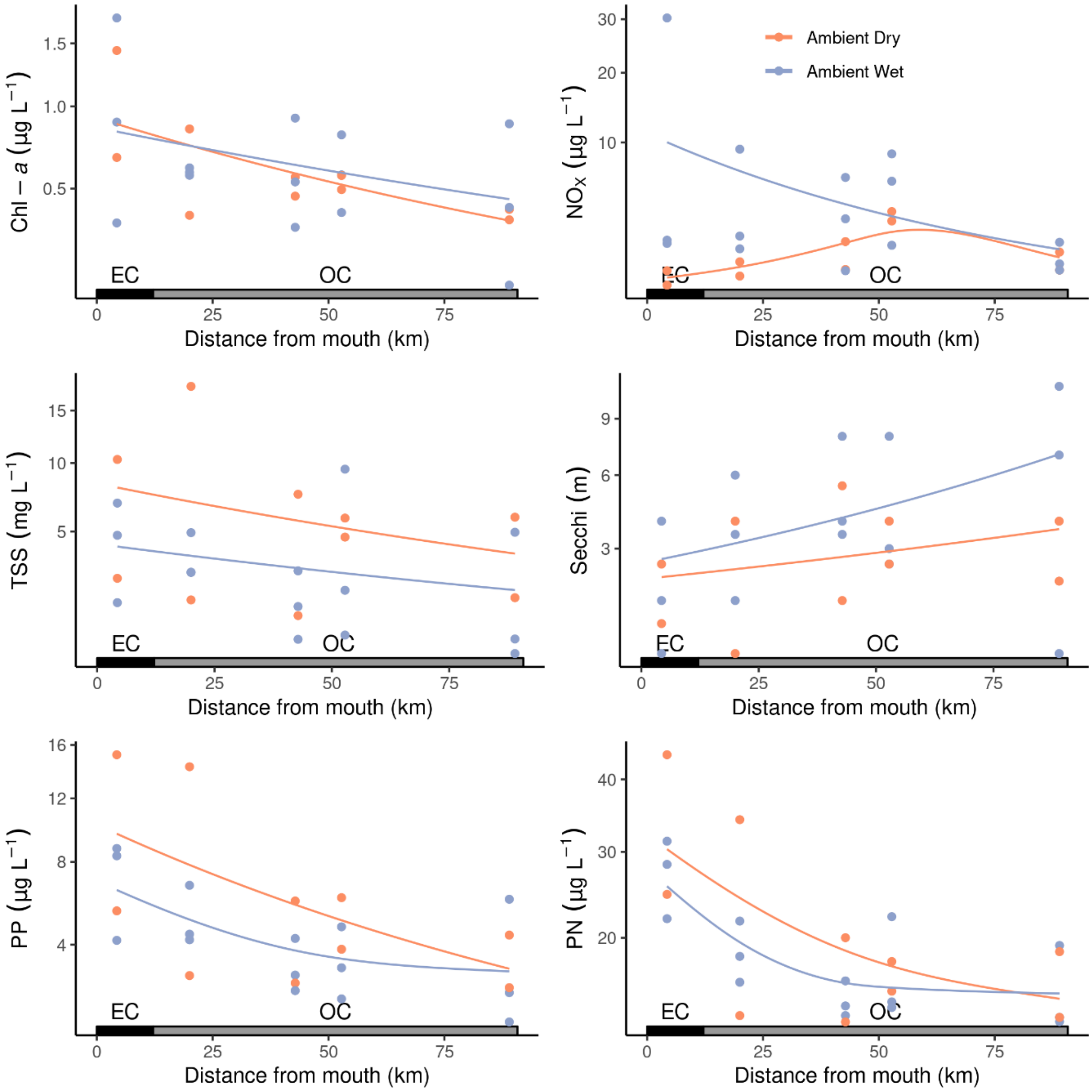


Figure 5-84: Water quality variables measured during ambient and event sampling in 2024–25 along the Mackay-Whitsunday focus region transect. Chlorophyll *a* (Chl-*a*), nitrate/nitrite (NO_x), total suspended solids (TSS), Secchi depth, particulate nitrogen (PN), and particulate phosphorus (PP) are shown with distance from the O'Connell River mouth. Water body classifications are shown along the x-axes: Enclosed coastal (EC) and open coastal (OC). Note the y-axes are logarithmic scales. Fitted lines are generalised additive models.

This year, some seasonal differences in NO_x, TSS, PN, PP, and Secchi depth were observed. During the wet season, concentrations of NO_x were high near the river mouth but converged with dry season concentrations at sites further away from the river mouth. TSS, PN, and PP showed greater concentrations (and Secchi depths showed reduced water clarity) during the dry season compared to the wet season, indicating that resuspension of previously-deposited material due to waves and tides may be particularly important in this focus region. Concentrations of Chl-*a* did not show seasonal differences along the transect (Figure 5-84).

Distinct long-term trends (since 2005) were observed in some water quality variables, while others showed little change (Figure 5-85). Site-specific statistics and comparison to GVs for all variables are available in Table C-1.

Secchi depth gradually decreased (i.e., water clarity worsened) over the period 2005–2017 (Figure 5-85b). Over the period 2017–2023, mean Secchi depth showed a slight increase (i.e., water clarity improved) which reversed again in 2024–25. Secchi depth has generally been below (did not meet) GVs since monitoring began in 2005, and Secchi depth in 2024–25 was below (did not meet) the local GVs at any of the 5 sites sampled.

Concentrations of TSS fluctuated above and below the GVs since monitoring began in 2005, although tended to be more stable than other focus regions (Figure 5-85c). Mean TSS reached a minima in the available data record around 2023 but increased (conditions deteriorated) during 2024–25. TSS in 2024–25 was above (did not meet) the local water quality GVs at 4 of the 5 sites sampled. This recent increase in TSS may be related to the large rainfall events in the Mackay-Whitsunday during the 2024–25 wet season.

Turbidity varied above the GVs since monitoring began in 2007 (Figure 5-85d). Over the period 2015–2025, turbidity slightly decreased, and trend analysis showed that levels in 2025 were significantly lower (improved) than in 2015. Turbidity in 2024–25 was above (did not meet) the GVs at 2 sites (WHI4, WHI5) of the 4 sites monitored (Table C-2).

Concentrations of NO_x were generally steady and well above (did not meet) the local GVs since ~2010 (Figure 5-85e). Over the period 2015–2025, mean concentration of NO_x decreased (conditions improved), driven predominantly by changes in recent years. NO_x in 2024–25 was above (did not meet) the local GVs at 3 of the 5 sites sampled.

Concentrations of PO_4 were variable and above (did not meet) the local GVs for the first ~10 years of the program (Figure 5-85f). Over the period ~2015–2025, mean concentration of PO_4 decreased (conditions improved) to a minima around 2021. Over the last 4 years, PO_4 again increased (conditions deteriorated). PO_4 in 2024–25 was above (did not meet) the local GVs at any of the 5 sites sampled.

Concentrations of PN were generally below (met) local GVs from 2005–2015 (Figure 5-85g). Over the period 2015–2025, mean PN concentration increased to a maxima around 2018 before decreasing to a minima around 2023. PN in 2024–25 was above (did not meet) the local GVs at 4 of the 5 sites sampled.

Concentrations of PP increased and were generally above (did not meet) local GVs from the period 2005–2017 (Figure 5-85h). Over the period 2017–2025, mean concentration of PP decreased (conditions improved) to a minima in around 2023, although PP concentration has again increased over the last 2 years. PP in 2024–25 was above (did not meet) the local GVs at 4 of the 5 sites sampled.

Concentrations of POC showed a large oscillation since monitoring began in 2005 (Figure 5-85i) and reached a minima in around 2023. Over the period 2015–2025, mean concentration of POC decreased (conditions improved), and trend analysis showed that concentrations in 2025 were significantly lower than concentrations in 2015. Concentrations of DOC increased over the period 2005–2017 but have stabilised in recent years (Figure 5-85j).

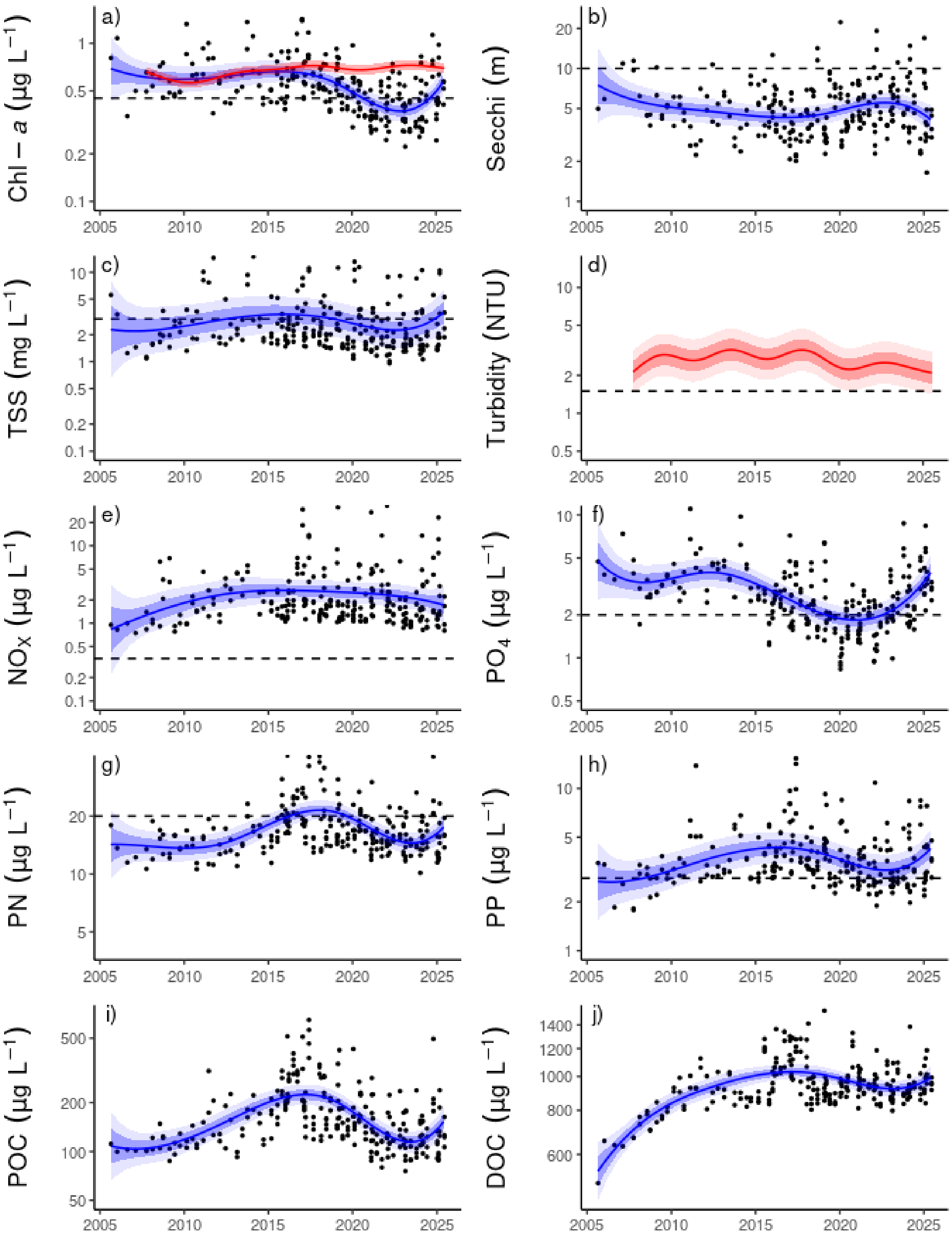


Figure 5-85: Temporal trends in water quality variables for the Mackay-Whitsunday focus region: a) chlorophyll *a* (Chl-*a*), b) Secchi depth, c) total suspended solids (TSS), d) turbidity, e) nitrate/nitrite (NO_x), f) phosphate (PO_4), g) particulate nitrogen (PN), h) particulate phosphorus (PP), i) particulate organic carbon (POC) and j) dissolved organic carbon (DOC). Generalised additive mixed effect models (trends) are represented by blue lines with shaded areas defining 95% confidence intervals of those trends and black dots represent observed data (depth weighted averages). These trends and data are accounting for the effects of seasons after applying x-z detrending. Trends of records from ECO FLNTUSB instruments are represented in red, and individual records can be found in Figure C-1. Dashed horizontal reference lines indicate annual guidelines for open coastal waters.

The WQ Index is calculated using 2 different formulations to communicate the a) long-term trend in water quality (based on the pre-2015 sampling design) and b) annual condition of water quality (based on the post-2015 sampling design, which increased the power to detect change). Section 2.1.5 and Appendix B contain details of the calculations for both Index formulations.

The long-term WQ Index showed a small (i.e., changed by a single grade) overall decline in water quality from period 2008–2017, driven by water clarity, PN, and PP indicators (Figure 5-86a). This trend then reversed (conditions improved) from 2017–24, driven by improvements in all indicators except NO_x. In 2024–25, water quality showed a trend of decline, which is the first time a decline has been measured since 2016 (Figure 5-86a).

The annual condition WQ Index scored water quality as 'moderate' or 'poor' since its inception (2015–present), with the 2024–25 year receiving a 'moderate' score (Figure 5-86b). The annual condition Index showed a general trend of improvement since 2015, but the 2024–25 monitoring year showed a marked decline (conditions deteriorated) in score driven by most indicators but particularly TSS and Chl-*a*. This deterioration was most likely driven by the large rainfall events in this region in 2024–25.

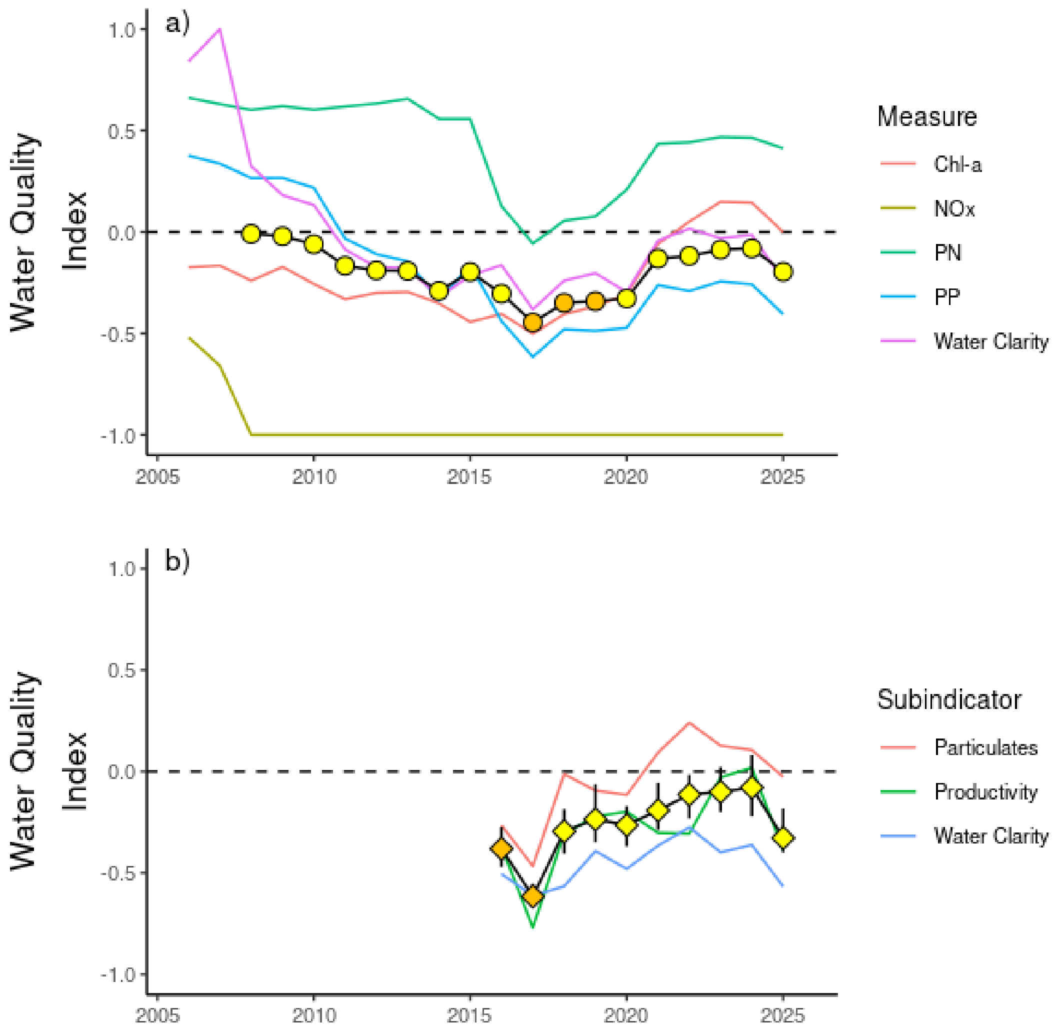


Figure 5-86: The Water Quality Index (WQ Index) for the Mackay-Whitsunday focus region. The WQ Index uses 2 formulations to communicate: a) long-term trend (based on pre-2015 sampling design) and b) the annual condition (based on post-2015 sampling design). WQ Index colour coding: ● / ◆– 'very good'; ● / ◆ – 'good'; ● / ◆ – 'moderate; ● / ◆ – 'poor'; ● / ◆ – 'very poor'. Indicators or sub-indicators that are used to calculate the WQ Index are shown as coloured lines on each plot. Error bars (vertical black lines) on the WQ Index represent the 95% quantile intervals. Calculations for both formulations are described in Appendix B.

Event water quality

No event sampling was conducted during the 2024–25 wet season in the Mackay-Whitsunday focus region.

5.5 Fitzroy region

Three sites were sampled in this focus region 3 times per year until the end of 2014. A five-year gap in monitoring occurred from 2014–2020. From 2020 onwards, 6 sites have been sampled in this focus region up to 10 times per year (Table A-1). The sites are located along a northerly transect from the Fitzroy River mouth to mid-shelf waters, representing a gradient in water quality. One site is in enclosed coastal waters, 4 sites are in open coastal waters, and one site is in mid-shelf waters (Figure 5-87).

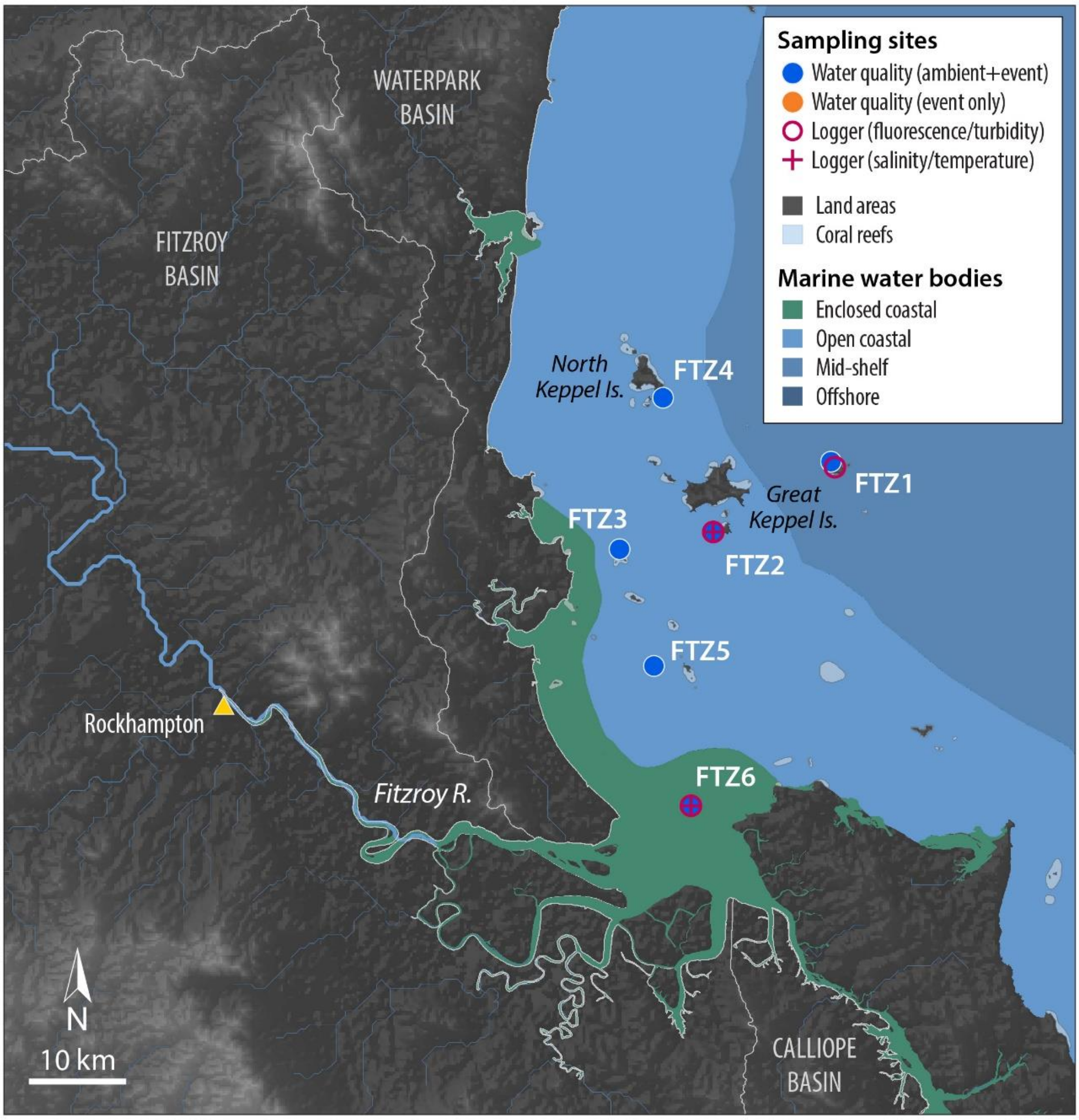


Figure 5-87: Sampling sites in the Fitzroy focus region, shown with the water body boundaries. Sites FTZ1–FTZ3 were monitored from 2005–2014 under the Marine Monitoring Program.

From 2008–2013, the Fitzroy NRM region experienced several years of intense flooding with annual discharge from the Fitzroy River exceeding the long-term median in 2008, 2010, 2011, 2012, and 2013 (Figure 5-88, Figure 3-5). In 4 of these years, the freshwater discharge was greater than 3 times the long-term median, with the 2011 flood event being the largest on record (Figure 5-89). Annual discharge of the Fitzroy River from 2014–2025 was generally close to or less than the long-term median (Figure 5-88).

Annual discharge for the Fitzroy Basin in the 2024–25 water year was just above the long-term median (Figure 5-89; Table 3-1). The combined discharge and loads calculated for the 2024–25 water year were around the long-term average. Over the 19-year period between 2006–07 and the current water year:

- discharge ranged from 437 GL (2020–21) to 41,736 GL (2010–11)
- TSS loads ranged from 16 kt (2013–14) to 7,000 kt (2010–11)
- DIN loads ranged from 74 t (2020–21) to 3,900 t (2010–11)
- PN loads ranged from 100 t (2020–21) to 17,000 t (2010–11).

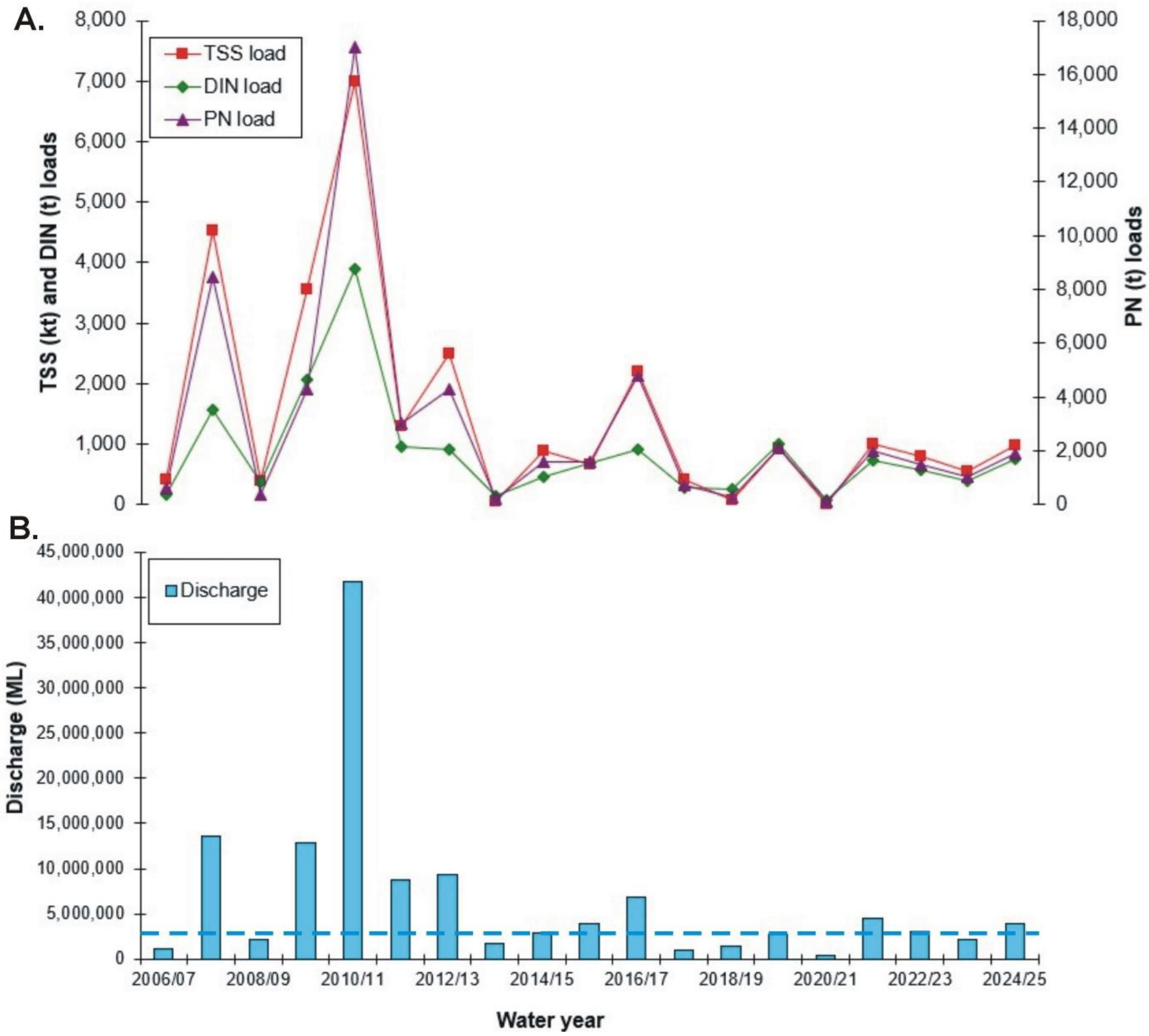


Figure 5-88: Loads of (A) TSS, DIN and PN and (B) discharge for the Fitzroy Basin from 2006 to 2025.The loads reported here are based on the monitoring data from the Fitzroy River as reported in the GBR Catchment Loads Monitoring Program with a long-term annual mean concentration of the existing data calculated to produce a load for the 2023–24 water year (where monitored load data have not yet been reported). Dotted line represents the long-term median for basin discharge. Note the different scales on the 2 y-axes.

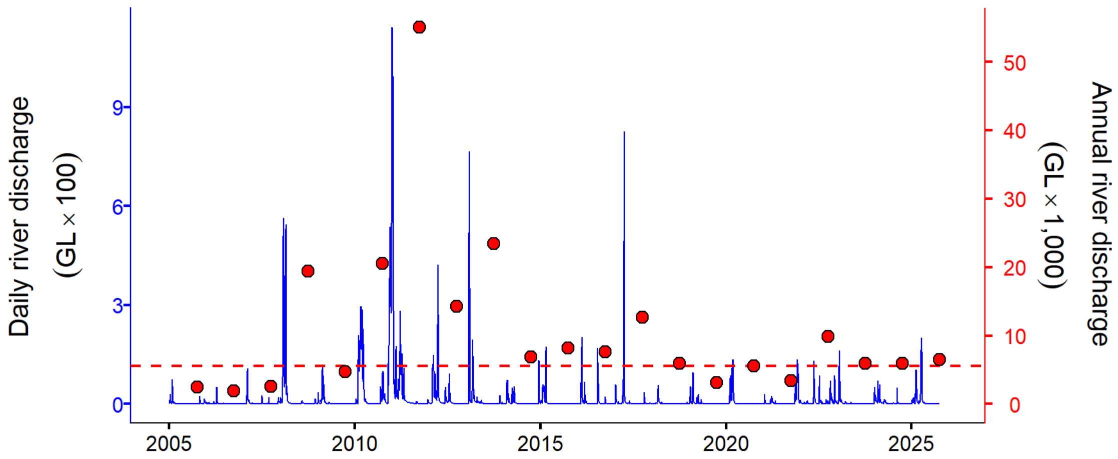


Figure 5-89: Total discharge from rivers in the Fitzroy region including the Fitzroy (gauge 130005A – The Gap) and Calliope (gauge 132001A – Castlehope) rivers and Waterpark creek (gauge 129001A – Byfield). Daily (blue) and water year (1 October to 30 September, red) discharge is shown. Red dashed line represents the long-term median annual discharge.

Ambient water quality and the in situ *Water Quality Index*

Water quality showed trends along the sampling transect (cross-shelf gradient in northerly direction). Sites located nearest to the river mouth (distance from river mouth = 0 km) had high concentrations of Chl-*a*, NO_x, TSS, and particulate nutrients (PN and PP), which declined with distance away from the river mouth, reaching low levels in mid-shelf waters (Figure 5-90). Secchi depths were low at sites near the river mouth (water clarity was poor) and increased (water clarity improved) with distance from the river mouth. These spatial patterns are generally consistent with those that are typically observed in the region.

Seasonal differences were not observed in any variables except NO_x. Concentrations of NO_x were greater during the wet season compared to the dry season at inshore sites (enclosed and open coastal), but seasonal differences disappeared at sites further offshore (mid-shelf) (Figure 5-90). The lack of seasonal differences is likely related to relatively low river discharge this year.

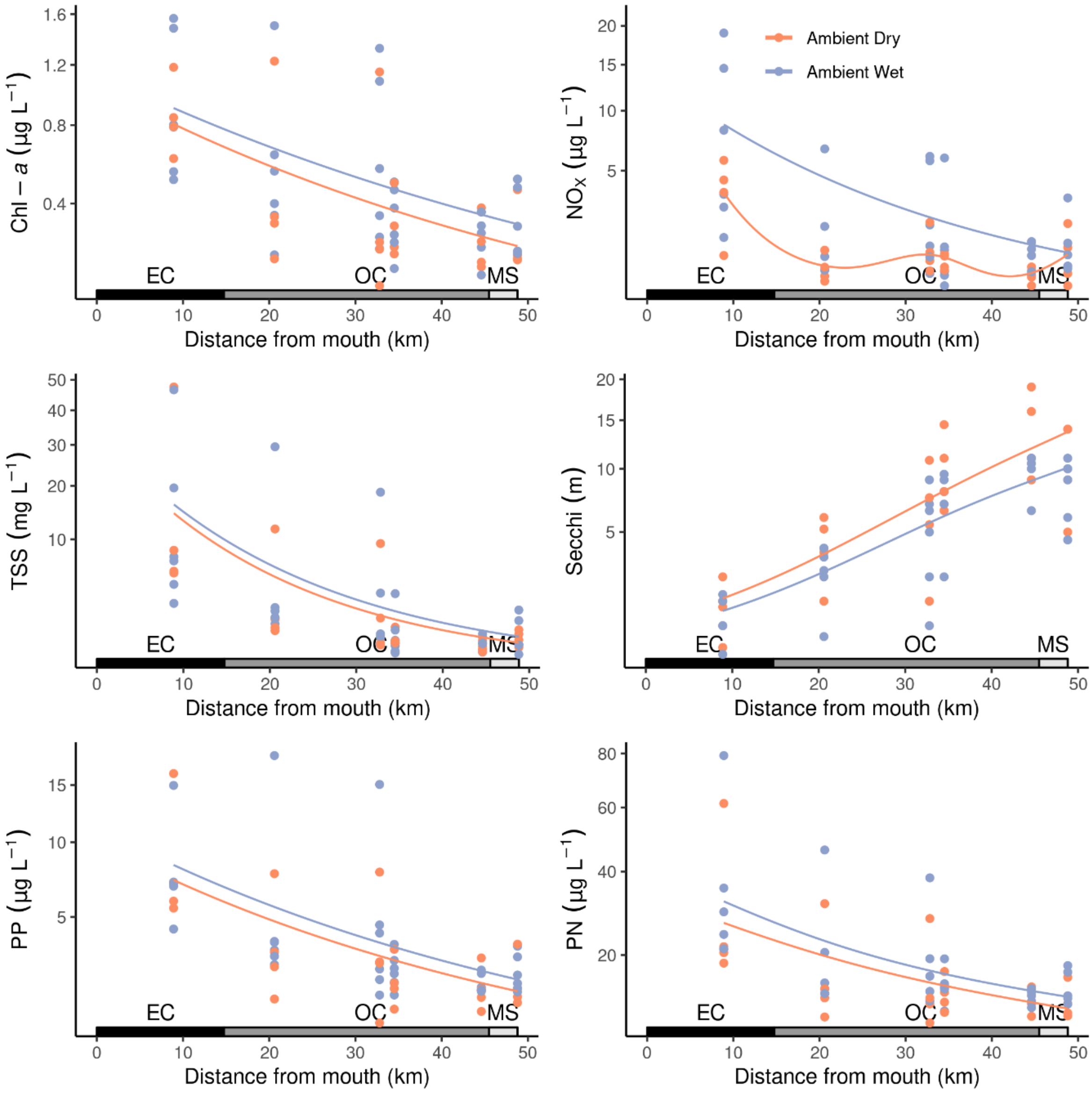


Figure 5-90: Water quality variables measured during ambient sampling in 2024–25 along the Fitzroy focus region transect. Chlorophyll *a* (Chl-*a*), nitrate/nitrite (NO_x), total suspended solids (TSS), Secchi depth, particulate nitrogen (PN), and particulate phosphorus (PP) are shown with distance from the Fitzroy River mouth. Water body classifications are shown along the x-axes: Enclosed coastal (EC), open coastal (OC) and mid-shelf (MS). Note the y-axes are logarithmic scales. Fitted lines are generalised additive models.

Long-term trends in the water quality variables are shown in Figure 5-91 and site-specific water quality results are presented in Table C-1. The gap in observational data between 2015 and 2020 limits the utility of the GAMMs in detecting long-term trends over this interval, so trends presented below should be considered preliminary until further data are collected.

Concentrations of Chl-*a* prior to 2015 were generally variable around the GVs (Figure 5-91a). Since 2020, mean concentration of Chl-*a* has slightly increased (conditions deteriorated) and is near GVs. Chl-*a* in 2024–25 was above (did not meet) the local GVs at 3 of the 6 sites sampled. Chlorophyll fluorescence measured by FLNTU instruments (Figure 5-91a) generally fluctuated above (did not meet) GVs since monitoring began in 2007 (Table C-2). The differences between FLNTU chlorophyll fluorescence and Chl-*a* concentration reflect differences in sampling location and frequency (e.g., FLNTUs are only present at a subset of sites and monitor year-round).

Secchi depth was generally stable and below (did not meet GVs) prior to 2015 (Figure 5-91b). Since 2020, mean Secchi depth showed a slight increase (i.e., water clarity improved), and levels are now approaching GVs. Secchi depth in 2024–25 was below (did not meet) the local GVs at 5 of the 6 sites sampled.

Concentrations of TSS prior to 2015 showed a slight decline (conditions improved) and were generally below (met) GVs (Figure 5-91c). Since 2020, mean concentration of TSS has been stable followed by a decline (conditions improved) over the last year. TSS in 2024–25 was above (did not meet) the local water quality GVs at 2 of the 6 sites sampled.

Turbidity varied above the GVs since monitoring began in 2007 (Figure 5-91d). Since 2020, turbidity has been relatively stable and exceeded (did not meet) GVs. Turbidity in 2024–25 was above (did not meet) the GVs at 2 sites (FTZ1, FTZ2) of the 3 sites monitored (Table C-2).

Concentrations of NO_x prior to 2015 showed a substantial increasing trend (conditions deteriorated) and were above (did not meet) GVs (Figure 5-91e). Since 2020, mean concentration of NO_x decreased (conditions improved) to a minima around 2024. NO_x in 2024–25 was above (did not meet) the local GVs at any of the 6 sites sampled.

Concentrations of PO_4 prior to 2015 reached around 2010 and showed a decreasing trend (conditions improved) over the following 5 years (Figure 5-91f). When monitoring resumed in 2020, PO_4 concentrations were well below 2015 levels and were below (met) local GVs. Since 2020, mean concentration of PO_4 again increased (conditions deteriorated) and concentrations are near GVs. PO_4 in 2024–25 was above (did not meet) the local GVs at 3 of the 6 sites sampled.

Concentrations of PN prior to 2015 were generally stable and below (met) local GVs (Figure 5-91g). Since 2015, mean PN concentration has continued to be relatively stable and similar to pre-2015 concentrations. PN in 2024–25 was above (did not meet) the local GVs at one of the 6 sites sampled.

Concentrations of PP prior to 2015 were generally stable and close to GVs (Figure 5-91h). Since 2015, mean concentration of PP remained relatively stable and close to GVs. PP in 2024–25 was above (did not meet) the local GVs at 2 of the 6 sites sampled.

Concentrations of POC declined since monitoring began in 2005 and are presently at the lowest levels measured (Figure 5-91i). Concentrations of DOC have fluctuated but show a generally increasing trend since monitoring began in 2005 (Figure 5-91j).

The WQ Index is calculated using 2 different formulations to communicate the a) long-term trend in water quality (based on the pre-2015 sampling design) and b) annual condition of water quality (based on the post-2015 sampling design, which increased the power to detect change). Section 2.1.5 and Appendix B contain details of the calculations for both Index formulations.

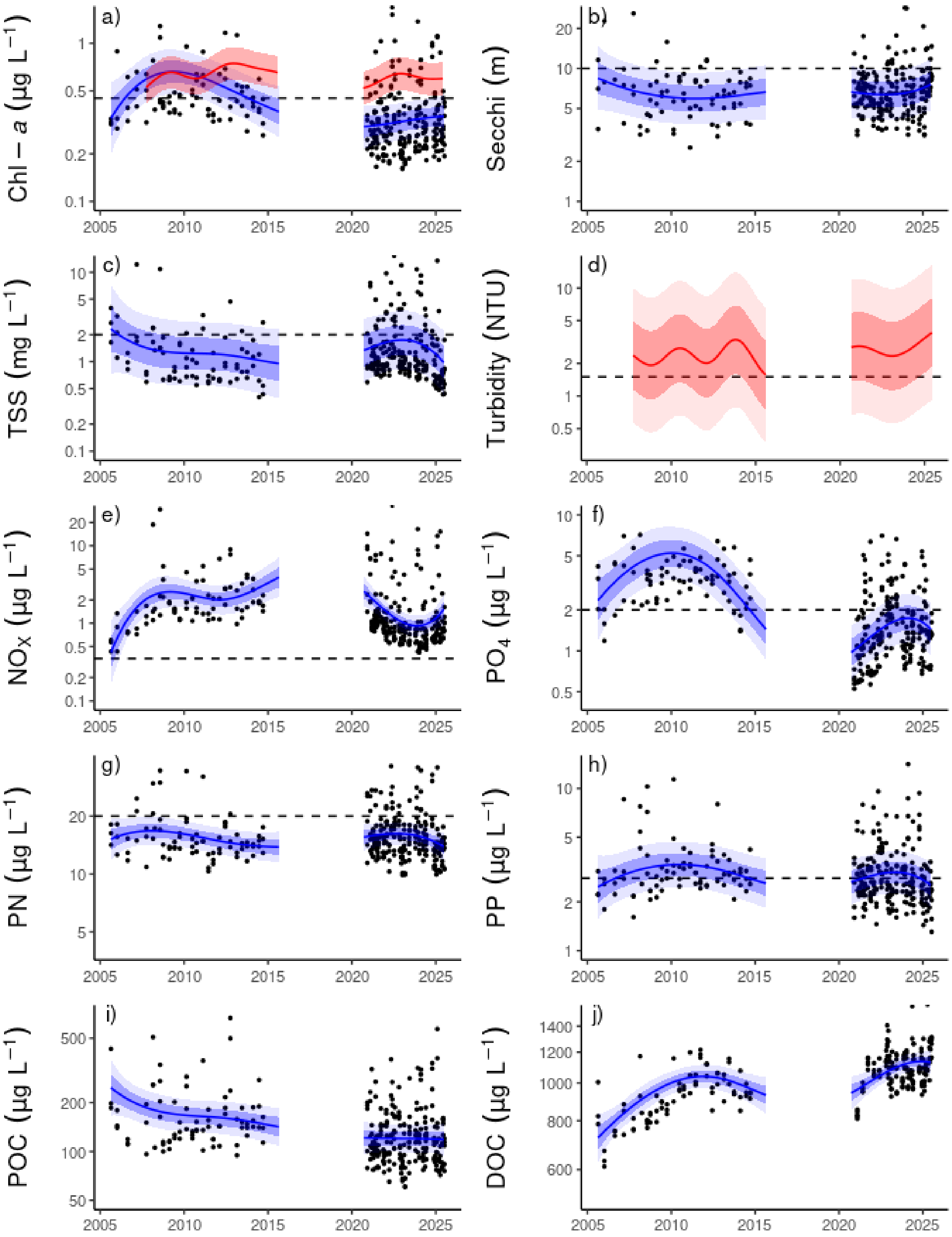


Figure 5-91: Temporal trends in water quality variables for the Fitzroy focus region: a) chlorophyll *a* (Chl-*a*), b) Secchi depth, c) total suspended solids (TSS), d) turbidity, e) nitrate/nitrite (NO_x), f) phosphate (PO_4), g) particulate nitrogen (PN), h) particulate phosphorus (PP), i) particulate organic carbon (POC) and j) dissolved organic carbon (DOC). Generalised additive mixed effect models (trends) are represented by blue lines with shaded areas defining 95% confidence intervals of those trends and black dots represent observed data (depth weighted averages). These trends and data are accounting for the effects of seasons after applying x-z detrending. Trends of records from ECO FLNTUSB instruments are represented in red, and individual records can be found in Figure C-1. Dashed horizontal reference lines indicate annual guidelines. A five-year gap in monitoring occurred from 2014–2020.

The long-term WQ Index showed a small (i.e., changing by a single grade) overall improvement in water quality from the period 2007–2015, driven by Chl-*a*, PN, and PP indicators (Figure 5-92a). Since monitoring resumed in 2020, the long-term WQ Index score has been relatively stable (Figure 5-92a).

The annual condition WQ Index scored water quality as ‘good’ since its inception (2020–present), with the 2024–25 year also receiving a ‘good’ score (Figure 5-92b). The Index has been relatively stable over the last 5 years of monitoring, likely due to near-median or below-median discharge in this region over the last 8 years.

It is important to note that the 2 versions of the WQ Index are designed to answer separate questions and therefore differences in scores between the versions are expected.

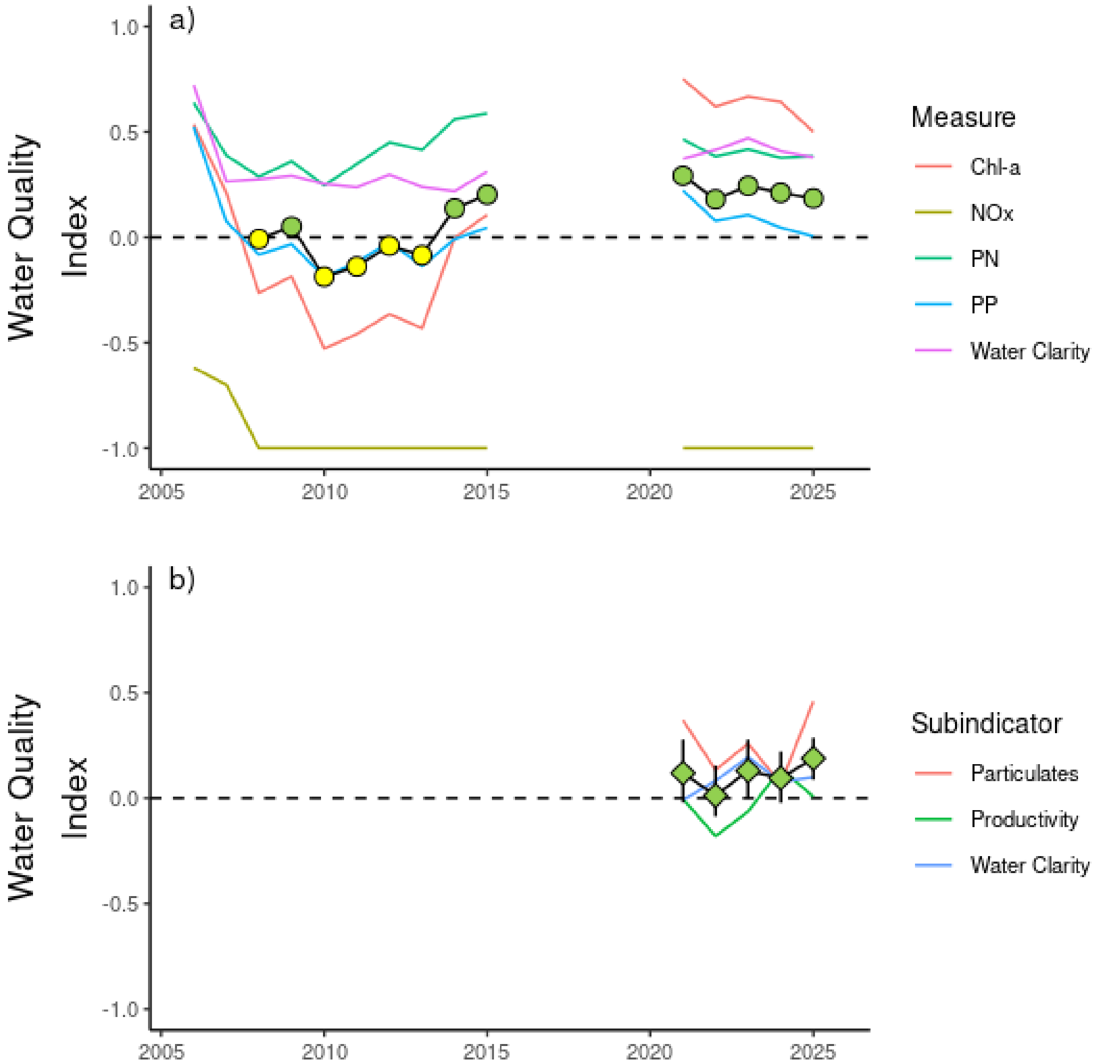


Figure 5-92: The Water Quality Index (WQ Index) for the Fitzroy focus region. The WQ Index uses 2 formulations to communicate: a) long-term trend (based on pre-2015 sampling design) and b) the annual condition (based on post-2015 sampling design). WQ Index colour coding: ● / ◆– ‘very good’; ● / ◆ – ‘good’; ● / ◆ – ‘moderate; ● / ◆ – ‘poor’; ● / ◆ – ‘very poor’. Indicators or sub-indicators that are used to calculate the WQ Index are shown as coloured lines. Error bars (vertical black lines) on the WQ Index represent the 95% quantile intervals. Calculations for both formulations are described in Methods and Appendix B. A five-year gap in monitoring occurred from 2014–2020.

6 ROUTINE PESTICIDE MONITORING

6.1 Passive sampler results

A total of 40 ED passive water samplers (including 4 duplicates) were successfully deployed and returned between November 2024 and May 2025 at 8 fixed sites along the inshore region (Figure 2-3, Table A-2). Two ED passive samplers were lost during deployment over the course of the sampling program (not shown). Duration of deployments varied between 14 and 44 days with variations due to marine conditions preventing access during some periods.

During the 2024–25 sampling period, a total of 17 out of 25 pesticides were detected in the Empore disk (ED) passive sampler extracts above the limits of reporting (LOR), with at least one pesticide detected in every sample (Table 6-1). A mixture of pesticides was detected in most samples, with only one sample (High Island, November) containing a single detected pesticide above limits of reporting. PSII herbicides were the most commonly detected group, indicative of pesticide runoff from agricultural land, such as sugarcane farms, with diuron frequency the highest (100% detection frequency), followed by hexazinone (97%) and atrazine (94%).

Total ∑pesticides concentrations at sites ranged from 0.28 ng L^{-1} for High Island (in November 2024) to 135 ng L^{-1} for Sandringham Bay (deployed during January and February 2025) (Figure 6-1). Four out of the 8 sites (High Island, Dunk Island, Flat Top, and Sandringham Bay) showed the highest pesticide loads were detected in January 2025. Ten of the 17 pesticides detected had highest concentrations in samples from Haughton River Mouth.

Table 6-1: Summary of chemical analytes detected in Empore disk (ED) passive samplers in 2024–25, number of detections across sites and deployment periods, percent (%) detection, and minimum and maximum concentrations observed.

Analyte	Number of Detects	% Detection	Min reported (ng L^{-1})	Max reported (ng L^{-1})
2,4-D	5	14	0.936	1.61
Ametryn	0	0	<LOR	<LOR
Atrazine	34	94	0.238	45.4
Atrazine desethyl	24	67	0.317	5.12
Atrazine desisopropyl	4	11	0.219	1.11
Bromacil	20	56	0.153	3.14
Diuron	36	100	0.284	47.1
Fluazifop	0	0	<LOR	<LOR
Fluometuron	0	0	<LOR	<LOR
Fluroxypyr	0	0	<LOR	<LOR
Haloxyfop	11	31	0.105	0.487
Hexazinone	35	97	0.308	25.8
Imazapic	0	0	<LOR	<LOR
Imidacloprid	25	69	0.228	56.1
MCPA	0	0	<LOR	<LOR
Metolachlor (S+R)	28	78	0.184	6.88
Metribuzin	9	25	0.288	6.62
Metsulfuron methyl	14	39	0.26	2.28
Prometryn	0	0	<LOR	<LOR
Propazine	1	3	0.378	0.378

Simazine	3	8	0.129	0.323
Tebuconazole	1	3	0.219	0.219
Tebuthiuron	24	67	0.15	11.9
Terbuthylazine	17	47	0.198	7.85
Terbutryn	0	0	<LOR	<LOR

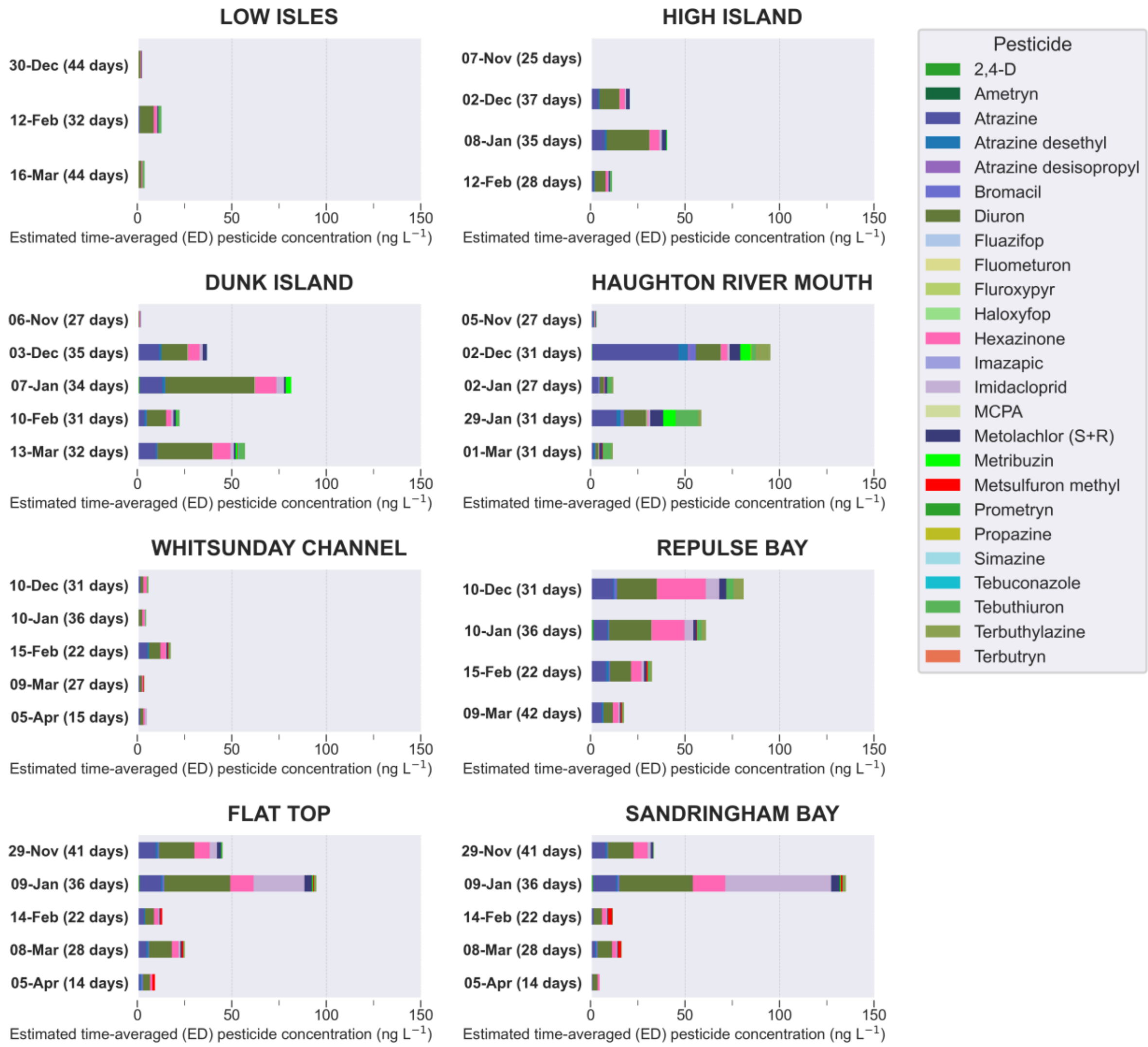


Figure 6-1: Total estimated concentrations (ng L^{-1}) of ΣPesticides at each routine site/deployment period derived from ED passive samplers. Dates correspond to the start of the deployment period, with total deployment length given in brackets

The 2024–25 results show higher detection frequencies and higher maximum pesticide concentrations compared to results from the 2023–24 monitoring period (Thompson *et. al.* 2025). General trends remain the same, with diuron, hexazinone and atrazine consistently the most frequently detected pesticides. Hexazinone, diuron, metolachlor, atrazine and imidacloprid show patterns of increasing concentrations at most of the studied sites (Figure 6-2) over the last 3 monitoring years. This agrees with previous work by Taucare *et. al.* (2022), who suggests that concentrations of PSII herbicides are increasing at some MMP sites, despite efforts to reduce pesticide runoff to the Reef.

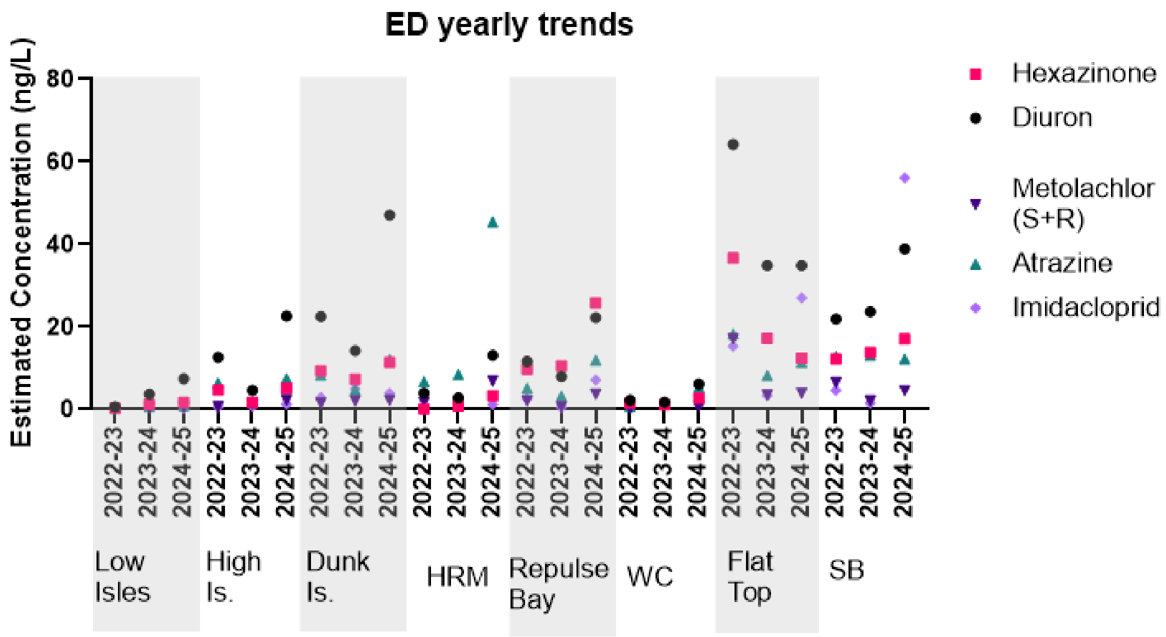


Figure 6-2: Maximum Empore Disk-derived estimated water concentrations of hexazinone, diuron, metolachlor, atrazine and imidacloprid for the monitoring years 2022–23, 2023–24 and 2024–25 at routine pesticide monitoring sites. HRM = Haughton River Mouth; WC = Whitsunday Channel; SB = Sandringham Bay

6.2 Grab sample results

A total of 45 grab samples were collected from the 8 fixed sampling sites between 1 November 2024 and 13 April 2025, with one final sample collected from Low Isles in August 2025. Additionally, 71 flood monitoring grab samples were collected from the Wet Tropics, Burdekin and Mackay-Whitsunday regions between 5–25 February 2025 (Figure 2-3, Table A-3). Grab samples included 9 duplicate samples across all sites.

Twenty pesticides were detected across all grab samples taken from the routine monitoring sites (Table 6-2 and Figure 6-3). The most frequently detected pesticides across sites were diuron (with 90% detection frequency), followed by atrazine (88%), hexazinone (76%), and metolachlor (71%), following similar detection patterns to the passive samplers. Diuron and atrazine were also found at the highest concentrations, with maximum concentrations of 79 ng L^{-1} and 39 ng L^{-1}, respectively. Three samples did not have any pesticides detected above the LOR (Dunk Island 6 November 2024, Haughton River Mouth 5 November 2024, and Low Isles 6 August 2025). The lowest reported concentration was ametryn (0.208 ng L^{-1}) at Flat Top. The total ∑pesticide concentrations at sites ranged from 0.296 ng L^{-1} for High Island (December 2024) to 173 ng L^{-1} for Dunk Island (February 2025) (Figure 6-3).

Pesticide concentrations detected in grab samples are not directly comparable to passive samplers, since grab samples represent a single point in time, whereas passive samplers provide an estimated water concentration that is averaged over the entire deployment period.

Samples taken during January and February 2025 showed the highest total pesticide concentrations at each site. As described above, additional samples were collected for analysis in the Tully focus region following high river discharge, and during the major events of the Herbert and Burdekin regions in February 2025. The results are also presented in Appendix C.

Table 6-2: Summary of chemical analytes detected in grab samples, number of detections across sites, percent (%) detection and minimum and maximum concentrations observed.

Analyte	Number of Detects	% Detection	Min reported (ng L^{-1})	Max reported (ng L^{-1})
2,4-D	26	62	0.495	17.5
Ametryn	5	12	0.208	0.384
Atrazine	37	88	0.379	39
Atrazine desethyl	20	48	0.361	4.71
Atrazine desisopropyl	13	31	0.552	2.05
Bromacil	12	29	0.462	3.89
Diuron	38	90	0.296	79
Fluazifop	0	0	<LOR	<LOR
Fluometuron	0	0	<LOR	<LOR
Fluroxypyr	6	14	0.914	1.83
Haloxyfop	6	14	0.335	1.35
Hexazinone	32	76	0.357	27.5
Imazapic	1	2	1.24	1.24
Imidacloprid	14	33	0.409	9.75
MCPA	12	29	0.605	3.52
Metolachlor (S+R)	30	71	0.311	4.03
Metribuzin	5	12	0.64	2.14
Metsulfuron methyl	5	12	0.558	0.699
Prometryn	0	0	<LOR	<LOR
Propazine	0	0	<LOR	<LOR
Simazine	3	7	0.302	0.494
Tebuconazole	2	5	0.378	0.459
Tebuthiuron	23	55	0.218	5.18
Terbuthylazine	13	31	0.426	6.68
Terbutryn	0	0	<LOR	<LOR

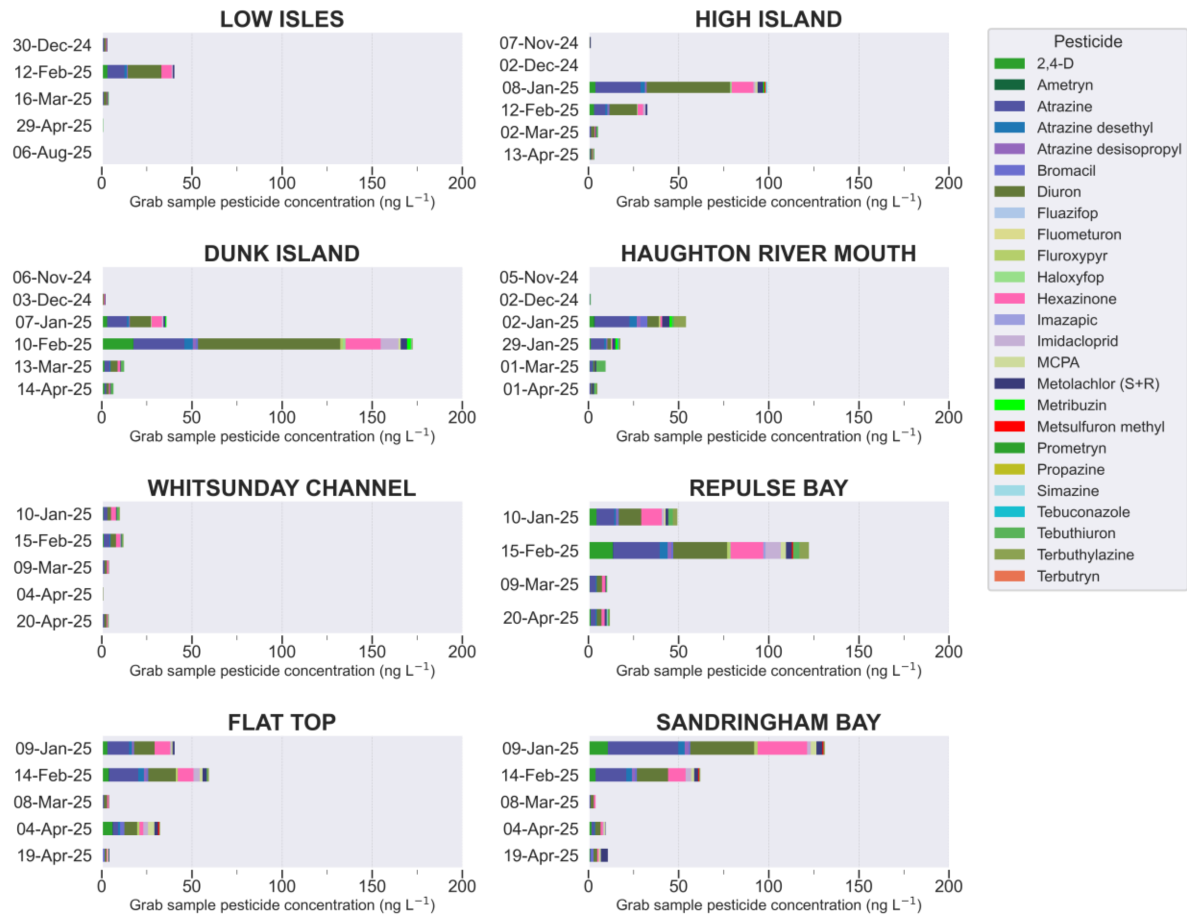


Figure 6-3: Water concentrations (ng L^{-1}) of ΣPesticides at each routine monitoring site derived from grab samples.

6.3 Comparison with species protection guideline values

Maximum concentrations from grab and passive samplers were compared with Australian Freshwater and Marine Species Protection Guidelines (ANZG 2018; Table 6-3). Guidelines are very limited for marine environments. Only diuron had 99% and 95% marine species protection guideline values available. For other chemicals, comparisons were made with freshwater guidelines where possible. Applying freshwater guidelines to marine systems introduces uncertainty due to potential differences in physiology and contaminant sensitivity between freshwater and marine species, as well as differences in water chemistry (e.g. salinity, ionic strength, organic carbon) which can alter contaminant bioavailability and toxicity (ANZG, 2018).

Metolachlor and tebuthiuron had instances that exceeded the 99% species protection guideline values in the flood event grab samples (Table 6-3, highlighted in pink). Metolachlor's 99% species protection value was exceeded 6 times in the event samples, at 3 Halifax sites (JCF405, JCF 407 and JCF408), as well as Pelorus (JCF400), Taylors Beach (JCF409) and a Burdekin site (JCF425). Tebuthiuron was found at levels above the 99% species protection threshold at 3 Burdekin event sites (JCF411, JCF425, and JCF430), all sampled on 15 February 2025. While metolachlor and tebuthiuron are commonly used agricultural herbicides in Reef catchments, including in sugarcane production and cattle-grazing, it is difficult to attribute specific observations from this program to specific source activities due to the remoteness of marine monitoring sites from potential sources.

Table 6-3: Summary of maximum herbicide concentrations detected at sites in passive and grab samples and how these compare to species protection guidelines (ANZECC 2000), where values were available. Pink shading indicates values in exceedance of guideline values.

	Grab samples	ED passive samplers	Flood monitoring grab samples	ANZECC & ARMCANZ Guidelines (updated 2025) (ng/L)	
Analyte	**Max reported (ng/L)**	**Max reported (ng/L)**	**Max reported (ng/L)**	**99% Species Protection**	**95% Species Protection**
2,4-D	17.5	1.61	47.7	140000	280000
Ametryn	0.384	<LOR	5.09	17	100
Atrazine	39	45.4	79.2	700	13000
Atrazine desethyl	4.71	5.12	8.31		
Atrazine desisopropyl	2.05	1.11	3.47		
Bromacil	3.89	3.14	6.79		
Diuron	79	47.1	223	270*	590*
Fluazifop	<LOR	<LOR	0		
Fluometuron	<LOR	<LOR	0		
Fluroxypyr	1.83	<LOR	2.12		
Haloxyfop	1.35	0.487	2.21		
Hexazinone	27.5	25.8	37		
Imazapic	1.24	<LOR	0		
Imidacloprid	9.75	56.1	51.7		
MCPA	3.52	<LOR	4.74	3000	7700
Metolachlor (S+R)	4.03	6.88	9.17	8.4	460
Metribuzin	2.14	6.62	9.63		
Metsulfuron methyl	0.699	2.28	1.3	3.7	18
Prometryn	<LOR	<LOR	0		
Propazine	<LOR	0.378	0.504		
Simazine	0.494	0.323	2.77	6100	12000
Tebuconazole	0.459	0.219	1.31		
Tebuthiuron	5.18	11.9	101	20	2200
Terbuthylazine	6.68	7.85	7.64		
Terbutryn	<LOR	<LOR	<LOR		

*Diuron guideline values are for marine waters. All other guidelines are based on freshwater.

6.4 Pesticide Risk Metric

A limitation of solely comparing water concentration estimates with guideline values, is that this method only considers individual pesticide risk. However, both grab and passive samplers show that pesticides are more commonly found in mixtures. The Reef 2050 WQIP has moved away from a target to reduce end-of-catchment pesticide loads, to a new target of protecting at least 99% of aquatic species at the end-of-catchments by 2025. To that end, mixture toxicity must be assessed to improve risk measurement accuracy.

Overall, passive sampler risk was low; however, 3 sites surpassed the 1% species affected threshold (Haughton River Mouth December 2024, Sandringham Bay January 2025, and Flat Top January 2025 Figure 6-4). 'Other' (non-PSII) herbicides were mostly influencing the PRM results for the passive samplers, with small input from PSII herbicides. Insecticides did not influence the PRM scores significantly, except at Sandringham Bay (January) and Flat Top (January), which had high levels of imidacloprid compared to the other sites. Samplers from Whitsunday Channel had the lowest percentage of species affected, with less than 0.01% species estimated to be affected in samples from December 2024, January 2025 and April

2025. Since passive samplers represent average concentrations over time, these results indicate low level chronic exposure to pesticides.

From the same sites grab samples generally showed similar pesticide risk to the passive samplers, with the exception of Dunk Island, which had a calculated PRM of 2.5% species affected for the 10 February 2025 grab sample (Figure 6-5). There were 9 instances across 5 sites (Dunk Island, High Island, Repulse Bay, Sandringham Bay and Flat Top) where the PRM exceeded 1% species affected, and thus did not meet the Reef 2050 WQIP target of 99% species protected. Grab samples represent acute exposure to pesticides and can capture brief spikes in pesticide levels, which explains the higher frequency of PRM exceedances in grabs compared to the passive samplers.

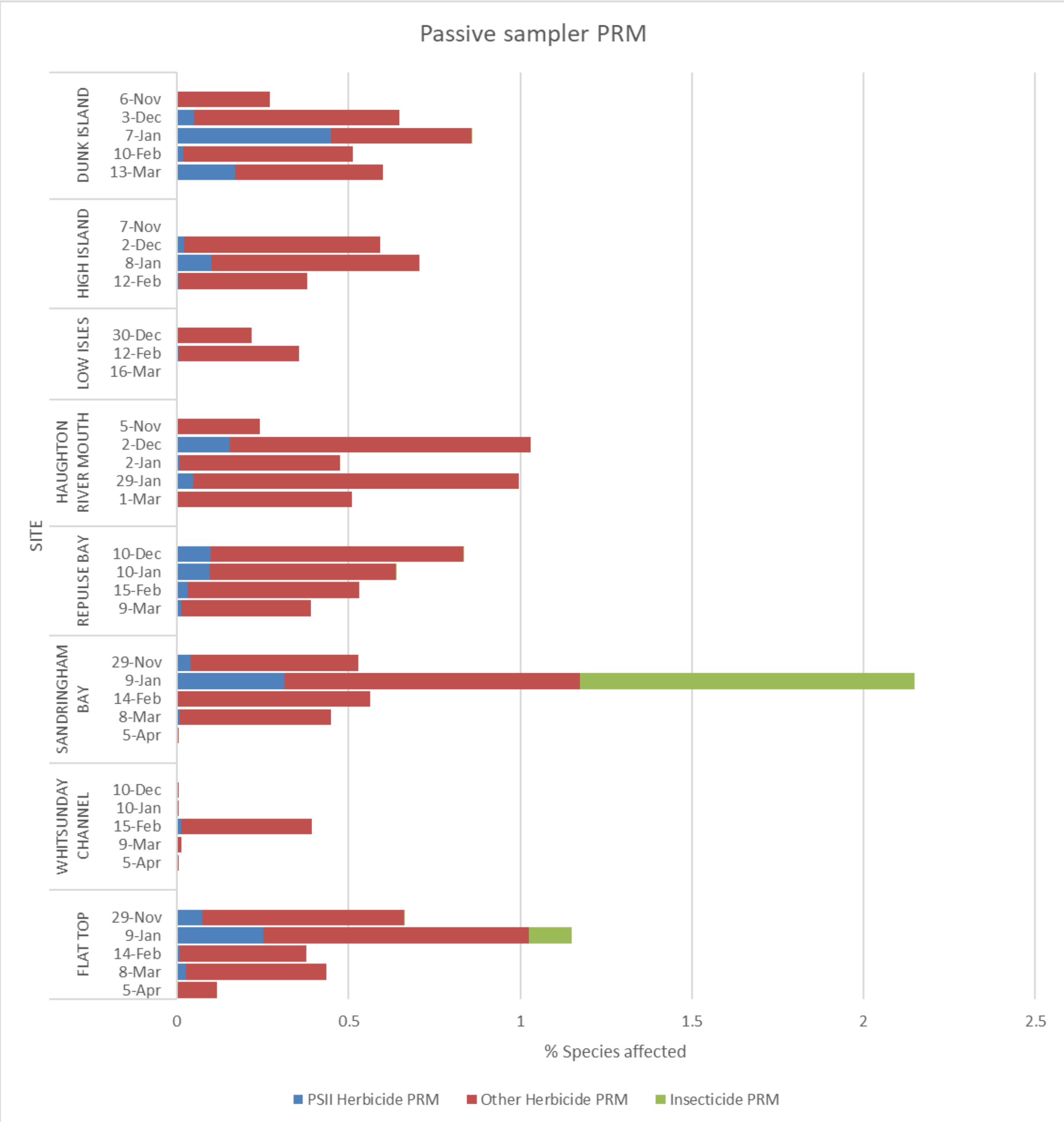


Figure 6-4: Estimated % species affected by pesticides calculated from water concentrations derived from Empore disk (ED) passive samplers at the MMP routine pesticide monitoring sites 2024–25. Pesticide risk is grouped for PSII herbicides, other herbicides and insecticides. Dates correspond to the start of the sampling period.

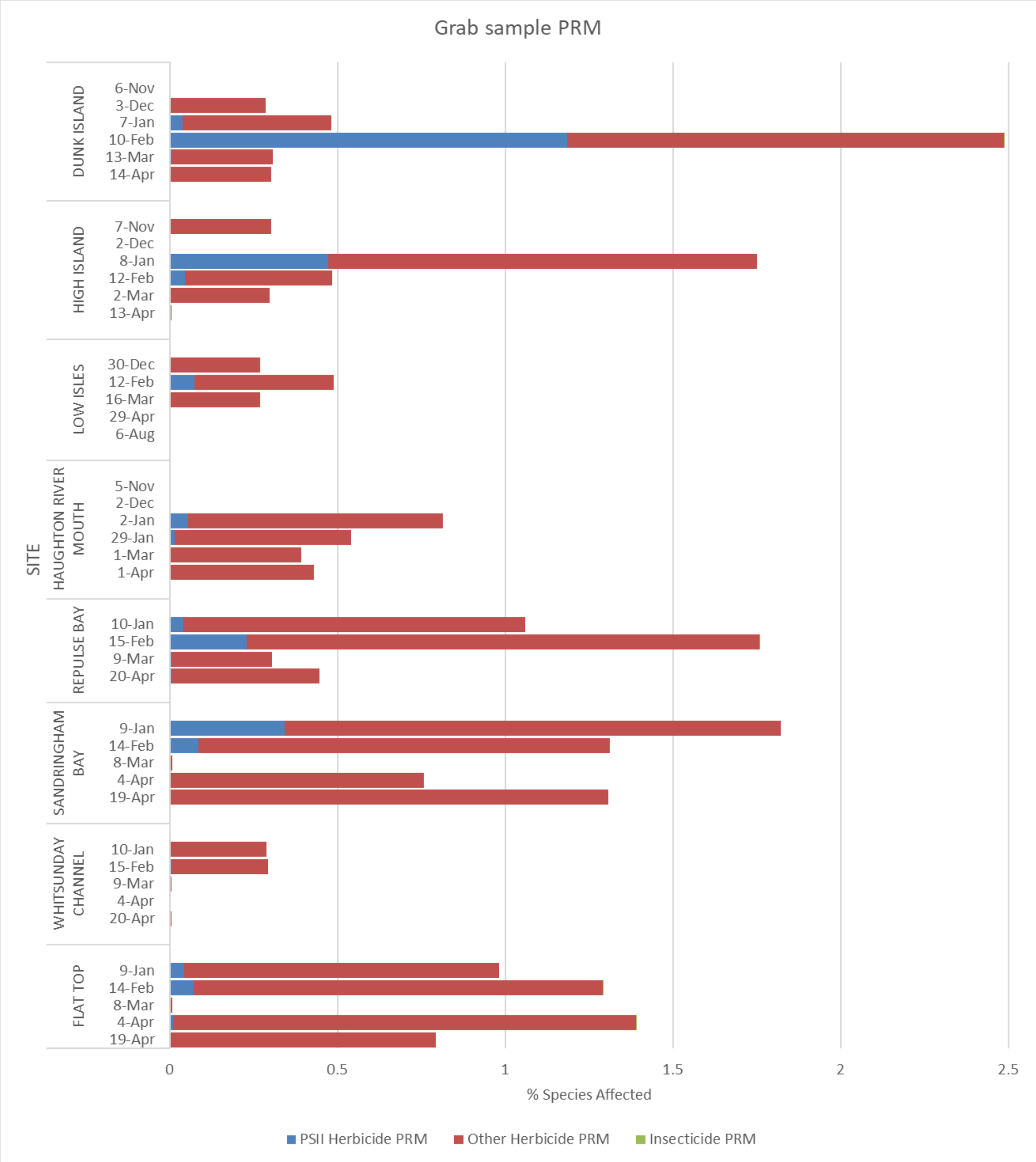


Figure 6-5: Estimated % species affected by PSII herbicides, other herbicides and insecticides calculated from water concentrations derived from grab samples collected at routine monitoring sites 2024–25. Pesticide risk is grouped for PSII herbicides, other herbicides and insecticides.

6.5 Pesticide Summary

Twenty-one different pesticides were detected across both passive and grab samples during the 2024–25 wet season between November 2024 and May 2025. Concentrations of single pesticides ranged from 0.105 ng L^{-1} (haloxyfop) to 56 ng L^{-1} (imidacloprid), although most samples showed the presence of pesticide mixtures. The most frequently detected pesticides across both passive samplers and grab samples were diuron, atrazine, hexazinone and metolachlor, with diuron detected in 100% of the passive samplers, consistent with previous years. Ametryn, fluroxypyr, imazapic, and MCPA were detected in grab samples but not passives, whereas propazine was detected in passive samplers but not grabs, highlighting the complementary nature of the 2 sampling methods.

The total ∑pesticide concentrations observed at sites ranged from 0.28 ng L^{-1} for High Island (in November 2024) to 135 ng L^{-1} for Sandringham Bay (January/February 2025) in passive samplers, and from 0.296 ng L^{-1} (High Island, December 2024) to 173 ng L^{-1} (Dunk Island, February 2025) in grab samples. Grab samples taken during January and February 2025 had typically higher pesticide concentrations compared to the other sampling months.

Metolachlor, a chloroacetanilide herbicide used commonly to control broadleaf weeds, and tebuthiuron, a urea herbicide that inhibits photosynthesis, were both found in event grab samples above the 99% Australian freshwater species protection guidelines. The pesticide risk metric, used to assess toxicity of pesticide mixtures, may be more relevant than comparing single pesticides against guideline values. In general, the calculated PRM for passive sampler extracts was low, with 3 samples exceeding the 1% species affected threshold, with a maximum of 2.1% species affected at Sandringham Bay. Grab samples, representing acute pesticide exposure, exceeded the 1% affected species threshold in 9 instances across 5 sites.

Three sites were monitored in the Wet Tropics region. Low Isles typically had the lowest pesticide concentrations in both passive and grab samples. The Dunk Island grab sample taken 10 February 2025 had the highest total ∑pesticide concentration (173 ng L^{-1}) out of all routine grab samples taken during the 2024–25 sampling campaign. Dunk Island also had the highest ED total ∑pesticide concentration in the region (81 ng L^{-1}, January 2025), and the highest diuron concentration across all sites (47 ng L^{-1}).

Haughton River Mouth was the sole site sampled in the Burdekin region during the 2024–25 wet season. The December and February passive samplers had the highest individual pesticide concentrations for 10 of the 17 pesticides detected across all sites (atrazine, atrazine desethyl, atrazine desisopropyl, bromacil, propazine and terbuthylazine in December; haloxyfop, metolachlor, metribuzin and tebuthiuron in February). The highest total ∑pesticide concentrations observed at the site were 95 ng L^{-1} in the December 2024 passive sampler and 54 ng L^{-1} in the grab sample taken 2 January 2025.

In the Mackay-Whitsunday region, grab and passive samplers from Whitsunday Channel had the lowest pesticide concentrations detected compared to the other 3 sites monitored in the region (Sandringham Bay, Repulse Bay, and Flat Top). The grab sample taken from Sandringham Bay 9 January 2025, and the ED passive sampler deployed there on the same day, both had the highest total ∑pesticide concentrations observed in the region (131 ng L^{-1} in grab sample and 135 ng L^{-1} in passive sampler). The January Sandringham Bay ED also had the highest calculated PRM of 2.1% species affected, strongly influenced by the relatively high levels of imidacloprid.

7 CONCLUSIONS

In 2024–25, the overall Reef catchment area had discharge of 1.9 times the long-term median, the largest discharge since the extreme 2010–11 water year. On a regional basis, the Burdekin and Burnett Mary NRM regions had discharge much higher than their respective long-term medians (6.8 and 3.4 times, respectively). The Mackay-Whitsunday and Wet Tropics NRM regions also had discharge above their respective long-term medians (2.8 and 1.6 times, respectively) and the Cape York and Fitzroy NRM regions were just above their long-term medians (1.4 and 1.2 times, respectively).

There were no cyclones which affected the Reef during 2024–25. This likely contributed to patterns seen in the long-term and annual condition WQ Index scores as well as the patterns observed from remote sensing products (Table 7-1) for the Wet Topics region.

In 2024–25, the long-term WQ Index showed trends of stability or deterioration in water quality in all regions where this score is able to be generated. The annual condition WQ Index scored water quality as either ‘good’ or ‘moderate’ in all focus regions in 2024–25. The Wet Tropics annual condition WQ Index deteriorated overall from ‘good’ in 2023–24 to ‘moderate’ in 2024–25 and Mackay-Whitsunday region showed deterioration but remains within the ‘moderate’ grade. These patterns are likely a result of high discharge in the 2024–25 (and 2023–24 in the case of the Wet Tropics) water year. Burdekin and Fitzroy regions showed stability, while Cape York showed a slight improvement, returning to a ‘good’ score after deteriorating to ‘moderate’ Index scores in 2023–24 resulting from Cyclone Jasper.

Trend analysis based on the previous 10 years of monitoring data (presented in the GAMMs) indicated that most water quality indicators were showing signs of stability in the focus regions. Some significant trends of deterioration were found for PN (all Wet Tropics focus regions), PO_4 (Barron-Daintree, Russell-Mulgrave, and Burdekin focus regions), PP (Russell-Mulgrave focus region), and turbidity (Burdekin region). Some significant trends of improvement were found for NO_x (Tully and Burdekin focus regions) and turbidity (Mackay-Whitsunday region) despite a series of flood events in these regions. Similar to the previous year, the Mackay-Whitsunday region showed trends of stability or improvement in all water quality indicators since 2015.

In 2024–25, no indicators met guideline values (GVs) in every focus region. TSS met GVs in all focus regions except Mackay-Whitsunday. Chl-*a*, PN, and PP met GVs in 6 of the 10 focus regions studied. NO_x met GVs in 2 of the 10 focus regions studied (Stewart and Normanby in Cape York) and was stable or improving in all focus regions; NO_x remains well above GVs in most regions and continued improvement is needed before GVs may be met. Turbidity and Secchi depth did not meet GVs in any focus region studied.

Results from the 2024–25 water year presented in this report demonstrate the close relationship between inshore water quality, interannual rainfall patterns, and coastal oceanographic drivers. Two consecutive years of above-median river discharge in many Reef regions led to deteriorating water quality conditions in the Wet Tropics and Mackay-Whitsunday regions and stable water quality conditions in the Burdekin and Fitzroy regions. The relationship between river discharge, oceanographic drivers, and coastal water quality is complex and is confounded by large interannual and decadal rainfall variability in tropical catchments. Progress of catchment management practice adoption is incremental and slow response timeframes are expected between land-based changes and marine water quality. Episodic disturbance events such as cyclones and major floods reduce coastal water quality, which then improves during drier periods. It is therefore important to understand that catchment load reductions cannot be expected to result in a linear improvement in inshore water quality. Rather, reduced loads of sediment and nutrients from catchments will lower the overall sediment/nutrient inputs into the Reef and allow long-term improvement of coastal water quality to improve more quickly following disturbance events. Trends in load reductions from the Great Barrier Reef Catchment Loads Monitoring Program (Water Quality &

Investigations, 2024a) are an important line of evidence that need to be established before trends in inshore water quality could be conclusively related to catchment practices, and this work is currently underway through inter-agency collaborations. Further research is needed to distinguish oceanographic and climatic drivers of observed water quality trends and to predict how climate change will impact coastal water quality in the Reef. Climate change is predicted to cause less frequent but more severe cyclones and more intense short-duration rainfall events in Reef catchments (CSIRO and Bureau of Meteorology 2024), which may alter the transport of catchment-derived sediment and nutrients into the coastal ocean.

Twenty-one different pesticides were detected across passive samplers and grab samples in the Wet Tropics, Burdekin and Mackay Whitsunday regions from November 2024 to May 2025. Most samples contained pesticide mixtures, with diuron, atrazine, hexazinone, and metolachlor being the most frequently detected; diuron was detected in all passive samplers. Total pesticide concentrations varied widely across sites and across the wet season, with samples collected during January and February, coinciding with the periods of peak river discharge, typically showing the highest concentrations. Notably, Dunk Island, in the Tully focus region, recorded the highest grab sample concentration in February 2025, while Sandringham Bay in the Mackay Whitsunday focus region had the highest passive sample concentration in January/February 2025. Metolachlor and tebuthiuron exceeded the 99% Australian freshwater species protection guidelines in event-based grab samples, with exceedances recorded during floods in the Herbert River (Halifax Bay and Palm Island group) and Burdekin River, respectively. The Pesticide Risk Metric (PRM), which assesses mixture toxicity, showed low risk in most passive samplers, but exceeded the 1% species affected threshold in 9 grab samples across 5 sites in the high discharge period from the Tully, Herbert and Burdekin Rivers. Regional patterns were evident, with the Low Isles sites in the Wet Tropics reporting consistently low concentrations, while Dunk Island and Sandringham Bay had the highest concentrations. In the Burdekin region, the Haughton River Mouth passive samplers recorded the highest individual pesticide concentrations detected in passive samplers for 10 pesticides. Within the Mackay-Whitsunday region, grab and passive samplers from Whitsunday Channel had the lowest concentrations in the Region, compared to Sandringham Bay, Repulse Bay, and Flat Top whereas Sandringham Bay had the highest concentrations and Pesticide Risk Metric (2.1% of species affected), driven by elevated imidacloprid levels.

Several program improvements to pesticide monitoring would enhance our understanding of pesticide behaviour in the inshore Reef. Extending the monitoring period into the dry season would provide further assessment of baseline concentrations of pesticides when not influenced by rainfall, allowing for a more comparable temporal assessment of pesticide concentrations. It may further inform longer term persistence of pesticides at the sites investigated. Sampling locations further upstream, especially during the wet season, and/or correlating with existing data from upstream sampling (e.g., DETSI monitoring programs), may help elucidate the more dominant concentration inputs to the system. In future reporting, continuing to assess data using the PRM approach would be more representative of chemical mixtures present in the catchment and provide a more robust benchmark against the target stipulated in the Reef 2050 WQIP. Finally, inclusion of additional pesticides and chemicals of concern (above the 25 currently included in the program) would better represent mixture toxicity effects, especially when considering the PRM approach.

The main findings for each NRM region are highlighted below and the results are separated into ambient (routine sampling during wet and dry seasons) and event-based monitoring (sampling during flood events). Table 7-1 provides a high-level summary by NRM region.

In conclusion, the inshore water quality component of the Marine Monitoring Program continues to provide a high value, long-term dataset to inform management of the Reef. The multiple lines of evidence utilised in the Program include *in situ* water chemistry sample collection, *in situ* water quality time-series' from dataloggers, remote sensing analysis, and marine modelling, which all assist in providing a high degree of confidence in the interpretation of the results. The Program's outputs have a wide application across scientific, management, government, and public audiences. Findings from the Marine Monitoring Program were used extensively in the recent update of the 2022 Scientific Consensus Statement (Waterhouse *et al.*, 2024), the Great Barrier Reef Outlook Report 2024 (Great Barrier Reef Marine Park Authority, 2024), the updated Reef Spatial Management Prioritisation (Waterhouse et al., 2025), the review of the Reef water quality targets, and continue to be used in the Regional Report Cards. The Marine Monitoring Program measurements are the main *in situ* chemistry validation dataset for the eReefs Biogeochemical Model suite (a core tool for management and decision-making for the Reef), which provides confidence in model outputs and improvements over time. Continuation of the Marine Monitoring Program and strengthening of linkages with other Paddock to Reef components will further enhance the value of long-term monitoring efforts of the Reef.

Table 7-1: Summary of results for some of the primary indicators measured in the MMP Inshore Water Quality program, 2024–25. River discharge colour scheme: <1.5 times long-term median, 1.5–2 times long-term median, and >2 times long-term median. *Arrows indicate difference relative to long-term patterns: [→] area exposed in 2024–25 similar (difference ≤ 5%) to long-term patterns, [↘] decrease in area exposed (difference > 5%), [↗] increase in area exposed (difference >5 %), [coral] coral reef, [seagrass] seagrass.

	Drivers and Pressures		Remote sensing mapping and modelling		Water Quality Index	
NRM region	**Cyclone activity (timing)**	**River discharge (relative to long-term median)**	**Area (in %) exposed to a potential risk* (categories II-IV)** ***[and difference relative to long term]***	**Area (in %) exposed to the <u>highest</u> potential risk (categories III and IV)*** ***[and difference relative to long term]***	**Annual 2024–25**	**Long-term**
Reef-wide	N/A	1.9	Reef: 10%exposed [→ <+1% change] [coral] 3% exposed [→ <-1% change] [seagrass] 71% exposed [→ <+1% change] • ***Note:*** *[↗ +5%] in seagrass area exposed to potential cat. of risk III. Likely related to ↗ in Wet tropics region.*	Reef: 3% exposed [→ +1% change] [coral] 1% exposed [→ < +1% change] [seagrass] 31% exposed [→ 3% change] •***Note:*** *Only <u>inshore</u> Reef waters and habitats, with the largest proportion in the enclosed coastal waters.*	N/A	N/A
Cape York	N/A	1.4	Cape York: 6% exposed [→ <-1% change] [coral] 3% exposed [→ <-1% change] [seagrass] 55% exposed [→ -1% change] • ***Note:*** *Exposure in the Cape York region was similar to long-term trends this wet season*	Cape York: 2% [→ < +1% change] [coral] 1% exposed [→ < +1% change] [seagrass] 15% exposed [→ -3% change] • ***Note:*** *Only <u>inshore</u> Cape York waters and habitats are exposed to the highest categories of potential risk III and IV, with the largest proportion in the enclosed coastal waters.*	Good	N/A
Wet Tropics	N/A	1.6	Wet Tropics: 21% exposed [↗ +8% change] [coral] 6% exposed [→ +3% change] [seagrass] 98% exposed [→ <1% change]	Wet Tropics: 6% [→ +3% change] [coral] 2% exposed [→ +1% change] [seagrass] 90% exposed [↗ +14% change]	Moderate	**Deteriorated** between 2008–2018, **improved** 2018–2024 and **deteriorated** in 2024–25

NRM region	Drivers and Pressures: Cyclone activity (timing)	Drivers and Pressures: River discharge (relative to long-term median)	Remote sensing mapping and modelling: Area (in %) exposed to a potential risk* (categories II-IV) *[and difference relative to long term]*	Remote sensing mapping and modelling: Area (in %) exposed to the <u>highest</u> potential risk (categories III and IV)* *[and difference relative to long term]*	Water Quality Index: Annual 2024–25	Water Quality Index: Long-term
			• ***Note***: *There was an increase in Wet Tropics areas exposed to the lowest potential risk categories (II: +5%). Exposure of Wet tropics seagrasses to the potential risk category III increased by 21%*	• ***Note:*** *Only <u>inshore</u> Wet Tropics waters and habitats are exposed, with the largest proportion in the enclosed coastal waters.*		
Burdekin	N/A	6.8	Burdekin: 15% exposed [+5% change] 1% exposed [<1% change] 89% exposed [+2% change] • ***Note:*** *In the Burdekin region, there was a shift in seagrass exposure from potential risk category II to category III, with an 18% increase in potential risk category III. However, the total seagrass area exposed to a potential risk (II–IV) was similar to the long-term trends.*	Burdekin: 6% exposed [+3% change] 1% exposed [<+1% change] 65% exposed [+21% change] • ***Note:*** Only <u>inshore</u> Burdekin waters and habitats are exposed, with the largest proportion in the enclosed coastal waters.	Good	**Deteriorated** gradually from 2010–2018, **improved and stabilised** since 2021
Mackay-Whitsunday	N/A	2.8	Mackay-Whitsunday: 11% exposed [-2% change] 4% exposed [-2% change] 92% exposed [-5% change] ***Note:*** There was a decrease in seagrass area exposed to the potential risk category II (-9%) toward the no/very low potential risk category (+5%). Exposure results likely underestimated due to the cloud cover in this region.	Mackay-Whitsunday: 3% exposed [+1% change] 2% exposed [+1% change] 40% exposed [+4% change] ***Note:*** Only <u>inshore</u> Mackay-Whitsunday waters and habitats are exposed, with the largest proportion in the enclosed coastal waters.	Moderate	**Deteriorated** 2008–2017, **improved** 2017–2024, **deteriorated** in 2024–25
Fitzroy	N/A	1.2	Fitzroy: 8% exposed [-1% change] 3% exposed [<-1% change]	Fitzroy: 3% exposed [<-1% change] 1% exposed [<1% change]	Good	**Improved** from 2008–2015, **stable** over last 5 years

	Drivers and Pressures		Remote sensing mapping and modelling		Water Quality Index	
NRM region	Cyclone activity (timing)	River discharge (relative to long-term median)	Area (in %) exposed to a potential risk* (categories II-IV) *[and difference relative to long term]*	Area (in %) exposed to the <u>highest</u> potential risk (categories III and IV)* *[and difference relative to long term]*	Annual 2024–25	Long-term
			99% exposed [↗ +9% change] **Note** There was a decrease in seagrass area exposed to the potential risk category IV (-6%) and to no/very low potential risk (-9%) but an increase of the potential risk category II (+12%)	35% exposed [→ -3% change] ***Note:*** Only <u>inshore</u> Fitzroy waters and habitats are exposed, with the largest proportion in the enclosed coastal waters.		
Burnett-Mary	N/A	3.4	Burnett-Mary: 5% exposed [→ <1% change] 2% exposed [→ <1% change] 97% exposed [↗ +13% change] **Note** There was an increase in seagrass area exposed to the potential risk categories II and III (+8% and +8%)	Burnett-Mary: 1% exposed [→ <+1% change] 2% exposed [→ 1% change] 34% exposed [↗ +5% change] ***Note:*** Only <u>inshore</u> Burnett-Mary waters and habitats are exposed, with the largest proportion in the enclosed coastal waters.	NA	NA

7.1 Cape York

The annual condition WQ Index for the Cape York region was 'good' for the 2024–25 water year. The Annan-Endeavour focus region had a 'moderate' score for the annual WQ Index, while the Normanby, Stewart, and Pascoe focus regions were 'good'. This was the first 'good' score for the Normanby and Stewart regions. Sufficient data does not exist in the Cape York region to evaluate long-term trends, but annual scores generally improved from 'moderate' scores in 2023–24 which were related to the impacts of Tropical Cyclone Jasper (landfall December 2023). The exception was the Annan-Endeavour transect score, which declined over the 2024–25 wet season, likely due to long-term impacts on Annan River water quality from Tropical Cyclone Jasper.

Discharge from rivers in the Cape York region was between 1 to 1.5 times the long-term median discharge for all focus regions. While there was typical high discharge across the wet season, there were no major above-average magnitude flood events.

Ambient water quality - Enclosed coastal, open coastal, and mid-shelf waters:

- NO_x exceeded the GVs at most Pascoe and Annan-Endeavour transect sites but met the GVs at most sites in the Stewart and Normanby focus regions. Median concentrations increased at the Pascoe and Annan sites compared to median values from the 2023–24 wet season, contributing to declines in the productivity sub-indicator scores for these focus regions. Median concentrations decreased in the Stewart and Normanby focus regions.
- Similarly, Chl-*a* met the GVs at most Stewart and Normanby sites and exceeded the GVs at the Pascoe and Annan-Endeavour focus regions. Median concentrations increased at the Pascoe and Endeavour focus regions and decreased at the Normanby and Stewart focus regions, contributing to declines and improvements in respective productivity scores.
- Median Secchi depths were less than (did not meet) the GVs in any focus regions.
- TSS met the GVs at most sites. Median concentrations decreased at the Pascoe and Normanby sub-regions, increased at the Annan-Endeavour, and were stable at the Stewart sub-region.
- PP concentrations met the GVs at all focus regions and median concentrations decreased at all focus regions except for the Annan-Endeavour.
- PN met the GVs at the Pascoe focus region but exceeded the GVs at most sites at the remaining 3 focus regions. Median concentrations decreased at the Pascoe sites but increased or stayed the same at the other regions.
- PO_4 met the GVs at all sites except the Pascoe.
- Median wet season turbidity and chlorophyll concentrations measured continuously at Dawson Reef (6 km from the Annan River mouth) decreased compared to the previous wet season (with Tropical Cyclone Jasper impacts on water quality) and met the GV for the open coastal water body. The contrast between declines in water quality along the Annan-Endeavour transect and improvements at Dawson reef are likely due to the small magnitude of flood events during the 2024–25 wet season and the northward flow of flood plumes. However, turbidity and Chl-*a* concentrations at Dawson exceeded the relevant GVs for approximately 70 and 37 days over the wet season respectively.
- Median wet season turbidity and chlorophyll fluorescence measured continuously at Forrester Reef (30 km to the northeast from Dawson Reef), decreased compared to the previous wet season and met the GVs for the mid-shelf water body. However, chlorophyll fluorescence remained elevated above the previous (2019–20 to 2022–23) wet seasons, and concentrations exceeded the GV for approximately 80 days over the wet season

Table 7-2: Water quality indicator summary for Cape York in 2024–25. Performance relative to guideline values is shown as: generally exceeding (✗) or meeting (✓) guideline values across all sites.

Water quality indicator	Pascoe	Stewart	Normanby	Annan-Endeavour
NO_x	✗	✓	✓	✗
PO_4	✗	✓	✓	✓
PN	✓	✗	✗	✗
PP	✓	✓	✓	✓
TSS	✓	✓	✓	✓
Secchi depth	✗	✗	✗	✗
Chl-*a*	✗	✓	✓	✗

Event water quality

- Flood events over the wet season were generally minor (relatively low discharge), particularly in comparison to the extreme flooding that occurred over the previous wet season.
- The largest magnitude event of the year for the Pascoe transect occurred in April 2025. Event samples were collected across the Pascoe transect on 24 April 2025, following peak discharge at the upstream gauge 3 days prior. Satellite images from the 24 April showed turbid plume water across the whole region, with plume water from the Pascoe River, Olive River to the north, and the Nesbit and Lockhart Rivers to the south creating a combined turbid plume from the coast out to mid-shelf reefs.
- TSS remained low across the Pascoe flood plume (maximum 3.4 mg L^{-1} near the river mouth), and PN and PP concentrations were close to average ambient concentrations; however, Secchi depths of 2.1 m and 3.2 m showed poor water clarity in open coastal waters. DIN and DIP were elevated above the GVs and typical ambient concentrations across the transect out to Eel Reef, with maximum DIN concentrations (2.28 µg L^{-1}) measured close to the river mouth. Chl-*a* concentrations were slightly elevated above the GVs and ambient concentrations, with a maximum concentration of 1.02 mg L^{-1} near the river mouth.
- No event sampling was conducted in the 2024–25 wet season in the Normanby focus region. However, a significant flood plume was observed in Princess Charlotte Bay satellite images from at least 13 February to 20 February 2025, with turbid plume water from the Normanby and Kennedy estuaries inundating an area of approximately 3,500 km^2, extending to the east beyond the outer reef and north past the Stewart River transect. Regular ambient sampling 2 weeks later on 3 March 2025 showed a slight freshwater influence near the river mouth (salinity 32), and Chl-*a* remained elevated (max 1.9 µg L^{-1}) across the Normanby transect out to Corbett Reef, particularly in sub-surface samples.

- There were no major flood events on the Annan or Endeavour Rivers, however discharge was relatively high through most of February and March, peaking at 39 GL d^{-1} on 17 March. Event samples were collected on 18 and 19 March 2025. TSS was elevated near the river mouths (11 and 20 mg L^{-1}) and decreased along the salinity gradient while Secchi depth increased from 0.3 to 7.1 m with distance from the river mouth. DIN, PN, PP, DOC, and POC concentrations close to the river mouths were highly elevated above mean ambient concentrations and decreased along the transect. In contrast, DIP concentrations increased with increasing salinity across the plume. Maximum Chl-*a* concentrations (>1 µg L^{-1}) occurred both close to the Annan River mouth and in the mid-shelf water body, correlating to DIN uptake and increased light availability.
- In the Cape York region, 94% of the area was not exposed to a potential risk category, in keeping with the long-term average (93%), and <1% (451 km^2) of the region was exposed to the highest potential risk category IV. Approximately 3% (293 km^2) of the region's coral reefs and 55% (1,450 km^2) of the region's seagrasses were exposed to a potential risk (combined potential risk categories II–IV). The total coral and seagrass area exposed to a potential risk (II–IV) were similar the long-term average (≤1% change) which was consistent with the 'good' Water Quality Index score for 2024–25. Only the inshore Cape York waters, seagrass, and coral habitats were exposed to the highest categories of potential risk (III and IV), with the largest proportion located in the region's enclosed coastal waters. Mid-shelf and offshore Cape York reefs and seagrasses were exposed to the lower potential risk category II or to no/very low potential risk.
- Mapping of river-derived pollutants showed a relatively constrained influence of anthropogenic DIN, TSS and PN in 2024–25 across the Cape York region.

7.2 Wet Tropics

The combined discharge from the Daintree, Mossman, and Barron basins was around 1.6 times greater than the long-term median. Discharge from the Russell-Mulgrave and Johnstone basins was 1.3 times higher than the long-term median, following a large discharge year in 2023–24. Discharge from the Tully-Murray-Herbert basins was 2.0 times the long-term median which also followed an above-average year in 2023–24.

Ambient water quality - Enclosed coastal, open coastal, and mid-shelf waters:

- NO_x, PO_4, PP, Secchi depth, and turbidity did not meet water quality GVs for any focus region in the Wet Tropics (Table 7-3).
- TSS and PN met GVs for all focus regions in the Wet Tropics.
- Chl-a met GVs for 2 of the 3 focus regions in the Wet Tropics.
- Over the period from 2015–2025, NO_x showed a trend of improvement in one of the 3 focus regions in the Wet Tropics.
- Many indicators showed a trend of stability (no net improvement or deterioration) across all focus regions of the Wet Tropics.
- PN showed trends of deterioration in all focus regions, while PO_4, PP, and Secchi depth showed deterioration in at least one of the 3 focus regions.
- Long-term Water Quality Index scores showed a deterioration this year after showing a trend of improvement since ~2017. For the 2024–25 water year, the annual condition Water Quality Index score was 'moderate' likely related to repeated flood events in the region.

Table 7-3: Water quality indicator summary for the 3 focus regions of the Wet Tropics in 2024–25. Performance relative to guideline values is shown as: generally exceeding (✗) or meeting (✓) guideline values across all sites. The trend of the indicator (2015–present) is shown as: deteriorating (↘), improving (↗) or stable (→).

Water quality indicator	Barron-Daintree	Russell-Mulgrave	Tully
NO_x	✗ →	✗ →	✗ ↗
PO_4	✗ ↘	✗ ↘	✗ →
PN	✓ ↘	✓ ↘	✓ ↘
PP	✗ →	✗ ↘	✗ →
TSS	✓ →	✓ →	✓ →
Secchi depth	✗ →	✗ ↘	✗ →
Turbidity	N/A	✗ →	✗ →
Chl-*a*	✗ →	✓ →	✓ →

- Pesticide monitoring was conducted at 3 sites in the Wet Tropics region. Low Isles typically had the lowest pesticide concentrations in both passive and grab samples. The Dunk Island grab sample taken 10 February 2025 had the highest total ∑pesticide concentration (173 ng L^{-1}) out of all routine grab samples taken during the 2024–25 sampling campaign. Dunk Island also had the highest ED total ∑pesticide concentration in the region (81 ng L^{-1}, January 2025), and the highest diuron concentration across all sites (47 ng L^{-1}).

Wet season and event water quality

- The Tully River at Euramo gauge recorded 2 notable flood events in 2024–25, peaking at 8.7 m on 2 February and 7.8 m on 17 March 2025, with several smaller flows just below minor flood levels throughout the season. The total annual discharge was around 1.35 times the long-term median. Although monitoring focused on Burdekin and Herbert flood plumes, JCU and AIMS teams sampled the Tully transect during discharge peaks, with satellite imagery showing extensive plumes in Rockingham Bay. Water quality data were concentrated in the 15–35 salinity zone, showing patterns across the salinity gradient consistent with previous event sampling. Passive samplers at Dunk Island and opportunistic pesticide grab samples showed elevated risks during high discharge, with PRM values exceeding 1% species affected at all sites sampled between 9–11 February 2025 and reaching 2.5% at Dunk Island.
- The Herbert River experienced 3 major flow events during the 2024–25 water year, including a significant flood in early February that peaked at 14.9 m—one of the highest levels in the 110-year record. This event produced a discharge of nearly 495,000 ML per day and contributed to a total seasonal discharge of 8.95 million ML, ranking third largest on record. The extended flooding triggered targeted water quality sampling in February 2025, covering sites in Halifax Bay, the Palm Island group, and mid-shelf reefs. The results showed strong salinity gradients, with high TSS and variable nutrient concentrations in the low-salinity zone, reflecting multiple river and creek inputs. Chl-a concentrations followed typical plume dynamics, with elevated concentrations in mid-salinity zones where nutrient availability and light conditions support productivity.
- Pesticide grab samples collected during the Herbert River event showed atrazine, diuron, and 2,4-D inputs consistent with sugarcane land use in the Ingham district. Concentrations were highly variable in the freshwater-influenced zone, with diuron approaching 250 ng L^{-1} but remaining below proposed marine guideline values. The PRM exceeded the 1% species affected threshold at all sites sampled on 6 February 2025, with Paluma Shoals reaching nearly 8% and other coastal and island sites ranging from 2–5%.
- In the Wet Tropics, 79% of the region was not exposed to a potential risk, which was below the long-term average of 88%, reflecting wetter conditions in this region during the 2024–25 wet season. 2% (or 565 km2) of the region was exposed to the highest potential risk category IV, representing an increase of 129 km^2 compared to the long-term average of 436 km^2. Approximately 6% (153 km2) of the region's coral reefs were exposed to a potential risk (combined potential risk categories II–IV) marking an increase of 17 km^2 compared to the long-term average of 77 km 2 (+3%). 98% (227 km2) of the region's seagrass meadows were exposed to a potential risk (combined potential risk categories II–IV), consistent with the long-term average
- While the total area in the Wet Tropics exposed to potential risk (categories II–IV) was 4% greater than the long-term average, this did not significantly affect ecosystem exposure results. The total coral and seagrass areas exposed to potential risk categories II–IV remained similar to the long-term average, with changes of ≤1% for seagrasses and 3% for coral reefs. However, there was a notable shift in seagrass exposure: areas exposed to potential risk category II decreased by 13%, and category IV by 8%, while category III increased by 21%. Only the inshore Wet Tropics seagrass and coral habitats were exposed to the highest potential risk categories (III and IV),

with the largest proportion located in enclosed coastal waters. In contrast, mid-shelf and offshore reefs and mid-shelf seagrasses were largely exposed to no or very low potential risk (>76%), although 1% of mid-shelf waters were also exposed to potential risk category III.

- Mapping of river-derived pollutants in 2024–25 showed extensive influence of anthropogenic DIN across the Wet Tropics region extending to mid-shelf areas, with a high influence of TSS south of Cairns particularly the Tully and Herbert Rivers, and PN the Barron, Johnstone, Tully and Herbert Rivers.

7.3 Burdekin

The combined discharge from the Burdekin and Haughton basins was 6.9 times the long-term median (note this is slightly different to the Burdekin NRM region which was 6.8 times the long-term median), following 4 years of above-median discharge (1.3 times higher in 2023–24, 2.2 times higher in 2022–23,1.2 times higher in 2021–22 and 1.8 times higher in 2020–21).

Ambient water quality - Enclosed coastal, open coastal, and mid-shelf waters:

- NO_x, Secchi depth, turbidity, and PO_4 did not meet water quality GVs in the Burdekin region (Table 7-4).
- Chl-*a*, TSS, PN and PP met GVs in the Burdekin region.
- Over the period from 2015–2025, NO_x showed a trend of improvement in the Burdekin region. Most other indicators showed a trend of stability (no net improvement or deterioration). PO_4 and turbidity showed trends of deterioration.
- Water Quality Index scores showed a long-term trend of deterioration from 2010–2018 followed by a period of stability. There was an improvement between 2021–2023 driven by improvements in PN, PP, and Chl-*a* but this trend has stabilised over the last 2 years. For the 2024–25 water year, the annual condition Water Quality Index score was ‘good’.

Table 7-4: Water quality indicator summary for the Burdekin region in 2024–25. Performance relative to guideline values is shown as: generally exceeding (✗) or meeting (✓) guideline values across all sites. The trend of the indicator (2015–present) is shown as: deteriorating (↘), improving (↗) or stable (→).

Water quality indicator	Burdekin
NO_x	✗ ↗
PO_4	✗ ↘
PN	✓ →
PP	✓ →
TSS	✓ →
Secchi depth	✗ →

Turbidity	
Chl-*a*	

- Pesticide monitoring was conducted at the Haughton River Mouth. The December and February passive samplers had the highest individual pesticide concentrations for 10 of the 17 pesticides detected across all sites (atrazine, atrazine desethyl, atrazine desisopropyl, bromacil, propazine, and terbuthylazine in December; haloxyfop, metolachlor, metribuzin and tebuthiuron in February). The highest total ∑pesticide concentrations observed at the site were 95 ng L^{-1} in the December 2024 passive sampler and 54 ng L^{-1} in the grab sample taken 2 January 2025.

Wet season and event water quality

- The Burdekin River experienced 2 major flow events in 2024–25, with the February flood peaking at 15.04 m and producing the largest daily discharge since 2008–09 (over 1.6 million ML d^{-1}) and a total annual discharge of 30.6 million ML (the fourth largest in the 104-year record). This event generated an extensive flood plume that persisted for weeks, reaching inshore, mid-shelf, and outer reefs. Event sampling captured strong salinity gradients, very high TSS concentrations at the river mouth, alongside variable nutrient patterns. Chl-a concentrations peaked in mid-salinity zones, reflecting enhanced productivity, while water column profiles showed plume influence throughout the depth, with little light penetration beyond 5–10 m.
- The pesticide monitoring also showed distinct herbicide patterns linked to land use. Atrazine and diuron, associated with sugarcane and grain cropping, peaked in the 10–25 salinity zone rather than at the river mouth, indicating inputs from Lower Burdekin floodplain waterways such as the Haughton River, Barratta Creek, and Plantation Creek. In contrast, tebuthiuron, used in grazing lands, was highest at the river mouth and followed a conservative mixing pattern, confirming the Burdekin River as its primary source. All herbicide concentrations remained below marine guideline values.
- A PRM >1% was calculated for all samples (n=13) collected on 6 February 2025, and Paluma Shoals had a PRM of almost 8%, primarily from PSII herbicides but with contributions from other herbicides and insecticides. The coastal site off Forest Beach (HAL5) had a PRM of 5.4%, primarily from PSII herbicides, and the PRM at Havannah Island (HAV) was almost 4%. Site close to Orpheus Island (HAL3, HAL4) ranged from 2.2% to 3%.
- During the 2024–25 wet season, 85% of the Burdekin area was not exposed to a potential risk, which was below the long-term average of 90%, reflecting wetter conditions in this region. 2% of the Burdekin region (796 km^2) was exposed to the highest potential risk category IV, representing an increase of 178 km^2 compared to the long-term average of 617 km^2 (+5%). 1% (43 km2) of the region's coral reefs and 89% (632 km2) of the region's seagrasses were exposed to a potential risk (combined potential risk categories II–IV), consistent with the long-term average. There was an increase in the seagrass areas exposed to potential risk category III (+18%) from the lowest category of potential risk. However, the total seagrass area exposed to a potential risk (II–IV) was similar to the long-term t average (+ 2% change).
- The enclosed coastal and open coastal Burdekin waters were the most exposed to the highest categories of potential risk (III and IV), but a small proportion (<1%) of the mid-shelf Burdekin coastal waters was also exposed to the potential risk category III. As a result, the inshore Burdekin seagrass and coral habitats were the most exposed to the highest categories of potential risk (III and IV), with the largest proportion located in

the region's enclosed coastal waters. Mid-shelf Burdekin seagrasses and mid-shelf and offshore Burdekin reefs were largely exposed to no/very low potential risk (>95%). A very small proportion of mid-shelf Burdekin reefs were furthermore exposed to potential risk category III (0.04% of the offshore Burdekin reefs corresponding to 0.1 km2).

- Mapping of river-derived pollutants in 2024–25 showed intensive influence of anthropogenic DIN, TSS and PN across the Burdekin region. DIN loading was most intensive in Bowling Green Bay and the Ross River mouth, while TSS and PN extended further north to Halifax Bay and mid-shelf areas.

7.4 Mackay-Whitsunday

The combined discharge from the Proserpine, O'Connell, Pioneer, and Plane Basins was 2.5 times higher than the long-term median which followed a relatively below average year in 2023–24, a relatively wet year in 2022–23 (around 2 times the long-term median), and 3 years of well below-median discharge prior to that.

Ambient water quality - Enclosed coastal and open coastal waters:

- PN was the only indicator that met GVs within the Mackay-Whitsunday region.
- NO_x, PO_4, Chl-*a*, TSS, turbidity, PN, PP, and Secchi depth did not meet water quality GVs in the Mackay-Whitsunday region (Table 7-5).
- Over the period from 2015–2025, most indicators showed a trend of stability in the Mackay-Whitsunday region except for turbidity, which showed a trend of improvement. No indicators showed a trend of deterioration.
- Water Quality Index scores showed a long-term trend of deterioration from 2008–2017. The trend then improved from 2017–2024. In 2024–25, conditions again deteriorated, which is the first time this has occurred since 2016. For the 2024–25 water year, the annual condition Water Quality Index score was 'moderate'.

Table 7-5: Water quality indicator summary for Mackay-Whitsunday in 2024–25. Performance relative to guideline values is shown as: generally exceeding (✗) or meeting (✓) guideline values across all sites. The trend of the indicator (2015–present) is shown as: deteriorating (↘), improving (↗) or stable (⇨).

Water quality indicator	Mackay-Whitsunday
NO_x	✗ ⇨
PO_4	✗ ⇨
PN	✓ ⇨
PP	✗ ⇨
TSS	✗ ⇨
Secchi depth	✗ ⇨

Turbidity	
Chl-*a*	

- In the Mackay-Whitsunday region, grab and passive samplers from Whitsunday Channel had the lowest pesticide concentrations detected compared to the other 3 sites monitored in the region (Sandringham Bay, Repulse Bay, and Flat Top). The grab sample taken from Sandringham Bay 9 January 2025, and the ED passive sampler deployed there on the same day, both had the highest total ∑pesticide concentrations observed in the region (131 ng L^{-1} in grab sample and 135 ng L^{-1} in passive sampler). The January Sandringham Bay ED also had the highest calculated PRM of 2.1% species affected, strongly influenced by the relatively high levels of imidacloprid.

Wet season and event water quality

- No specific event water quality monitoring was conducted in the Mackay-Whitsunday region due to the targeting of the large scale Herbert and Burdekin River events
- In the Mackay-Whitsunday region, 89% of the area was not exposed to a potential risk in keeping with the long-term average (87%) and only 1% (or 504 km^2) of the region was exposed to the highest potential risk category IV. Approximately 4% (138 km^2) of the region's coral reefs and 92% (283 km^2) of the region's seagrasses were exposed to a potential risk. Marine habitat areas exposed to respective potential risk categories II, III, or IV were overall similar to the long-term average, but there was a shift in the seagrass area exposed from lowest potential risk (II: -9%) to no/very low potential risk (+5%). Only inshore waters, seagrasses, and coral habitats were exposed to the highest categories of potential risk (III and IV), with the largest proportion located in the region's enclosed coastal waters. Mid-shelf and offshore Mackay-Whitsunday reefs were all exposed to no/very low potential risk (100%).
- Mapping of river-derived pollutants in 2024–25 showed intensive influence of anthropogenic DIN, TSS and PN adjacent to the river mouths of the Prosperine, Gregory, O'Connell and Pioneer Rivers.

7.5 Fitzroy

The discharge and loads calculated for the 2024–25 water year from the Fitzroy River were just above the long-term median. The discharge has been near or below-median for the previous 8 years in this region, and in the 2020–21 water year the discharge and loads calculated were amongst the lowest recorded over the past decade.

Ambient water quality - Enclosed coastal, open coastal, and mid-shelf waters:

- NO_x, Secchi depth, and turbidity did not meet GVs in the Fitzroy region (Table 7-6).
- PO_4, PN, PP, TSS, and Chl-*a* met GVs in the Fitzroy region.
- The trend analysis conducted for other MMP focus regions (trends since the change of monitoring design in 2015) is not appropriate for this dataset as monitoring re-commenced in 2020. However, visual analysis of GAMMs suggests that since 2020:
    - Chl-*a* and PO_4 show signs of slight deterioration.
    - TSS, Secchi depth, and NO_x show signs of improvement.
    - PN, PP, and turbidity show signs of stability.
- The long-term WQ Index showed a small (i.e., changing by a single grade) improvement in water quality over the period 2008–2015, which was driven by

improvements in PN, PP, and Chl-*a* indicators. Over last 5 years, a general trend of stability was seen. For the 2024–25 water year, the annual condition WQ Index score was ‘good’.

Table 7-6: Water quality indicator summary for Fitzroy region in 2024–25. Performance relative to guideline values is shown as: generally exceeding (✗) or meeting (✓) guideline values across all sites.

Water quality indicator	Fitzroy
NO_x	✗
PO_4	✓
PN	✓
PP	✓
TSS	✓
Secchi depth	✗
Turbidity	✗
Chl-*a*	✓

Wet season and event water quality

- In the Fitzroy region, 92% of the area was not exposed to a potential risk in keeping with the long-term average (91%) and only 2% (or 1,332 km^2) of the region was exposed to the highest potential risk category IV. Approximately 3% (153 km^2) of the region’s coral reefs and 99% (471 km^2) of the region’s seagrasses were exposed to a potential risk. Reef habitat areas exposed to respective potential risk categories II, III, or IV were overall similar to the long-term averages but there was a shift in the seagrass area exposed from no/very low potential risk (-12%) to lowest potential risk (II:+12%) and from the potential risk category III (+6%) to the greatest potential risk category IV (-9%). Only inshore waters, seagrasses, and coral habitats were exposed to the highest categories of potential risk (III and IV), with the largest proportion located in the region’s enclosed coastal waters. Mid-shelf and offshore Mackay-Whitsunday reefs were mostly exposed to no/very low potential risk (>98%).
- Mapping of river-derived pollutants in 2024–25 showed relatively constrained influence of anthropogenic DIN, TSS and PN with the most intensive areas adjacent to the Fitzroy river mouth.

8 REFERENCES

Álvarez-Romero JG, Devlin MJ, Teixeira da Silva E, Petus C, Ban N, Pressey RJ, Kool J, Roberts S, Cerdeira WA, Brodie J (2013). A novel approach to model exposure of coastal-marine ecosystems to riverine flood plumes based on remote sensing techniques. Journal of Environmental Management 119:194-207.

ANZG (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra, ACT, Australia. https://www.waterquality.gov.au/anz-guidelines

Australian and Queensland governments, (2003). Reef Water Quality Protection Plan for catchments adjacent to the Great Barrier Reef World Heritage Area. The State of Queensland and Commonwealth of Australia. Queensland Department of Premier and Cabinet, Brisbane. 43 pp.

Australian and Queensland governments, (2018a). Reef 2050 Water Quality Improvement Plan 2017-2022. Queensland government, Brisbane, Australia.

Australian and Queensland governments, (2018b). Paddock to Reef Integrated Monitoring, Modelling and Reporting Program: Program Design 2018-2022. Queensland government, Brisbane, Australia.

Bainbridge ZT, Wolanski E, Álvarez-Romero JG, Lewis SE, Brodie JE (2012). Fine sediment and nutrient dynamics related to particle size and floc formation in a Burdekin River flood plume, Australia. Marine Pollution Bulletin, The Catchment to Reef Continuum: Case studies from the Great Barrier Reef 65, 236–248. doi:10.1016/j.marpolbul.2012.01.043

Beggs C, Neelamraju C, Kaserzon SL, VanderGragt ML (2025). Exposure and combined risk of pesticide mixtures in tropical wetland waters, Australia. Science of The Total Environment 979: 179454. https://doi.org/10.1016/j.scitotenv.2025.179454.

Brinkman R, Herzfeld M, Andrewartha J, Rizwi F, Steinberg C, Spagnol S (2011). Hydrodynamics at the whole of GBR scale. AIMS Final Project Report MTSRF Project 2.5i.1, June 2011. Report to Reef and Rainforest Research Centre. Australian Institute of Marine Science, Townsville. 42 pp.

Brodie J, Waterhouse J, Schaffelke B, Furnas M, Maynard J, Collier C, Lewis S, Warne M, Fabricius K, Devlin M, McKenzie L, Yorkston H, Randall L, Bennett J, Brando V (2013). Scientific Consensus Statement. Chapter 3: Relative risks to the Great Barrier Reef from degraded water quality The State of Queensland. Published by the Reef Water Quality Protection Plan Secretariat, July 2013. http://www.reefplan.qld.gov.au/about/scientific-consensus-statement/water-quality-risks.aspx

Brooks A, Spencer J, Olley J, Pietsch T, Borombovits D, Curwen G, Shellberg J, Howley C, Gleeson A, Simon A, Bankhead N, Klimetz D, Eslami-Endargoli L, Bourgeault A (2013) An empirically-based sediment budget for the Normanby Basin: sediment sources, sinks, and drivers on the Cape York Savannah, Australian Rivers Institute, Griffith University, Final report for the Australian Government Caring for Our Country - Reef Rescue Program.

Bureau of Meteorology [BOM] (2011). Climate averages, average monthly wind velocity over Australia. Australian Government, Bureau of Meteorology, viewed 7 December 2017, http://www.bom.gov.au/jsp/ncc/climate_averages/wind-velocity/index.jsp?period=jan#maps

Bureau of Meteorology [BOM] (2022). Rainfall data, accessed online October 2022, http://www.bom.gov.au/climate/data/

Bureau of Meteorology [BOM] (2017). eReefs Catchments: simulations, nowcasts, and forecasts of water quantity and quality flowing to the Great Barrier Reef. Final Report, eReefs Project Phase 3, Great Barrier Reef Foundation, Brisbane, QLD Australia.

Cape York NRM and South Cape York Catchments (2016). Eastern Cape York Water Quality Improvement Plan. Cape York Natural Resource Management and South Cape York Catchments, Cooktown, Queensland, Australia.

Carstensen J, Klais R, Cloern, JE (2015). Phytoplankton blooms in estuarine and coastal waters: Seasonal patterns and key species. Estuarine, Coastal and Shelf Science 162*:* 98-109.

Ceccarelli DM, Evans RDM, Logan M, Mantel P, Puotinen M, Petus C, Russ GR, Williamson DH (2020). Long- term Dynamics and Drivers of Coral and Macroalgal Cover on Inshore Reefs of the Great Barrier Reef Marine Park. Ecological Applications 30:1-20.

Chamberlain MA, Oke PR, Fiedler RA, Beggs HM, Brassington GB, Divakaran P (2021). Next generation of Bluelink ocean reanalysis with multiscale data assimilation: BRAN2020. Earth System Science Data 13(12):5663-88.

Commonwealth of Australia (2018). Reef 2050 Long-Term Sustainability Plan. http://www.environment.gov.au/marine/gbr/publications/reef-2050-long-term-sustainability-plan.

CSIRO and Bureau of Meteorology (2024). State of the Climate Report. Government of Australia. https://www.csiro.au/en/research/environmental-impacts/climate-change/State-of-the-Climate.

Davis A, Pearson R (2024). Question 1.4 How are the Great Barrier Reef's key ecosystem processes connected from the catchment to the reef and what are the primary factors that influence these connections? In Waterhouse J, Pineda M-C, Sambrook K (Eds) 2022 Scientific Consensus Statement on land-based impacts on Great Barrier Reef water quality and ecosystem condition. Commonwealth of Australia and Queensland Government.

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

De'ath G, Fabricius KE (2010). Water quality as a regional driver of coral biodiversity and macroalgae on the Great Barrier Reef. Ecological Applications 20: 840–850.

Deloitte Access Economics (2025). At what cost? Safeguarding the Great Barrier Reef's role in Australia's economy. Great Barrier Reef Foundation, October 2025.

Department of Environment and Resource Management (2009). Queensland Water Quality Guidelines, Version 3. 167 p. Available at www.derm.qld.gov.au. ISBN 978-0-9806986-0-2.

Department of Regional Development, Manufacturing and Water (DRMW) (2024). River discharge data. https://water-monitoring.information.qld.gov.au/ Accessed October 2024.

Devlin M, McKinna LW, Álvarez-Romero J, Petus C, Abott B, Harkness P, Brodie J (2012). Mapping the pollutants in surface plume waters in the Great Barrier Reef, Australia. Marine Pollution Bulletin 65: 224-235. doi:10.1016/j.marpolbul.2012.03.001

Devlin MJ, Teixeira da Silva E, Petus C, Wenger A, Zeh D, Tracey D, Álvarez-Romero J, Brodie J (2013). Combining water quality and remote sensed data across spatial and temporal scales to measure wet season chlorophyll *a* variability: Great Barrier Reef lagoon (Queensland, Australia). Ecological Processes 2.

Devlin M, Petus C, Teixeira da Silva E, Tracey D, Wolff N, Waterhouse J, Brodie J (2015). Water quality and river plume monitoring in the Great Barrier Reef: An Overview of Methods Based on Ocean Colour Satellite Data. Remote Sensing 7: 12909-12941.

Egbert GD, Svetlana YE (2002). Efficient inverse modeling of barotropic ocean tides. *Journal of Atmospheric and Oceanic Technology* 19.2: 183-204.

Great Barrier Reef Marine Park Authority (2010). Water Quality Guidelines for the Great Barrier Reef Marine Park. Revised Edition 2010. Great Barrier Reef Marine Park Authority, Townsville. 100pp.

Great Barrier Reef Marine Park Authority (2014). Great Barrier Reef Region Strategic Assessment. Great Barrier Reef Marine Park Authority, Townsville.

Great Barrier Reef Marine Park Authority (2019). Great Barrier Reef Outlook Report 2019, Great Barrier Reef Marine Park Authority, Townsville.

Great Barrier Reef Marine Park Authority (2024). Great Barrier Reef Outlook Report 2024, Reef Authority, Townsville.

Grill G, Lehner B, Thieme M. *et al.* (2019). Mapping the world's free-flowing rivers. Nature 569, 215–221. https://doi.org/10.1038/s41586-019-1111-9

Gruber R, Petus C, Thompson K, Thompson A, McKenzie L, Bove U, Choukroun S, Collier C, Davidson J, Elisei G, Howley C, James C, Kaserzon S, Lewis S, Massuger J, Mellors J, Molinari B, Moran D, Mueller J, O'Callaghan M, Paxman C, Tracey D, Thompson C, and Waterhouse J. 2025. Great Barrier Reef Marine Monitoring Program Quality Assurance and Quality Control Manual 2023–24, Great Barrier Reef Marine Park Authority, Townsville, 175 pp.

Gruber R, Waterhouse J, Petus C, Howley C, Lewis S, Moran D, James C, Logan M, Bove U, Brady B, Choukroun S, Connellan K, Davidson J, Mellors J, O'Callaghan M, O'Dea C, Shellberg J, Tracey D, Zagorskis I. (2024). Great Barrier Reef Marine Monitoring Program Inshore Water Quality Monitoring: Annual Report 2022–23. Great Barrier Reef Marine Park Authority, Townsville. 298 pp.

Gruber R, Waterhouse J, Logan M, Petus C, Tracey D, Lewis S, Howley C, Tonin H, Skuza M, Doyle J, Costello P, Davidson J, Gunn K, Wright M, Zagorskis I, Kroon F, Neilen A (2018). Marine Monitoring Program: Annual Report for inshore water quality monitoring 2016-2017. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville.

Howley C. (2020) Natural and Anthropogenic Drivers of Water Quality in the Normanby Basin and Princess Charlotte Bay, Northern Australia. PhD Dissertation. Griffith University, Australian Rivers Institute, School of Environment, Brisbane, Qld (199pp).

Howley C, Scobell L, Albert-Mitchell O, Shellberg J, Rosendale B (2024). Cyclone Jasper Environmental Impact Technical Investigation and Community Engagement Report for the Cape York Region: Annan & Bloomfield Catchments Focus. Report produced by Cape York Water Partnership for the Queensland Government Department of Environment, Science and Innovation.

Jenks GF, Caspall FC (1971). Error on Choroplethic Maps: Definition, Measurement Reduction. Annals of the Association of American Geographers 61: 217-44.

Kaserzon SL, Hawker DW, Kennedy K, Bartkow M, Carter S, Booij K, Mueller JM (2014). Characterisation and comparison of the uptake of ionizable and polar pesticides, pharmaceuticals and personal care products by POCIS and Chemcatchers. Environ. Sci.: Processes Impacts 16: 2517–2526.

Kaserzon S, O'Malley E, Thompson K, Paxman C, Elisei G, Eaglesham G, Gallen M, Mueller J (2017). Catchment and Drinking Water Quality Micro Pollutant Monitoring Program – Passive Sampling Report 6 – Summer 2017 and summary report, prepared for Seqwater, 11 August 2017.

Kaserzon S, Yeh R, Thompson K, Paxman C, Gallen C, Elisei G, Prasad P, Schacht V, Van Niekerk S, Verhagen R, Vijayasarathy S, Gallen M, Reeks T, Jiang H, Eaglesham G, Mueller J (2018). Catchment and Drinking Water Quality Micro Pollutant Monitoring

Program – Passive Sampling Report 8 – Summer 2018 and summary report, prepared for Seqwater, August 2018.

Kaserzon S, Shiels R, Elisei G, Paxman C, Li Y, Carswell C, Xia S, Prasad P, Gallen M, Reeks T, Thompson K, Taucare G, Marano K, Gorji SG, Mueller J (2024). Marine Monitoring Program Annual Report for Inshore Pesticide Monitoring: 2022–23. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville.

King OC, Smith RA, Mann RM, Warne MSt.J (2017) Proposed aquatic ecosystem protection guideline values for pesticides commonly used in the Great Barrier Reef catchment area: Part 1 (amended) - 2,4-D, Ametryn, Diuron, Glyphosate, Hexazinone, Imazapic, Imidacloprid, Isoxaflutole, Metolachlor, Metribuzin, Metsulfuron-methyl, Simazine, Tebuthiuron. Department of Environment and Science. Brisbane, Queensland, Australia. 296 pp.

Kuhnert PM, Liu Y, Henderson B, Dambacher J, Lawrence E, Kroon FJ (2015). Review of the Marine Monitoring Program (MMP). Final Report for the Great Barrier Reef Marine Park Authority, CSIRO, Australia: 278

Lewis S, Brodie J, Endo G, Lough J, Furnas M, Bainbridge Z (2014). Synthesizing historical land use change, fertiliser and pesticide usage and pollutant load data in the regulated catchments to quantify baseline and changing Loads exported to the Great Barrier Reef. Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Technical Report 14/20, James Cook University, Townsville, 105 pp.

Lewis SE, Bartley R, Wilkinson SN, Bainbridge ZT, Henderson AE, James CS, Irvine SA, Brodie JE (2021). Land use change in the river basins of the Great Barrier Reef, 1860 to 2019: A foundation for understanding environmental history across the catchment to reef continuum. Marine Pollution Bulletin. 166:112193.

Lewis S, James C, Bainbridge Z (2023). 'Water quality signatures of pristine and near-pristine landscapes in the Great Barrier Reef Catchment Area,' Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Report 23/12, James Cook University, Townsville. 66 pp.

Lloyd-Jones LR, Kuhnert PM, Lawrence E, Lewis SE, Waterhouse J, Gruber RK, Kroon FJ (2022). Sampling re-design increases power to detect change in the Great Barrier Reef's inshore water quality. PLOS ONE 17(7): e0271930. https://doi.org/10.1371/journal.pone.0271930

Lønborg C, Álvarez–Salgado XA, Duggan S, Carreira C (2018), Organic matter bioavailability in tropical coastal waters: The Great Barrier Reef. Limnology and Oceanography 63: 1015-1035. https://doi.org/10.1002/lno.10717

Maggiorano A, Baird M, Langlais C, Mongin M, Skerratt J (2025). Impact of phytoplankton, CDOM, and suspended sediments on the vertical attenuation of light, changing heat content and circulation on a continental shelf: a modelling study of the Great Barrier Reef. Ocean Modelling: 193:102465.

Magnusson M, Heimann K, Negri AP (2008). Comparative effects of herbicides on photosynthesis and growth of tropical estuarine microalgae. Marine Pollution Bulletin, 56(9), 1545-1552. https://doi.org/https://doi.org/10.1016/j.marpolbul.2008.05.023

Margvelashvili N, Andrewartha J, Baird M, Herzfeld M, Jones E, Mongin M, Rizwi F, Robson BJ, Skerratt J, Wild-Allen K, Steven A (2018). Simulated fate of catchment-derived sediment on the Great Barrier Reef shelf. Marine Pollution Bulletin 135: 954-962.

McCloskey GL, Baheerathan R, Dougall C, Ellis R, Bennett FR, Waters D, Darr S, Fentie B, Hateley LR, Askildsen M (2021). Modelled estimates of fine sediment and particulate nutrients delivered from the Great Barrier Reef catchments. Marine Pollution Bulletin 165: 112163 https://doi.org/10.1016/j.marpolbul.2021.112163.

McKenzie LJ, Collier CJ, Langlois LA, Brien H, Wilson N, and Yoshida RL (2026). Marine Monitoring Program: Annual Report for Inshore Seagrass Monitoring 2024–25. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville. 189pp.

Moran D, Robson B, Gruber R, Waterhouse J, Logan M, Petus C, Howley C, Lewis S, James C, Tracey D, Mellors J, O'Callaghan M, Bove U, Davidson J, Glasson K, Jaworski S, Lefevre C, Nordborg M, Vasile R, Zagorskis I, Shellberg J. (2023). Marine Monitoring Program: Annual Report for Inshore Water Quality Monitoring 2021–22. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville.

Negri AP, Flores F, Mercurio P, Mueller JF, Collier CJ (2015). Lethal and sub-lethal chronic effects of the herbicide diuron on seagrass. Aquatic Toxicology, 165, 73-83. https://doi.org/https://doi.org/10.1016/j.aquatox.2015.05.007

Newlands M, Olayioye O (2024). Question 1.1 What are the socio-ecological, cultural, economic, and intrinsic values of the Great Barrier Reef? In Waterhouse J, Pineda M-C, Sambrook K (Eds) 2022 Scientific Consensus Statement on land-based impacts on Great Barrier Reef water quality and ecosystem condition. Commonwealth of Australia and Queensland Government.

Novoa S, Wernand MR, Van der Woerd HJ, (2013). The Forel-Ule scale revisited spectrally: preparation protocol, transmission measurements and chromaticity. Journal of the European Optical Society-Rapid Publications 8, 13057.

O'Brien D, Chiswell B, Mueller JF (2009). A novel method for the in-situ calibration of flow effects on a phosphate passive sampler. Journal of Environmental Monitoring 11: 201-219.

O'Brien D, Booij K, Hawker D, Mueller JF (2011a). Method for the in-situ Calibration of a Passive Phosphate Sampler in Estuarine and Marine Waters. Environmental Science & Technology 45 (7): 2871-2877.

O'Brien D, Bartkow M, Mueller JF (2011b). Determination of deployment specific chemical uptake rates for SDB-RPS EmporeTM disk using a passive flow monitor. Chemosphere 83 (9): 1290-1295.

Petus C, da Silva ET, Devlin M, Wenger AS, JG Álvarez-Romero JC (2014). Using MODIS data for mapping of water types within river plumes in the Great Barrier Reef, Australia: Towards the production of river plume risk maps for reef and seagrass ecosystems. Journal of environmental management 137, 163-177.Petus C, Devlin M, Thompson A, McKenzie L, Teixeira da Silva E, Collier C, Tracey D, Martin K (2016). Estimating the exposure of coral reefs and seagrass meadows to land-sourced contaminants in river flood plumes of the Great Barrier Reef: validating a simple Satellite Risk Framework with Environmental Data. Remote Sensing 8: 210.

Petus C, Devlin M, da Silva E, Lewis S, Waterhouse J, Wenger A, Bainbridge Z, Tracey D (2018) Defining wet season water quality target concentrations for ecosystem conservation using empirical light attenuation models: a case study in the Great Barrier Reef (Australia). Journal of Environmental Management 213: 1-16.

Petus C, Waterhouse J, Lewis S, Vacher M, Tracey D, Devlin M. (2019). A flood of information: Using Sentinel-3 water colour products to assure continuity in the monitoring of water quality trends in the Great Barrier Reef (Australia). Journal of Environmental Management 248: 109255.

Pinheiro JC, Bates DM (2000). Mixed-effects models in S and S-PLUS, Statistics and Computing Series, Springer-Verlag, New York, NY.

Puignou Lopez, O. Lewis, S.E. James, C.S. Davis, A.M. Mackay, S.J. (2025). Hydrology of the Great Barrier Reef catchment area along a latitudinal gradient: Implications for estimating discharge. Journal of Hydrology: Regional Studies 61, 102603

Queensland Land Use Mapping Program [QLUMP] (2021). Great Barrier Reef catchments land use mapping. Queensland Government website, accessed 27 February 2025. Available at: https://www.qld.gov.au/environment/land/management/mapping/statewide-monitoring/qlump.

Queensland Land Use Mapping Program [QLUMP] (2019). Fitzroy and Burnett Mary natural resource management regions, https://www.qld.gov.au/environment/land/management/mapping/statewide-monitoring/qlump/qlump-datasets accessed 30 August, 2021.

Queensland Land Use Mapping Program [QLUMP] (2015). Land use mapping for the Cape York NRM region, prepared by DNRM.

R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: https://www.R-project.org/

Schaffelke B, Carleton J, Skuza M, Zagorskis I, Furnas MJ (2012). Water quality in the inshore Great Barrier Reef lagoon: Implications for long-term monitoring and management. Marine Pollution Bulletin 65:249-260. DOI: 10.1016/j.marpolbul.2011.10.031

Shellberg J, Brooks A (2013). Alluvial Gully Prevention and Rehabilitation Options for Reducing Sediment Loads in the Normanby Catchment and Northern Australia. Australian Rivers Institute, Griffith University, Final report for the Australian Government Caring for Our Country - Reef Rescue Program.

Shellberg JG, Spencer J, Brooks AP, Pietsch TJ (2016). Degradation of the Mitchell River fluvial megafan by alluvial gully erosion increased by post-European land use change, Queensland, Australia. Geomorphology, 266, 105-120.

Skerratt JH, Mongin M, Baird ME, Wild-Allen KA, Robson BJ, Schaffelke B, Davies CH, Richardson AJ, Margvelashvili N, Soja-Wozniak M, Steven ADL (2019). Simulated nutrient and plankton dynamics in the Great Barrier Reef (2011–2016). Journal of Marine Systems, 192, 51-74. http://dx.doi.org/10.1016/j.jmarsys.2018.12.006

Skerratt J, Baird ME, Mongin M, Ellis R, Smith RA, Shaw M, Steven ADL (2023) Dispersal of the pesticide diuron in the Great Barrier Reef. Science of the Total Environment, 879, 163.

Spencer J, Brooks A, Curwen G, Tews K (2016). A Disturbance Index Approach for Assessing Water Quality Threats in Eastern Cape York. A report to South Cape York Catchments and Cape York NRM for the Cape York Water Quality Improvement Plan, by the Australian Rivers Institute, Griffith University, 42 pp

State of Queensland (2020). Environmental Protection (Water and Wetland Biodiversity) Policy 2019: Environmental Values and Water Quality Objectives, Eastern Cape York Basins https://environment.des.qld.gov.au/management/water/policy/cape-york-eastern-basins

Steven AD, Baird ME, Brinkman R, Ca, NJ, Cox SJ, Herzfeld M, Hodge J, Jones E, King E, Margvelashvili N, Robillot C, (2019). eReefs: An operational information system for managing the Great Barrier Reef. Journal of Operational Oceanography, pp.1-17.

Su CH, Eizenberg N, Steinle P, Jakob D, Fox-Hughes P, White CJ. Rennie S, Franklin C, Dharssi I, Zhu H (2019). BARRA v1.0: the Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia, *Geosci. Model Dev.*, 12, 2049–2068, https://doi.org/10.5194/gmd-12-2049-2019

Taucare G, Bignert A, Kaserzon S, Thai P, Mann RM, Gallen C, Mueller J (2022). Detecting long temporal trends of photosystem II herbicides (PSII) in the Great Barrier Reef lagoon. Marine Pollution Bulletin, 177: 113490.

Thompson A, Davidson J, Logan M, Thompson C (2026). Marine Monitoring Program Annual Report for Inshore Coral Reef Monitoring: 2024–25. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville. 160 pp.

Thompson K, Shiels R, Beggs C, Elisei G, Paxman C, Li Y, Carswell C, Xia S, Prasad P, Gallen M, Reeks T, Clokey J, Marano K, Kaserzon S, 2025, Marine Monitoring Program Annual Report for Inshore Pesticide Monitoring: 2023–24. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville.

Townsend, SA, Douglas, MM (2000). The effect of 3 fire regimes on stream water quality, water yield and export coefficients in a tropical savanna (northern Australia). Journal of Hydrology, 229(3-4): 118-137.

Traas TP, van de Meent D, Posthuma L, Hamers T, Kater BJ, De Zwart D, Aldenberg T (2002). The potentially affected fraction as a measure of ecological risk. In Species Sensitivity Distributions in Ecotoxicology, 315–344.

Van der Woerd JH, Wernand RM (2018). Hue-angle product for low to medium spatial resolution optical satellite sensors. Remote Sensing 10, 180.

Van der Woerd JH, Wernand RM, Peters M, Brockmann C (2016). True colour analysis of natural waters with SeaWiFS, MODIS, MERIS and OLCI by SNAP, Ocean Optics conference. At Victoria BC Canada XXIII.

Vrana, B, Greenwood R, Mills G, Dominiak E, Svensson K, Knutsson J, Morrison G (2005). Passive sampling techniques for monitoring pollutants in water. Trends in Analytical Chemistry 10: 845-868.

Warne MStJ, Neelamraju C, Strauss J, Smith RA, Turner RDR, Mann RM (2020). Development of a method for estimating the toxicity of pesticide mixtures and a Pesticide Risk Baseline for the Reef 2050 Water Quality Improvement Plan. Brisbane: Department of Environment and Science, Queensland Government.

Warne MStJ, Neelamraju C, Strauss J, Turner RDR, Smith RA, Mann RM (2023). Estimating the aquatic risk from exposure to up to twenty-two pesticide active ingredients in waterways discharging to the Great Barrier Reef. Science of The Total Environment, 892: 164632.

Water Quality & Investigations (2024a). Great Barrier Reef Catchment Loads Monitoring Program: Loads and yields for sediment and nutrients, and Pesticide Risk Metric results (2021–2022) for rivers that discharge to the Great Barrier Reef, Department of Environment, Science and Innovation, Brisbane, Australia.

Water Quality & Investigations (2024b). Pesticide Risk Metric Calculator, Department of the Environment, Tourism, Science and Innovation, Brisbane, Australia.

Waterhouse J, Brodie J, Tracey D, Smith R, Vandergragt M, Collier C, Petus C, Baird M, Kroon F, Mann R, Sutcliffe T, Waters D, Adame F (2017). Scientific Consensus Statement 2017: A synthesis of the science of land-based water quality impacts on the Great Barrier Reef, Chapter 3: The risk from anthropogenic pollutants to Great Barrier Reef coastal and marine ecosystems. State of Queensland, 2017.

Waterhouse J, Burton J, Garzon-Garcia A, Lewis S, Brodie J, Bainbridge Z, Robson R, Burford MA, Gruber RK, Dougall C (2018). Synthesis of knowledge and concepts - Bioavailable Nutrients: Sources, delivery and impacts in the Great Barrier Reef, July 2018. Supporting Concept Paper for the Bioavailable Nutrients Workshop, 15 March 2018. Reef and Rainforest Research Centre, 84pp.

Waterhouse J, Gruber R, Logan M, Petus C, Howley C, Lewis S, Tracey D, James C, Mellors J, Tonin H, Skuza M, Costello P, Davidson J, Gunn K, Lefevre C, Moran D, Robson B, Shanahan M, Zagorskis I, Shellberg J (2021). Marine Monitoring Program: Annual Report for Inshore Water Quality Monitoring 2019–20. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville.

Waterhouse J, Petus C, Lewis S, James C, O'Callaghan M, Tracey D, Doyle J, Patel F, Uthicke S (2023). Pilot study to investigate options for water quality sampling as part of the Reef Trust Partnership Crown of Thorns Starfish Control Program, Final Report July 2023. Report for the Reef Trust Partnership. TropWATER Report No. 23/50. 92 pp. James Cook University, Townsville.

Waterhouse J, Pineda M-C, Sambrook K, Newlands M, McKenzie L, Davis A, Pearson R, Fabricius K, Lewis S, Uthicke S, Bainbridge Z, Collier C, Adame F, Prosser I, Wilkinson S, Bartley R, Brooks A, Robson B, Diaz-Pulido G, Reyes C, Caballes C, Burford M, Thorburn P, Weber T, Waltham N, Star M, Negri A, Warne M St J, Templeman S, Silburn M, Chariton A, Coggan A, Murray-Prior R, Schultz T, Espinoza T, Burns C, Gordon I, Devlin M (2024). 2022 Scientific Consensus Statement: Conclusions. In Waterhouse J, Pineda M-C, Sambrook K (Eds) 2022 Scientific Consensus Statement on land-based impacts on Great Barrier Reef water quality and ecosystem condition. Published by C2O Consulting on behalf of the Australian Government's Department of Climate Change, Energy, the Environment and Water (DCCEEW) and the Queensland Government's Office of the Great Barrier Reef and World Heritage (OGBRWH).

Waterhouse J, Star M, Molinari B, Sambrook K, VanderGragt M, Leigh C, Sutcliffe T, Smith R, Choukroun S, Tracey D, Lewis S. (2025) Decision framework for management options to maintain and improve water quality in the Great Barrier Reef catchment area. Analysis of key spatial factors impacting water quality and the condition of wetlands, corals and seagrass in the Great Barrier Reef. Commonwealth of Australia and Queensland Government.

Wells SC, Cole SJ, Moore RJ, Black KB, Khan U, Hapuarachchi P, Gamage N, Hasan M, MacDonald A, Bari M, Tuteja NK (2018). Forecasting the water flows draining to the Great Barrier Reef using the G2G Distributed Hydrological Model. Technical Report (Contract No. 112-2015-16), Centre for Ecology & Hydrology Wallingford, OX10 8BB, UK.

Wenger AS, Williamson DH, da Silva ET, Ceccarelli DM, Browne NK, Petus C, Devlin M (2016). Effects of reduced water quality on coral reefs in and out of no-take marine reserves. Conservation Biology 30 (1), 142-153

Wernand MR, Hommersom A, Van der Woerd HJ (2012). MERIS-based ocean colour classification with the discrete Forel–Ule scale. Ocean Science Discussions 9, 2817–2849.

Wernand MR, Van der Woerd HJ, Gieskes WWC (2013). Trends in ocean colour and chlorophyll concentration from 1889 to present. PLoS One, 0063766.

Wijffels S, Beggs H, Griffin C, Middleton J, Cahill M, King E, Jones E, Feng M, Benthuysen J, Steinberg C, Sutton P (2018). A fine spatial-scale sea surface temperature atlas of the Australian regional seas (SSTAARS): Seasonal variability and trends around Australasia and New Zealand revisited. Journal of Marine Systems. 187. 10.1016/j.jmarsys.2018.07 .005.

Wood SN (2006). Generalized additive models: An introduction with R. Chapman & Hall/CRC Publisher, City.

Wood SN (2011). Fast stable restricted maximum likelihood and marginal likelihood estimation of semiparametric generalized linear models. Journal of the Royal Statistical Society (B) 73: 3-36.

APPENDIX A: WATER QUALITY SITE LOCATIONS AND FREQUENCY OF MONITORING

Table A-1: Description of the water quality sites sampled by AIMS, JCU, and CYWP. The proposed number of visits is shown in black text, while the actual number of visits is shown in parentheses in red text. Actual visits can differ from proposed due to poor weather limiting site access.

Site location	Logger Deployment		Ambient sampling at fixed sites: proposed (actual)			Event-based sampling
NRM region	**Turbidity and chlorophyll**	**Salinity**	**Number of sampling depths**	**Number of times site is visited /year by AIMS**	**Number of times site is visited/year by JCU/ CYWP**	**Additional surface-sampling/year by JCU/ CYWP**
Cape York						
Normanby-Kennedy transect						
Kennedy mouth (KR01)						
Kennedy inshore (KR02)						
Cliff Islands (CI01)			2		4 (4)	
Bizant River mouth (BR01)						
Normanby River mouth (NR01)						
Normanby inshore (NR02)			2		4 (4)	
NR03 (NR03)			2		4 (4)	
NR04 (NR04)			2		4 (4)	
NR05 (NR05)			2		4 (4)	
Corbett Reef (NR06)			2		4 (4)	
Pascoe transect						
Pascoe mouth north (PRN01)						
Pascoe mouth south (PRS01)			1		5 (5)	1
PRN02 (PRN02)			1		5 (5)	1
PRN04 (PRN04)			2		5 (5)	1
Eel Reef (PRN05)						
Eel Reef North (PRN06)						
PRS2.5 (PRS2.5)			2		5 (5)	1
Middle Reef (PRBB)			2		5 (5)	1
Eel Reef South (PR-S05)			2		5 (5)	1

Site location	Logger Deployment		Ambient sampling at fixed sites: proposed (actual)			Event-based sampling
NRM region	**Turbidity and chlorophyll**	**Salinity**	**Number of sampling depths**	**Number of times site is visited /year by AIMS**	**Number of times site is visited/year by JCU/ CYWP**	**Additional surface-sampling/year by JCU/ CYWP**
Annan and Endeavour transect						
Annan mouth (AR01)						1
Walker Bay (AR02b)			2		5 (5)	1
Dawson Reef (AR03b)	✓		2		5 (5)	1
Endeavour mouth (ER01)						1
Endeavour north shore (ER02b)			2		5 (5)	1
Endeavour offshore (ER03)			2		5 (5)	1
Egret and Boulder Reef (AE04)			2		5 (5)	1
Forrester Reef (ER06)	✓					
Stewart transect						
Stewart mouth (SR01)						
SR02 (SR02)			2		5 (5)	
SR03 (SR03)			2		5 (5)	
Burkitt Island (SR04)			2		5 (5)	
Hannah Island (SR05)			2		5 (5)	
Wet Tropics						
Barron-Daintree Focus Region						
Cape Tribulation (C1)*			2	3 (3)		
Port Douglas (C4)*			2	3 (3)		
Double Island (C5)*			2	3 (3)		
Yorkey's Knob (C6)*			2	3 (3)		
Fairlead Buoy (C8)*			2	3 (3)		
Green Island (C11)*			2	3 (3)		

Site location	Logger Deployment		Ambient sampling at fixed sites: proposed (actual)			Event-based sampling
NRM region	Turbidity and chlorophyll	Salinity	Number of sampling depths	Number of times site is visited /year by AIMS	Number of times site is visited/year by JCU/ CYWP	Additional surface-sampling/year by JCU/ CYWP
Russell-Mulgrave Focus Region						
Fitzroy Island West (RM1)	✓		2	5 (5)		
RM2 (RM2)						
RM3 (RM3)			2	5 (5)	5 (5)	
RM4 (RM4)						
High Island East (RM5)						
Normanby Island (RM6)						
Frankland Group West (Russell Island) (RM7)*	✓		2	5 (5)	5 (5)	
High Island West (RM8)*	✓	✓	2	5 (5)	5 (5)	
Palmer Point (RM9)						
Russell-Mulgrave River mouth mooring (RM10)	✓	✓	2	5 (5)	5 (5)	
Russell-Mulgrave River mouth (RM11)						
Russell-Mulgrave junction [River] (RM12)						
Tully Focus Region						
King Reef (TUL1)						
East Clump Point (TUL2)			2	5 (5)	5 (5)	
Dunk Island North (TUL3)*	✓	✓	2	5 (5)	5 (5)	
South Mission Beach (TUL4)						
Dunk Island South East (TUL5)			2	5 (5)	5 (5)	
Between Tam O'Shanter and Timana (TUL6)			2	5 (5)	5 (5)	
Hull River mouth (TUL7)						

Site location	Logger Deployment		Ambient sampling at fixed sites: proposed (actual)			Event-based sampling
NRM region	**Turbidity and chlorophyll**	**Salinity**	**Number of sampling depths**	**Number of times site is visited /year by AIMS**	**Number of times site is visited/year by JCU/ CYWP**	**Additional surface-sampling/year by JCU/ CYWP**
Bedarra Island (TUL8)			2	5 (5)	5 (5)	
Triplets (TUL9)						
Tully River mouth mooring (TUL10)	✓	✓	2	5 (5)	5 (5)	
Tully River (TUL11)						
Burdekin						
Burdekin Focus Region						
Pelorus and Orpheus Island West (BUR1)*	✓		2	4 (4)	5 (5)	3
Pandora Reef (BUR2)*	✓		2	4 (4)	5 (5)	3
Cordelia Rocks (BUR3)						1
Magnetic Island (Geoffrey Bay) (BUR4)*	✓		2	4 (4)	5 (5)	2
Inner Cleveland Bay (BUR5)						2
Cape Cleveland (BUR6)						2
Haughton 2 (BUR7)			2	4 (4)	5 (5)	2
Haughton River mouth (BUR8)						1
Barratta Creek (BUR9)						1
Yongala IMOS NRS (BUR10)	✓	✓	2	4 (4)		
Cape Bowling Green (BUR11)						
Plantation Creek (BUR12)						
Burdekin River mouth mooring (BUR13)	✓	✓	2	4 (4)	5 (5)	1
Burdekin Mouth 2 (BUR14)						2
Burdekin Mouth 3 (BUR14)						1
Mackay-Whitsunday						

Site location	Logger Deployment		Ambient sampling at fixed sites: proposed (actual)			Event-based sampling
NRM region	**Turbidity and chlorophyll**	**Salinity**	**Number of sampling depths**	**Number of times site is visited /year by AIMS**	**Number of times site is visited/year by JCU/ CYWP**	**Additional surface-sampling/year by JCU/ CYWP**
Whitsunday focus Region						
Double Cone Island (WHI1)*	✓		2	5 (5)		
Hook Island W (WHI2)						
North Molle Island (WHI3)						
Pine Island (WHI4)*	✓	✓	2	5 (5)		
Seaforth Island (WHI5)	✓		2	5 (5)		
OConnell River mouth (WHI6)	✓	✓	2	5 (5)		
Repulse Islands dive mooring (WHI7)			2	5 (5)		
Rabbit Island NE (WHI8)						
Brampton Island (WHI9)						
Sand Bay (WHI10)						
Pioneer River mouth (WHI11)						
Fitzroy						
Fitzroy focus Region						
Barren Island (FTZ1)*	✓		2	10 (10)		
Humpy Island FTZ2)*	✓	✓	2	10 (10)		
Pelican Island (FTZ3)*			2	10 (10)		
North Keppel (FTZ4)			2	10 (10)		
Peak West (FTZ5)			2	10 (10)		
Fitzroy River Mouth (WHI7)	✓	✓	2	10 (10)		

*Sites which were part of the MMP sampling design from 2005–2015.

Table A-2: Pesticide passive sampler deployment locations (from north to south) in 2024–25. Natural Resource Management (NRM) region, site name, dates, lengths of deployment period and water velocity measured at each site. ED = Empore disk and PFM = passive flow monitor.

NRM Region	Site Name	Deployment Date	Retrieval Date	Days Deployed	Flow Velocity (cm s^{-1})	Comment
Wet Tropics	Low Isles	2024-12-30	2025-02-12	44	22.3	PFMs empty
	Low Isles	2025-02-12	2025-03-16	32	31	PFMs empty
	Low Isles	2025-03-16	2025-04-29	44	22	ED replicate. PFMs empty
	High Island	2024-11-07	2024-12-02	25	40.7	ED replicate. PFMs empty
	High Island	2024-12-02	2025-01-08	37	27	PFMs empty
	High Island	2025-01-08	2025-02-12	35	28.1	ED replicate. PFMs empty
	High Island	2025-02-12	2025-03-12	28	31.1	
	Dunk Island	2024-11-06	2024-12-03	27	36.8	PFMs empty
	Dunk Island	2024-12-03	2025-01-07	35	28.4	ED stained/PFMs empty
	Dunk Island	2025-01-07	2025-02-10	34	29.6	PFMs empty
	Dunk Island	2025-02-10	2025-03-13	31	31.9	ED replicate. PFMs empty
	Dunk Island	2025-03-13	2025-04-14	32	30.2	PFMs empty
Burdekin	Haughton River Mouth	2024-11-05	2024-12-02	27	37.7	Membrane lifted and ED biofouled/PFMs empty
	Haughton River Mouth	2024-12-02	2025-01-02	31	32.3	PFMs empty
	Haughton River Mouth	2025-01-02	2025-01-29	27	42.2	PFMs empty
	Haughton River Mouth	2025-01-29	2025-03-01	31	32.1	PFMs empty
	Haughton River Mouth	2025-03-01	2025-04-01	31	31.2	PFMs empty
Mackay-Whitsunday	Whitsunday Channel	2024-12-10	2025-01-10	31	22.5	1 PFM estimated final weight (end snipped)/ED muddy
	Whitsunday Channel	2025-01-10	2025-02-15	36	26.3	
	Whitsunday Channel	2025-02-15	2025-03-09	22	27.8	
	Whitsunday Channel	2025-03-09	2025-04-05	27	25.2	
	Whitsunday Channel	2025-04-05	2025-04-20	15	32.2	
	Repulse Bay	2024-12-10	2025-01-10	31	24.8	ED muddy
	Repulse Bay	2025-01-10	2025-02-15	36	27.6	1 PFM empty
	Repulse Bay	2025-02-15	2025-03-09	22	32.3	
	Repulse Bay	2025-03-09	2025-04-20	42	22.1	1 PFM empty
	Flat Top	2024-11-29	2025-01-09	41	23.4	ED muddy/1 PFM empty
	Flat Top	2025-01-09	2025-02-14	36	23.7	
	Flat Top	2025-02-14	2025-03-08	22	31.1	
	Flat Top	2025-03-08	2025-04-05	28	27.7	
	Flat Top	2025-04-05	2025-04-19	14	33.9	
	Sandringham Bay	2024-11-29	2025-01-09	41	24.3	ED muddy/PFMs empty
	Sandringham Bay	2025-01-09	2025-02-14	36	25.4	
	Sandringham Bay	2025-02-14	2025-03-08	22	30.3	

NRM Region	Site Name	Deployment Date	Retrieval Date	Days Deployed	Flow Velocity (cm s-1)	Comment
	Sandringham Bay	2025-03-08	2025-04-05	28	26.7	
	Sandringham Bay	2025-04-05	2025-04-19	14	35.8	

Table A-3. Pesticide grab sampling collection dates for routine and event samples 2024–25.

Natural Resource Management (NRM) Region	Site Name	Collection Date	Comment
Routine grab sampling			
Wet Tropics	Low Isles	2024-12-30	
	Low Isles	2025-02-12	
	Low Isles	2025-03-16	
	Low Isles	2025-04-29	
	Low Isles	2025-08-06	
	High Island	2024-11-07	
	High Island	2024-12-02	
	High Island	2025-01-08	
	High Island	2025-02-12	
	High Island	2025-03-02	
	High Island	2025-04-13	
	Dunk Island	2024-11-06	Duplicate
	Dunk Island	2024-12-03	
	Dunk Island	2025-01-07	
	Dunk Island	2025-02-10	
	Dunk Island	2025-03-13	
	Dunk Island	2025-04-14	
Burdekin	Haughton River Mouth	2024-11-05	
	Haughton River Mouth	2024-12-02	Duplicate
	Haughton River Mouth	2025-01-02	
	Haughton River Mouth	2025-01-29	
	Haughton River Mouth	2025-03-01	
	Haughton River Mouth	2025-04-01	
Mackay-Whitsunday	Whitsunday Channel	2025-01-10	
	Whitsunday Channel	2025-02-15	
	Whitsunday Channel	2025-03-09	
	Whitsunday Channel	2025-04-04	
	Whitsunday Channel	2025-04-20	
	Repulse Bay	2025-01-10	
	Repulse Bay	2025-02-15	
	Repulse Bay	2025-03-09	
	Repulse Bay	2025-04-20	
	Flat Top	2025-01-09	
	Flat Top	2025-02-14	
	Flat Top	2025-03-08	

Natural Resource Management (NRM) Region	Site Name	Collection Date	Comment
	Flat Top	2025-04-04	
	Flat Top	2025-04-19	
	Sandringham Bay	2025-01-09	
	Sandringham Bay	2025-02-14	
	Sandringham Bay	2025-03-08	
	Sandringham Bay	2025-04-04	
	Sandringham Bay	2025-04-19	
Event grab sampling			
Wet Tropics	WQR134 - Green Island	2025-02-13	
	WQR131 - Fitzroy Island coral site	2025-02-13	
	JCD437 - High Island Routine	2025-02-25	
	WQR128 - High Island	2025-02-13	
	WQR124 - Russell-Mulgrave River mooring	2025-02-12	
	JCD439 - Russell-Mulgrave River mouth mooring routine	2025-02-25	
	WQR126 - Russell Island Franklands	2025-02-12	
	JCF485 - King Reef	2025-02-11	
	WQR117 - East Clump Point	2025-02-11	
	WQR121 - Dunk Island	2025-02-10	
	JCF484 - South Mission Beach	2025-02-10	Duplicate
	JCD442 - Dunk Island routine	2025-02-24	
	WQR118 - Dunk Island South East	2025-02-10	Duplicate
	WQR120 - Between Tam OShanter and Timana	2025-02-10	
	JCF483 - Hull River mouth	2025-02-10	
	WQR119 - Bedarra Island	2025-02-09	
	JCD443 - Tully River mouth mooring routine	2025-02-24	
	WQR115 - Tully River Mouth mooring	2025-02-10	
Burdekin	JCF482 - Herbert 3	2025-02-09	Duplicate
	JCF481 - Herbert 2 - Britomart	2025-02-09	
	JCF480 - Herbert 1	2025-02-09	
	JCF405 - Halifax 1	2025-02-06	
	JCF406 - Halifax 2B	2025-02-06	
	JCF407 - Halifax 2X	2025-02-06	Duplicate
	JCF417 - Pelorus	2025-02-13	
	WQR112 - Pelorus / Orpheus Island	2025-02-09	
	JCF400 - Pelorus	2025-02-06	
	JCF408 - Halifax Bay	2025-02-06	
	JCF404 - Halifax 3	2025-02-06	
	JCF421 - Halifax 3	2025-02-13	
	JCF409 - Taylors Beach	2025-02-06	
	JCF403 - Halifax 4	2025-02-06	
	JCF410 - Halifax Bay	2025-02-06	
	JCF401 - Pandora	2025-02-06	
	JCF416 - Pandora	2025-02-13	

Natural Resource Management (NRM) Region	Site Name	Collection Date	Comment
Burdekin	WQR110 - Pandora Reef	2025-02-08	Duplicate
	JCF402 - Havana	2025-02-06	
	JCF420 - Halifax Havana	2025-02-13	
	JCF414 - Halifax Bay 7	2025-02-06	
	JCF415 - Halifax Bay 6	2025-02-06	
	JCF419 - Archeron	2025-02-13	
	JCF413 - Geoffrey Bay	2025-02-13	
	WQR108 - Geoffrey Bay	2025-02-08	
	JCF422 - Burdekin Event Cape Cleveland	2025-02-14	
	JCF418 - Cleveland Bay	2025-02-13	
	WQR107 - Haughton 2	2025-02-07	
	JCF412 - Burdekin Event	2025-02-14	
	WQR106 - Yongala IMOS NRS	2025-02-07	
	JCF426 - Burdekin Event	2025-02-14	
	JCF437 - Burdekin Event	2025-02-19	
	JCF425 - Burdekin Event	2025-02-14	
	JCF425 - Burdekin Event	2025-02-15	
	JCF430 - Burdekin Event	2025-02-15	Duplicate
	JCF411 - Burdekin River Mouth Mooring	2025-02-15	
	WQR104 - Burdekin River Mooring	2025-02-07	
Mackay-Whitsunday	WQR101 - Double Cone Island	2025-02-05	
	WQR099 - Pine Island	2025-02-05	
	WQR097 - Seaforth Island	2025-02-06	
	WQR096 - Repulse Islands dive mooring	2025-02-05	D1 sample also received
	WQR094 - O'Connell River	2025-02-05	

APPENDIX B: WATER QUALITY MONITORING AND POTENTIAL RISK CATEGORISATION METHODS

B-1 Comparison with Reef Water Quality guideline values

The Water Quality Guidelines provide a useful framework to interpret monitoring data and for the purposes of this report are collated from multiple sources, which are described below. Table B-1 gives a summary of the guideline values (GVs) for water quality variables in 4 cross-shelf water bodies (Great Barrier Reef Marine Park Authority, 2010).

At present, the Water Quality Guidelines do not define GVs for dissolved inorganic nutrients (nitrate and phosphate) in the Reef lagoon as these nutrients are rapidly cycled through uptake and release by biota and are variable on small spatial and temporal scales (Furnas *et al.*, 2005, 2011). Due to this high variability, their concentrations did not show as clear spatial patterns or correlations with coral reef attributes as the other water quality parameters that were included in the Guidelines and are considered to be more representative of nutrient availability integrated over time (De'ath and Fabricius, 2010). However, the Queensland Water Quality Guidelines (Department of Environment and Resource Management [DERM], 2009) identify GVs for dissolved inorganic nutrients in marine water bodies. Guideline values for dissolved inorganic nutrients and turbidity (in enclosed coastal waters) were drawn from Queensland Water Quality Guidelines or provided by the Reef Authority. Site-specific GVs for all water quality variables are shown in Appendix C Table C-9.

Table B-1: Guidelines values for 4 cross-shelf water bodies, provided by the Reef Authority. Values come from the Water Quality Guidelines for the Great Barrier Reef Marine Park (Great Barrier Reef Marine Park Authority, 2010). Guidelines for some values come from other sources, as indicated below.

		Enclosed coastal		Open coastal		Mid-shelf		Offshore	
Parameter	Unit	Wet Tropics	Central Coast	Wet Tropics	Central Coast	Wet Tropics	Central Coast	Wet Tropics	Central Coast
Chlorophyll *a**	µg L^{-1}	2.0	2.0	0.45	0.45	0.45	0.45	0.40	0.40
Particulate nitrogen*	µg L^{-1}	n/a	n/a	20.0	20.0	20.0	20.0	17.0	17.0
Particulate phosphorus*	µg L^{-1}	n/a	n/a	2.8	2.8	2.8	2.8	1.9	1.9
Suspended solids*	mg L^{-1}	5.0	15.0	2.0	2.0	2.0	2.0	0.7	0.7
Turbidity	NTU	10.0^{QLD}	6.0^{QLD}	1.5**	1.5**	1.5**	1.5**	<1^{QLD}	<1^{QLD}
Secchi depth	m	1.0	1.5	10.0	10.0	10.0	10.0	17.0	17.0
NO_x	µg L^{-1}	10.0^{QLD}	3.0^{QLD}	0.35***	0.35***	0.35***	0.35***	2.0^{QLD}	2.0^{QLD}
PO_4	µg L^{-1}	5.0^{QLD}	6.0^{QLD}	4.0^{QLD}	6.0^{QLD}	4.0^{QLD}	6.0^{QLD}	4.0^{QLD}	5.0^{QLD}

^{QLD} Values are Queensland Water Quality Guidelines (Department of Environment and Resource Management [DERM], 2009). Note these are 80th percentile guidelines.

* Seasonal adjustments to these parameters are used to produce seasonal (wet and dry) guidelines for producing satellite exposure maps (Table B-4).

** Turbidity trigger value (1.5 NTU) was derived for the MMP reporting by transforming the suspended solids GVs (2 mg L^{-1}) using an equation based on a comparison between direct water samples and instrumental turbidity readings (see MMP QA/QC Reports and Schaffelke *et al.*, 2009).

*** NO_x GVs for open coastal and mid-shelf sites were provided by the Reef Authority.

B-2 Calculation of the Water Quality Index

In the Great Barrier Reef Report Cards published prior to 2016, water quality assessments were based on the MMP broad-scale monitoring using ocean colour remote sensing imagery that covers a larger area than the fixed sampling locations reported here (Brando *et al.*, 2011). However, the current design of the MMP focuses on interpreting trends in site-specific water quality within key focus regions.

The Water Quality Index (WQ Index) is an interpretation tool developed by AIMS to visualise trends in the suite of water quality variables measured and to compare monitored water quality to Water Quality Guidelines (based on Department of Environment and Resource Management, 2009; Great Barrier Reef Marine Park Authority, 2010). The WQ Index uses a set of 5 key indicators:

- Water clarity (see definitions below for Index version),
- Chl-*a* concentrations,
- PN concentrations,
- PP concentrations, and
- NO_x concentrations.

These 5 indicators are a subset of the comprehensive suite of water quality variables measured in the MMP inshore water quality program. They have been selected because GVs are available for these measures, and they can be considered as relatively robust indicators that integrate a number of bio-physical processes in the coastal ocean.

TSS concentration, turbidity, and Secchi depth are indicators of the clarity of the water, which is influenced by a number of factors, including wind, waves, tides, and river inputs of particulate material. Chl-*a* concentration is widely used as a proxy for phytoplankton biomass as a measure of the productivity of a system or its eutrophication status and is used to indicate nutrient availability (Brodie *et al.*, 2007). Particulate nutrients (PN, PP) are an indicator of nutrient stocks in the water column (predominantly bound in phytoplankton and other organic particles as well as adsorbed to fine sediment particles) but are less affected by small-scale variability in space and time than dissolved nutrients (Furnas *et al.*, 2005, 2011). Nitrate is included as an indicator of dissolved nutrient concentrations in the coastal zone, which tend to be rapidly used by phytoplankton. Guideline values for NO_x were provided by the Reef Authority as available NO_x GVs from the Queensland Water Quality Guidelines (Department of Environment and Resource Management [DERM], 2009) are the 80th percentiles, which are considered to be high and not representative of values normally found in the Reef lagoon.

The WQ Index is calculated using 2 different methods due to changes in the MMP design that occurred in 2015, as well as concerns that the Index was not responsive to changes in environmental pressures of each year. The changes in design included increased number of sites, increased sampling frequency and a higher sampling frequency during December to April to better represent wet season variability. Thus, statistical comparisons between MMP data from 2005–15 and data from 2015–onwards must account for these changes. The 2 versions of the WQ Index have different purposes.

Long-term trend: This version of the WQ Index is based on the pre-2015 MMP sampling design and uses only the original sites (located in the open coastal water body) and 3 sampling dates per year (typically 2 dry season and one wet season). This sampling design had low temporal and spatial resolution and was aimed at detecting long-term trends in inshore water quality. To compensate for infrequent sampling, four-year running means are applied to reduce the effect of sampling date on the Index. Monitoring data are compared against broad water body GVs that do not include wet and dry season GVs (Table B-1). Steps in the calculation of this version of the WQ Index are:

1. Calculate four-year mean values for each of the 7 indicators (i.e., all values from 2005–08, 2006–09, 2007–10, etc).

2. Calculate the proportional deviations (ratios) of these running mean values (V) from the associated guideline value (GV) (Table B-1) as the difference of binary logarithms of values and guidelines:

$$\text{Ratio} = \log_2(GV) - \log_2(V)$$

for values where exceeding the GV constitutes a "fail". For values where exceeding the GV constitutes a "pass" (i.e., Secchi depth), the right side of this equation would be reversed.
3. Binary logarithm transformations are useful for exploring data on powers of 2 scales, and thus are ideal for generating ratios of 2 numbers in a manner that will be symmetrical around 0. Ratios of 1 and -1 signify a doubling and a halving, respectively, compared to the guideline. Hence, a ratio of 0 indicates a running mean that is the same as its GV, ratios <0 signify running means that are deteriorating or exceeded the GV and ratios >0 signify running means that are improving or complied with the GV.
4. Ratios exceeding 1 or -1 (more than twice or half the GV) are capped at 1 to bind the WQ Index scales to the region -1 to 1.
5. A combined water clarity ratio is generated by averaging the ratios of TSS and turbidity from loggers (where available).
6. The WQ Index for each site per four-year period is calculated by averaging the ratios of PP, PN, NO_x, Chl-*a*, and water clarity.
7. In accordance with other Great Barrier Reef Report Card indicators, the WQ Index scores (ranging from -1 to 1) are converted to a 'traffic light' colour scheme for reporting whereby:
   - < -2/3 to -1 equates to 'very poor' and is coloured red
   - < -1/3 to -2/3 equates to 'poor' and is coloured orange
   - < 0 to -1/3 equates to 'moderate' and is coloured yellow
   - 0 to < 1/2 equates to 'good' and is coloured light green
   - 1/2 to 1 equates to 'very good' and is coloured dark green.
8. For the focus region summaries, the Index scores of all sampling sites within a focus region (for example, all sites in the Tully focus region) are averaged (median) and converted into the colour scheme as above. For regional summaries, the Index scores of all sampling sites within a region (for example, all sites in the Wet Tropics region) are averaged (median) and converted as above.

Annual condition: This version of the WQ Index is based on the post-2015 MMP sampling design and uses all samples from open coastal and mid-shelf water bodies each year. (Note that the WQ Index in reports published prior to the 2018–19 report included enclosed coastal sites, see below). Due to high spatial and temporal sampling, a running mean is not used. Monitoring data are compared against site-specific GVs that include wet and dry season GVs (Table C-9). Steps in the calculation of this version of the WQ Index are:

1. For each of the 7 indicators, the annual, wet, and dry season (aggregations) means and medians (statistic) are calculated per year.
2. Guidelines from the Reef Authority are consulted to select the appropriate aggregation (annual, wet, or dry season) and statistic (mean or median) for each site and indicator (Table C-9).
3. Calculate the proportional deviations (ratios) of these aggregation statistics from the associated GVs as the difference of base 2 logarithms of values and GVs:

$$\text{Ratio} = \log_2(GV) - \log_2(V)$$

for values where exceeding the GV constitutes a "fail". For values where exceeding the GV constitutes a "pass" (i.e., Secchi depth), the right side of this equation would be reversed.

4. Ratios exceeding 1 or -1 (more than twice or half the GV) are capped at 1 to bind the WQ Index scales to the region -1 to 1.
5. Ratios of several indicators are combined to create a hierarchical structure (e.g., multiple measurements in parentheses are averaged together to create indicators). Three groups were created by averaging ratios as follows:
   - water clarity (average of Secchi depth, TSS, and turbidity from loggers ratios),
   - productivity (average of Chl-*a* and NO_x ratios), and
   - particulate nutrients (average of PN and PP ratios).
6. The WQ Index for each site is calculated by averaging the ratios of water clarity, productivity, and particulate nutrients.
7. In accordance with other Reef Report Card indicators, the WQ Index scores (ranging from -1 to 1) are converted to a 'traffic light' colour scheme for reporting whereby:
   - < -2/3 to -1 equates to 'very poor' and is coloured red
   - < -1/3 to -2/3 equates to 'poor' and is coloured orange
   - < 0 to -1/3 equates to 'moderate' and is coloured yellow
   - 0 to < 1/2 equates to 'good' and is coloured light green
   - 1/2 to 1 equates to 'very good' and is coloured dark green.
8. For the focus region summaries, the Index scores of all sampling locations within a focus region (for example, all sites in the Tully focus region) are averaged and converted into the colour scheme as above. For regional summaries, the Index scores of all sampling locations within a region (for example, all sites in the Wet Tropics region) are averaged and converted as above.
9. As of the 2018–19 report, this version of the Index now includes error bars, which propagate error in the Index via bootstrapping. Aggregation uncertainty is propagated through the spatial (site > focus region > region) and measure (measure > sub-indicator > indicator) hierarchies by repeatedly re-sampling (100 times with replacement) and aggregating bootstrapping. Each aggregation yields 100 estimates of each mean, and thus error bars represent the 95% quantile confidence intervals.

The annual condition version of the WQ Index has only been calculated since 2016 and is subject to future revision and refinement.

B-3 Monitoring of Reef water quality trends using remote sensing data

Remote sensing imagery is a useful assessment tool in the monitoring of turbid water masses and river flood plumes (hereafter river plumes) in the Reef lagoon. Ocean colour imagery provides synoptic-scale information regarding the movement, frequency of occurrence and composition of turbid waters in the Reef lagoon. Combined with *in situ* water quality sampling and modelling, the use of remote sensing is a valid and practical way to estimate wet season marine conditions as well as the extent and frequency of water type exposure on Reef ecosystems, including river plumes and resuspension events.

Until 2020, marine areas exposed to wet season water types were mapped using MODIS true colour images and a wet season (WS) water colour classification method, composed of 6 colours. This method is extensively presented in Álvarez-Romero *et al.* (2013) and used in, for example, Devlin *et al.* (2013) and Petus *et al.* (2014b, 2016, 2018 and 2019). Since 2020–21, the use of Sentinel-3 Ocean Land Colour Instrument (OLCI) satellite imagery and another colour scale (the Forel-Ule (FU) colour scale) was adopted, as the quality of the MODIS images was declining (Petus *et al.*, 2019).

The FU colour scale is an historical colour scale standard to determine the colour and classifies worldwide bodies of water (Novoa *et al.*, 2013). It is composed of 22 colours; going from indigo blue to cola brown, and is applicable for all natural waters (inland, estuarine, inshore and offshore) and all environmental conditions, including wet and dry season conditions (Wernand *et al.*, 2012, 2013; Van der Woerd *et al.*, 2016; Van der Woerd and Wernand, 2018). MODIS-Aqua WS and Sentinel-3 FU colour class maps showed very similar patterns over the 2017–18 wet season in a case study focusing on Wet Tropics and Burdekin regions of the Reef (Petus *et al.*, 2019 and Figure 2-2b and Table 2-2). This suggested that Sentinel-3 FU water colour products can be used to assure continuity in the monitoring of Reef water quality trends.

Production of the Reef water type maps

Previous methods used Daily MODIS Level-0 data acquired from the NASA Ocean Colour website, spectrally enhanced (from red-green-blue to hue-saturation-intensity colour system) and classified to 6 colour categories through a supervised classification using spectral signatures from typical wet season water masses types (including river plumes) in the Reef lagoon (Álvarez-Romero *et al.* 2013).

For this report, Reef water type maps were produced using daily Sentinel-3 OLCI Level 2 (hereafter, Sentinel-3 or S3) imagery reclassified to 21 distinct colour classes defined by their colour properties and using the Forel-Ule colour classification scale.

- Sentinel-3 imagery of the study area was downloaded on the EUMETSAT Data centre (URL: https://www.eumetsat.int/eumetsat-data-centre). Sentinel-3 are atmospherically corrected
- The imagery was processed with the FU Satellite Toolbox implemented in the Sentinel Application Platform (https://step.esa.int/main/toolboxes/snap/) and using automated tools (python scripts and ArcGIS toolboxes) developed through MMP funding

The FU satellite algorithm converts satellite normalised multi-band reflectance information into a discrete set of FU numbers using uniform colourimetric functions (Van der Woerd *et al.*, 2016, Van der Woerd and Wernand, 2018). The derivation of the colour of natural waters is based on the calculation of Tristimulus values of the 3 primaries (X, Y, Z) that specify the colour stimulus of the human eye. The algorithm is validated by a set of hyperspectral measurements from inland, coastal and marine waters (Van der Woerd *et al.*, 2016, Van der Woerd and Wernand, 2018). Technical details about the FU scale algorithm are synthetised through the European citclops (URL: http://www.citclops.eu/) and Eye on Water project webpages (https://www.eyeonwater.org/).

Production of weekly Reef water type maps

Weekly Reef water type composites are then created to minimise the image area contaminated by dense cloud cover and intense sun glint (Álvarez-Romero *et al.*, 2013).

- The maximum FU value of each pixel/week is used to keep the colour class with the highest turbidity level for each wet season week.
- The weekly composite maps are then cleaned to remove single or small clusters of cells sometimes misclassified by the FU satellite algorithm in the offshore regions of the Great Barrier Reef (including, for example, around coral reefs due to bottom interference and residual glint contamination). The aim of cleaning is to minimise the image area contaminated by dense cloud cover and intense sun glint, and to remove shallow water interference around reefs. In all cases the effect of these phenomena can be that offshore waters are misclassified as, for example, Reef WT1 waters (FU ≥ 10, previously primary waters). To minimise these effects an automated process is applied to the rasters that has the effect of sequentially infilling contiguous water-type areas one colour class at a time from FU1 through to FU21 using Python 2.7.3 (Python Software Foundation, 2012) and ArcGIS 10.7 (ESRI, 2019). Infilling was achieved using the following steps: 1) Raster to Polygon conversion (not simplified), 2) Union (no gaps) then 3) removal, using Erase, of an external polygon, and 4) Polygon to Raster conversion. This process generates a separate raster mask (values 1 or 0) for each colour class, and the final cleaned raster is created by adding the component raster masks. Whilst this process is effective at removing noise offshore it can occasionally have the effect of removing areas of turbid coastal and plume water if they are not directly connected to the coast. To counter this, a final step is included in the cleaning process whereby waters classified as FU classes ≥10 i.e., in the cleaned raster are replaced with pixels of FU classes ≥10 in the original raster, using Con (Spatial Analyst). Thus, pixels adjacent to the coast that are classified as highly turbid water are kept and pixels within otherwise contiguous water types offshore are removed.

Production of annual, multi-annual, and typical wet and dry Reef frequency maps

- Four distinct Reef water type (WT) are defined by grouping the FU colour classes 1–3 (Reef WT4, equivalent to marine waters in the WS scale), FU colour classes 4–5 (reef WT3, equivalent to WS Tertiary water type), FU colour classes 6–9 (Reef WT2, equivalent to WS Secondary water type) and FU≥10 (Reef WT1, equivalent to wet season primary water type), as defined in Petus *et al.* (2019). The Reef water types are fully described in Table 2-2.
- Weekly Reef water type composites are thus overlaid in ArcGIS (i.e., presence/absence of one Reef water type), normalised (0–1) to compute each year a seasonal normalised frequency maps of occurrence of each Reef water type individually and of the Reef WT1–2 combined. Pixel (or cell) values of these maps range from 0 to 1; with a value of 1 meaning that one pixel has been exposed for all weeks out of the 22 week period (1 December to 30 April) of the wet season which was documented.
- Annual frequency maps are then overlaid in ArcGIS to create multi-annual normalised frequency composites of occurrence of Reef water types. Multi-annual composites are calculated over different time frames, using the archive of MODIS-Aqua (2002–03 to 2019–20) and Sentinel-3 (2020–21 to 2022–23) water type maps. In order to combine the MODIS-Aqua and Sentinel-3 frequency composites, the MODIS frequency rasters were resampled to the same spatial resolution as the Sentinel imagery (0.00329 decimal degrees) using the Nearest Interpolation methods in ArcMAP 10.6 (Resample toll, Data Management)

Multi-annual frequency composites include: (i) a long-term period (2002–03 to 2021–22: 20 wet seasons) and (ii) a typical recovery period for Reef corals (2012–2017).

Composite frequency maps are also produced to represent typical wet year and dry year conditions. To account for broad-scale spatial variability in wet season river flows, wet- and dry-year maps are first produced separately by averaging frequency maps from the 4 wettest and driest years in each NRM region (Table B-2). The wet-year maps for each NRM region are combined into a single composite Reef-wide map using the maximum value of the input rasters. This method captures wet-year plume conditions across the entire Reef even if the most significant plume events originate outside the NRM (for example, if Fitzroy plumes are dominant in the Mackay-Whitsunday region the top-quartile discharges from the Fitzroy are already included in the composite raster). Conversely, the dry-year maps are combined into a Reef-wide composite map using the minimum value of the input rasters, which thus represents the least extensive plume from an average of the driest years in each NRM region.

Except for the coral recovery period, reference maps (long-term, wet and dry frequency maps) were all updated in 2023 to ensure they remains valid as a representative period and to improve their accuracy as more satellite data are available. The previous update was in 2019.

The daily, weekly, and wet season frequency maps are used to illustrate the wet season conditions for every year, to assess the extent of river flood plumes and resuspension events in the Reef and to compare seasonal with long-term trends, as well as trend in water composition during typical dry and wet years. Results are presented in the main report and in Appendix C.

Table B-2: Wettest and driest years used to compute the typical wet and typical dry composite frequency maps in each NRM region. All years are in the top/bottom quartiles, except 2005 and 2007 for Cape York which are under the long-term median.

Region	Wet years				Dry years			
Cape York	2021	2006	2011	2019	2003	2016	2005	2007
Wet Tropics	2018	2009	2019	2011	2003	2020	2015	2005
Burdekin	2019	2008	2009	2011	2015	2016	2004	2003
Mackay-Whitsunday	2012	2008	2010	2011	2004	2015	2003	2006
Fitzroy	2008	2010	2013	2011	2006	2005	2007	2004
Burnett-Mary	2012	2022	2013	2011	2021	2006	2007	2005

Susceptibility assessment

Frequency maps are compared with ecological health information collected through the coral reef and seagrass components of the MMP (e.g., McKenzie *et al.*, 2019, Thompson *et al.*, 2019) to better understand the susceptibility of the seagrass meadow and coral reef ecosystems to water quality conditions.

Composition of Reef water types

The classification of 4 Reef water types allows mapping of large Reef waterbodies with different colour characteristics and concentrations of optically active components (TSS, CDOM, and Chl-*a*), water quality indicators (e.g. nutrients levels; Devlin *et al.*, 2015; Petus *et al.*, 2019), and light attenuation levels (Petus *et al.*, 2018) typically found in the Reef during the wet season (Table 2-2). Match-up of *in situ* concentrations of water quality parameters and the 4 Reef water types are performed to validate this concept and quantify the range and average of water quality concentrations found in each Reef water type.

Match-ups between sampled date and corresponding weekly Reef water type maps are performed at site location basis using the *extract tool of* the raster package (Hijmans *et al.*, 2015) with bilinear interpolation method in R 3.2.4 or the Extract Multi Values to Point (Spatial

Analyst) in ArcMap (from 2020). The R tool interpolates from the values of the 4 nearest raster cells (R Core Team, 2019) while the ArcMap tool extract cell values at the exact location (used from 2020). Several land-based pollutants are investigated through match-ups between *in situ* data and the 6 colour class maps, including NO_x, DIP, PP, PN, TSS, Chl-*a*, CDOM, and K_D or Secchi depth. Boxplots of water quality parameters across water types (Figure 4-3) and MODIS WS colour classes (Table B-2) as well as the mean long-term concentrations of water quality parameters across the 3 wet season water types in all focus regions (Figure B-2) are presented. Work is currently underway to break down the turbid WT1 into a greater number of water types and identify Sentinel-3 Forel-Ule colour classes equivalent to the former MODIS colour classes 1 to 4.

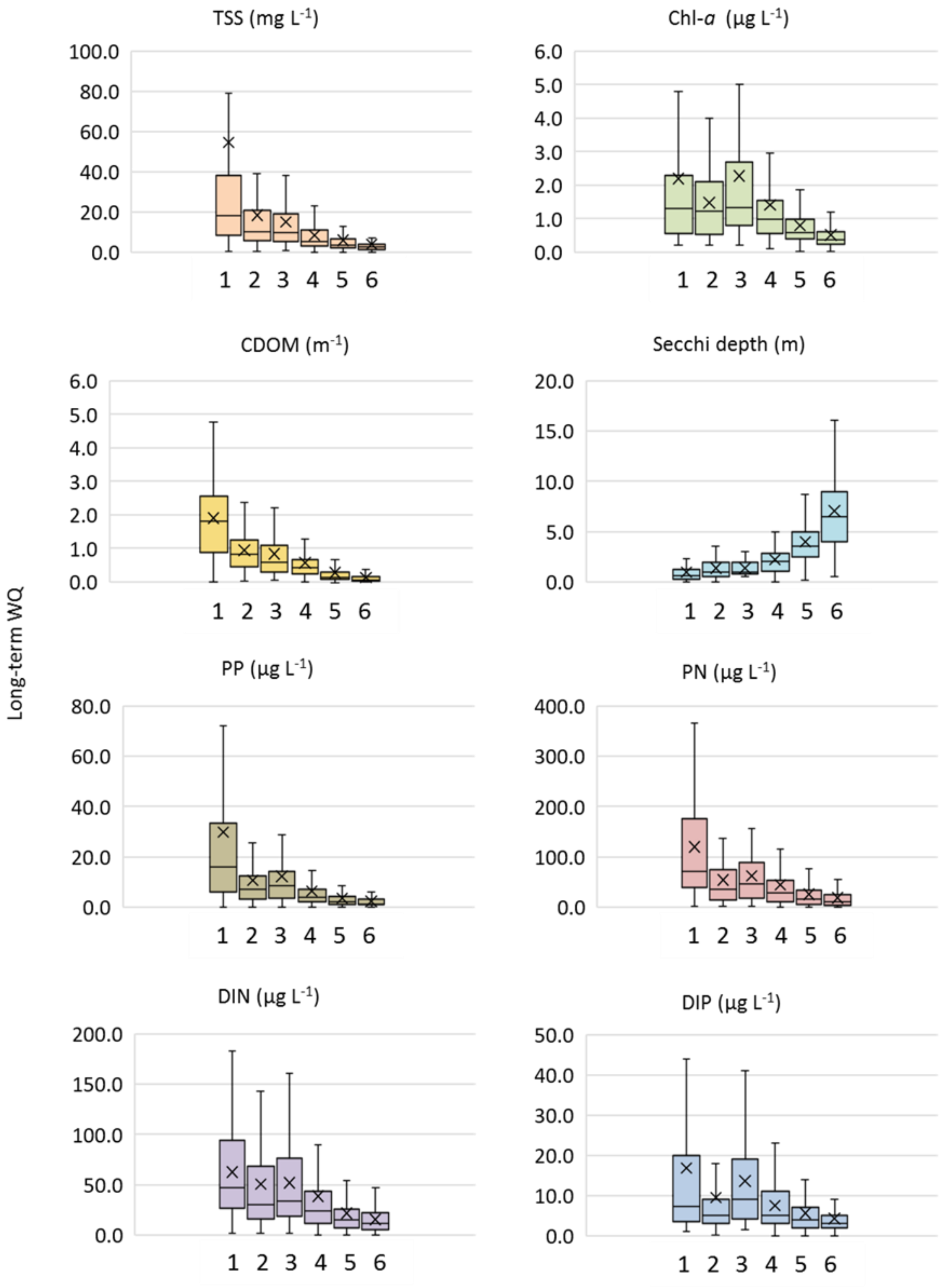


Figure B-1: Long-term water quality (WQ) concentrations and Secchi depth boxplots for each wet season colour class. The mean is plotted as a cross (x) and its numerical value is indicated. The interquartile range is delimited by the box and the median by the line inside the box. Whiskers indicate variability outside the upper and lower quartiles. Data beyond the whiskers range are considered outliers and are not plotted. Long-term water quality values are reviewed and updated every 4 years (and/or in the case of extremely wet year or specific event patterns) to ensure the water type characterization remains valid as a representative period, and to improve its accuracy as more field data are collected every wet seasons. The last update was in 2019, using all field data available (from 2004–2019). Work is underway to update this figure.

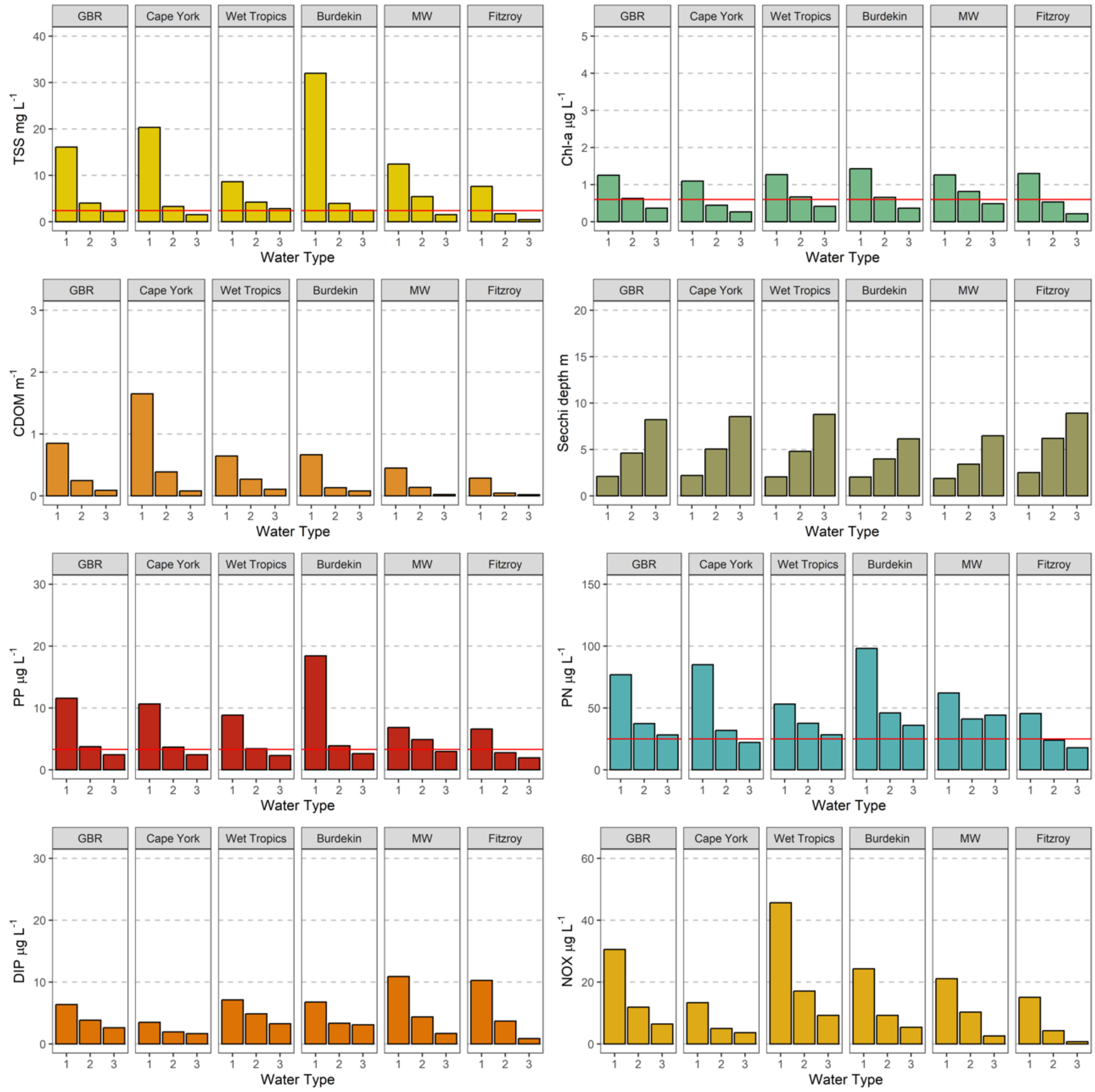


Figure B-2: Mean long-term (2004–2023) concentrations of water quality parameters across the 3 wet season water types in all focus regions . Red lines show the Reef-wide wet season GVs (Table B-4). The Burdekin region has the greatest average TSS, PP, and PN concentrations in the Reef water type 1, which exceeded the long-term Reef-scale average. The greatest mean NO_x and CDOM concentrations are measured in the Reef water type 1 of the Wet Tropics and Cape York regions, respectively. The greatest mean Chl-*a* concentrations are measured in the Reef water type 1 of the Burdekin region, but concentrations are more uniform across region. Mean long-term concentrations of water quality parameters include samples collected from the enclosed coastal water body (Table B-1), where high TSS, PN, and PP concentrations are likely to contribute to exceedances of the Reef-wide GVs.

Detailed summaries of water quality parameters (mean, standard deviation, minimum, maximum, and number of values for each parameter across colour classes and water types) for the long-term are provided in Appendix C. Long-term water quality values are calculated using all surface data (<0.2 m) collected between December and April by JCU (since 2004), AIMS, and the CYWP (since 2016–17) in the whole of the Reef.

Potential risk maps and exposure assessment

Information on the long-term water chemistry concentrations measured in the Reef water type are compared to published water quality guideline values and, combined with frequency maps of occurrence of wet season colour classes, are used in a *"magnitude x likelihood"* risk management framework to develop potential risk maps . Different frameworks have been used to estimate the exposure and potential risk from exposure and are described in Petus *et al.*

(2014a, 2016), Waterhouse *et al.* (2017), Gruber *et al.* (2019), and used in the MMP reports before 2015–16. In a collaborative effort between the MMP monitoring providers (JCU water quality and seagrass teams and the AIMS coral monitoring team), an updated potential risk assessment framework was developed in 2015–16 (modified from Petus *et al.*, 2016), where the 'potential risk' corresponds to an exposure to above guideline concentrations of land-based pollutant during wet season conditions and focuses on the TSS, Chl-*a*, PP, and PN concentrations.

- The *'magnitude of the risk'* corresponds to the long-term concentration of pollutants (proportional exceedance of the guideline) mapped through the Reef WT1, WT2 and WT3 (primary, secondary and tertiary water types).
- The *'likelihood of the risk'* is estimated by calculating the frequency of occurrence of each Reef water type. The exposure for each of the water quality parameters defined is as the proportional exceedance of the guideline multiplied by the likelihood of exposure in each of the Reef water type and calculated as below. For each cell (500 m x 500 m):

For each pollutant (Poll.) the exposure in the Reef WT1, WT2, WT3 (primary or secondary or tertiary): $Poll\_expo_{water\ type}$ is calculated:

$$Poll\_expo_{water\ type} = magnitude_{water\ type} \times likelihood_{water\ type}$$

$$magnitude_{water\ type} = ([Poll.]_{water\ type} - guideline)/guideline$$

$$likelihood_{water\ type} = frequency_{water\ type}$$

where $water\ type$ is the Reef WT1, WT2 or WT3 (primary, secondary and tertiary water types), $[Poll.]_{water\ type}$ is long-term mean TSS, Chl-*a*, PN, or PP concentration measured in each respective wet season water types and $guideline$ is the Reef-wide wet season GV from De'ath and Fabricius (2008) for TSS, Chl-*a*, PP, and PN (Table B-4).

Table B-3: Reef-wide wet season guideline values used to calculate the exposure score for satellite exposure maps. These guidelines are based on seasonal adjustments to Reef-wide annual guidelines (Great Barrier Reef Marine Park Authority, 2010), where wet season guidelines are +20% for TSS, PN, and PP, and +40% for Chl-*a* of annual guidelines (De'ath and Fabricius 2008).

Parameter	Unit	Reef-wide
Chlorophyll *a*	$\mu g\ L^{-1}$	0.63
Particulate nitrogen	$\mu g\ L^{-1}$	25
Particulate phosphorus	$\mu g\ L^{-1}$	3.3
Suspended solids	$mg\ L^{-1}$	2.4

These GVs are compared against the mean long-term concentrations to calculate the magnitude score in the satellite potential risk of ecosystem exposure to wet season water quality maps (proportional exceedance of the guideline). Mean long-term concentrations of water quality parameters are calculated using all available surface water quality data in all Reef marine regions and water bodies (Table B-4). The variability in the number of samples between regions and water types is primarily driven by the sampling design which was reviewed in 2014. The small number of samples in the Burnett-Mary region reflects the geographic extent of the MMP; with a majority of the samples collected by JCU in the 2011 and 2013 flood events when the design of the event monitoring was more opportunistic across the whole Reef. The relatively small number of samples in offshore waters reflects the geographic focus of the MMP design which is largely constrained to the open coastal and mid-shelf waters. The last update in the mean long-term concentrations was in the 2022–23 reporting year (Gruber *et al.*, 2024), using field data collected from 2004 to 2019. Note also that the long-term and Reef-wide concentrations of water quality parameters are used rather than the seasonal and/or regional mean concentrations in water type to avoid bias due to differential regional and seasonal sampling distribution.

Table B-4: Number of collected *in situ* samples used in the calculation of the magnitude score by region and water type. Samples include all wet season (Dec–April) surface samples since 2004 (from JCU) and since the 2016–17 water year (AIMS and the CYWP) and up to April 2022.

Region	Reef Water type	Secchi	TSS	CHL	CDOM	NO_X	DIP	PP	PN
Cape York	WT1	157	208	218	160	214	218	102	80
	WT2	225	295	301	180	301	301	188	170
	WT3	126	176	181	109	178	178	120	111
	Marine	8	13	13	4	13	13	5	4
Wet Tropics	WT1	185	406	399	388	356	356	57	58
	WT2	400	623	637	574	611	615	228	229
	WT3	203	289	296	239	273	274	143	143
	Marine	25	33	35	29	33	33	19	19
Burdekin	WT1	102	157	156	113	151	155	63	73
	WT2	202	258	260	194	258	260	99	106
	WT3	61	97	96	71	81	82	40	40
	Marine	21	33	39	23	28	29	20	19
Mackay-Whitsunday	WT1	28	45	42	43	45	45	20	20
	WT2	73	134	129	98	127	132	74	75
	WT3	20	39	39	27	33	34	27	27
	Marine	7	13	13	8	9	10	6	6
Fitzroy	WT1	22	103	104	78	105	105	17	17
	WT2	27	64	78	65	82	84	22	22
	WT3	8	20	25	11	16	17	8	8
	Marine	0	6	6	1	6	6	0	0
Burnett-Mary	WT1	7	16	16	7	7	16	0	0
	WT2	5	9	9	5	5	9	0	0
	WT3	0	2	2	0	0	0	0	0
	Marine	0	8	8	1	3	3	0	0
Reef-wide	WT1	501	935	935	789	878	895	259	248
	WT2	932	1383	1414	1116	1384	1401	611	602
	WT3	418	623	639	457	581	585	338	329
	Marine	61	106	114	66	92	94	50	48

For each pollutant, the total exposure ($Poll\_expo$) is calculated at the exposure for each of the Reef water types:

$$Poll\_expo = Poll\_expo_{Primary} + Poll\_expo_{Secondary} + Poll\_expo_{Tertiary}$$

The overall exposure score ($Score\_expo$) is calculated as the sum of the total exposure for each of the water quality parameters:

$$Score\_expo = TSS.\exp + Chla.exp + PP.\exp + PN.exp$$

For example, using the long-term mean Chl-*a* values measured during high flow conditions in the Reef WT1, WT2, and WT3:

$$Chla\_exp_{WT1} = \frac{1.45-0.63}{0.63} \times frequency_{water\ type\ (0-1, cell-specific)}$$

$$Chla\_exp_{WT2} = \frac{0.65-0.63}{0.63} \times frequency_{water\ type\ (0-1, cell-specific)}$$

$Chla\_exp_{WT3}$ = 0 as Chl-*a* levels are below the guideline for Chl-*a*;

The total exposure for Chl-*a*:

$$Chla\_expo = Chla\_expo_{WT1} + Chla\_expo_{WT2} + Chla\_expo_{WT3}$$

The overall exposure scores are then grouped into 4 potential classes (I–IV) based on a "Natural Break (or Jenks)" classification. Jenks is a statistical procedure, embedded in ArcGIS that analyses the distribution of values in the data and finds the most evident breaks in it (i.e., the steep or marked breaks; Jenks and Caspall, 1971). The Jenks classification determine the best arrangement of values into different classes by reducing the variance within classes and maximising the variance between classes.

The potential risk classes are defined by applying the Jenks classification to the mean long-term potential risk map (2003–2022), because this map presented the highest number of observations. Using the 2003–2018 mean potential risk map, categories were defined as [>0–0.9] = cat. I, [0.9–3.5] = cat. II, [3.2–7.9] = cat III and >7.9 = cat IV. Category I and areas mapped as "potential risk = 0 (no potential risk)", are re-grouped into a unique category I (no or very low potential risk). These categories are to all potential risk composites created (seasonal, coral recovery period, typical wet and dry periods).

The methods presented above are slightly different than methods used in previous wet season's reports (2016–17 and 2017–18 wet seasons) where (i) seasonal mean concentrations of water quality parameters across water types were used to produce the seasonal exposure map and (ii) potential risk maps were reclassified using 4 equally-distributed colour classes. Changes in 2019 (using only long-term mean concentrations of water quality parameters and a Jenk's classification of the potential risk maps) were made in response to: (i) concerns that water quality concentrations collected in a specific wet season would likely get biased toward the sample size and the location and timing of sampling in this particular wet season conditions and (ii) that the equally-distributed categories were not responsive enough to changes in environmental pressures of each year.

Potential risk of ecosystem exposure to wet season water quality is for the whole of the Reef, for all focus regions and over different time frames:

- for the current reporting wet season (using the Sentinel-3 FU imagery),
- over several multi-year reference periods (using the archive of MODIS WS imagery):
    - the long-term (2002–03 to 2021–22: 20 wet seasons),
    - a documented recovery period for coral reefs (2012–2017 period) and
    - representations of typical wet-year and dry-year conditions.

The potential risk assessments for the reference periods (long-term, representative wet and representative dry periods) were updated in 2023 to ensure they remain valid as a representative period and to improve their accuracy as more satellite data are available. The previous update was in 2019. The potential risk assessment for the coral recovery period was not updated along with the other reference periods because the documented recovery period for coral reefs (2012–2017) is fixed and therefore is not influenced by the availability of new data.

Finally, assessments of the potential risk of exposure of Reef ecosystem exposure to wet season water quality are made through the calculation of the areas (km^2) and percentages (%) of each region, coral reefs and seagrass meadows affected by different categories of potential risk. The area and percentage are calculated as a relative measure between regions and waterbodies. The difference in percentages between the current year and in the long-term is also calculated. Figure B-3 presents the marine boundaries used for the Marine Park, each NRM region, the Reef waterbodies and the seagrass and coral reefs ecosystems. The area (km^2) and percentages of seagrass and coral reefs in the Reef and regional waterbodies is indicated in Figure B-3. We assumed in this study that the seagrass shapefile can be used as a representation of the actual seagrass distribution. It is known, however, that absence on the composite map does not definitively equate to absence of seagrass and may also indicate un-surveyed areas.

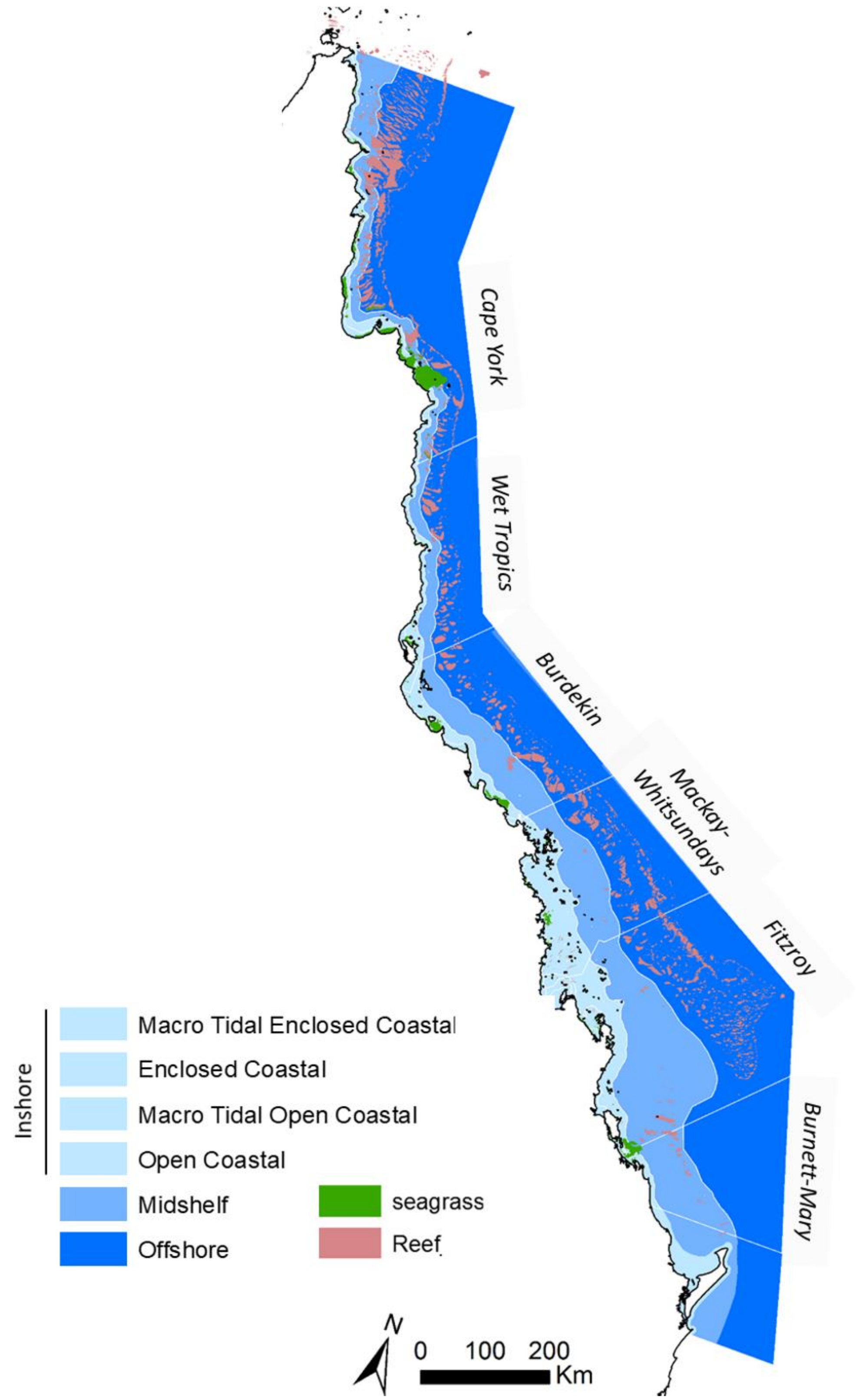


Figure B-3: Boundaries used for the Marine Park, each NRM region, and the coral reefs and seagrass ecosystems. Coral reef and NRM layers derived from the Reef Authority, supplied 2013. Seagrass layer is a composite of surveys conducted by Department of Agriculture and Fisheries, QLD.

B-4 Rivers included in the Loading Maps

Figure B-4: eReefs model for the loading maps: Grouping of rivers into the Great Barrier Reef 35 major basins.Notes: [1]: eReefs phase 4 (2011 to 2016) rivers in bold, all others are eReefs phase 5 rivers (this reports version: 2011 to 2022). In eReefs phase 4 these rivers were entered as river fluxes (loads without freshwater flow). All loads for rivers/basins for the eReefs marine model are supplied by GBR Dynamic SedNet model.

NRM Region	35 GBR basins with freshwater flow[1]	Additional rivers with freshwater flow in eReefs phase 5 (2011–2022) with flows reflecting affiliation to one of the 35 basin catchment parents
Cape York	Jacky Jacky	Jacky Jacky
	Olive-Pascoe	Olive
		Pascoe
	Lockhart	Lockhart
	Stewart	Stewart
	Normanby	North Kennedy
		Normanby
	Jeannie	Jeannie
	Endeavour	Endeavour
		Annan
Wet Tropics	**Daintree**	Bloomfield
		Daintree
	Mossman	Mossman
	Barron	Barron
	Mulgrave Russell	Mulgrave Russell
	Johnstone	Liverpool
		Johnstone
	Tully	Tully
	Murray	Murray
		Meunga
	Herbert	Herbert
Burdekin	Black	Bluewater
		Black
	Ross	Bohle
		Ross
		Alligator
	Haughton	Haughton
		Barratta
	Burdekin	Burdekin
	Don	Elliot
		Euri
		Don
Mackay-Whitsunday	Proserpine	Gregory
		Proserpine
	OConnell	OConnell
		StHelens

NRM Region	**35 GBR basins with freshwater flow**[1]	**Additional rivers with freshwater flow in eReefs phase 5 (2011–2022) with flows reflecting affiliation to one of the 35 basin catchment parents**
		Constant
	Pioneer	Pioneer
	Plane	Sandy
		Plane
		Carmila
Fitzroy	Styx	Styx
	Shoalwater	Shoalwater
	Waterpark	Waterpark
	Fitzroy	Fitzroy
	Calliope	Calliope
	Boyne	Boyne
Burnett-Mary	Baffle	Baffle
	Kolan	Kolan
	Burnett	Burnett
	Burrum	Eliott
		Burrum
	Mary	Mary

B-5 References

Álvarez-Romero JG, Devlin MJ, Teixeira da Silva E, Petus C, Ban N, Pressey RJ, Kool J, Roberts S, Cerdeira WA, Brodie J (2013). A novel approach to model exposure of coastal-marine ecosystems to riverine flood plumes based on remote sensing techniques. Journal of Environmental Management 119: 194-207.

Brando VE, Blondeau-Patissier D, Schroeder T, Dekker AG, Clementson L (2011). Reef Rescue Marine Monitoring Program: Assessment of terrestrial run-off entering the Reef and inshore marine water quality monitoring using earth observation data. Final Report for 2010/11 Activities. CSIRO, Canberra. 201 pp.

Brodie, J., De'ath, G., Devlin, M., Furnas, M., Wright, M., (2007). Spatial and temporal patterns of near-surface chlorophyll a in the Great Barrier Reef lagoon. Marine and Freshwater Research 58, 342–353.

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

De'ath G, Fabricius KE (2010). Water quality as a regional driver of coral biodiversity and macroalgae on the Great Barrier Reef. Ecological Applications 20: 840–850.

Department of Environment and Resource Management (DERM) (2009). Queensland Water Quality Guidelines, Version 3. 167 p. Available at www.derm.qld.gov.au. ISBN 978-0-9806986-0-2.

Devlin MJ, Wenger A, Petus C, da Silva ET, DeBose J, Álvarez-Romero J (2013). Reef Rescue Marine Monitoring Program. Final report of JCU activities 2011/12: flood plumes and extreme weather monitoring for the Great Barrier Reef Marine Park Authority (Report). James Cook University.

Devlin M, Petus C, Teixeira da Silva E, Tracey D, Wolff N, Waterhouse J, Brodie J (2015). Water quality and river plume monitoring in the Great Barrier Reef: An Overview of Methods Based on Ocean Colour Satellite Data. Remote Sensing 7: 12909-12941.

Furnas MJ, Mitchell AW, Skuza M, Brodie J (2005). In the other 90%: Phytoplankton responses to enhanced nutrient availability in the Great Barrier Reef lagoon. Marine Pollution Bulletin 51: 253-256.

Furnas M, Alongi D, McKinnon D, Trott L, Skuza M (2011). Regional-scale nitrogen and phosphorus budgets for the northern (14°S) and central (17°S) Great Barrier Reef shelf ecosystem. Continental Shelf Research 31: 1967-1990. doi:10.1016/j.csr.2011.09.007

Great Barrier Reef Marine Park Authority (2010). Water Quality Guidelines for the Great Barrier Reef Marine Park. Revised Edition 2010. Great Barrier Reef Marine Park Authority, Townsville. 100 pp.

Gruber R, Waterhouse J, Logan M, Petus C, Howley C, Lewis S, Tracey D, Langlois L, Tonin H, Skuza M, Costello P, Davidson J, Gunn K, Lefevre C, Shanahan M, Wright M, Zagorskis I, Kroon F, Neilen A (2019). Marine Monitoring Program: Annual Report for Inshore Water Quality Monitoring 2017-18. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville, 304pp.

Gruber R, Waterhouse J, Logan M, Petus C, Howley C, Lewis S, Tracey D, Langlois L, Tonin H, Skuza M, Costello P, Davidson J, Gunn K, Lefevre C, Moran D, Robson B, Shanahan M, Zagorskis I, Shellberg J, Neilen A (2020). Marine Monitoring Program: Annual Report for Inshore Water Quality Monitoring 2018–19. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville, 262pp.

Hijmans RJ, Etten J van, Mattiuzzi M, Sumner M, Greenberg JA, Lamigueiro OP, Bevan A, Racine, EB, Shortridge A (2015). raster: Geographic Data Analysis and Modelling.

Jenks GF and Caspall FC (1971). Error on Choroplethic Maps: Definition, Measurement Reduction. Annals of the Association of American Geographers 61: 217-44.

McKenzie LJ, Collier CJ, Langlois LA, Yoshida RL, Uusitalo J, Smith N, Waycott M (2019). Marine Monitoring Program: Annual Report for inshore seagrass monitoring 2017-2018. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville, 188 pp.

Petus C, Teixera da Silva E, Devlin M, Álvarez-Romero J, Wenger A (2014a). Using MODIS data for mapping of water types within flood plumes in the Great Barrier Reef, Australia: towards the production of river plume risk maps for reef and seagrass ecosystems. Journal of Environmental Management 137: 163-177.

Petus C, Collier C, Devlin M, Rasheed M, McKenna S (2014b). Using MODIS data for understanding changes in seagrass meadow health: A case study in the Great Barrier Reef (Australia). Marine Environmental Research 98: 68-85.

Petus C, Devlin M, Thompson A, McKenzie L, Teixeira da Silva E, Collier C, Tracey D, Martin K (2016). Estimating the exposure of coral reefs and seagrass meadows to land-sourced contaminants in river flood plumes of the Great Barrier Reef: validating a simple Satellite Risk Framework with Environmental Data. Remote Sensing, 8, 210.

Petus C, Devlin M, da Silva E, Lewis S, Waterhouse J, Wenger A, Bainbridge Z and Tracey D (2018) Defining wet season water quality target concentrations for ecosystem conservation using empirical light attenuation models: a case study in the Great Barrier Reef (Australia). Journal of Environmental Management 213: 1-16.

Petus C, Waterhouse J, Lewis S, Vacher M, Tracey D, Devlin M. (2019). A flood of information: Using Sentinel-3 water colour products to assure continuity in the monitoring of water quality trends in the Great Barrier Reef (Australia). Journal of Environmental Management 248: 109255.

R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: https://www.R-project.org/

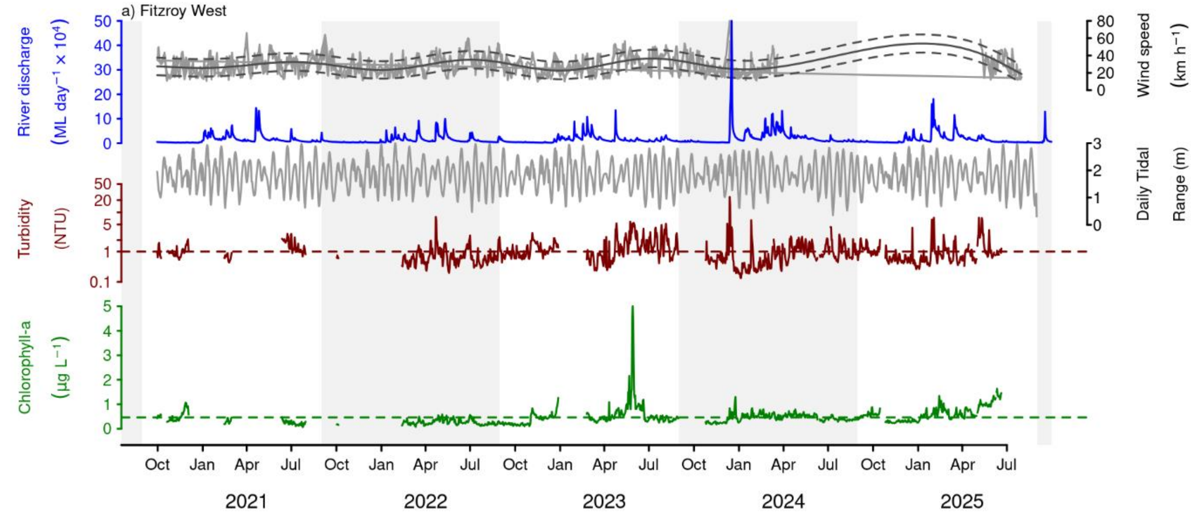
Schaffelke B, Thompson A, Carleton J, Davidson J, Doyle J, Furnas M, Gunn K, Skuza M, Wright M, Zagorskis I (2009). Reef Rescue Marine Monitoring Program. Final Report of AIMS Activities 2008/09. Report for Reef and Rainforest Research Centre. Australian Institute of Marine Science, Townsville. 146 pp.

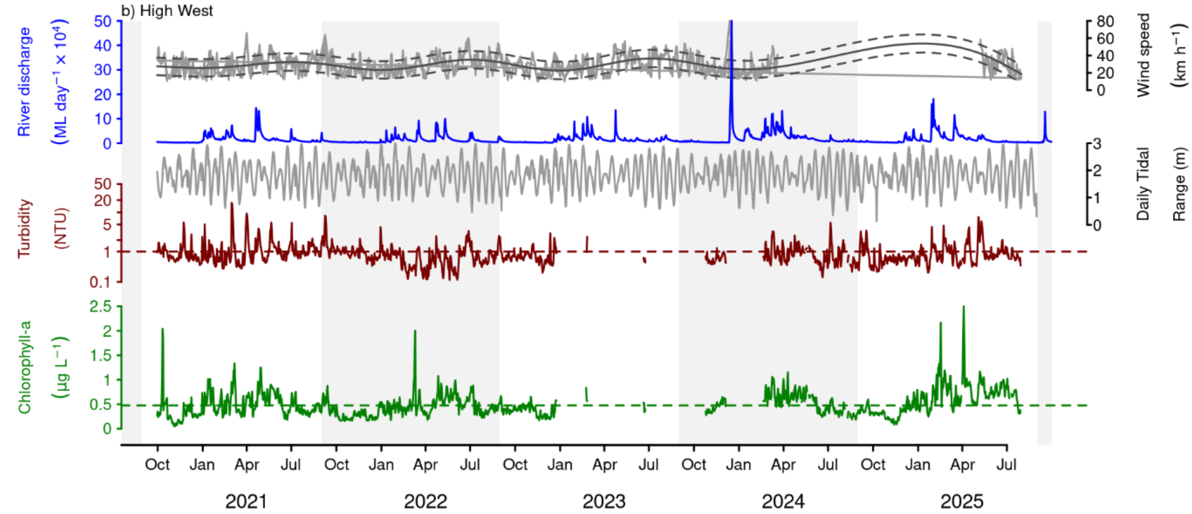
Thompson A, Costello P, Davidson J, Logan M, Coleman G (2019). Marine Monitoring Program: Annual report for inshore coral reef monitoring 2017-18. Great Barrier Reef Marine Park Authority, Townsville.127pp.

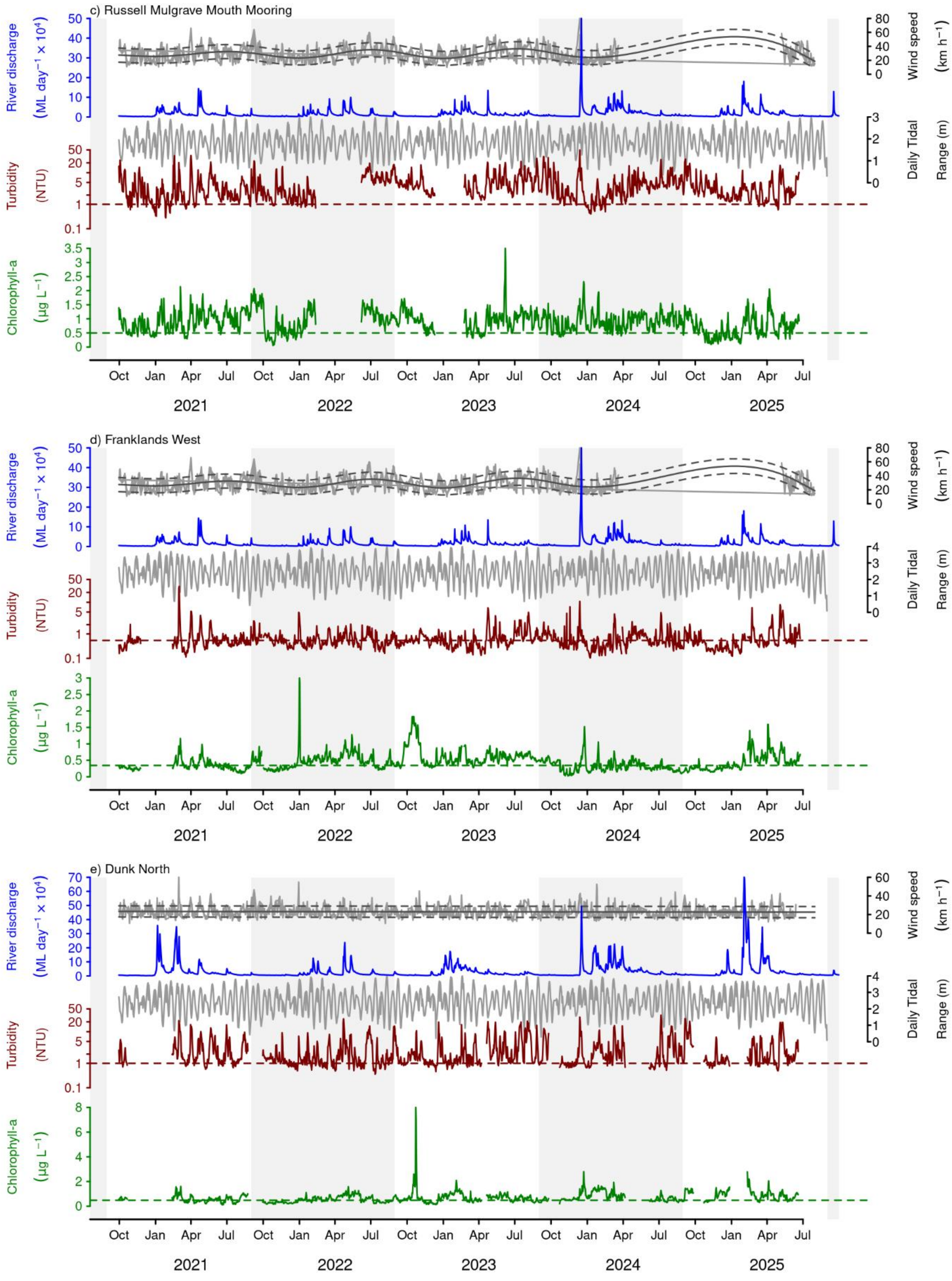
Waterhouse J, Lønborg C, Logan M, Petus C, Tracey D, Lewis S, Tonin H, Skuza M, da Silva E, Carreira C, Costello P, Davidson J, Gunn K, Wright M, Zagorskis I, Brinkman R, Schaffelke B (2017) Marine Monitoring Program: Annual Report for inshore water quality monitoring 2015-2016. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville, 227pp.

APPENDIX C: ADDITIONAL INFORMATION

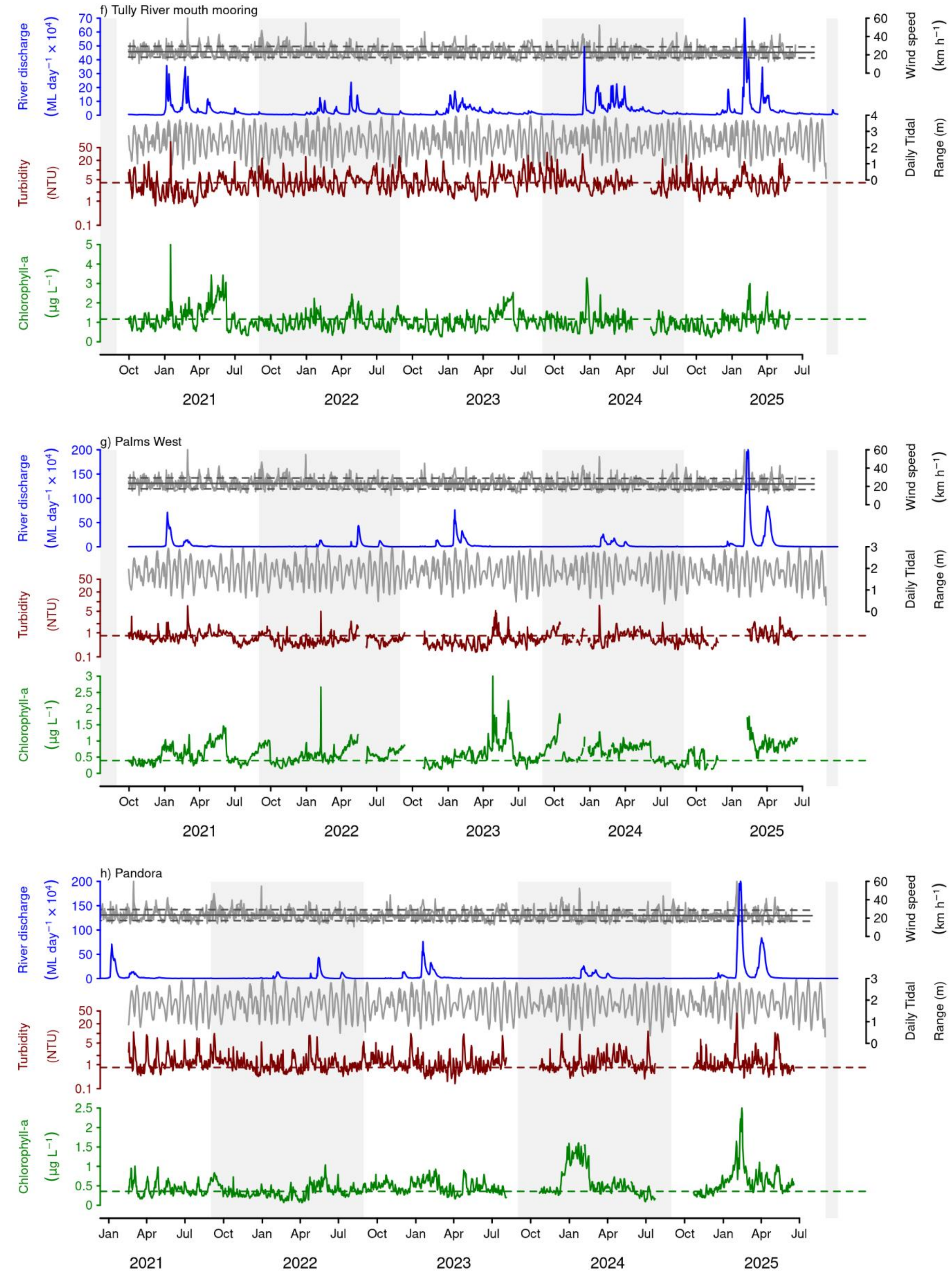
C-1 Time-series of turbidity and chlorophyll

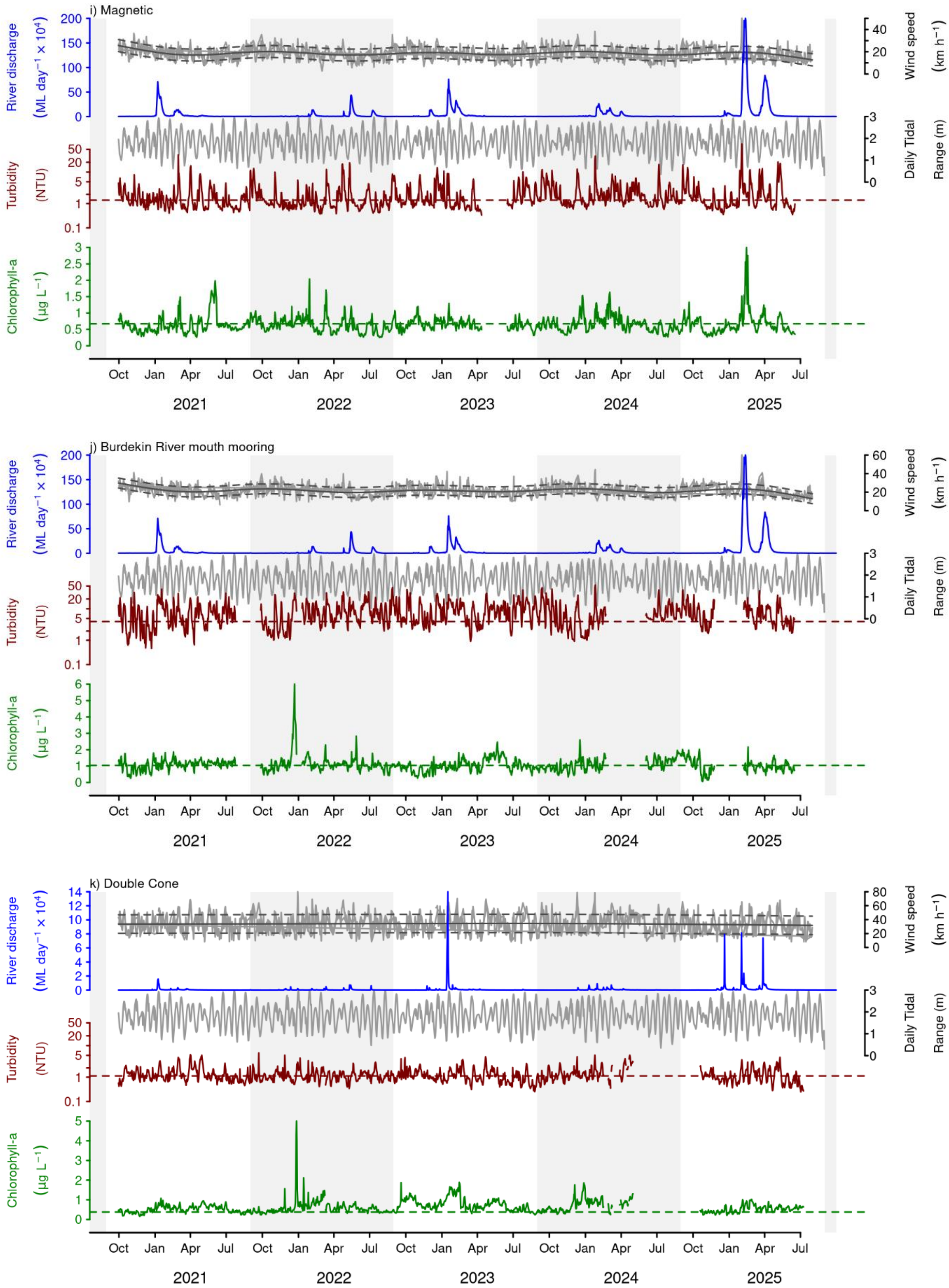


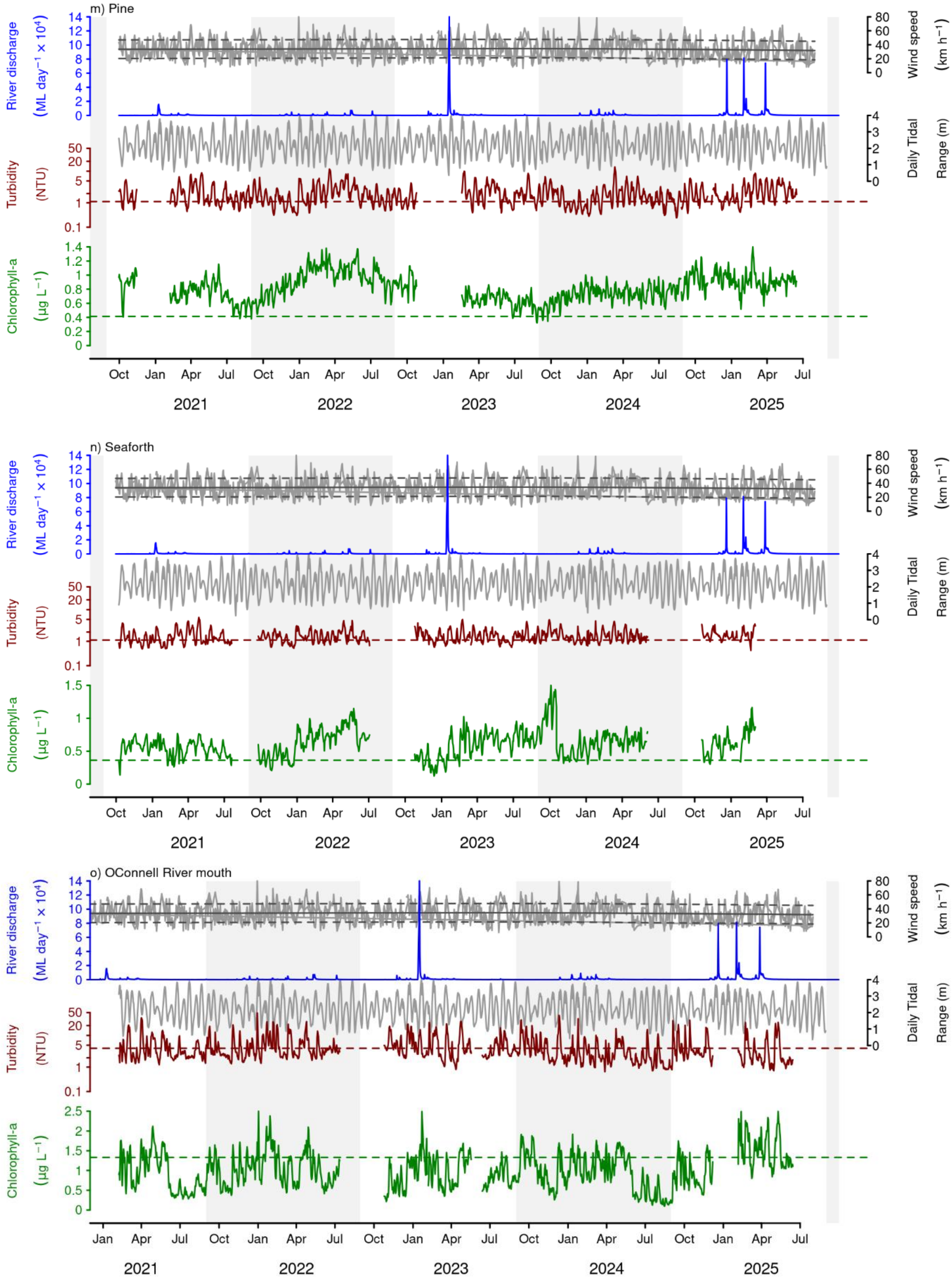


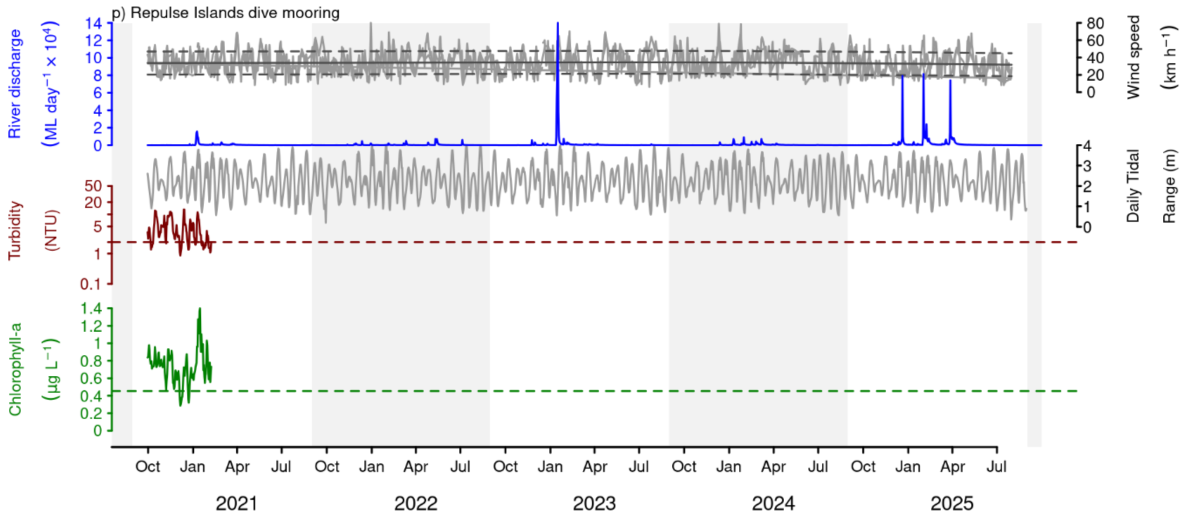


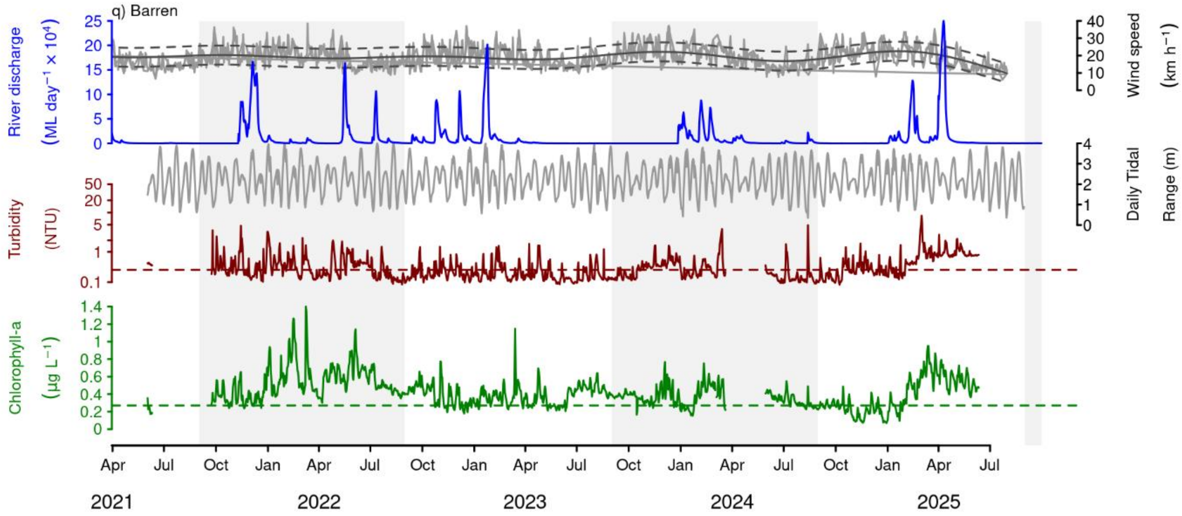
c) Russell Mulgrave Mouth Mooring
d) Franklands West
e) Dunk North
River discharge (ML day⁻¹ × 10⁴)
Wind speed (km h⁻¹)
Daily Tidal Range (m)
Turbidity (NTU)
Chlorophyll-a (µg L⁻¹)
Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul
2021 2022 2023 2024 2025

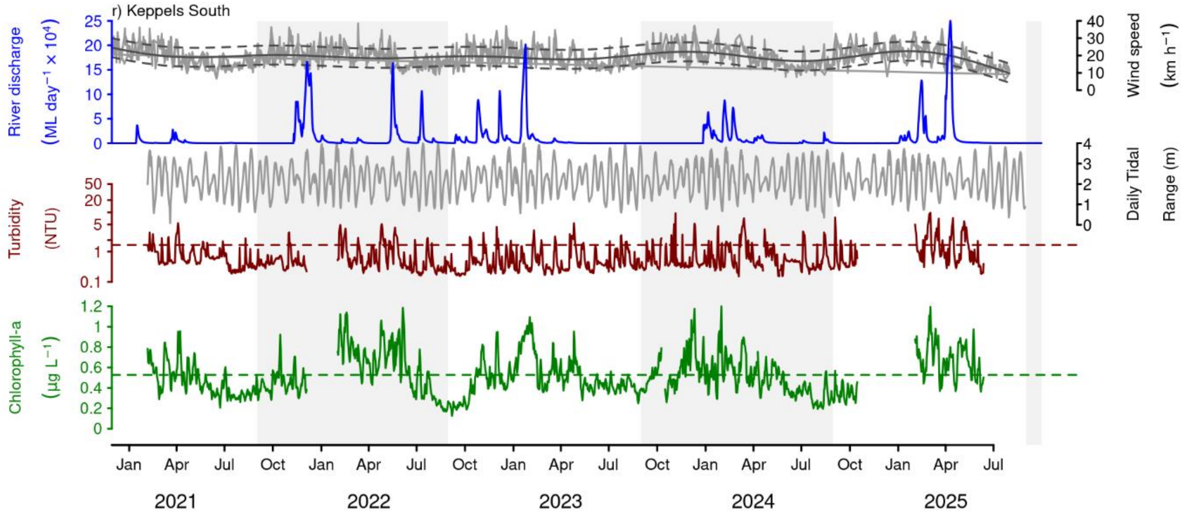

f) Tully River mouth mooring
g) Palms West
h) Pandora
River discharge (ML day⁻¹ × 10⁴)
Wind speed (km h⁻¹)
Daily Tidal Range (m)
Turbidity (NTU)
Chlorophyll-a (µg L⁻¹)
2021
2022
2023
2024
2025


i) Magnetic
j) Burdekin River mouth mooring
k) Double Cone
River discharge
(ML day⁻¹ × 10⁴)
Wind speed
(km h⁻¹)
Daily Tidal
Range (m)
Turbidity
(NTU)
Chlorophyll-a
(µg L⁻¹)
Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul
2021 2022 2023 2024 2025


m) Pine
River discharge (ML day⁻¹ x 10⁴)
Turbidity (NTU)
Chlorophyll-a (µg L⁻¹)
Wind speed (km h⁻¹)
Daily Tidal Range (m)
Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul
2021 2022 2023 2024 2025
n) Seaforth
River discharge (ML day⁻¹ x 10⁴)
Turbidity (NTU)
Chlorophyll-a (µg L⁻¹)
Wind speed (km h⁻¹)
Daily Tidal Range (m)
Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul
2021 2022 2023 2024 2025
o) OConnell River mouth
River discharge (ML day⁻¹ x 10⁴)
Turbidity (NTU)
Chlorophyll-a (µg L⁻¹)
Wind speed (km h⁻¹)
Daily Tidal Range (m)
Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul
2021 2022 2023 2024 2025


p) Repulse Islands dive mooring
River discharge
(ML day⁻¹ × 10⁴)
Turbidity
(NTU)
Chlorophyll-a
(µg L⁻¹)
Wind speed
(km h⁻¹)
Daily Tidal
Range (m)
Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul
2021 2022 2023 2024 2025


q) Barren
River discharge
(ML day⁻¹ × 10⁴)
Turbidity
(NTU)
Chlorophyll-a
(µg L⁻¹)
Wind speed
(km h⁻¹)
Daily Tidal
Range (m)
Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul
2021 2022 2023 2024 2025


r) Keppels South
River discharge
(ML day⁻¹ × 10⁴)
Turbidity
(NTU)
Chlorophyll-a
(µg L⁻¹)
Wind speed
(km h⁻¹)
Daily Tidal
Range (m)
Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul
2021 2022 2023 2024 2025

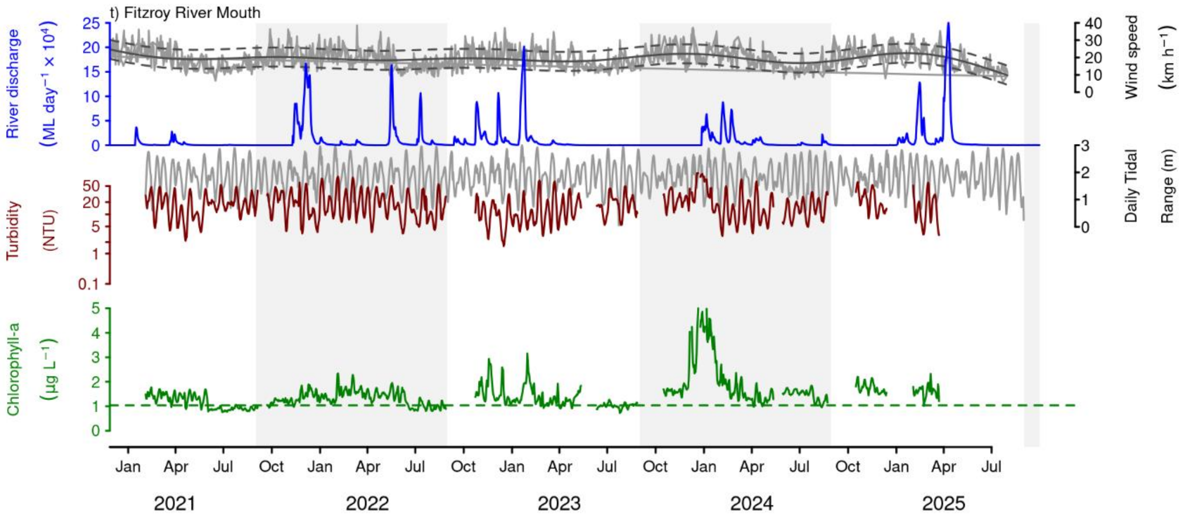


Figure C-1: Time-series of daily means of chlorophyll fluorescence and turbidity measured by moored ECO FLNTUSB instruments coloured dashed lines represent the water quality GVs. Daily river discharge from the nearest river, daily wind speeds from the nearest weather stations, and daily tidal range from the nearest tidal gauge are also shown. Locations of loggers are shown in Figure 2-1, Section 5, and panels continue on additional pages: a) Fitzroy West; b) High West; c) Russell-Mulgrave Mouth Mooring; d) Franklands West; e) Dunk North; f) Tully Mouth Mooring; g) Palms West; h) Pandora; i) Magnetic; j) Burdekin Mouth Mooring; k) Double Cone; m) Pine; n) Seaforth; o) O'Connell River, p) Repulse Island (discontinued in 2021), q) Barren, r) Keppels South, and t) Fitzroy River Mouth.

C-2 Time-series of temperature and salinity

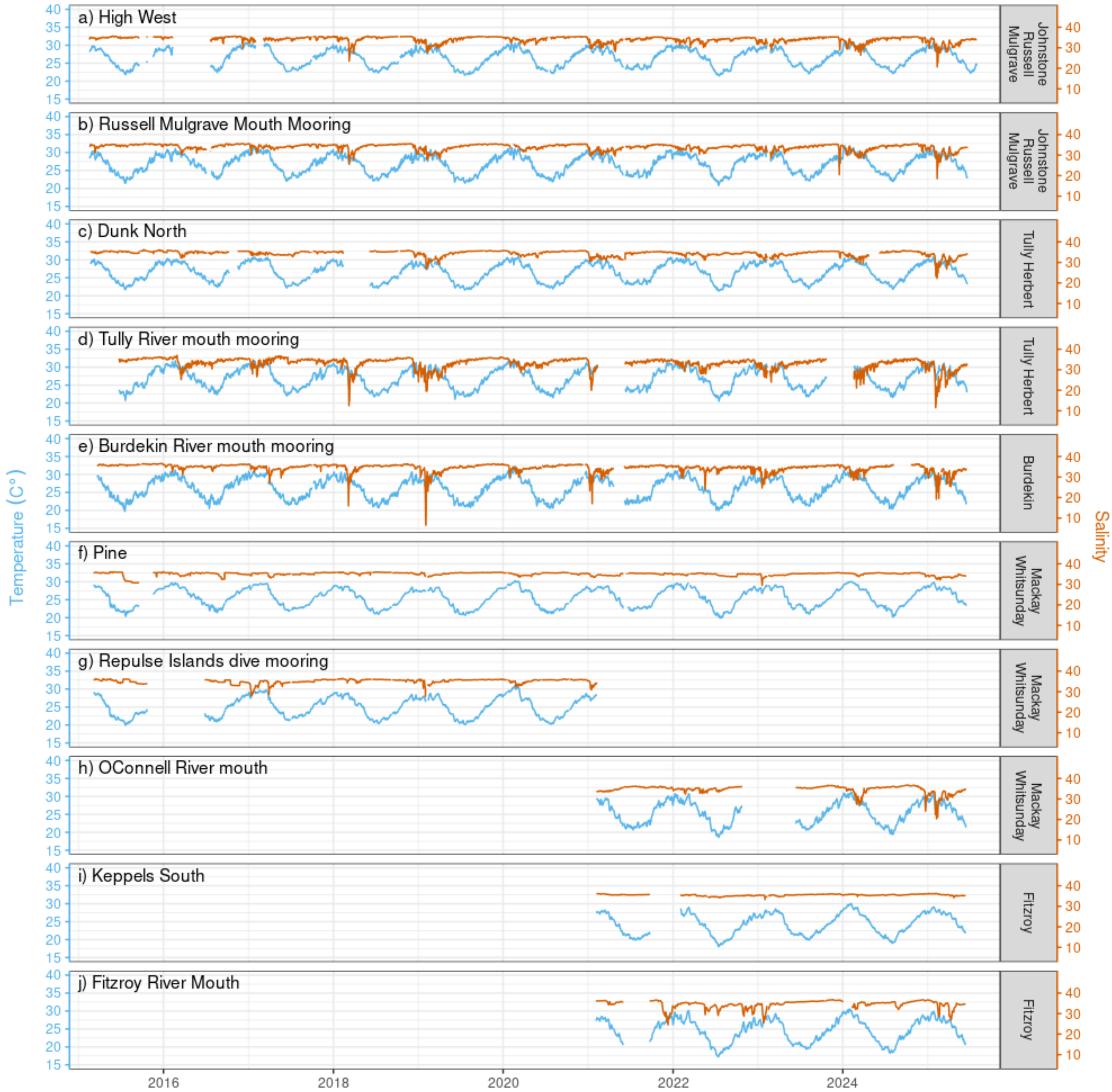


Figure C-2: Time-series of daily means of temperature and salinity derived from moored loggers (Sea-Bird Electronics SBE37s). Sub-figures represent instrument locations at: a) High West, b) Russel Mulgrave Mouth Mooring, c) Dunk North, d) Tully River Mouth Mooring, e) Burdekin Mouth Mooring, f) Pine, g) Repulse, h) O'Connell River mouth, i) Keppels South, and j) Fitzroy River mouth.

C-3 Summary statistics for all sites

Table C-1: Summary statistics for water quality parameters at individual monitoring sites from 1 October 2024 to 30 September 2025. N = number of sampling occasions. See Section 2 for descriptions of each analyte and its abbreviation. Mean and median values that exceed available Water Quality Guidelines (DERM, 2009; Great Barrier Reef Marine Park Authority, 2010; State of Queensland, 2020) are shaded in red. Means that exceed dry season guidelines are shaded in yellow. DOF is direction of failure ('H' = high values fail, while 'L' = low values fail).

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
Cape York	Pascoe	Eel Reef (PRN05)	DIN (µg L^{-1})	1	6.17	6.17	6.17	6.17	6.17	6.17					
			DOC (µg L^{-1})	1	1177.25	1177.25	1177.25	1177.25	1177.25	1177.25					
			DON (µg L^{-1})	1	83.66	83.66	83.66	83.66	83.66	83.66					
			DOP (µg L^{-1})	1	3.78	3.78	3.78	3.78	3.78	3.78					
			Chl-a (µg L^{-1})	1	0.45	0.45	0.45	0.45	0.45	0.45	H	Median	0.27		
			NH4 (µg L^{-1})	1	4.43	4.43	4.43	4.43	4.43	4.43					
			NO_x (µg L^{-1})	1	1.74	1.74	1.74	1.74	1.74	1.74	H	Median	0.35		
			PN (µg L^{-1})	1	20.09	20.09	20.09	20.09	20.09	20.09	H	Mean			
			PN (µg L^{-1})	1	20.09	20.09	20.09	20.09	20.09	20.09	H	Median	18.00		
			PO_4 (µg L^{-1})	1	1.16	1.16	1.16	1.16	1.16	1.16	H	Median	0.62		
			POC (µg L^{-1})	1	94.30	94.30	94.30	94.30	94.30	94.30					
			PP (µg L^{-1})	1	1.77	1.77	1.77	1.77	1.77	1.77	H	Mean			
			PP (µg L^{-1})	1	1.77	1.77	1.77	1.77	1.77	1.77	H	Median	2.00		
			Secchi (m)	1	11.10	11.10	11.10	11.10	11.10	11.10	L	Mean	10.00		
			Secchi (m)	1	11.10	11.10	11.10	11.10	11.10	11.10	L	Median			
			SiO_4 (µg L^{-1})	1	198.21	198.21	198.21	198.21	198.21	198.21					
			TSS (mg L^{-1})	1	0.75	0.75	0.75	0.75	0.75	0.75	H	Mean			
			TSS (mg L^{-1})	1	0.75	0.75	0.75	0.75	0.75	0.75	H	Median	1.50		
		PRN04 (PRN04)	DIN (µg L^{-1})	5	4.30	4.53	3.51	4.02	4.71	4.73					
			DOC (µg L^{-1})	5	1077.34	1074.09	950.70	987.98	1162.09	1211.86					
			DON (µg L^{-1})	5	94.79	85.61	72.61	81.50	110.97	123.24					
			DOP (µg L^{-1})	5	4.97	4.78	4.14	4.52	5.34	6.08					
			Chl-a (µg L^{-1})	5	0.36	0.36	0.16	0.25	0.51	0.52	H	Median	0.27		
			NH4 (µg L^{-1})	5	3.40	3.49	2.27	2.61	4.24	4.41					
			NO_x (µg L^{-1})	5	0.90	1.19	0.26	0.33	1.30	1.42	H	Median	0.35		
			PN (µg L^{-1})	5	16.78	16.73	14.32	15.24	18.39	19.19	H	Mean			
			PN (µg L^{-1})	5	16.78	16.73	14.32	15.24	18.39	19.19	H	Median	18.00		
			PO_4 (µg L^{-1})	5	1.08	1.23	0.59	0.96	1.26	1.36	H	Median	0.62		

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			POC (μg L^{-1})	5	83.38	83.43	73.65	77.48	90.67	91.65					
			PP (μg L^{-1})	5	1.80	1.77	1.37	1.60	1.95	2.30	H	Mean			
			PP (μg L^{-1})	5	1.80	1.77	1.37	1.60	1.95	2.30	H	Median	2.00		
			Secchi (m)	5	10.13	9.70	8.66	9.14	10.84	12.31	L	Mean	10.00		
			Secchi (m)	5	10.13	9.70	8.66	9.14	10.84	12.31	L	Median			
			SiO$_4$ (μg L^{-1})	5	92.97	52.31	37.77	42.80	156.06	175.91					
			TSS (mg L^{-1})	5	0.63	0.56	0.31	0.39	0.84	1.06	H	Mean			
			TSS (mg L^{-1})	5	0.63	0.56	0.31	0.39	0.84	1.06	H	Median	1.50		
		PRN02 (PRN02)	DIN (μg L^{-1})	5	4.00	3.43	1.99	2.28	5.36	6.96					
			DOC (μg L^{-1})	5	1119.26	996.55	930.40	963.62	1152.73	1552.99					
			DON (μg L^{-1})	5	88.64	88.21	78.27	79.11	96.94	100.68					
			DOP (μg L^{-1})	5	4.49	4.49	3.19	3.93	4.96	5.88					
			Chl-a (μg L^{-1})	5	0.31	0.28	0.17	0.22	0.43	0.46	H	Median	0.36	0.25	0.46
			NH4 (μg L^{-1})	5	3.04	2.80	1.78	2.07	4.06	4.48					
			NO$_x$ (μg L^{-1})	5	0.97	0.21	0.21	0.21	1.22	2.98	H	Median	0.35	0.32	0.45
			PN (μg L^{-1})	5	20.71	20.65	17.19	17.32	22.74	25.64	H	Mean		16.00	
			PN (μg L^{-1})	5	20.71	20.65	17.19	17.32	22.74	25.64	H	Median	18.00		20.00
			PO$_4$ (μg L^{-1})	5	0.77	0.77	0.31	0.31	1.05	1.42	H	Median	1.40	1.86	0.93
			POC (μg L^{-1})	5	107.55	103.71	93.72	99.23	120.03	121.03					
			PP (μg L^{-1})	5	2.13	2.07	1.91	2.02	2.20	2.43	H	Mean		2.30	
			PP (μg L^{-1})	5	2.13	2.07	1.91	2.02	2.20	2.43	H	Median	2.60		3.00
			Secchi (m)	5	4.38	4.35	4.04	4.18	4.56	4.74	L	Mean	10.00		
			Secchi (m)	5	4.38	4.35	4.04	4.18	4.56	4.74	L	Median			
			SiO$_4$ (μg L^{-1})	5	236.74	163.48	77.61	81.66	311.74	549.22					
			TSS (mg L^{-1})	5	1.24	0.81	0.43	0.54	2.10	2.34	H	Mean		1.60	
			TSS (mg L^{-1})	5	1.24	0.81	0.43	0.54	2.10	2.34	H	Median	1.90		1.70
			DIN (μg L^{-1})	5	10.39	8.61	1.67	1.83	14.06	25.78					
			DOC (μg L^{-1})	5	1547.18	1069.82	896.53	981.64	1624.92	3163.02					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
		Pascoe River mouth south (PRS01)	DON (µg L⁻¹)	5	92.27	73.16	71.95	72.54	114.30	129.38					
			DOP (µg L⁻¹)	5	4.03	4.65	2.11	2.85	5.08	5.45					
			Chl-a (µg L⁻¹)	5	0.32	0.38	0.20	0.22	0.39	0.41	H	Median			0.70
			NH4 (µg L⁻¹)	5	5.52	6.30	1.46	1.62	8.85	9.35					
			NO_x (µg L⁻¹)	5	4.87	1.47	0.21	0.21	5.88	16.59	H	Median			1.50
			PN (µg L⁻¹)	5	43.74	28.14	20.95	21.62	53.20	94.79	H	Mean			
			PN (µg L⁻¹)	5	43.74	28.14	20.95	21.62	53.20	94.79	H	Median			
			PO_4 (µg L⁻¹)	5	1.18	0.31	0.31	0.31	1.73	3.22	H	Median			3.00
			POC (µg L⁻¹)	5	317.91	162.75	118.43	127.08	348.10	833.18					
			PP (µg L⁻¹)	5	4.23	3.19	2.18	2.59	4.57	8.62	H	Mean			
			PP (µg L⁻¹)	5	4.23	3.19	2.18	2.59	4.57	8.62	H	Median			
			Secchi (m)	5	3.42	4.00	1.62	2.58	4.30	4.60	L	Mean			
			Secchi (m)	5	3.42	4.00	1.62	2.58	4.30	4.60	L	Median			3.00
			SiO_4 (µg L⁻¹)	5	882.87	182.59	47.92	103.20	933.60	3147.04					
			TSS (mg L⁻¹)	5	6.67	0.94	0.63	0.73	7.41	23.66	H	Median			4.00
		PRS05 (PRS05)	DIN (µg L⁻¹)	4	4.48	4.29	2.90	3.64	5.25	6.32					
			DOC (µg L⁻¹)	4	975.62	987.33	905.10	939.76	1016.17	1029.76					
			DON (µg L⁻¹)	4	88.85	90.81	74.03	81.68	96.81	100.92					
			DOP (µg L⁻¹)	4	4.69	4.71	4.33	4.37	5.02	5.02					
			Chl-a (µg L⁻¹)	4	0.36	0.34	0.18	0.20	0.51	0.57	H	Median	0.27		
			NH4 (µg L⁻¹)	4	3.69	3.66	2.60	3.09	4.28	4.81					
			NO_x (µg L⁻¹)	4	0.79	0.63	0.25	0.38	1.14	1.55	H	Median	0.35		
			PN (µg L⁻¹)	4	16.13	16.26	11.46	12.54	19.77	20.62	H	Mean			
			PN (µg L⁻¹)	4	16.13	16.26	11.46	12.54	19.77	20.62	H	Median	18.00		
			PO_4 (µg L⁻¹)	4	1.25	1.31	0.84	1.05	1.48	1.59	H	Median	0.62		
			POC (µg L⁻¹)	4	79.41	81.66	54.30	64.84	94.89	101.39					
			PP (µg L⁻¹)	4	1.61	1.60	1.25	1.31	1.91	1.99	H	Mean			
			PP (µg L⁻¹)	4	1.61	1.60	1.25	1.31	1.91	1.99	H	Median	2.00		

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			Secchi (m)	4	11.75	10.45	8.51	9.24	13.74	16.82	L	Mean	10.00		
			Secchi (m)	4	11.75	10.45	8.51	9.24	13.74	16.82	L	Median			
			SiO_4 (µg L^{-1})	4	69.73	74.72	32.93	50.22	91.23	99.54					
			TSS (mg L^{-1})	4	0.68	0.71	0.37	0.46	0.91	0.95	H	Mean			
			TSS (mg L^{-1})	4	0.68	0.71	0.37	0.46	0.91	0.95	H	Median	1.50		
		PRS2.5 (PRS2.5)	DIN (µg L^{-1})	5	5.12	2.42	1.90	1.98	5.83	13.45					
			DOC (µg L^{-1})	5	1179.55	961.38	946.36	950.88	1242.68	1796.46					
			DON (µg L^{-1})	5	87.17	91.34	69.80	71.17	99.90	103.66					
			DOP (µg L^{-1})	5	4.44	4.75	3.28	3.93	5.08	5.18					
			Chl-a (µg L^{-1})	5	0.32	0.31	0.26	0.27	0.37	0.39	H	Median	0.36	0.25	0.46
			NH4 (µg L^{-1})	5	3.12	2.21	1.53	1.73	3.68	6.42					
			NO_x (µg L^{-1})	5	2.00	0.42	0.21	0.21	2.15	7.03	H	Median	0.35	0.32	0.45
			PN (µg L^{-1})	5	22.26	22.40	17.13	17.98	26.13	27.66	H	Mean		16.00	
			PN (µg L^{-1})	5	22.26	22.40	17.13	17.98	26.13	27.66	H	Median	18.00		20.00
			PO_4 (µg L^{-1})	5	1.10	1.07	0.55	0.83	1.26	1.81	H	Median	1.40	1.86	0.93
			POC (µg L^{-1})	5	124.76	109.87	101.74	104.29	128.93	178.99					
			PP (µg L^{-1})	5	2.44	2.29	2.03	2.05	2.89	2.94	H	Mean		2.30	
			PP (µg L^{-1})	5	2.44	2.29	2.03	2.05	2.89	2.94	H	Median	2.60		3.00
			Secchi (m)	5	4.99	4.50	4.02	4.08	5.92	6.43	L	Mean	10.00		
			Secchi (m)	5	4.99	4.50	4.02	4.08	5.92	6.43	L	Median			
			SiO_4 (µg L^{-1})	5	327.07	123.47	39.13	67.26	360.73	1044.77					
			TSS (mg L^{-1})	5	2.07	1.33	0.99	1.18	2.21	4.63	H	Mean		1.60	
			TSS (mg L^{-1})	5	2.07	1.33	0.99	1.18	2.21	4.63	H	Median	1.90		1.70
		Middle Reef (PRBB)	DIN (µg L^{-1})	5	4.52	4.94	3.13	3.73	5.25	5.57					
			DOC (µg L^{-1})	5	1006.57	1012.63	926.17	948.27	1067.95	1077.82					
			DON (µg L^{-1})	5	96.37	81.22	71.86	75.08	103.60	150.08					
			DOP (µg L^{-1})	5	4.83	4.78	3.63	4.37	5.42	5.97					
			Chl-a (µg L^{-1})	5	0.43	0.44	0.28	0.33	0.55	0.56	H	Median	0.27		

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			NH4 (µg L^{-1})	5	3.34	3.48	2.38	2.63	4.06	4.15					
			NO_x (µg L^{-1})	5	1.18	1.11	0.26	0.40	1.73	2.42	H	Median	0.35		
			PN (µg L^{-1})	5	17.96	18.59	15.03	15.24	19.83	21.09	H	Mean			
			PN (µg L^{-1})	5	17.96	18.59	15.03	15.24	19.83	21.09	H	Median	18.00		
			PO_4 (µg L^{-1})	5	1.23	1.08	0.80	0.89	1.60	1.79	H	Median	0.62		
			POC (µg L^{-1})	5	86.20	88.77	76.09	79.69	92.73	93.71					
			PP (µg L^{-1})	5	1.80	1.69	1.59	1.61	1.91	2.19	H	Mean			
			PP (µg L^{-1})	5	1.80	1.69	1.59	1.61	1.91	2.19	H	Median	2.00		
			Secchi (m)	5	8.15	7.30	7.03	7.10	9.44	9.86	L	Mean	10.00		
			Secchi (m)	5	8.15	7.30	7.03	7.10	9.44	9.86	L	Median			
			SiO_4 (µg L^{-1})	5	110.71	104.14	41.47	72.90	161.23	173.82					
			TSS (mg L^{-1})	5	0.72	0.66	0.46	0.52	0.80	1.14	H	Mean			
			TSS (mg L^{-1})	5	0.72	0.66	0.46	0.52	0.80	1.14	H	Median	1.50		
	Stewart	Hannah Island (SR05)	DIN (µg L^{-1})	4	2.47	2.13	1.38	1.39	3.41	4.03					
			DOC (µg L^{-1})	4	1024.91	1057.15	892.91	970.34	1092.36	1111.76					
			DON (µg L^{-1})	4	88.25	78.80	76.57	76.83	95.89	113.17					
			DOP (µg L^{-1})	4	5.17	5.17	4.81	4.85	5.49	5.52					
			Chl-a (µg L^{-1})	4	0.26	0.26	0.13	0.18	0.34	0.40	H	Median	0.27		
			NH4 (µg L^{-1})	4	2.11	1.81	1.01	1.03	3.07	3.64					
			NO_x (µg L^{-1})	4	0.36	0.36	0.29	0.32	0.39	0.41	H	Median	0.35		
			PN (µg L^{-1})	4	15.85	15.33	14.25	14.62	16.87	18.18	H	Mean			
			PN (µg L^{-1})	4	15.85	15.33	14.25	14.62	16.87	18.18	H	Median	18.00		
			PO_4 (µg L^{-1})	4	1.48	1.30	0.54	0.78	2.11	2.68	H	Median	0.62		
			POC (µg L^{-1})	4	78.09	74.31	67.59	68.18	86.50	93.89					
			PP (µg L^{-1})	4	1.65	1.69	1.27	1.39	1.94	1.98	H	Mean			
			PP (µg L^{-1})	4	1.65	1.69	1.27	1.39	1.94	1.98	H	Median	2.00		
			Secchi (m)	4	8.22	7.70	6.67	6.90	9.34	10.51	L	Mean	10.00		
			Secchi (m)	4	8.22	7.70	6.67	6.90	9.34	10.51	L	Median			

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			SiO_4 (µg L⁻¹)	4	117.28	110.90	83.92	89.88	142.13	159.57					
			TSS (mg L⁻¹)	4	0.60	0.64	0.26	0.38	0.84	0.88	H	Mean			
			TSS (mg L⁻¹)	4	0.60	0.64	0.26	0.38	0.84	0.88	H	Median	1.50		
		Burkitt Island (SR04)	DIN (µg L⁻¹)	4	2.21	1.99	1.39	1.62	2.71	3.33					
			DOC (µg L⁻¹)	4	1016.31	1051.64	885.22	964.16	1082.59	1097.95					
			DON (µg L⁻¹)	4	90.59	91.13	76.42	79.14	102.25	104.00					
			DOP (µg L⁻¹)	4	5.33	5.26	5.00	5.14	5.49	5.75					
			Chl-a (µg L⁻¹)	4	0.23	0.22	0.12	0.17	0.29	0.35	H	Median	0.36	0.25	0.46
			NH4 (µg L⁻¹)	4	1.93	1.71	1.04	1.27	2.50	3.13					
			NO_x (µg L⁻¹)	4	0.28	0.28	0.21	0.21	0.35	0.35	H	Median	0.35	0.32	0.45
			PN (µg L⁻¹)	4	17.95	15.65	12.86	13.10	21.88	26.26	H	Mean		16.00	
			PN (µg L⁻¹)	4	17.95	15.65	12.86	13.10	21.88	26.26	H	Median	18.00		20.00
			PO_4 (µg L⁻¹)	4	1.39	1.24	0.40	0.68	2.04	2.60	H	Median	1.40	1.86	0.93
			POC (µg L⁻¹)	4	82.18	75.31	52.71	57.07	104.53	121.26					
			PP (µg L⁻¹)	4	2.01	1.81	1.24	1.27	2.66	3.05	H	Mean		2.30	
			PP (µg L⁻¹)	4	2.01	1.81	1.24	1.27	2.66	3.05	H	Median	2.60		3.00
			Secchi (m)	4	6.34	5.38	5.31	5.34	6.96	8.71	L	Mean	10.00		
			Secchi (m)	4	6.34	5.38	5.31	5.34	6.96	8.71	L	Median			
			SiO_4 (µg L⁻¹)	4	117.63	115.98	87.87	97.26	137.33	149.68					
			TSS (mg L⁻¹)	4	0.89	0.88	0.53	0.57	1.20	1.27	H	Mean		1.60	
			TSS (mg L⁻¹)	4	0.89	0.88	0.53	0.57	1.20	1.27	H	Median	1.90		1.70
		SR03 (SR03)	DIN (µg L⁻¹)	4	2.37	2.58	1.13	1.58	3.23	3.30					
			DOC (µg L⁻¹)	4	1072.45	1032.41	871.93	925.94	1202.95	1329.03					
			DON (µg L⁻¹)	4	87.01	81.62	77.38	77.45	94.42	104.20					
			DOP (µg L⁻¹)	4	5.28	5.26	4.78	5.04	5.51	5.79					
			Chl-a (µg L⁻¹)	4	0.27	0.17	0.08	0.10	0.40	0.60	H	Median	0.36	0.25	0.46
			NH4 (µg L⁻¹)	4	2.09	2.24	0.88	1.21	3.03	3.09					
			NO_x (µg L⁻¹)	4	0.28	0.21	0.21	0.21	0.32	0.44	H	Median	0.35	0.32	0.45
			PN (µg L⁻¹)	4	21.87	18.11	14.27	16.22	26.02	34.75	H	Mean		16.00	

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			PN (µg L^{-1})	4	21.87	18.11	14.27	16.22	26.02	34.75	H	Median	18.00		20.00
			PO_4 (µg L^{-1})	4	1.15	0.99	0.38	0.58	1.66	2.16	H	Median	1.40	1.86	0.93
			POC (µg L^{-1})	4	100.49	91.16	61.53	76.64	120.62	152.53					
			PP (µg L^{-1})	4	2.35	2.26	1.36	1.72	2.95	3.47	H	Mean		2.30	
			PP (µg L^{-1})	4	2.35	2.26	1.36	1.72	2.95	3.47	H	Median	2.60		3.00
			Secchi (m)	4	5.56	5.28	4.12	4.48	6.53	7.41	L	Mean	10.00		
			Secchi (m)	4	5.56	5.28	4.12	4.48	6.53	7.41	L	Median			
			SiO_4 (µg L^{-1})	4	198.53	169.81	146.97	155.86	229.71	290.30					
			TSS (mg L^{-1})	4	1.51	0.96	0.64	0.66	2.14	3.14	H	Mean		1.60	
			TSS (mg L^{-1})	4	1.51	0.96	0.64	0.66	2.14	3.14	H	Median	1.90		1.70
		SR02 (SR02)	DIN (µg L^{-1})	4	2.60	2.30	1.34	1.68	3.40	4.28					
			DOC (µg L^{-1})	4	1182.77	1121.35	929.23	1006.36	1334.62	1522.29					
			DON (µg L^{-1})	4	107.60	106.69	99.57	102.06	112.78	116.91					
			DOP (µg L^{-1})	4	4.92	4.94	4.42	4.56	5.28	5.39					
			Chl-a (µg L^{-1})	4	0.37	0.20	0.14	0.17	0.49	0.83	H	Median			0.40
			NH4 (µg L^{-1})	4	2.15	2.05	0.88	1.30	2.96	3.56					
			NO_x (µg L^{-1})	4	0.45	0.40	0.22	0.26	0.62	0.76	H	Median			1.50
			PN (µg L^{-1})	4	23.49	22.63	18.40	19.78	26.85	29.76	H	Mean			
			PN (µg L^{-1})	4	23.49	22.63	18.40	19.78	26.85	29.76	H	Median			
			PO_4 (µg L^{-1})	4	0.91	0.85	0.35	0.48	1.32	1.55	H	Median			2.00
			POC (µg L^{-1})	4	187.73	136.37	83.33	104.81	250.11	364.04					
			PP (µg L^{-1})	4	2.51	2.79	1.51	2.03	3.10	3.11	H	Mean			
			PP (µg L^{-1})	4	2.51	2.79	1.51	2.03	3.10	3.11	H	Median			
			Secchi (m)	4	4.38	4.57	3.39	3.94	4.90	5.12	L	Mean			
			Secchi (m)	4	4.38	4.57	3.39	3.94	4.90	5.12	L	Median			3.10
			SiO_4 (µg L^{-1})	4	275.68	153.14	149.54	150.58	351.77	573.39					
			TSS (mg L^{-1})	4	1.07	1.04	0.75	0.79	1.34	1.43	H	Mean			
			TSS (mg L^{-1})	4	1.07	1.04	0.75	0.79	1.34	1.43	H	Median			5.00

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
	Normanby	Corbett Reef (NR06)	DIN (µg L⁻¹)	4	2.63	2.59	2.07	2.32	2.93	3.25					
			DOC (µg L⁻¹)	4	964.34	970.79	914.44	937.00	994.27	1005.23					
			DON (µg L⁻¹)	4	90.41	88.92	78.92	83.82	96.40	103.99					
			DOP (µg L⁻¹)	4	4.69	4.85	4.10	4.45	4.99	5.06					
			Chl-a (µg L⁻¹)	4	0.30	0.26	0.21	0.21	0.37	0.43	H	Median	0.26		
			NH4 (µg L⁻¹)	4	2.27	2.19	1.82	1.94	2.56	2.82					
			NO_x (µg L⁻¹)	4	0.37	0.33	0.21	0.21	0.51	0.57	H	Median	0.42		
			PN (µg L⁻¹)	4	17.06	17.15	15.61	16.14	18.02	18.40	H	Median	16.00		
			PO_4 (µg L⁻¹)	4	0.81	0.85	0.38	0.58	1.05	1.18	H	Median	0.39		
			POC (µg L⁻¹)	4	89.24	91.27	79.29	84.16	95.14	96.35					
			PP (µg L⁻¹)	4	1.55	1.54	1.30	1.33	1.78	1.83	H	Mean			
			PP (µg L⁻¹)	4	1.55	1.54	1.30	1.33	1.78	1.83	H	Median	1.90		
			Secchi (m)	4	12.07	11.50	8.15	8.92	15.00	16.80	L	Mean	17.00		
			Secchi (m)	4	12.07	11.50	8.15	8.92	15.00	16.80	L	Median			
			SiO_4 (µg L⁻¹)	4	66.51	68.41	36.27	42.12	91.66	94.11					
			TSS (mg L⁻¹)	4	0.54	0.57	0.39	0.47	0.62	0.65	H	Mean			
			TSS (mg L⁻¹)	4	0.54	0.57	0.39	0.47	0.62	0.65	H	Median	0.50		
		NR05 (NR05)	DIN (µg L⁻¹)	4	3.09	3.20	2.24	2.70	3.53	3.79					
			DOC (µg L⁻¹)	4	1130.53	1136.15	1015.32	1049.08	1214.23	1237.88					
			DON (µg L⁻¹)	4	84.18	84.89	71.30	78.22	90.43	96.08					
			DOP (µg L⁻¹)	4	4.42	4.46	4.16	4.23	4.62	4.62					
			Chl-a (µg L⁻¹)	4	0.41	0.38	0.14	0.22	0.59	0.74	H	Median	0.27		
			NH4 (µg L⁻¹)	4	2.57	2.78	2.01	2.42	2.81	2.83					
			NO_x (µg L⁻¹)	4	0.52	0.42	0.23	0.27	0.73	0.96	H	Median	0.35		
			PN (µg L⁻¹)	4	20.31	21.32	14.42	16.70	24.33	24.81	H	Mean			
			PN (µg L⁻¹)	4	20.31	21.32	14.42	16.70	24.33	24.81	H	Median	18.00		
			PO_4 (µg L⁻¹)	4	1.15	1.08	0.95	1.02	1.26	1.46	H	Median	0.62		
			POC (µg L⁻¹)	4	90.71	90.43	70.34	77.32	103.99	111.48					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			PP (µg L⁻¹)	4	1.89	1.86	1.29	1.56	2.20	2.52	H	Mean			
			PP (µg L⁻¹)	4	1.89	1.86	1.29	1.56	2.20	2.52	H	Median	2.00		
			Secchi (m)	4	11.15	11.60	7.80	8.70	13.78	13.87	L	Mean	10.00		
			Secchi (m)	4	11.15	11.60	7.80	8.70	13.78	13.87	L	Median			
			SiO_4 (µg L⁻¹)	4	80.42	80.22	56.53	61.74	99.02	104.60					
			TSS (mg L⁻¹)	4	0.82	0.85	0.49	0.63	1.02	1.09	H	Mean			
			TSS (mg L⁻¹)	4	0.82	0.85	0.49	0.63	1.02	1.09	H	Median	1.50		
		NR04 (NR04)	DIN (µg L⁻¹)	4	2.29	2.55	1.42	1.92	2.76	2.79					
			DOC (µg L⁻¹)	4	1032.59	1019.17	1011.37	1012.66	1047.14	1072.58					
			DON (µg L⁻¹)	4	89.22	88.00	74.55	77.18	100.76	105.59					
			DOP (µg L⁻¹)	4	5.15	5.17	4.22	4.51	5.79	6.04					
			Chl-a (µg L⁻¹)	4	0.32	0.30	0.22	0.26	0.36	0.43	H	Median	0.36	0.25	0.46
			NH4 (µg L⁻¹)	4	1.84	1.92	1.14	1.43	2.29	2.44					
			NO_x (µg L⁻¹)	4	0.45	0.23	0.21	0.21	0.60	1.01	H	Median	0.35	0.32	0.45
			PN (µg L⁻¹)	4	18.39	17.42	14.83	15.82	20.58	23.30	H	Mean		16.00	
			PN (µg L⁻¹)	4	18.39	17.42	14.83	15.82	20.58	23.30	H	Median	18.00		20.00
			PO_4 (µg L⁻¹)	4	0.77	0.69	0.61	0.61	0.89	1.03	H	Median	1.40	1.86	0.93
			POC (µg L⁻¹)	4	93.77	93.15	81.07	87.11	100.18	107.35					
			PP (µg L⁻¹)	4	1.75	1.72	1.37	1.53	1.95	2.18	H	Mean		2.30	
			PP (µg L⁻¹)	4	1.75	1.72	1.37	1.53	1.95	2.18	H	Median	2.60		3.00
			Secchi (m)	4	10.55	10.55	7.10	7.68	13.42	14.00	L	Mean	10.00		
			Secchi (m)	4	10.55	10.55	7.10	7.68	13.42	14.00	L	Median			
			SiO_4 (µg L⁻¹)	4	75.94	75.66	54.50	56.38	95.38	97.76					
			TSS (mg L⁻¹)	4	0.69	0.76	0.31	0.51	0.91	0.98	H	Mean		1.60	
			TSS (mg L⁻¹)	4	0.69	0.76	0.31	0.51	0.91	0.98	H	Median	1.90		1.70
		Cliff Isles (CI01)	DIN (µg L⁻¹)	4	2.66	2.77	2.09	2.42	2.95	3.09					
			DOC (µg L⁻¹)	4	1310.57	1299.51	1100.30	1172.47	1444.25	1536.33					
			DON (µg L⁻¹)	4	96.33	92.54	82.41	86.63	104.51	115.54					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			DOP (µg L⁻¹)	4	4.99	4.96	4.17	4.26	5.70	5.84					
			Chl-a (µg L⁻¹)	4	0.32	0.33	0.21	0.25	0.40	0.43	H	Median	0.36	0.25	0.46
			NH4 (µg L⁻¹)	4	2.24	2.22	1.81	1.93	2.54	2.69					
			NO_x (µg L⁻¹)	4	0.43	0.42	0.24	0.33	0.52	0.64	H	Median	0.35	0.32	0.45
			PN (µg L⁻¹)	4	27.83	27.59	26.73	26.86	28.71	29.27	H	Mean		16.00	
			PN (µg L⁻¹)	4	27.83	27.59	26.73	26.86	28.71	29.27	H	Median	18.00		20.00
			PO_4 (µg L⁻¹)	4	0.97	1.04	0.54	0.80	1.17	1.30	H	Median	1.40	1.86	0.93
			POC (µg L⁻¹)	4	143.32	141.86	117.11	126.37	159.68	171.58					
			PP (µg L⁻¹)	4	3.10	3.34	2.23	2.68	3.62	3.63	H	Mean		2.30	
			PP (µg L⁻¹)	4	3.10	3.34	2.23	2.68	3.62	3.63	H	Median	2.60		3.00
			Secchi (m)	4	3.90	3.95	2.44	3.16	4.66	5.29	L	Mean	10.00		
			Secchi (m)	4	3.90	3.95	2.44	3.16	4.66	5.29	L	Median			
			SiO_4 (µg L⁻¹)	4	260.74	267.22	113.39	182.66	341.41	399.02					
			TSS (mg L⁻¹)	4	1.88	1.38	0.95	1.08	2.48	3.51	H	Mean		1.60	
			TSS (mg L⁻¹)	4	1.88	1.38	0.95	1.08	2.48	3.51	H	Median	1.90		1.70
		NR03 (NR03)	DIN (µg L⁻¹)	4	2.61	2.49	2.08	2.10	3.07	3.29					
			DOC (µg L⁻¹)	4	1164.79	1083.44	1023.18	1041.74	1255.30	1420.30					
			DON (µg L⁻¹)	4	87.03	85.28	80.44	81.63	91.73	96.07					
			DOP (µg L⁻¹)	4	4.57	4.67	4.11	4.41	4.78	4.90					
			Chl-a (µg L⁻¹)	4	0.40	0.39	0.31	0.33	0.47	0.50	H	Median	0.36	0.25	0.46
			NH4 (µg L⁻¹)	4	2.33	2.23	1.72	1.82	2.80	3.06					
			NO_x (µg L⁻¹)	4	0.28	0.26	0.21	0.21	0.34	0.38	H	Median	0.35	0.32	0.45
			PN (µg L⁻¹)	4	21.77	22.21	17.25	19.12	24.61	25.69	H	Mean		16.00	
			PN (µg L⁻¹)	4	21.77	22.21	17.25	19.12	24.61	25.69	H	Median	18.00		20.00
			PO_4 (µg L⁻¹)	4	0.52	0.49	0.33	0.40	0.62	0.73	H	Median	1.40	1.86	0.93
			POC (µg L⁻¹)	4	117.16	114.10	94.38	100.75	132.35	144.24					
			PP (µg L⁻¹)	4	2.60	2.85	1.76	2.29	3.01	3.11	H	Mean		2.30	
			PP (µg L⁻¹)	4	2.60	2.85	1.76	2.29	3.01	3.11	H	Median	2.60		3.00
			Secchi (m)	4	6.38	6.15	3.63	4.62	8.04	9.44	L	Mean	10.00		

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			Secchi (m)	4	6.38	6.15	3.63	4.62	8.04	9.44	L	Median			
			SiO_4 (µg L^{-1})	4	163.35	160.38	75.26	112.10	213.41	255.58					
			TSS (mg L^{-1})	4	0.98	0.96	0.71	0.80	1.16	1.28	H	Mean		1.60	
			TSS (mg L^{-1})	4	0.98	0.96	0.71	0.80	1.16	1.28	H	Median	1.90		1.70
		Normanby inshore (NR02)	DIN (µg L^{-1})	4	3.51	3.51	1.25	1.58	5.43	5.75					
			DOC (µg L^{-1})	4	1669.34	1504.87	1175.77	1236.14	2036.74	2393.16					
			DON (µg L^{-1})	4	106.75	112.46	87.96	98.60	117.19	117.55					
			DOP (µg L^{-1})	4	4.97	4.78	4.18	4.33	5.54	6.04					
			Chl-a (µg L^{-1})	4	0.96	0.98	0.52	0.58	1.34	1.35	H	Median			0.70
			NH4 (µg L^{-1})	4	2.70	2.80	1.05	1.38	4.06	4.22					
			NO_x (µg L^{-1})	4	0.81	0.55	0.21	0.21	1.30	1.77	H	Median			1.00
			PN (µg L^{-1})	4	53.58	54.18	48.18	49.38	58.02	58.15	H	Mean			
			PN (µg L^{-1})	4	53.58	54.18	48.18	49.38	58.02	58.15	H	Median			
			PO_4 (µg L^{-1})	4	1.73	1.45	1.04	1.04	2.31	2.83	H	Median			2.00
			POC (µg L^{-1})	4	291.78	286.02	266.69	271.04	310.22	324.94					
			PP (µg L^{-1})	4	6.68	6.40	6.24	6.26	6.99	7.51	H	Mean			
			PP (µg L^{-1})	4	6.68	6.40	6.24	6.26	6.99	7.51	H	Median			
			Secchi (m)	4	1.73	1.60	1.33	1.42	1.98	2.29	L	Mean			
			Secchi (m)	4	1.73	1.60	1.33	1.42	1.98	2.29	L	Median			1.50
			SiO_4 (µg L^{-1})	4	495.03	435.11	142.00	217.72	748.37	931.95					
			TSS (mg L^{-1})	4	4.95	5.45	3.55	4.46	5.64	5.65	H	Mean			
			TSS (mg L^{-1})	4	4.95	5.45	3.55	4.46	5.64	5.65	H	Median			6.00
	Endeavour	Endeavour offshore (ER03)	DIN (µg L^{-1})	5	4.23	3.78	2.48	2.71	5.58	6.58					
			DOC (µg L^{-1})	5	1050.82	1057.25	904.08	919.28	1133.83	1239.68					
			DON (µg L^{-1})	5	84.36	80.65	77.56	79.50	88.52	95.56					
			DOP (µg L^{-1})	5	4.47	4.46	3.72	3.81	4.84	5.51					
			Chl-a (µg L^{-1})	5	0.49	0.50	0.21	0.38	0.64	0.70	H	Median	0.36	0.25	0.46
			NH4 (µg L^{-1})	5	2.40	2.57	1.85	1.97	2.74	2.84					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			NO_x ($\mu g\ L^{-1}$)	5	1.83	0.91	0.29	0.51	3.43	4.01	H	Median	0.35	0.32	0.45
			PN ($\mu g\ L^{-1}$)	5	19.82	17.73	15.69	16.13	21.22	28.36	H	Mean		16.00	
			PN ($\mu g\ L^{-1}$)	5	19.82	17.73	15.69	16.13	21.22	28.36	H	Median	18.00		20.00
			PO_4 ($\mu g\ L^{-1}$)	5	1.20	1.08	0.81	0.90	1.29	1.95	H	Median	1.40	1.86	0.93
			POC ($\mu g\ L^{-1}$)	5	97.21	88.49	77.20	78.30	106.67	135.39					
			PP ($\mu g\ L^{-1}$)	5	1.88	2.03	1.33	1.55	2.16	2.35	H	Mean		2.30	
			PP ($\mu g\ L^{-1}$)	5	1.88	2.03	1.33	1.55	2.16	2.35	H	Median	2.60		3.00
			Secchi (m)	5	7.43	6.96	4.72	5.68	9.84	9.96	L	Mean	10.00		
			Secchi (m)	5	7.43	6.96	4.72	5.68	9.84	9.96	L	Median			
			SiO_4 ($\mu g\ L^{-1}$)	5	203.13	145.18	57.64	63.27	330.76	418.78					
			TSS ($mg\ L^{-1}$)	5	1.41	0.93	0.44	0.58	2.36	2.73	H	Mean		1.60	
			TSS ($mg\ L^{-1}$)	5	1.41	0.93	0.44	0.58	2.36	2.73	H	Median	1.90		1.70
		Endeavour north shore (ER02b)	DIN ($\mu g\ L^{-1}$)	5	3.79	3.08	2.71	2.78	5.10	5.27					
			DOC ($\mu g\ L^{-1}$)	5	1076.37	1096.12	1003.91	1009.83	1117.23	1154.76					
			DON ($\mu g\ L^{-1}$)	5	81.07	82.97	71.92	79.19	84.37	86.88					
			DOP ($\mu g\ L^{-1}$)	5	4.48	4.59	3.70	3.79	5.00	5.31					
			Chl-a ($\mu g\ L^{-1}$)	5	0.50	0.54	0.24	0.45	0.60	0.67	H	Median	0.36	0.25	0.46
			NH4 ($\mu g\ L^{-1}$)	5	2.69	2.35	1.65	2.04	3.18	4.22					
			NO_x ($\mu g\ L^{-1}$)	5	1.10	0.76	0.65	0.71	1.38	2.00	H	Median	0.35	0.32	0.45
			PN ($\mu g\ L^{-1}$)	5	23.20	22.85	19.86	21.96	24.76	26.56	H	Mean		16.00	
			PN ($\mu g\ L^{-1}$)	5	23.20	22.85	19.86	21.96	24.76	26.56	H	Median	18.00		20.00
			PO_4 ($\mu g\ L^{-1}$)	5	0.92	0.77	0.37	0.55	1.22	1.68	H	Median	1.40	1.86	0.93
			POC ($\mu g\ L^{-1}$)	5	126.22	126.16	108.78	117.43	135.14	143.59					
			PP ($\mu g\ L^{-1}$)	5	2.79	2.56	2.33	2.48	3.15	3.42	H	Mean		2.30	
			PP ($\mu g\ L^{-1}$)	5	2.79	2.56	2.33	2.48	3.15	3.42	H	Median	2.60		3.00
			Secchi (m)	5	5.69	6.30	3.09	5.18	6.68	7.22	L	Mean	10.00		
			Secchi (m)	5	5.69	6.30	3.09	5.18	6.68	7.22	L	Median			
			SiO_4 ($\mu g\ L^{-1}$)	5	230.97	177.52	73.47	89.96	402.53	411.36					
			TSS ($mg\ L^{-1}$)	5	1.39	1.18	0.46	0.75	2.21	2.37	H	Mean		1.60	

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			TSS (mg L⁻¹)	5	1.39	1.18	0.46	0.75	2.21	2.37	H	Median	1.90		1.70
		Egret and Boulder Reef (AE04)	DIN (µg L⁻¹)	5	6.02	3.82	2.91	3.08	8.49	11.81					
			DOC (µg L⁻¹)	5	986.50	949.77	903.86	904.77	1062.97	1111.14					
			DON (µg L⁻¹)	5	75.95	74.64	70.96	71.98	80.63	81.57					
			DOP (µg L⁻¹)	5	4.45	4.40	3.75	3.89	5.09	5.11					
			Chl-a (µg L⁻¹)	5	0.50	0.59	0.15	0.27	0.66	0.81	H	Median	0.27		
			NH4 (µg L⁻¹)	5	3.27	3.05	2.48	2.61	3.86	4.36					
			NO_x (µg L⁻¹)	5	2.75	0.77	0.43	0.48	4.13	7.95	H	Median	0.35		
			PN (µg L⁻¹)	5	17.99	16.73	10.76	14.79	22.37	25.28	H	Mean			
			PN (µg L⁻¹)	5	17.99	16.73	10.76	14.79	22.37	25.28	H	Median	18.00		
			PO_4 (µg L⁻¹)	5	1.71	1.62	1.05	1.19	2.14	2.56	H	Median	0.62		
			POC (µg L⁻¹)	5	83.31	87.23	51.35	71.82	97.62	108.50					
			PP (µg L⁻¹)	5	1.77	1.91	1.13	1.54	2.13	2.13	H	Mean			
			PP (µg L⁻¹)	5	1.77	1.91	1.13	1.54	2.13	2.13	H	Median	2.00		
			Secchi (m)	5	11.76	11.90	5.38	7.42	16.12	17.98	L	Mean	10.00		
			Secchi (m)	5	11.76	11.90	5.38	7.42	16.12	17.98	L	Median			
			SiO_4 (µg L⁻¹)	5	197.99	249.94	66.10	94.37	268.32	311.22					
			TSS (mg L⁻¹)	5	0.92	0.98	0.06	0.07	1.30	2.20	H	Mean			
			TSS (mg L⁻¹)	5	0.92	0.98	0.06	0.07	1.30	2.20	H	Median	1.50		
		Dawson Reef (AR03b)	DIN (µg L⁻¹)	5	3.63	3.43	2.92	2.92	4.40	4.48					
			DOC (µg L⁻¹)	5	1010.26	995.37	948.51	972.00	1040.61	1094.79					
			DON (µg L⁻¹)	5	84.66	83.21	81.63	82.50	87.06	88.92					
			DOP (µg L⁻¹)	5	4.71	4.76	3.68	4.15	5.14	5.81					
			Chl-a (µg L⁻¹)	5	0.39	0.37	0.17	0.23	0.50	0.68	H	Median	0.36	0.25	0.46
			NH4 (µg L⁻¹)	5	2.70	2.64	2.32	2.42	2.85	3.26					
			NO_x (µg L⁻¹)	5	0.93	0.98	0.29	0.55	1.24	1.61	H	Median	0.35	0.32	0.45
			PN (µg L⁻¹)	5	16.81	16.95	15.31	16.27	17.65	17.91	H	Mean		16.00	
			PN (µg L⁻¹)	5	16.81	16.95	15.31	16.27	17.65	17.91	H	Median	18.00		20.00

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			PO_4 (µg L^{-1})	5	1.14	0.93	0.56	0.84	1.42	1.98	H	Median	1.40	1.86	0.93
			POC (µg L^{-1})	5	82.69	80.37	74.59	78.75	86.86	92.88					
			PP (µg L^{-1})	5	1.97	1.87	1.64	1.81	2.21	2.29	H	Mean		2.30	
			PP (µg L^{-1})	5	1.97	1.87	1.64	1.81	2.21	2.29	H	Median	2.60		3.00
			Secchi (m)	5	7.42	6.10	5.04	5.16	8.42	12.38	L	Mean	10.00		
			Secchi (m)	5	7.42	6.10	5.04	5.16	8.42	12.38	L	Median			
			SiO_4 (µg L^{-1})	5	176.79	200.15	79.57	88.78	238.87	276.60					
			TSS (mg L^{-1})	5	1.16	0.83	0.33	0.44	1.74	2.43	H	Mean		1.60	
			TSS (mg L^{-1})	5	1.16	0.83	0.33	0.44	1.74	2.43	H	Median	1.90		1.70
		Walker Bay (AR02b)	DIN (µg L^{-1})	5	4.92	4.68	2.90	3.40	5.84	7.79					
			DOC (µg L^{-1})	5	1059.46	1023.73	938.50	993.59	1129.49	1211.98					
			DON (µg L^{-1})	5	84.60	87.60	68.62	78.65	92.02	96.12					
			DOP (µg L^{-1})	5	4.82	4.96	3.80	3.94	5.59	5.81					
			Chl-a (µg L^{-1})	5	0.40	0.35	0.20	0.27	0.46	0.73	H	Median	0.36	0.25	0.46
			NH4 (µg L^{-1})	5	4.01	3.57	2.47	3.14	4.59	6.29					
			NO_x (µg L^{-1})	5	0.91	0.66	0.27	0.43	1.59	1.62	H	Median	0.35	0.32	0.45
			PN (µg L^{-1})	5	21.73	19.43	16.12	16.95	22.95	33.20	H	Mean		16.00	
			PN (µg L^{-1})	5	21.73	19.43	16.12	16.95	22.95	33.20	H	Median	18.00		20.00
			PO_4 (µg L^{-1})	5	1.15	1.07	0.65	0.74	1.40	1.90	H	Median	1.40	1.86	0.93
			POC (µg L^{-1})	5	109.31	96.00	84.68	89.42	117.24	159.19					
			PP (µg L^{-1})	5	2.33	2.27	1.92	1.99	2.58	2.86	H	Mean		2.30	
			PP (µg L^{-1})	5	2.33	2.27	1.92	1.99	2.58	2.86	H	Median	2.60		3.00
			Secchi (m)	5	6.58	7.40	3.72	4.76	8.20	8.80	L	Mean	10.00		
			Secchi (m)	5	6.58	7.40	3.72	4.76	8.20	8.80	L	Median			
			SiO_4 (µg L^{-1})	5	218.59	225.99	106.11	175.69	290.24	294.95					
			TSS (mg L^{-1})	5	1.09	0.68	0.34	0.52	1.50	2.41	H	Mean		1.60	
			TSS (mg L^{-1})	5	1.09	0.68	0.34	0.52	1.50	2.41	H	Median	1.90		1.70
Wet Tropics	Barron Daintree	Cape Tribulation (C1)	DIN (µg L^{-1})	3	2.84	2.31	2.28	2.29	3.28	3.76					
			DOC (µg L^{-1})	3	1016.07	1033.67	883.41	933.49	1102.17	1136.41					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			DON (µg L⁻¹)	3	100.82	98.25	80.23	86.24	114.89	123.20					
			DOP (µg L⁻¹)	3	5.26	5.26	4.64	4.85	5.68	5.89					
			Chl-a (µg L⁻¹)	3	0.49	0.62	0.27	0.39	0.62	0.62	H	Mean	0.45		
			Chl-a (µg L⁻¹)	3	0.49	0.62	0.27	0.39	0.62	0.62	H	Median		0.32	0.63
			NH4 (µg L⁻¹)	3	2.14	1.96	1.83	1.88	2.36	2.56					
			NO_x (µg L⁻¹)	3	0.70	0.49	0.33	0.39	0.97	1.21	H	Median	0.35		
			PN (µg L⁻¹)	3	14.74	14.95	12.63	13.40	16.12	16.71	H	Mean	20.00		
			PN (µg L⁻¹)	3	14.74	14.95	12.63	13.40	16.12	16.71	H	Median		16.00	25.00
			PO_4 (µg L⁻¹)	3	2.48	2.63	1.45	1.84	3.14	3.40	H	Median	2.00		
			POC (µg L⁻¹)	3	118.71	115.67	86.02	95.90	140.91	153.53					
			PP (µg L⁻¹)	3	3.35	2.56	2.30	2.39	4.16	4.96	H	Mean	2.80		
			PP (µg L⁻¹)	3	3.35	2.56	2.30	2.39	4.16	4.96	H	Median		2.30	3.30
			Secchi (m)	3	4.83	3.50	2.15	2.60	6.80	8.45	L	Mean	10.00		
			Secchi (m)	3	4.83	3.50	2.15	2.60	6.80	8.45	L	Median			
			SiO_4 (µg L⁻¹)	3	211.68	225.35	102.93	143.74	282.36	310.87					
			TSS (mg L⁻¹)	3	2.40	1.45	0.91	1.09	3.51	4.54	H	Mean	2.00		
			TSS (mg L⁻¹)	3	2.40	1.45	0.91	1.09	3.51	4.54	H	Median		1.60	2.40
		Port Douglas (C4)	DIN (µg L⁻¹)	3	4.39	4.48	3.47	3.81	4.99	5.25					
			DOC (µg L⁻¹)	3	1018.68	972.74	853.64	893.34	1134.84	1215.88					
			DON (µg L⁻¹)	3	94.05	87.37	85.40	86.05	100.70	107.37					
			DOP (µg L⁻¹)	3	5.19	4.96	4.89	4.91	5.42	5.65					
			Chl-a (µg L⁻¹)	3	0.31	0.38	0.17	0.24	0.39	0.40	H	Median	0.30	0.32	0.63
			NH4 (µg L⁻¹)	3	3.43	3.61	2.91	3.14	3.75	3.83					
			NO_x (µg L⁻¹)	3	0.96	0.63	0.54	0.57	1.29	1.62	H	Median	0.31		
			PN (µg L⁻¹)	3	12.57	13.57	9.80	11.05	14.29	14.66	H	Median	14.00	16.00	25.00
			PO_4 (µg L⁻¹)	3	2.22	2.71	1.25	1.73	2.80	2.85	H	Median	2.00		
			POC (µg L⁻¹)	3	92.71	108.07	63.99	78.68	109.82	110.69					
			PP (µg L⁻¹)	3	2.68	3.05	1.78	2.21	3.22	3.31	H	Median	2.00	2.30	3.30

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			Secchi (m)	3	6.67	6.00	4.20	4.80	8.40	9.60	L	Median	13.00		
			SiO_4 (µg L^{-1})	3	210.91	163.83	74.97	104.59	307.81	379.80					
			TSS (mg L^{-1})	3	1.15	0.75	0.59	0.65	1.57	1.98	H	Median	1.20	1.60	2.40
		Double Island (C5)	DIN (µg L^{-1})	3	5.09	3.36	2.32	2.67	7.16	9.06					
		Double Island (C5)	DOC (µg L^{-1})	3	1019.86	985.02	848.90	894.27	1138.49	1215.22					
		Double Island (C5)	DON (µg L^{-1})	3	110.01	111.38	87.85	95.69	124.61	131.22					
		Double Island (C5)	DOP (µg L^{-1})	3	5.37	5.65	4.12	4.63	6.16	6.42					
		Double Island (C5)	Chl-a (µg L^{-1})	3	0.53	0.49	0.18	0.28	0.77	0.91	H	Median	0.30	0.32	0.63
		Double Island (C5)	NH4 (µg L^{-1})	3	3.27	2.98	1.90	2.26	4.21	4.83					
		Double Island (C5)	NO_x (µg L^{-1})	3	1.82	0.42	0.39	0.40	2.96	4.23	H	Median	0.31		
		Double Island (C5)	PN (µg L^{-1})	3	12.88	13.55	10.44	11.48	14.42	14.85	H	Median	14.00	16.00	25.00
		Double Island (C5)	PO_4 (µg L^{-1})	3	2.68	2.79	2.51	2.60	2.79	2.79	H	Median	2.00		
		Double Island (C5)	POC (µg L^{-1})	3	94.04	103.41	68.15	79.90	110.04	113.36					
		Double Island (C5)	PP (µg L^{-1})	3	2.74	3.14	1.85	2.28	3.27	3.34	H	Median	2.00	2.30	3.30
		Double Island (C5)	Secchi (m)	3	7.17	8.00	4.85	5.90	8.60	8.90	L	Median	13.00		
		Double Island (C5)	SiO_4 (µg L^{-1})	3	165.47	134.76	73.96	94.23	230.58	278.48					
		Double Island (C5)	TSS (mg L^{-1})	3	1.12	0.89	0.65	0.73	1.47	1.76	H	Median	1.20	1.60	2.40
		Green Island (C11)	DIN (µg L^{-1})	3	8.16	3.34	2.89	3.04	12.32	16.81					
		Green Island (C11)	DOC (µg L^{-1})	3	938.48	872.96	872.74	872.82	991.04	1050.08					
		Green Island (C11)	DON (µg L^{-1})	3	81.84	83.10	69.82	74.24	89.69	92.99					
		Green Island (C11)	DOP (µg L^{-1})	3	4.75	5.11	4.00	4.37	5.20	5.25					
		Green Island (C11)	Chl-a (µg L^{-1})	3	0.29	0.20	0.11	0.14	0.42	0.53	H	Median	0.30	0.32	0.63
		Green Island (C11)	NH4 (µg L^{-1})	3	2.47	2.52	2.33	2.39	2.56	2.58					
		Green Island (C11)	NO_x (µg L^{-1})	3	5.69	0.75	0.36	0.49	9.90	14.47	H	Median	0.31		
		Green Island (C11)	PN (µg L^{-1})	3	10.75	9.74	8.93	9.20	12.10	13.28	H	Median	14.00	16.00	25.00
		Green Island (C11)	PO_4 (µg L^{-1})	3	2.68	2.56	2.07	2.23	3.11	3.39	H	Median	2.00		
		Green Island (C11)	POC (µg L^{-1})	3	68.62	52.43	41.89	45.40	88.61	106.69					
		Green Island (C11)	PP (µg L^{-1})	3	1.68	1.44	1.22	1.30	2.02	2.31	H	Median	2.00	2.30	3.30
		Green Island (C11)	Secchi (m)	3	10.33	10.00	6.40	7.60	13.00	14.50	L	Median	13.00		
		Green Island (C11)	SiO_4 (µg L^{-1})	3	139.33	65.17	43.49	50.72	213.10	287.07					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			TSS (mg L⁻¹)	3	0.49	0.60	0.26	0.37	0.63	0.64	H	Median	1.20	1.60	2.40
		Yorkey's Knob (C6)	DIN (µg L⁻¹)	3	3.86	3.50	2.81	3.04	4.61	5.17					
			DOC (µg L⁻¹)	3	1016.08	895.69	895.26	895.40	1112.68	1221.18					
			DON (µg L⁻¹)	3	118.51	124.64	96.13	105.64	132.60	136.58					
			DOP (µg L⁻¹)	3	5.39	5.73	4.75	5.08	5.78	5.80					
			Chl-a (µg L⁻¹)	3	0.66	0.75	0.35	0.49	0.85	0.90	H	Mean	0.45		
			Chl-a (µg L⁻¹)	3	0.66	0.75	0.35	0.49	0.85	0.90	H	Median		0.32	0.63
			NH4 (µg L⁻¹)	3	3.01	3.15	2.24	2.54	3.51	3.69					
			NO_x (µg L⁻¹)	3	0.85	0.60	0.37	0.45	1.20	1.51	H	Median	0.35		
			PN (µg L⁻¹)	3	16.35	16.98	14.70	15.46	17.37	17.57	H	Mean	20.00		
			PN (µg L⁻¹)	3	16.35	16.98	14.70	15.46	17.37	17.57	H	Median		16.00	25.00
			PO_4 (µg L⁻¹)	3	2.63	2.94	1.83	2.20	3.13	3.22	H	Median	2.00		
			POC (µg L⁻¹)	3	143.65	161.46	109.52	126.83	164.03	165.32					
			PP (µg L⁻¹)	3	4.40	4.20	2.79	3.26	5.49	6.14	H	Mean	2.80		
			PP (µg L⁻¹)	3	4.40	4.20	2.79	3.26	5.49	6.14	H	Median		2.30	3.30
			Secchi (m)	3	4.83	5.00	2.30	3.20	6.50	7.25	L	Mean	10.00		
			Secchi (m)	3	4.83	5.00	2.30	3.20	6.50	7.25	L	Median			
			SiO_4 (µg L⁻¹)	3	269.15	220.93	128.84	159.54	369.12	443.21					
			TSS (mg L⁻¹)	3	2.98	1.27	1.18	1.21	4.40	5.97	H	Mean	2.00		
			TSS (mg L⁻¹)	3	2.98	1.27	1.18	1.21	4.40	5.97	H	Median		1.60	2.40
		Fairlead Buoy (C8)	DIN (µg L⁻¹)	3	4.04	3.36	2.48	2.77	5.17	6.07					
			DOC (µg L⁻¹)	3	1066.03	985.98	872.80	910.53	1205.51	1315.28					
			DON (µg L⁻¹)	3	109.23	97.59	91.07	93.24	122.89	135.55					
			DOP (µg L⁻¹)	3	5.08	5.26	4.64	4.85	5.36	5.40					
			Chl-a (µg L⁻¹)	3	0.97	0.94	0.38	0.56	1.37	1.59	H	Mean	0.45		
			Chl-a (µg L⁻¹)	3	0.97	0.94	0.38	0.56	1.37	1.59	H	Median		0.32	0.63
			NH4 (µg L⁻¹)	3	2.63	2.38	2.03	2.15	3.05	3.39					
			NO_x (µg L⁻¹)	3	1.41	0.98	0.44	0.62	2.11	2.68	H	Median	0.35		

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			PN (µg L⁻¹)	3	21.83	24.64	15.41	18.49	25.74	26.29	H	Mean	20.00		
			PN (µg L⁻¹)	3	21.83	24.64	15.41	18.49	25.74	26.29	H	Median		16.00	25.00
			PO_4 (µg L⁻¹)	3	2.84	3.10	1.84	2.26	3.47	3.65	H	Median	2.00		
			POC (µg L⁻¹)	3	205.19	220.10	137.32	164.92	248.44	262.61					
			PP (µg L⁻¹)	3	6.19	5.88	3.60	4.36	7.96	9.01	H	Mean	2.80		
			PP (µg L⁻¹)	3	6.19	5.88	3.60	4.36	7.96	9.01	H	Median		2.30	3.30
			Secchi (m)	3	3.00	3.00	1.65	2.10	3.90	4.35	L	Mean	10.00		
			Secchi (m)	3	3.00	3.00	1.65	2.10	3.90	4.35	L	Median			
			SiO_4 (µg L⁻¹)	3	299.18	210.32	137.26	161.62	418.98	523.30					
			TSS (mg L⁻¹)	3	5.04	2.32	2.23	2.26	7.28	9.75	H	Mean	2.00		
			TSS (mg L⁻¹)	3	5.04	2.32	2.23	2.26	7.28	9.75	H	Median		1.60	2.40
	Johnstone Russell Mulgrave	Fitzroy West (RM1)	DIN (µg L⁻¹)	5	6.28	3.50	2.88	3.11	7.99	13.94					
			DOC (µg L⁻¹)	5	948.49	928.81	851.89	863.37	1015.05	1083.33					
			DON (µg L⁻¹)	5	96.16	93.88	84.79	89.99	101.59	110.56					
			DOP (µg L⁻¹)	5	5.33	5.50	4.54	5.14	5.64	5.82					
			Chl-a (µg L⁻¹)	5	0.38	0.22	0.19	0.21	0.52	0.76	H	Mean	0.45		
			Chl-a (µg L⁻¹)	5	0.38	0.22	0.19	0.21	0.52	0.76	H	Median		0.32	0.63
			NH4 (µg L⁻¹)	5	3.86	2.77	1.91	2.18	4.97	7.49					
			NO_x (µg L⁻¹)	5	2.42	1.68	0.44	0.50	3.02	6.45	H	Median	0.35		
			Turbidity (NTU)	274	1.17	0.91	0.52	0.65	1.29	2.78	H	Median	1.00		
			PN (µg L⁻¹)	5	15.58	16.39	10.74	11.59	18.54	20.66	H	Mean	20.00		
			PN (µg L⁻¹)	5	15.58	16.39	10.74	11.59	18.54	20.66	H	Median		16.00	25.00
			PO_4 (µg L⁻¹)	5	2.23	2.56	1.30	1.49	2.74	3.07	H	Median	2.00		
			POC (µg L⁻¹)	5	122.73	126.78	68.32	86.80	165.00	166.78					
			PP (µg L⁻¹)	5	2.40	2.15	1.88	1.96	2.59	3.42	H	Mean	2.80		
			PP (µg L⁻¹)	5	2.40	2.15	1.88	1.96	2.59	3.42	H	Median		2.30	3.30
			Secchi (m)	5	9.20	9.00	6.20	6.80	10.20	13.80	L	Mean	10.00		
			Secchi (m)	5	9.20	9.00	6.20	6.80	10.20	13.80	L	Median			

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles Q5	Q20	Q80	Q95	Guideline Values DOF	Location	Annual	Dry	Wet
			SiO_4 (µg L⁻¹)	5	158.65	99.44	77.96	81.80	213.03	321.03					
			TSS (mg L⁻¹)	5	0.75	0.75	0.33	0.44	1.01	1.23	H	Mean	2.00		
			TSS (mg L⁻¹)	5	0.75	0.75	0.33	0.44	1.01	1.23	H	Median		1.60	2.40
		RM3 (RM3)	DIN (µg L⁻¹)	10	6.75	5.66	2.13	2.43	11.47	13.36					
			DOC (µg L⁻¹)	10	1051.64	1061.68	842.53	908.34	1151.60	1307.81					
			DON (µg L⁻¹)	10	95.40	97.89	74.68	89.42	101.89	112.13					
			DOP (µg L⁻¹)	10	5.43	5.46	4.78	5.08	5.74	6.02					
			Chl-a (µg L⁻¹)	10	0.46	0.36	0.25	0.25	0.59	0.95	H	Median	0.30	0.32	0.63
			NH4 (µg L⁻¹)	10	5.28	4.60	1.57	1.95	8.51	9.95					
			NO_x (µg L⁻¹)	10	1.47	0.84	0.35	0.48	1.62	4.55	H	Median	0.31		
			PN (µg L⁻¹)	10	23.93	19.19	12.14	13.72	32.80	44.17	H	Median	14.00	16.00	25.00
			PO_4 (µg L⁻¹)	10	2.18	2.36	1.31	1.39	2.69	3.03	H	Median	2.00		
			POC (µg L⁻¹)	10	161.31	155.11	90.62	113.08	189.79	265.22					
			PP (µg L⁻¹)	10	2.80	2.74	1.62	1.94	3.65	4.21	H	Median	2.00	2.30	3.30
			Secchi (m)	10	7.65	6.25	3.45	4.40	9.80	15.20	L	Median	13.00		
			SiO_4 (µg L⁻¹)	10	183.49	132.55	74.80	95.59	322.96	364.40					
			TSS (mg L⁻¹)	10	1.46	1.13	0.58	0.76	2.05	3.04	H	Median	1.20	1.60	2.40
		High West (RM8)	DIN (µg L⁻¹)	10	7.05	5.69	3.36	3.94	9.22	14.59					
			DOC (µg L⁻¹)	10	1057.57	1006.91	861.35	953.64	1150.22	1367.01					
			DON (µg L⁻¹)	10	95.68	92.00	78.50	86.97	102.78	121.03					
			DOP (µg L⁻¹)	10	5.29	5.34	4.32	4.86	5.57	6.26					
			Chl-a (µg L⁻¹)	10	0.42	0.34	0.17	0.23	0.60	0.85	H	Mean	0.45		
			Chl-a (µg L⁻¹)	10	0.42	0.34	0.17	0.23	0.60	0.85	H	Median		0.32	0.63
			NH4 (µg L⁻¹)	10	4.52	3.71	2.30	2.93	5.99	8.05					
			NO_x (µg L⁻¹)	10	2.53	1.08	0.44	0.78	2.76	8.88	H	Median	0.35		
			Turbidity (NTU)	329	1.09	0.82	0.44	0.62	1.32	2.72	H	Median	1.00		
			PN (µg L⁻¹)	10	27.42	21.08	12.60	15.07	32.93	59.65	H	Mean	20.00		
			PN (µg L⁻¹)	10	27.42	21.08	12.60	15.07	32.93	59.65	H	Median		16.00	25.00
			PO_4 (µg L⁻¹)	10	2.26	2.40	1.31	1.52	2.77	3.06	H	Median	2.00		

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			POC (µg L⁻¹)	10	180.60	156.97	90.37	122.10	205.20	345.22					
			PP (µg L⁻¹)	10	3.58	3.11	1.84	2.14	4.78	6.33	H	Mean	2.80		
			PP (µg L⁻¹)	10	3.58	3.11	1.84	2.14	4.78	6.33	H	Median		2.30	3.30
			Secchi (m)	10	5.74	4.50	1.94	2.42	7.80	13.20	L	Mean	10.00		
			Secchi (m)	10	5.74	4.50	1.94	2.42	7.80	13.20	L	Median			
			SiO_4 (µg L⁻¹)	10	240.89	189.82	101.68	127.87	402.89	423.01					
			TSS (mg L⁻¹)	10	2.63	1.63	0.40	1.03	4.19	6.72	H	Mean	2.00		
			TSS (mg L⁻¹)	10	2.63	1.63	0.40	1.03	4.19	6.72	H	Median		1.60	2.40
		Russell Mulgrave Mouth Mooring (RM10)	DIN (µg L⁻¹)	10	18.34	9.36	2.33	5.80	29.97	51.13					
			DOC (µg L⁻¹)	10	1193.85	1133.58	881.08	982.89	1354.87	1654.59					
			DON (µg L⁻¹)	10	101.69	103.27	79.54	93.39	111.65	120.19					
			DOP (µg L⁻¹)	10	5.22	5.03	4.37	4.86	5.90	6.26					
			Chl-a (µg L⁻¹)	10	0.87	0.88	0.27	0.31	1.32	1.58	H	Mean	0.45		
			Chl-a (µg L⁻¹)	10	0.87	0.88	0.27	0.31	1.32	1.58	H	Median		0.32	0.63
			NH4 (µg L⁻¹)	10	4.99	4.81	1.92	2.65	7.18	8.25					
			NO_x (µg L⁻¹)	10	13.35	4.24	0.41	2.00	23.55	42.92	H	Median	0.35		
			Turbidity (NTU)	294	4.00	2.72	1.20	1.57	5.15	12.26	H	Median	1.00		
			PN (µg L⁻¹)	10	37.90	32.29	14.76	20.46	54.31	70.51	H	Mean	20.00		
			PN (µg L⁻¹)	10	37.90	32.29	14.76	20.46	54.31	70.51	H	Median		16.00	25.00
			PO_4 (µg L⁻¹)	10	3.22	3.37	1.39	1.58	4.46	5.13	H	Median	2.00		
			POC (µg L⁻¹)	10	301.42	273.48	141.76	173.90	401.61	508.84					
			PP (µg L⁻¹)	10	7.65	7.29	3.48	3.68	11.35	13.60	H	Mean	2.80		
			PP (µg L⁻¹)	10	7.65	7.29	3.48	3.68	11.35	13.60	H	Median		2.30	3.30
			Secchi (m)	10	3.16	3.25	1.00	1.40	4.20	6.10	L	Mean	10.00		
			Secchi (m)	10	3.16	3.25	1.00	1.40	4.20	6.10	L	Median			
			SiO_4 (µg L⁻¹)	10	620.08	445.72	95.89	184.17	1153.63	1356.60					
			TSS (mg L⁻¹)	10	5.84	4.27	1.24	1.59	9.54	13.08	H	Mean	2.00		
			TSS (mg L⁻¹)	10	5.84	4.27	1.24	1.59	9.54	13.08	H	Median		1.60	2.40

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
		Franklands West (RM7)	DIN (µg L⁻¹)	10	6.67	4.93	2.59	2.74	6.85	16.82					
			DOC (µg L⁻¹)	10	991.83	970.16	835.88	889.88	1015.48	1251.54					
			DON (µg L⁻¹)	10	95.10	95.01	81.99	88.76	99.55	110.53					
			DOP (µg L⁻¹)	10	5.16	5.26	4.37	4.72	5.54	5.86					
			Chl-a (µg L⁻¹)	10	0.45	0.40	0.19	0.28	0.64	0.80	H	Median	0.30	0.32	0.63
			NH4 (µg L⁻¹)	10	4.27	3.29	2.19	2.26	4.76	9.53					
			NO_x (µg L⁻¹)	10	2.39	1.06	0.37	0.53	2.95	8.02	H	Median	0.31		
			Turbidity (NTU)	292	0.92	0.62	0.31	0.41	1.08	2.40	H	Median	0.60		
			PN (µg L⁻¹)	10	21.11	19.46	11.45	13.30	30.00	33.07	H	Median	14.00	16.00	25.00
			PO_4 (µg L⁻¹)	10	2.10	1.94	1.27	1.50	2.54	3.38	H	Median	2.00		
			POC (µg L⁻¹)	10	127.15	131.16	74.38	99.89	163.23	169.64					
			PP (µg L⁻¹)	10	2.33	2.15	1.85	1.94	2.52	3.35	H	Median	2.00	2.30	3.30
			Secchi (m)	10	6.11	7.00	2.70	3.30	7.40	10.40	L	Median	13.00		
			SiO_4 (µg L⁻¹)	10	167.57	113.94	72.45	76.64	299.62	352.72					
			TSS (mg L⁻¹)	10	1.12	0.85	0.53	0.63	1.49	2.34	H	Median	1.20	1.60	2.40
	Tully Herbert	Clump Point East (TUL2)	DIN (µg L⁻¹)	10	4.60	4.99	1.97	2.44	6.54	6.96					
			DOC (µg L⁻¹)	10	1053.53	1042.03	876.49	946.74	1157.76	1262.48					
			DON (µg L⁻¹)	10	106.43	103.85	87.84	94.00	119.64	129.70					
			DOP (µg L⁻¹)	10	5.51	5.42	4.24	4.80	6.22	6.86					
			Chl-a (µg L⁻¹)	10	0.34	0.26	0.12	0.16	0.44	0.75	H	Median	0.30	0.32	0.63
			NH4 (µg L⁻¹)	10	4.04	4.31	1.66	2.08	5.92	6.40					
			NO_x (µg L⁻¹)	10	0.57	0.47	0.30	0.37	0.60	1.14	H	Median	0.31		
			PN (µg L⁻¹)	10	20.87	18.94	11.06	13.11	28.02	34.83	H	Median	14.00	16.00	25.00
			PO_4 (µg L⁻¹)	10	2.01	2.09	1.43	1.53	2.34	2.61	H	Median	2.00		
			POC (µg L⁻¹)	10	135.62	133.64	73.23	111.67	158.68	200.06					
			PP (µg L⁻¹)	10	2.17	2.02	1.20	1.68	2.96	3.33	H	Median	2.00	2.30	3.30
			Secchi (m)	10	9.90	8.00	5.00	5.00	15.40	18.65	L	Median	13.00		
			SiO_4 (µg L⁻¹)	10	176.63	129.21	46.76	62.78	337.25	396.02					
			TSS (mg L⁻¹)	10	1.14	0.73	0.50	0.59	1.87	2.58	H	Median	1.20	1.60	2.40
			DIN (µg L⁻¹)	10	6.12	6.09	1.99	3.35	8.61	10.57					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
		Dunk North (TUL3)	DOC (μg L⁻¹)	10	1126.60	1080.13	895.66	969.53	1205.94	1493.16					
			DON (μg L⁻¹)	10	113.03	103.63	86.22	98.16	117.29	165.78					
			DOP (μg L⁻¹)	10	5.43	5.42	4.46	4.92	5.88	6.52					
			Chl-a (μg L⁻¹)	10	0.42	0.36	0.14	0.21	0.63	0.81	H	Mean	0.45		
			Chl-a (μg L⁻¹)	10	0.42	0.36	0.14	0.21	0.63	0.81	H	Median		0.32	0.63
			NH4 (μg L⁻¹)	10	4.82	4.45	1.74	2.86	7.63	8.23					
			NO_x (μg L⁻¹)	10	1.30	1.05	0.24	0.50	2.23	2.73	H	Median	0.35		
			Turbidity (NTU)	222	3.48	1.54	0.89	1.08	4.79	14.33	H	Median	1.00		
			PN (μg L⁻¹)	10	27.38	22.54	11.93	15.29	38.24	51.94	H	Mean	20.00		
			PN (μg L⁻¹)	10	27.38	22.54	11.93	15.29	38.24	51.94	H	Median		16.00	25.00
			PO_4 (μg L⁻¹)	10	2.36	2.44	1.25	1.92	2.97	3.18	H	Median	2.00		
			POC (μg L⁻¹)	10	187.85	158.37	102.88	144.53	261.58	314.84					
			PP (μg L⁻¹)	10	3.84	3.04	1.94	2.16	5.71	7.43	H	Mean	2.80		
			PP (μg L⁻¹)	10	3.84	3.04	1.94	2.16	5.71	7.43	H	Median		2.30	3.30
			Secchi (m)	10	5.17	5.75	1.79	2.50	7.20	8.55	L	Mean	10.00		
			Secchi (m)	10	5.17	5.75	1.79	2.50	7.20	8.55	L	Median			
			SiO_4 (μg L⁻¹)	10	296.41	206.43	101.32	131.41	502.16	642.03					
			TSS (mg L⁻¹)	10	3.33	1.81	0.57	0.97	5.21	9.81	H	Mean	2.00		
			TSS (mg L⁻¹)	10	3.33	1.81	0.57	0.97	5.21	9.81	H	Median		1.60	2.40
		Dunk Island South East (TUL5)	DIN (μg L⁻¹)	10	6.24	7.28	2.16	3.59	8.54	9.82					
			DOC (μg L⁻¹)	10	1099.82	1088.56	918.79	951.97	1181.57	1370.15					
			DON (μg L⁻¹)	10	100.02	102.57	82.26	88.60	111.80	115.29					
			DOP (μg L⁻¹)	10	5.44	5.46	4.25	4.92	6.09	6.62					
			Chl-a (μg L⁻¹)	10	0.49	0.40	0.23	0.24	0.75	0.93	H	Mean	0.45		
			Chl-a (μg L⁻¹)	10	0.49	0.40	0.23	0.24	0.75	0.93	H	Median		0.32	0.63
			NH4 (μg L⁻¹)	10	4.83	5.69	1.76	2.99	6.59	6.88					
			NO_x (μg L⁻¹)	10	1.41	0.82	0.40	0.62	2.03	3.39	H	Median	0.35		
			PN (μg L⁻¹)	10	26.61	20.25	12.64	14.35	32.76	57.02	H	Mean	20.00		

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			PN (µg L⁻¹)	10	26.61	20.25	12.64	14.35	32.76	57.02	H	Median		16.00	25.00
			PO_4 (µg L⁻¹)	10	2.61	2.63	1.76	2.01	3.19	3.51	H	Median	2.00		
			POC (µg L⁻¹)	10	183.10	145.06	95.29	122.57	190.60	394.66					
			PP (µg L⁻¹)	10	3.98	2.92	1.89	2.21	4.95	8.89	H	Mean	2.80		
			PP (µg L⁻¹)	10	3.98	2.92	1.89	2.21	4.95	8.89	H	Median		2.30	3.30
			Secchi (m)	10	6.00	6.50	2.95	3.90	8.00	8.55	L	Mean	10.00		
			Secchi (m)	10	6.00	6.50	2.95	3.90	8.00	8.55	L	Median			
			SiO_4 (µg L⁻¹)	10	264.98	155.62	83.67	105.73	492.50	601.08					
			TSS (mg L⁻¹)	10	3.31	1.18	1.01	1.04	3.02	11.60	H	Mean	2.00		
			TSS (mg L⁻¹)	10	3.31	1.18	1.01	1.04	3.02	11.60	H	Median		1.60	2.40
		Between Tam O'Shanter and Timana (TUL6)	DIN (µg L⁻¹)	10	7.02	5.79	1.85	4.15	9.58	14.60					
			DOC (µg L⁻¹)	10	1225.41	1233.50	907.82	978.00	1357.62	1673.12					
			DON (µg L⁻¹)	10	106.09	103.31	85.54	95.23	115.26	135.09					
			DOP (µg L⁻¹)	10	5.40	5.34	4.08	4.34	6.41	6.70					
			Chl-a (µg L⁻¹)	10	0.63	0.56	0.18	0.26	1.08	1.16	H	Mean	0.45		
			Chl-a (µg L⁻¹)	10	0.63	0.56	0.18	0.26	1.08	1.16	H	Median		0.32	0.63
			NH4 (µg L⁻¹)	10	4.26	4.06	1.60	2.79	5.88	7.35					
			NO_x (µg L⁻¹)	10	2.76	0.96	0.23	0.27	5.06	9.31	H	Median	0.35		
			PN (µg L⁻¹)	10	30.60	26.53	12.54	14.97	42.40	57.24	H	Mean	20.00		
			PN (µg L⁻¹)	10	30.60	26.53	12.54	14.97	42.40	57.24	H	Median		16.00	25.00
			PO_4 (µg L⁻¹)	10	2.27	2.17	1.34	1.66	2.94	3.20	H	Median	2.00		
			POC (µg L⁻¹)	10	213.57	177.25	101.29	141.66	296.94	396.18					
			PP (µg L⁻¹)	10	4.81	4.48	2.23	2.56	6.98	8.36	H	Mean	2.80		
			PP (µg L⁻¹)	10	4.81	4.48	2.23	2.56	6.98	8.36	H	Median		2.30	3.30
			Secchi (m)	10	3.95	3.50	2.00	2.40	5.20	7.10	L	Mean	10.00		
			Secchi (m)	10	3.95	3.50	2.00	2.40	5.20	7.10	L	Median			
			SiO_4 (µg L⁻¹)	10	647.31	638.13	105.44	220.48	1003.95	1376.11					
			TSS (mg L⁻¹)	10	3.96	2.81	1.03	1.30	5.66	10.17	H	Mean	2.00		

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			TSS (mg L⁻¹)	10	3.96	2.81	1.03	1.30	5.66	10.17	H	Median		1.60	2.40
		Bedarra (TUL8)	DIN (µg L⁻¹)	10	7.14	6.13	2.49	2.87	12.12	13.04					
			DOC (µg L⁻¹)	10	1125.46	1055.89	915.75	1010.56	1222.58	1489.84					
			DON (µg L⁻¹)	10	98.44	93.11	78.12	87.46	109.33	128.48					
			DOP (µg L⁻¹)	10	5.14	5.19	4.10	4.80	5.51	6.14					
			Chl-a (µg L⁻¹)	10	0.56	0.46	0.22	0.24	0.91	1.01	H	Mean	0.45		
			Chl-a (µg L⁻¹)	10	0.56	0.46	0.22	0.24	0.91	1.01	H	Median		0.32	0.63
			NH4 (µg L⁻¹)	10	5.19	4.48	2.08	2.42	7.22	10.19					
			NO_x (µg L⁻¹)	10	1.95	1.08	0.36	0.54	3.37	5.30	H	Median	0.35		
			PN (µg L⁻¹)	10	30.39	24.16	11.78	16.20	38.53	64.19	H	Mean	20.00		
			PN (µg L⁻¹)	10	30.39	24.16	11.78	16.20	38.53	64.19	H	Median		16.00	25.00
			PO_4 (µg L⁻¹)	10	2.45	2.32	1.53	1.77	3.10	3.61	H	Median	2.00		
			POC (µg L⁻¹)	10	197.46	171.55	79.98	124.07	234.63	391.02					
			PP (µg L⁻¹)	10	4.24	3.64	2.15	2.38	5.48	7.60	H	Mean	2.80		
			PP (µg L⁻¹)	10	4.24	3.64	2.15	2.38	5.48	7.60	H	Median		2.30	3.30
			Secchi (m)	10	4.83	4.75	2.13	2.98	6.20	8.10	L	Mean	10.00		
			Secchi (m)	10	4.83	4.75	2.13	2.98	6.20	8.10	L	Median			
			SiO_4 (µg L⁻¹)	10	453.65	406.11	134.91	150.25	656.04	946.44					
			TSS (mg L⁻¹)	10	4.41	1.68	0.64	0.96	5.50	15.13	H	Mean	2.00		
			TSS (mg L⁻¹)	10	4.41	1.68	0.64	0.96	5.50	15.13	H	Median		1.60	2.40
		Tully River mouth mooring (TUL10)	DIN (µg L⁻¹)	10	10.68	7.71	2.40	3.75	16.42	25.95					
			DOC (µg L⁻¹)	10	1248.80	1190.65	1021.82	1065.87	1404.41	1591.72					
			DON (µg L⁻¹)	10	105.29	99.84	91.25	92.88	112.85	134.55					
			DOP (µg L⁻¹)	10	5.73	5.57	3.83	4.44	6.53	8.33					
			Chl-a (µg L⁻¹)	10	0.83	0.73	0.27	0.40	1.27	1.67	H	Median	1.10		
			NH4 (µg L⁻¹)	10	4.30	4.73	1.82	2.38	5.78	6.59					
			NO_x (µg L⁻¹)	10	6.38	2.78	0.51	0.67	10.86	19.85	H	Median	3.00		
			Turbidity (NTU)	272	4.64	3.48	1.77	2.30	5.99	13.06	H	Median	4.00		

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			PN (µg L⁻¹)	10	41.52	34.95	18.49	24.70	56.05	73.84	H	Median			
			PO_4 (µg L⁻¹)	10	2.37	2.75	0.59	1.80	3.02	3.37	H	Median	3.00		
			POC (µg L⁻¹)	10	323.23	319.87	176.78	199.83	401.16	546.01					
			PP (µg L⁻¹)	10	6.17	6.61	2.92	3.91	8.32	8.60	H	Median			
			Secchi (m)	10	2.39	1.60	1.44	1.50	3.30	4.80	L	Median	1.60		
			SiO_4 (µg L⁻¹)	10	873.37	775.92	254.38	292.99	1127.76	2058.36					
			TSS (mg L⁻¹)	10	7.12	5.26	0.81	1.53	11.25	16.22	H	Median	5.00		
Burdekin	Burdekin	Palms West (BUR1)	DIN (µg L⁻¹)	9	6.57	4.20	1.60	2.77	10.23	13.05					
			DOC (µg L⁻¹)	9	1074.17	1070.69	828.03	897.38	1247.08	1412.52					
			DON (µg L⁻¹)	9	100.44	102.87	75.88	87.29	114.85	121.18					
			DOP (µg L⁻¹)	9	5.25	5.03	4.30	4.63	6.21	6.35					
			Chl-a (µg L⁻¹)	9	0.42	0.29	0.17	0.19	0.60	0.88	H	Median	0.35	0.32	0.63
			NH4 (µg L⁻¹)	9	4.57	3.22	1.34	2.06	7.44	8.01					
			NO_x (µg L⁻¹)	9	2.00	1.05	0.24	0.54	2.79	6.09	H	Median	0.28		
			Turbidity (NTU)	208	0.94	0.82	0.45	0.57	1.28	1.77	H	Median	0.80		
			PN (µg L⁻¹)	9	24.84	17.71	10.56	12.35	36.52	47.34	H	Median	12.00	16.00	25.00
			PO_4 (µg L⁻¹)	9	2.38	2.40	1.49	1.95	2.85	3.17	H	Median	1.00		
			POC (µg L⁻¹)	9	155.49	129.51	70.19	85.32	205.72	332.88					
			PP (µg L⁻¹)	9	2.93	2.66	1.31	1.70	4.29	5.08	H	Median	2.20	2.30	3.30
			Secchi (m)	9	7.14	7.00	3.56	6.02	9.04	9.64	L	Mean	10.00		
			Secchi (m)	9	7.14	7.00	3.56	6.02	9.04	9.64	L	Median			
			SiO_4 (µg L⁻¹)	9	243.62	92.06	60.30	82.80	351.94	725.97					
			TSS (mg L⁻¹)	9	1.08	0.57	0.29	0.48	1.72	2.83	H	Median	1.20	1.60	2.40
		Pandora (BUR2)	DIN (µg L⁻¹)	9	6.11	3.85	1.61	2.01	8.60	17.02					
			DOC (µg L⁻¹)	9	1187.05	1157.92	894.06	941.94	1330.69	1675.31					
			DON (µg L⁻¹)	9	103.46	105.08	83.02	88.09	115.86	129.49					
			DOP (µg L⁻¹)	9	6.25	5.73	5.05	5.51	6.12	9.04					
			Chl-a (µg L⁻¹)	9	0.38	0.37	0.19	0.27	0.45	0.63	H	Median	0.35	0.32	0.63
			NH4 (µg L⁻¹)	9	4.04	2.94	1.37	1.62	6.22	9.03					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			NO$_x$ (µg L^{-1})	9	2.07	0.53	0.22	0.26	2.38	7.99	H	Median	0.28		
			Turbidity (NTU)	240	1.93	1.06	0.62	0.80	1.72	5.02	H	Median	0.80		
			PN (µg L^{-1})	9	20.24	20.79	10.96	13.69	25.80	32.90	H	Median	12.00	16.00	25.00
			PO$_4$ (µg L^{-1})	9	2.81	3.10	1.21	1.58	3.28	4.86	H	Median	1.00		
			POC (µg L^{-1})	9	117.09	119.75	71.09	102.80	135.05	156.42					
			PP (µg L^{-1})	9	2.31	2.12	1.71	1.85	2.84	3.17	H	Median	2.20	2.30	3.30
			Secchi (m)	9	6.60	6.00	4.24	5.38	7.80	10.20	L	Mean	10.00		
			Secchi (m)	9	6.60	6.00	4.24	5.38	7.80	10.20	L	Median			
			SiO$_4$ (µg L^{-1})	9	272.47	186.80	58.82	89.83	471.13	563.15					
			TSS (mg L^{-1})	9	0.99	1.04	0.62	0.76	1.24	1.31	H	Median	1.20	1.60	2.40
		Magnetic (BUR4)	DIN (µg L^{-1})	8	5.57	5.17	2.15	3.07	7.94	9.97					
			DOC (µg L^{-1})	8	1244.43	1186.40	954.86	1023.48	1433.01	1662.29					
			DON (µg L^{-1})	8	107.55	102.61	96.06	98.44	115.84	127.48					
			DOP (µg L^{-1})	8	4.88	5.15	2.43	4.80	5.84	6.29					
			Chl-a (µg L^{-1})	8	0.59	0.53	0.30	0.41	0.81	1.03	H	Median	0.59	0.32	0.63
			NH4 (µg L^{-1})	8	4.23	4.06	1.76	2.51	5.81	6.74					
			NO$_x$ (µg L^{-1})	8	1.34	0.78	0.28	0.35	2.55	3.29	H	Median	0.28		
			Turbidity (NTU)	290	3.07	1.35	0.66	0.86	3.23	11.02	H	Median	1.30		
			PN (µg L^{-1})	8	22.83	21.03	12.92	17.17	29.36	35.15	H	Median	17.00	16.00	25.00
			PO$_4$ (µg L^{-1})	8	3.59	3.56	0.99	1.80	4.30	6.91	H	Median	1.00		
			POC (µg L^{-1})	8	147.09	148.86	84.40	123.27	186.31	195.31					
			PP (µg L^{-1})	8	3.91	4.00	2.03	3.06	5.00	5.44	H	Mean	2.80		
			PP (µg L^{-1})	8	3.91	4.00	2.03	3.06	5.00	5.44	H	Median		2.30	3.30
			Secchi (m)	8	4.27	4.33	2.65	3.26	5.40	6.00	L	Median	4.00		
			SiO$_4$ (µg L^{-1})	8	388.35	320.93	100.98	158.12	616.41	832.68					
			TSS (mg L^{-1})	8	2.87	1.24	0.82	0.93	2.16	9.52	H	Median	1.90	1.60	2.40
		Haughton 2 (BUR7)	DIN (µg L^{-1})	9	4.71	4.17	1.69	2.41	5.99	9.90					
			DOC (µg L^{-1})	9	1191.09	1103.45	902.95	977.00	1283.04	1756.48					
			DON (µg L^{-1})	9	105.46	96.61	89.06	92.74	124.97	127.07					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			DOP (µg L⁻¹)	9	5.51	5.57	4.83	5.30	5.73	6.10					
			Chl-a (µg L⁻¹)	9	0.52	0.45	0.30	0.33	0.65	0.98	H	Mean	0.45		
			Chl-a (µg L⁻¹)	9	0.52	0.45	0.30	0.33	0.65	0.98	H	Median		0.32	0.63
			NH4 (µg L⁻¹)	9	3.80	3.50	1.44	2.20	4.77	7.18					
			NO_x (µg L⁻¹)	9	0.91	0.56	0.21	0.25	1.23	2.72	H	Median	1.00		
			PN (µg L⁻¹)	9	28.69	29.40	13.41	13.84	38.04	51.44	H	Median	13.00	16.00	25.00
			PO_4 (µg L⁻¹)	9	2.68	2.48	0.91	1.80	3.10	5.05	H	Median	2.00		
			POC (µg L⁻¹)	9	175.52	172.06	97.84	118.92	211.01	290.93					
			PP (µg L⁻¹)	9	4.21	3.41	2.40	2.57	6.15	7.42	H	Median	2.10	2.30	3.30
			Secchi (m)	9	4.54	4.00	1.98	3.12	5.60	8.00	L	Mean	10.00		
			Secchi (m)	9	4.54	4.00	1.98	3.12	5.60	8.00	L	Median			
			SiO_4 (µg L⁻¹)	9	361.17	103.09	77.36	87.73	571.18	1048.66					
			TSS (mg L⁻¹)	9	2.19	1.69	1.30	1.40	2.59	4.36	H	Median	1.20	1.60	2.40
		Yongala (BUR10)	DIN (µg L⁻¹)	5	5.50	3.15	1.52	2.09	7.57	13.18					
			DOC (µg L⁻¹)	5	939.36	924.37	855.27	902.30	981.14	1033.73					
			DON (µg L⁻¹)	5	83.35	80.96	66.98	76.18	90.45	102.21					
			DOP (µg L⁻¹)	5	5.40	5.34	4.86	5.05	5.61	6.16					
			Chl-a (µg L⁻¹)	5	0.32	0.22	0.16	0.17	0.49	0.54	H	Median	0.33	0.32	0.63
			NH4 (µg L⁻¹)	5	4.31	2.77	1.25	1.86	6.12	9.56					
			NO_x (µg L⁻¹)	5	1.19	0.39	0.22	0.27	1.46	3.62	H	Median	0.28		
			PN (µg L⁻¹)	5	12.49	12.16	10.17	10.53	14.02	15.58	H	Median	14.00	16.00	25.00
			PO_4 (µg L⁻¹)	5	2.11	1.94	1.42	1.75	2.57	2.85	H	Median	1.00		
			POC (µg L⁻¹)	5	90.18	95.61	54.40	62.04	111.39	127.48					
			PP (µg L⁻¹)	5	1.79	1.59	1.26	1.46	2.13	2.49	H	Median	2.00	2.30	3.30
			Secchi (m)	5	10.60	11.00	5.20	8.80	13.40	14.60	L	Mean	10.00		
			Secchi (m)	5	10.60	11.00	5.20	8.80	13.40	14.60	L	Median			
			SiO_4 (µg L⁻¹)	5	124.09	73.74	50.96	65.83	163.60	266.32					
			TSS (mg L⁻¹)	5	0.43	0.43	0.10	0.16	0.64	0.82	H	Median	0.80	1.60	2.40
			DIN (µg L⁻¹)	9	16.90	8.51	2.40	3.01	35.14	47.34					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
		Burdekin River mouth mooring (BUR13)	DOC (µg L⁻¹)	9	1832.25	1286.41	1047.95	1105.34	2403.91	3450.63					
			DON (µg L⁻¹)	9	126.37	109.40	91.32	96.11	158.26	176.70					
			DOP (µg L⁻¹)	9	5.74	5.73	4.75	5.22	6.27	6.64					
			Chl-a (µg L⁻¹)	9	0.88	0.85	0.49	0.58	0.97	1.57	H	Median	1.00		
			NH4 (µg L⁻¹)	9	8.03	5.57	1.81	2.23	13.14	20.34					
			NO_x (µg L⁻¹)	9	8.87	2.28	0.29	0.60	20.22	27.88	H	Median	4.00		
			Turbidity (NTU)	215	8.16	5.83	2.12	3.46	11.68	19.63	H	Median	4.00		
			PN (µg L⁻¹)	9	55.63	52.92	17.97	20.64	88.26	105.84	H	Mean			
			PN (µg L⁻¹)	9	55.63	52.92	17.97	20.64	88.26	105.84	H	Median			
			PO_4 (µg L⁻¹)	9	6.38	3.17	1.50	1.87	10.76	17.82	H	Median	1.00		
			POC (µg L⁻¹)	9	385.40	248.12	169.57	173.10	604.53	806.27					
			PP (µg L⁻¹)	9	9.67	6.71	3.86	4.83	13.32	22.39	H	Median			
			Secchi (m)	9	1.84	1.10	0.10	0.40	3.70	4.12	L	Median	1.50		
			SiO_4 (µg L⁻¹)	9	1302.11	352.88	172.42	191.63	2565.42	3700.11					
			TSS (mg L⁻¹)	9	17.13	6.28	1.12	1.71	33.81	55.52	H	Median	2.00		
Mackay-Whitsunday	Mackay-Whitsunday	Double Cone (WHI1)	DIN (µg L⁻¹)	5	4.32	5.25	2.43	2.96	5.45	5.52					
			DOC (µg L⁻¹)	5	934.47	934.79	854.70	897.56	976.51	1008.82					
			DON (µg L⁻¹)	5	84.15	84.78	71.37	77.92	91.48	95.21					
			DOP (µg L⁻¹)	5	4.94	5.03	4.72	4.72	5.06	5.16					
			Chl-a (µg L⁻¹)	5	0.44	0.40	0.18	0.31	0.50	0.79	H	Median	0.36	0.32	0.63
			NH4 (µg L⁻¹)	5	3.37	3.78	1.86	2.38	4.37	4.45					
			NO_x (µg L⁻¹)	5	0.96	0.77	0.58	0.58	1.30	1.56	H	Median	1.00		
			Turbidity (NTU)	264	1.28	1.10	0.53	0.73	1.77	2.80	H	Median	1.10		
			PN (µg L⁻¹)	5	15.01	12.54	12.26	12.47	18.70	19.08	H	Mean	14.00		
			PN (µg L⁻¹)	5	15.01	12.54	12.26	12.47	18.70	19.08	H	Median		16.00	25.00
			PO_4 (µg L⁻¹)	5	2.60	3.10	1.29	1.66	3.39	3.58	H	Median	1.00		
			POC (µg L⁻¹)	5	124.70	90.77	89.31	89.71	166.46	187.23					
			PP (µg L⁻¹)	5	3.34	2.46	1.66	2.15	4.72	5.70	H	Median	2.30	2.30	3.30

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			Secchi (m)	5	4.90	4.00	0.80	1.70	7.80	10.20	L	Mean	10.00		
			Secchi (m)	5	4.90	4.00	0.80	1.70	7.80	10.20	L	Median			
			SiO_4 (µg L^{-1})	5	78.92	80.48	63.58	69.99	86.25	94.30					
			TSS (mg L^{-1})	5	2.72	1.80	0.40	0.56	5.15	5.72	H	Median	1.40	1.60	2.40
		Pine (WHI4)	DIN (µg L^{-1})	5	8.79	8.02	4.91	6.50	10.98	13.56					
			DOC (µg L^{-1})	5	922.50	908.90	835.20	889.28	977.58	1001.54					
			DON (µg L^{-1})	5	90.80	89.64	87.39	87.48	92.79	96.68					
			DOP (µg L^{-1})	5	5.33	4.80	4.60	4.69	5.57	6.97					
			Chl-a (µg L^{-1})	5	0.57	0.57	0.41	0.47	0.62	0.76	H	Median	0.36	0.32	0.63
			NH4 (µg L^{-1})	5	4.31	4.20	3.01	3.43	5.29	5.63					
			NO_x (µg L^{-1})	5	4.48	3.47	1.77	2.57	6.47	8.13	H	Median	1.00		
			Turbidity (NTU)	279	2.53	1.92	0.78	1.24	3.87	5.70	H	Median	1.10		
			PN (µg L^{-1})	5	16.38	14.81	13.47	13.76	18.53	21.33	H	Mean	14.00		
			PN (µg L^{-1})	5	16.38	14.81	13.47	13.76	18.53	21.33	H	Median		16.00	25.00
			PO_4 (µg L^{-1})	5	3.76	4.10	2.40	3.56	4.21	4.54	H	Median	1.00		
			POC (µg L^{-1})	5	143.81	122.45	97.63	113.05	175.92	210.02					
			PP (µg L^{-1})	5	3.98	3.82	2.32	2.93	5.02	5.83	H	Median	2.30	2.30	3.30
			Secchi (m)	5	4.00	3.00	2.50	2.50	4.80	7.20	L	Mean	10.00		
			Secchi (m)	5	4.00	3.00	2.50	2.50	4.80	7.20	L	Median			
			SiO_4 (µg L^{-1})	5	113.03	83.36	78.54	78.83	142.88	181.56					
			TSS (mg L^{-1})	5	4.55	4.67	0.97	1.80	6.57	8.76	H	Median	1.40	1.60	2.40
		Seaforth (WHI5)	DIN (µg L^{-1})	5	5.93	4.73	3.47	4.20	6.87	10.38					
			DOC (µg L^{-1})	5	929.83	919.80	848.84	879.43	996.91	1004.19					
			DON (µg L^{-1})	5	85.24	82.36	78.15	80.20	87.81	97.66					
			DOP (µg L^{-1})	5	5.02	5.26	4.37	4.92	5.26	5.26					
			Chl-a (µg L^{-1})	5	0.56	0.53	0.35	0.43	0.63	0.85	H	Median	0.36	0.32	0.63
			NH4 (µg L^{-1})	5	3.51	3.05	2.67	2.72	4.14	5.00					
			NO_x (µg L^{-1})	5	2.42	1.68	0.57	0.59	3.63	5.61	H	Median	1.00		
			Turbidity (NTU)	130	1.77	1.61	1.06	1.31	2.12	3.22	H	Median	1.10		

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			PN (µg L^{-1})	5	14.82	13.51	12.27	12.59	16.60	19.15	H	Mean	14.00		
			PN (µg L^{-1})	5	14.82	13.51	12.27	12.59	16.60	19.15	H	Median		16.00	25.00
			PO_4 (µg L^{-1})	5	3.38	3.41	2.17	3.10	4.06	4.15	H	Median	1.00		
			POC (µg L^{-1})	5	118.33	116.27	82.46	87.05	142.01	163.85					
			PP (µg L^{-1})	5	3.61	2.87	2.42	2.56	4.59	5.60	H	Median	2.30	2.30	3.30
			Secchi (m)	5	4.50	4.00	1.90	3.10	6.00	7.50	L	Mean	10.00		
			Secchi (m)	5	4.50	4.00	1.90	3.10	6.00	7.50	L	Median			
			SiO_4 (µg L^{-1})	5	117.81	115.45	80.56	88.61	148.40	156.03					
			TSS (mg L^{-1})	5	2.74	1.49	0.73	1.09	3.82	6.59	H	Median	1.40	1.60	2.40
		OConnell River mouth (WHI6)	DIN (µg L^{-1})	5	14.23	4.53	2.93	3.84	15.32	44.50					
			DOC (µg L^{-1})	5	1462.11	1245.54	1064.04	1190.21	1679.43	2131.33					
			DON (µg L^{-1})	5	115.21	112.39	94.96	96.73	129.11	142.88					
			DOP (µg L^{-1})	5	5.98	6.12	4.75	5.54	6.69	6.78					
			Chl-a (µg L^{-1})	5	1.01	0.89	0.41	0.60	1.50	1.67	H	Median	1.30		
			NH4 (µg L^{-1})	5	7.34	3.85	2.24	2.77	7.92	19.94					
			NO_x (µg L^{-1})	5	6.88	1.59	0.29	0.49	7.46	24.57	H	Median	4.00		
			Turbidity (NTU)	228	4.85	2.70	1.12	1.55	7.15	16.49	H	Median	4.00		
			PN (µg L^{-1})	5	30.07	28.41	22.60	24.25	33.85	41.26	H	Mean			
			PN (µg L^{-1})	5	30.07	28.41	22.60	24.25	33.85	41.26	H	Median			
			PO_4 (µg L^{-1})	5	6.53	5.42	2.34	4.48	7.85	12.59	H	Median	3.00		
			POC (µg L^{-1})	5	292.52	285.44	191.97	210.88	333.91	440.38					
			PP (µg L^{-1})	5	8.40	8.35	4.43	5.21	10.07	13.93	H	Median			
			Secchi (m)	5	1.90	1.50	0.60	0.90	2.80	3.70	L	Median	1.60		
			SiO_4 (µg L^{-1})	5	534.47	370.65	61.33	100.18	774.60	1365.58					
			TSS (mg L^{-1})	5	5.23	4.77	1.81	2.38	7.56	9.62	H	Median	5.00		
		Repulse Islands dive mooring (WHI7)	DIN (µg L^{-1})	5	7.95	5.93	3.60	3.89	8.83	17.49					
			DOC (µg L^{-1})	5	1114.35	1167.32	939.76	954.59	1240.75	1269.34					
			DON (µg L^{-1})	5	96.98	101.72	77.62	88.28	107.85	109.45					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			DOP (µg L⁻¹)	5	5.56	5.42	3.78	4.89	6.60	7.11					
			Chl-a (µg L⁻¹)	5	0.60	0.58	0.41	0.53	0.66	0.80	H	Mean	0.45		
			Chl-a (µg L⁻¹)	5	0.60	0.58	0.41	0.53	0.66	0.80	H	Median		0.32	0.63
			NH4 (µg L⁻¹)	5	5.19	3.99	2.84	3.39	5.90	9.85					
			NO_x (µg L⁻¹)	5	2.75	1.35	0.50	0.76	3.41	7.76	H	Median	0.25		
			PN (µg L⁻¹)	5	20.49	18.10	13.28	15.03	24.28	31.77	H	Median	18.00	16.00	25.00
			PO_4 (µg L⁻¹)	5	4.65	3.72	3.47	3.65	5.78	6.61	H	Median	2.00		
			POC (µg L⁻¹)	5	188.30	168.15	100.56	122.07	224.74	325.96					
			PP (µg L⁻¹)	5	6.50	4.43	3.12	3.93	8.24	12.79	H	Median	2.10	2.30	3.30
			Secchi (m)	5	3.10	3.50	0.70	1.30	4.40	5.60	L	Mean	10.00		
			Secchi (m)	5	3.10	3.50	0.70	1.30	4.40	5.60	L	Median			
			SiO_4 (µg L⁻¹)	5	242.44	231.81	96.97	101.56	368.23	413.65					
			TSS (mg L⁻¹)	5	5.99	2.84	1.94	2.61	7.47	15.10	H	Median	1.60	1.60	2.40
Fitzroy	Fitzroy	North Keppel Island (FTZ4)	DIN (µg L⁻¹)	10	6.53	6.03	2.00	4.02	9.41	11.64					
			DOC (µg L⁻¹)	10	1097.82	1108.06	966.46	1036.15	1167.77	1187.91					
			DON (µg L⁻¹)	10	91.42	92.24	73.65	81.64	101.44	105.78					
			DOP (µg L⁻¹)	10	5.41	5.40	4.59	5.01	5.61	6.34					
			Chl-a (µg L⁻¹)	10	0.33	0.27	0.20	0.21	0.48	0.51	H	Mean	0.45		
			Chl-a (µg L⁻¹)	10	0.33	0.27	0.20	0.21	0.48	0.51	H	Median		0.32	0.63
			NH4 (µg L⁻¹)	10	5.45	5.12	1.67	3.28	7.94	9.37					
			NO_x (µg L⁻¹)	10	1.08	0.73	0.30	0.50	1.40	2.72	H	Median	0.50		
			PN (µg L⁻¹)	10	13.12	12.51	9.93	11.20	16.02	17.42	H	Median	15.00	16.00	25.00
			PO_4 (µg L⁻¹)	10	1.10	1.01	0.34	0.72	1.26	2.24	H	Median	2.00		
			POC (µg L⁻¹)	10	105.33	97.89	64.59	80.13	135.99	159.80					
			PP (µg L⁻¹)	10	2.27	1.91	1.45	1.67	3.12	3.56	H	Median	2.50	2.30	3.30
			Secchi (m)	10	9.25	9.50	4.72	5.80	11.60	14.00	L	Median	10.00		
			SiO_4 (µg L⁻¹)	10	57.32	56.24	21.70	39.28	80.72	93.86					
			TSS (mg L⁻¹)	10	0.73	0.49	0.17	0.30	1.08	1.77	H	Median	1.00	1.60	2.40
		Barren (FTZ1)	DIN (µg L⁻¹)	10	6.17	5.96	1.98	4.01	8.65	10.75					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			DOC (µg L⁻¹)	10	1111.52	1106.48	968.97	1055.32	1189.98	1246.76					
			DON (µg L⁻¹)	10	90.75	90.07	73.56	81.22	101.85	108.69					
			DOP (µg L⁻¹)	10	5.33	5.27	4.67	4.94	5.76	5.98					
			Chl-a (µg L⁻¹)	10	0.27	0.27	0.16	0.19	0.36	0.37	H	Median	0.27	0.32	0.63
			NH4 (µg L⁻¹)	10	5.48	5.14	1.58	3.24	8.34	9.85					
			NO_x (µg L⁻¹)	10	0.69	0.52	0.27	0.37	1.10	1.29	H	Median	0.50		
			Turbidity (NTU)	284	0.76	0.59	0.21	0.32	0.95	1.77	H	Median	0.30		
			PN (µg L⁻¹)	10	12.34	12.32	10.25	11.42	13.65	14.05	H	Median	12.00	16.00	25.00
			PO_4 (µg L⁻¹)	10	0.91	0.76	0.31	0.31	1.40	2.00	H	Median	2.00		
			POC (µg L⁻¹)	10	96.52	92.11	69.01	84.64	105.71	133.12					
			PP (µg L⁻¹)	10	1.94	1.78	1.31	1.68	2.38	2.76	H	Median	1.90	2.40	3.40
			Secchi (m)	10	11.30	10.75	7.62	9.00	12.00	17.65	L	Median	12.00		
			SiO_4 (µg L⁻¹)	10	45.53	49.50	9.31	15.76	67.48	84.28					
			TSS (mg L⁻¹)	10	0.35	0.33	0.16	0.20	0.48	0.65	H	Median	0.40	1.70	2.50
		Keppels South (FTZ2)	DIN (µg L⁻¹)	10	6.51	6.55	2.71	4.60	7.67	10.69					
			DOC (µg L⁻¹)	10	1110.56	1153.85	938.40	1040.51	1161.06	1203.51					
			DON (µg L⁻¹)	10	94.92	93.31	86.12	88.53	97.63	109.63					
			DOP (µg L⁻¹)	10	5.27	5.39	4.38	4.66	5.86	5.88					
			Chl-a (µg L⁻¹)	10	0.33	0.29	0.19	0.23	0.47	0.49	H	Mean	0.45		
			Chl-a (µg L⁻¹)	10	0.33	0.29	0.19	0.23	0.47	0.49	H	Median		0.32	0.63
			NH4 (µg L⁻¹)	10	5.34	5.91	2.02	4.14	6.94	7.22					
			NO_x (µg L⁻¹)	10	1.19	0.70	0.29	0.44	1.04	3.76	H	Median	0.50		
			Turbidity (NTU)	176	1.72	0.94	0.43	0.54	2.51	5.34	H	Mean	1.50		
			Turbidity (NTU)	176	1.72	0.94	0.43	0.54	2.51	5.34	H	Median			
			PN (µg L⁻¹)	10	13.88	13.96	10.33	11.48	15.15	18.18	H	Mean	20.00		
			PN (µg L⁻¹)	10	13.88	13.96	10.33	11.48	15.15	18.18	H	Median		16.00	25.00
			PO_4 (µg L⁻¹)	10	1.09	0.93	0.49	0.87	1.30	1.90	H	Mean	2.00		
			PO_4 (µg L⁻¹)	10	1.09	0.93	0.49	0.87	1.30	1.90	H	Median			
			POC (µg L⁻¹)	10	113.70	108.92	74.71	95.29	126.83	165.16					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			PP (µg L⁻¹)	10	2.34	2.19	1.38	1.77	2.97	3.49	H	Mean	2.80		
			PP (µg L⁻¹)	10	2.34	2.19	1.38	1.77	2.97	3.49	H	Median		2.40	3.40
			Secchi (m)	10	8.40	8.00	4.30	6.90	9.80	12.92	L	Mean	10.00		
			Secchi (m)	10	8.40	8.00	4.30	6.90	9.80	12.92	L	Median			
			SiO_4 (µg L⁻¹)	10	58.20	55.94	17.79	24.71	101.37	107.68					
			TSS (mg L⁻¹)	10	0.75	0.41	0.16	0.28	0.91	2.30	H	Mean	2.00		
			TSS (mg L⁻¹)	10	0.75	0.41	0.16	0.28	0.91	2.30	H	Median		1.70	2.50
		Pelican (FTZ3)	DIN (µg L⁻¹)	10	8.11	8.01	3.72	5.39	9.60	13.92					
			DOC (µg L⁻¹)	10	1207.64	1118.33	1054.43	1074.73	1266.96	1540.18					
			DON (µg L⁻¹)	10	95.03	92.38	85.88	87.43	103.84	108.69					
			DOP (µg L⁻¹)	10	5.07	4.96	4.14	4.64	5.56	6.09					
			Chl-a (µg L⁻¹)	10	0.56	0.31	0.17	0.23	1.10	1.25	H	Mean	0.45		
			Chl-a (µg L⁻¹)	10	0.56	0.31	0.17	0.23	1.10	1.25	H	Median		0.32	0.63
			NH4 (µg L⁻¹)	10	6.09	6.98	2.53	4.65	7.83	8.07					
			NO_x (µg L⁻¹)	10	2.03	1.05	0.44	0.67	2.79	5.89	H	Median	0.50		
			PN (µg L⁻¹)	10	17.14	12.91	10.01	11.83	21.01	33.59	H	Mean	20.00		
			PN (µg L⁻¹)	10	17.14	12.91	10.01	11.83	21.01	33.59	H	Median		16.00	25.00
			PO_4 (µg L⁻¹)	10	2.88	2.12	0.55	1.65	3.84	7.07	H	Mean	2.00		
			PO_4 (µg L⁻¹)	10	2.88	2.12	0.55	1.65	3.84	7.07	H	Median			
			POC (µg L⁻¹)	10	158.68	121.13	68.46	91.94	208.99	343.24					
			PP (µg L⁻¹)	10	4.42	2.79	1.19	2.02	5.21	11.79	H	Mean	2.80		
			PP (µg L⁻¹)	10	4.42	2.79	1.19	2.02	5.21	11.79	H	Median		2.40	3.40
			Secchi (m)	10	5.61	6.00	1.09	2.30	7.80	9.99	L	Mean	10.00		
			Secchi (m)	10	5.61	6.00	1.09	2.30	7.80	9.99	L	Median			
			SiO_4 (µg L⁻¹)	10	135.73	77.09	24.23	44.02	118.64	444.14					
			TSS (mg L⁻¹)	10	3.62	0.70	0.35	0.52	4.59	14.46	H	Mean	2.00		
			TSS (mg L⁻¹)	10	3.62	0.70	0.35	0.52	4.59	14.46	H	Median		1.70	2.50
		Peak West (FTZ5)	DIN (µg L⁻¹)	10	10.39	8.75	3.17	5.14	10.79	24.65					

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			DOC ($\mu g\ L^{-1}$)	10	1229.46	1129.82	1025.11	1058.06	1294.33	1710.64					
			DON ($\mu g\ L^{-1}$)	10	95.45	92.29	81.45	87.51	103.10	116.15					
			DOP ($\mu g\ L^{-1}$)	10	5.18	5.20	4.18	4.41	5.88	6.17					
			Chl-a ($\mu g\ L^{-1}$)	10	0.57	0.38	0.21	0.30	0.75	1.38	H	Mean	0.45		
			Chl-a ($\mu g\ L^{-1}$)	10	0.57	0.38	0.21	0.30	0.75	1.38	H	Median		0.32	0.63
			NH4 ($\mu g\ L^{-1}$)	10	7.06	7.02	2.49	3.65	9.33	12.83					
			NO_x ($\mu g\ L^{-1}$)	10	3.36	0.69	0.32	0.47	2.84	14.55	H	Median	0.50		
			PN ($\mu g\ L^{-1}$)	10	18.91	13.87	10.86	12.96	22.72	39.63	H	Mean	20.00		
			PN ($\mu g\ L^{-1}$)	10	18.91	13.87	10.86	12.96	22.72	39.63	H	Median		16.00	25.00
			PO_4 ($\mu g\ L^{-1}$)	10	3.57	2.46	0.82	1.72	3.65	9.62	H	Median	2.00		
			POC ($\mu g\ L^{-1}$)	10	178.78	127.65	78.61	109.89	186.16	434.81					
			PP ($\mu g\ L^{-1}$)	10	4.95	3.28	1.99	2.69	4.52	13.34	H	Mean	2.80		
			PP ($\mu g\ L^{-1}$)	10	4.95	3.28	1.99	2.69	4.52	13.34	H	Median		2.40	3.40
			Secchi (m)	10	3.38	3.62	0.95	2.30	4.24	5.64	L	Mean	10.00		
			Secchi (m)	10	3.38	3.62	0.95	2.30	4.24	5.64	L	Median			
			SiO_4 ($\mu g\ L^{-1}$)	10	168.48	79.56	26.93	66.84	143.54	566.77					
			TSS ($mg\ L^{-1}$)	10	5.29	1.53	0.91	1.15	4.11	21.47	H	Mean	2.00		
			TSS ($mg\ L^{-1}$)	10	5.29	1.53	0.91	1.15	4.11	21.47	H	Median		1.70	2.50
		Fitzroy River Mouth (FTZ6)	DIN ($\mu g\ L^{-1}$)	10	13.28	10.98	7.08	7.92	15.79	26.40					
			DOC ($\mu g\ L^{-1}$)	10	1465.48	1303.44	1080.27	1164.50	1534.60	2356.59					
			DON ($\mu g\ L^{-1}$)	10	105.34	102.45	92.36	94.90	110.64	128.38					
			DOP ($\mu g\ L^{-1}$)	10	4.96	4.96	3.94	4.52	5.35	5.97					
			Chl-a ($\mu g\ L^{-1}$)	10	0.91	0.80	0.52	0.60	1.24	1.53	H	Median	1.00		
			NH4 ($\mu g\ L^{-1}$)	10	6.90	6.27	3.32	3.96	8.69	11.96					
			NO_x ($\mu g\ L^{-1}$)	10	6.41	3.99	1.12	2.53	9.45	17.01	H	Median	3.00		
			Turbidity (NTU)	109	21.82	17.68	4.15	8.71	33.46	52.29	H	Median		7.00	15.00
			PN ($\mu g\ L^{-1}$)	10	33.28	23.00	19.35	20.98	40.68	71.16	H	Median			
			PO_4 ($\mu g\ L^{-1}$)	10	6.52	5.04	2.95	4.02	8.03	14.12	H	Median	3.00		

Region	Subregion	Site	Measure	N	Mean	Median	Quantiles				Guideline Values				
							Q5	Q20	Q80	Q95	DOF	Location	Annual	Dry	Wet
			POC (µg L^{-1})	10	367.57	224.59	177.34	203.11	418.51	909.14					
			PP (µg L^{-1})	10	8.20	7.02	4.87	5.83	8.69	15.61	H	Median			
			Secchi (m)	10	1.21	1.40	0.24	0.66	1.55	2.16	L	Median			
			SiO_4 (µg L^{-1})	10	283.58	141.73	65.05	96.90	241.44	967.12					
			TSS (mg L^{-1})	10	15.44	7.20	3.30	5.21	24.96	47.13	H	Median			

Table C-2: Summary of turbidity measurements from moored loggers (site locations in Section 5 for the past 3 water years. N = number of daily means in the time-series; SE = standard error; '% d> Trigger' refers to the percentage of days each year with mean or median values above the site-specific water quality guideline values (Table C-9). Red shading indicates the annual means or medians that exceeded annual guideline values (Table C-9). Yellow shading indicates the means or medians that exceeded wet season guideline values for Cape York loggers which collect wet season data only (Table C-9). '% d> 5 NTU' refers to the percentage of days above 5 NTU, a threshold suggested by Cooper *et al.* (2007, 2008) above which hard corals are likely to experience photo-physiological stress.

Subregion	Site	Oct 2022 - Sept 2023						Oct 2023 - Sept 2024						Oct 2024 - Sept 2025					
		N	Annual Mean	SE	Annual Median	%d > Trigger	%d > 5 Trigger	N	Annual Mean	SE	Annual Median	%d > Trigger	%d > 5 Trigger	N	Annual Mean	SE	Annual Median	%d > Trigger	%d > 5 Trigger
Annan- Endeavour	Dawson Reef	136	1.36	0.13	0.66	43.4	4.4	150	1.95	0.33	0.85	54.0	4.0	167	1.52	0.2	0.64	37.72	8.38
	Forrester Reef	100	0.3	0.3	0.26	1	0	162	0.42	0.03	0.28	25.3	0	168	0.37	0.07	0.26	16.67	0
Johnstone Russell Mulgrave	Fitzroy West	277	1.58	0.06	1.19	64.98	2.17	334	1.20	0.09	0.89	41.32	1.20	245	1.15	0.07	0.84	35.10	2.04
	High West	93	0.91	0.05	0.79	29.03	0.00	251	1.03	0.04	0.83	38.65	0.40	299	1.07	0.05	0.81	30.77	1.34
	Russell Mulgrave Mouth Mooring	291	6.14	0.30	4.36	100.00	43.64	366	4.78	0.25	3.54	93.99	30.87	264	3.40	0.16	2.56	96.97	17.42
	Franklands West	360	0.95	0.04	0.76	69.72	0.56	365	0.88	0.05	0.64	55.34	0.55	262	0.91	0.07	0.60	50.38	1.53
Tully Herbert	Dunk North	347	3.59	0.22	1.72	89.91	21.61	280	3.72	0.29	1.70	80.71	19.29	196	2.73	0.24	1.44	84.69	13.78
	Tully River mouth mooring	365	5.76	0.24	4.26	52.33	42.19	319	4.69	0.21	3.75	44.20	24.14	242	4.34	0.20	3.39	38.43	26.45
Burdekin	Palms West	337	0.72	0.03	0.60	24.04	0.30	331	0.87	0.03	0.74	42.90	0.60	179	0.97	0.04	0.84	54.75	0.00
	Pandora	308	1.41	0.08	1.05	73.38	2.92	270	1.53	0.09	1.08	75.19	2.59	240	1.93	0.25	1.06	80.00	5.00
	Magnetic	301	2.42	0.13	1.43	55.48	13.29	366	2.60	0.15	1.66	68.31	8.74	260	2.91	0.38	1.24	47.69	11.54
	Burdekin River mouth mooring	365	10.33	0.39	8.96	78.08	67.67	265	7.98	0.45	5.66	72.83	58.49	185	7.43	0.40	5.37	67.57	57.30
Mackay-Whitsunday	Double Cone	365	1.26	0.03	1.10	49.86	0.00	182	1.63	0.07	1.33	70.33	1.10	264	1.28	0.04	1.10	50.00	0.00
	Pine	251	2.52	0.11	2.02	80.08	10.76	366	1.92	0.08	1.49	65.30	4.37	249	2.54	0.10	1.93	87.15	9.24
	Seaforth	340	1.68	0.04	1.46	78.24	0.29	248	1.69	0.05	1.49	81.85	0.00	130	1.77	0.05	1.61	93.08	0.00
	OConnell River mouth	314	6.24	0.30	4.06	50.64	41.40	366	4.11	0.25	2.47	27.87	23.77	198	4.55	0.36	2.60	26.26	21.72
Fitzroy	Barren	365	0.30	0.01	0.25	30.96	0.00	296	0.47	0.03	0.33	59.12	0.00	254	0.82	0.05	0.65	89.76	1.18
	Keppels South	365	0.83	0.04	0.57	13.42	0.27	357	1.03	0.06	0.61	17.09	1.68	146	1.86	0.16	1.06	37.67	7.53
	Fitzroy River Mouth	280	16.23	0.75	12.40		88.57	289	22.82	1.21	16.30		95.16	109	21.82	1.46	17.68		92.66

C-4 Data used to generate remote sensing maps

Table C-3: Summary of water quality data collected across the Sentinel-3 Reef water types (WT) as part of the wet season event sampling of the MMP. Multi-year samples were collected between December–April by AIMS and CYWP since 2016–17 and by JCU since 2003–04 and up to 2022–23.

Reef region	Multi-year		TSS (mg L^{-1})	Chl-*a* (µg L^{-1})	CDOM (m^{-1})	Secchi depth (m)	DIN (µg L^{-1})	DIP (µg L^{-1})	PP (µg L^{-1})	PN (µg L^{-1})
	WT1	mean	17.40	1.45	0.86	2.11	31.60	8.74	11.60	76.90
		SD	44.10	2.21	0.99	2.12	44.40	11.90	20.60	82.60
		min	0.00	0.07	0.00	0.00	0.24	0.00	0.00	0.00
		max	590.00	30.90	6.17	16.00	338.00	98.00	186.28	719.00
		count	935	935	789	501	878	895	259	248
	WT2	mean	4.63	0.65	0.25	4.61	12.10	4.40	3.75	37.50
		SD	7.00	0.75	0.41	2.77	23.50	5.22	4.01	23.40
		min	0.00	0.02	0.00	0.20	0.12	0.00	0.00	0.00
		max	130.00	12.50	3.50	17.00	363.00	63.00	58.00	210.50
		count	1383	1414	1116	932	1384	1401	611	602
	WT3	mean	2.35	0.37	0.09	8.22	6.51	2.76	2.46	28.30
		SD	3.94	0.40	0.18	4.14	10.50	3.24	3.80	21.30
		min	0.00	0.02	0.00	0.50	0.12	0.31	0.00	0.00
		max	31.00	5.34	2.00	22.00	77.00	21.00	49.00	268.00
		count	623	639	457	418	581	585	338	329
	WT4	mean	1.78	0.53	0.12	11.00	8.81	4.24	2.37	28.50
		SD	3.55	0.86	0.20	4.76	10.70	4.84	2.52	19.40
		min	0.00	0.02	0.00	0.50	0.14	0.31	0.77	8.36
		max	30.00	5.34	1.25	20.00	63.00	20.00	15.30	119.24
		count	93	101	58	54	83	84	44	42

Table C-4: Summary of water quality data collected in the Cape York region across the Sentinel-3 Reef water types (WT) as part of the wet season event sampling of the MMP. Multi-year samples were collected between December and April by CYWP since 2016–17 and up to 2022–23.

	Multi-year		TSS (mg L^{-1})	Chl-*a* (µg L^{-1})	CDOM (m^{-1})	Secchi depth (m)	DIN (µg L^{-1})	DIP (µg L^{-1})	PP (µg L^{-1})	PN (µg L^{-1})
Cape York	WT1	mean	20.36	1.10	1.65	2.21	13.37	3.49	10.66	85.03
		SD	44.13	1.13	1.59	2.23	14.64	2.58	12.64	87.21
		min	0.00	0.08	0.00	0.10	0.28	0.00	0.00	0.00
		max	320.00	8.82	6.17	12.00	73.14	13.32	68.00	563.78
		count	208	218	160	157	214	218	102	80
	WT2	mean	3.33	0.45	0.39	5.04	5.00	1.95	3.69	31.94
		SD	5.61	0.47	0.64	2.93	7.85	1.47	6.11	21.15
		min	0.00	0.04	0.00	0.20	0.28	0.31	0.00	8.84
		max	60.00	3.26	3.50	16.00	76.86	8.00	58.00	144.93
		count	295	301	180	225	301	301	188	170
	WT3	mean	1.53	0.27	0.08	8.54	3.64	1.67	2.47	22.18
		SD	2.00	0.31	0.24	3.81	6.99	1.46	5.83	12.89
		min	0.05	0.02	0.00	0.65	0.28	0.31	0.00	8.84
		max	14.00	1.95	2.00	17.50	68.00	7.14	49.00	76.71
		count	176	181	109	126	178	178	120	111
	WT4	mean	1.43	0.22	0.03	10.35	8.20	3.00	1.63	20.75
		SD	0.80	0.35	0.05	6.15	7.11	1.50	1.34	7.23
		min	0.41	0.02	0.00	2.50	0.28	0.31	0.77	13.84
		max	2.66	1.28	0.10	19.40	18.14	5.56	4.00	27.86
		count	13	13	4	8	13	13	5	4

Table C-5: Summary of water quality data collected in the Wet Tropics region across the Sentinel-3 Reef water types (WT) as part of the wet season event sampling of the MMP. Samples were collected between December and April by AIMS since 2016–17 and JCU since 2003–04 and up to and up to 2022–23.

	Multi-year		TSS (mg L^{-1})	Chl-*a* (µg L^{-1})	CDOM (m^{-1})	Secchi depth (m)	DIN (µg L^{-1})	DIP (µg L^{-1})	PP (µg L^{-1})	PN (µg L^{-1})
Wet Tropics	WT1	mean	8.66	1.27	0.64	2.05	45.66	7.13	8.86	53.22
		SD	9.71	1.84	0.51	2.13	57.32	5.12	8.50	29.84
		min	0.00	0.08	0.00	0.00	0.24	0.00	1.25	12.84
		max	92.00	30.90	3.56	14.00	338.00	21.00	40.86	173.71
		count	406	399	388	185	356	356	57	58
	WT2	mean	4.23	0.67	0.27	4.80	17.07	4.87	3.44	37.66
		SD	4.91	0.65	0.39	2.87	31.34	4.60	2.33	23.05
		min	0.00	0.02	0.00	0.50	0.12	0.00	0.53	7.74
		max	33.00	11.24	2.74	17.00	363.00	22.00	19.52	210.50
		count	623	637	574	400	611	615	228	229
	WT3	mean	2.84	0.42	0.11	8.77	9.23	3.28	2.34	28.46
		SD	4.79	0.49	0.16	4.53	13.20	3.60	1.72	13.68
		min	0.00	0.02	0.00	0.50	0.12	0.31	0.66	0.00
		max	31.00	5.34	1.38	22.00	77.00	21.00	13.53	100.19
		count	289	296	239	203	273	274	143	143
	WT4	mean	2.07	0.43	0.17	10.99	10.42	3.25	3.06	27.07
		SD	2.57	0.61	0.25	4.47	14.31	3.05	3.59	14.40
		min	0.01	0.10	0.00	1.30	0.14	0.31	0.93	8.36
		max	11.94	3.42	1.25	19.00	63.00	12.00	15.29	54.91
		count	33	35	29	25	33	33	19	19

Table C-6: Summary of water quality data collected in the Burdekin region across the Sentinel-3 Reef water types (WT) as part of the wet season event sampling of the MMP. Multi-years samples were collected between December and April by AIMS since 2016–17 and JCU since 2003–04 and up to 2022–23.

Multi-year			TSS (mg L-1)	Chl-*a* (µg L-1)	CDOM (m-1)	Secchi depth (m)	DIN (µg L-1)	DIP (µg L-1)	PP (µg L-1)	PN (µg L-1)
Burdekin	WT1	mean	32.00	1.43	0.66	2.03	24.28	6.78	18.43	98.16
		SD	83.22	1.84	0.84	2.23	37.50	6.92	36.89	113.01
		min	0.05	0.10	0.00	0.00	0.28	0.31	1.27	15.23
		max	590.00	13.78	3.48	16.00	323.00	46.00	186.28	719.00
		count	157	156	113	102	151	155	63	73
	WS2	mean	3.99	0.66	0.13	3.98	9.22	3.34	3.92	46.03
		SD	8.47	0.82	0.25	2.30	17.98	3.64	3.33	29.68
		min	0.05	0.07	0.00	0.20	0.12	0.31	0.97	0.00
		max	130.00	8.69	2.03	16.00	223.38	27.90	26.35	182.88
		count	258	260	194	202	258	260	99	106
	WS3	mean	2.47	0.37	0.08	6.16	5.38	3.11	2.62	36.03
		SD	2.71	0.22	0.15	3.41	5.86	3.42	3.06	41.72
		min	0.05	0.08	0.00	1.00	0.14	0.31	0.91	0.00
		max	16.00	1.14	1.11	17.00	31.00	20.00	20.57	268.00
		count	97	96	71	61	81	82	40	40
	WS4	mean	1.77	0.34	0.06	11.21	4.38	2.45	1.90	31.46
		SD	5.35	0.38	0.09	4.76	5.37	2.96	0.95	24.87
		min	0.00	0.10	0.00	0.50	0.14	0.31	0.95	11.14
		max	30.00	2.20	0.33	20.00	19.00	9.00	4.64	119.24
		count	33	39	23	21	28	29	20	19

Table C-7: Summary of water quality data collected in the Mackay-Whitsunday region across the Sentinel-3 Reef water types (WT) as part of the wet season event sampling of the MMP. Multi-year samples were collected between December and April by AIMS since 2016–17 and JCU since 2003–04 and up to 2022–23.

	Multi-year		TSS (mg L^{-1})	Chl-*a* (µg L^{-1})	CDOM (m^{-1})	Secchi depth (m)	DIN (µg L^{-1})	DIP (µg L^{-1})	PP (µg L^{-1})	PN (µg L^{-1})
Mackay-Whitsundays	WT1	mean	12.44	1.26	0.45	1.88	21.12	10.89	6.85	62.20
		SD	20.59	1.22	0.56	1.41	16.50	7.43	2.56	26.91
		min	0.57	0.07	0.03	0.20	0.28	0.31	2.85	27.24
		max	110.00	6.78	2.60	6.00	68.04	36.23	12.35	115.28
		count	45	42	43	28	45	45	20	20
	WT2	mean	5.44	0.82	0.14	3.42	10.30	4.38	4.91	41.11
		SD	6.79	0.58	0.15	2.06	11.54	3.35	2.20	16.54
		min	0.10	0.03	0.01	0.40	0.14	0.00	1.83	16.43
		max	41.00	3.88	0.88	11.00	52.78	15.00	10.74	79.36
		count	134	129	98	73	127	132	74	75
	WT3	mean	1.56	0.49	0.02	6.48	2.57	1.69	2.98	44.30
		SD	2.10	0.24	0.01	1.97	4.02	1.28	0.97	29.15
		min	0.19	0.10	0.01	4.00	0.12	0.31	1.72	16.54
		max	12.00	1.19	0.05	10.50	22.00	7.00	5.57	136.91
		count	39	39	27	20	33	34	27	27

Table C-8: Summary of water quality data collected in the Fitzroy region across the Sentinel-3 Reef water types (WT) as part of the wet season event sampling of the MMP. Multi-year samples were collected between December and April by AIMS since 2021–22 and JCU since 2007–08 and up to 2022–23.

	Multi-year		**TSS (mg L^{-1})**	**Chl-*a* (µg L^{-1})**	**CDOM (m^{-1})**	**Secchi depth (m)**	**DIN (µg L^{-1})**	**DIP (µg L^{-1})**	**PP (µg L^{-1})**	**PN (µg L^{-1})**
Fitzroy	WT1	mean	7.63	1.30	0.29	2.52	15.10	10.27	6.62	45.53
		SD	10.41	1.88	0.36	1.39	25.42	12.46	4.73	21.59
		min	0.69	0.24	0.04	0.25	0.28	0.93	2.53	26.74
		max	39.88	8.73	1.41	6.00	116.83	57.76	22.64	97.76
		count	22	22	17	22	22	22	17	17
	WT2	mean	1.73	0.53	0.05	6.20	4.30	3.69	2.79	24.11
		SD	1.10	0.60	0.03	2.98	7.27	4.81	1.08	7.29
		min	0.17	0.11	0.01	2.50	0.28	0.31	1.28	14.04
		max	3.60	2.21	0.13	12.00	22.00	19.00	4.92	39.88
		count	27	27	22	27	27	27	22	22
	WT3	mean	0.49	0.22	0.02	8.91	0.77	0.87	1.95	17.92
		SD	0.38	0.09	0.02	2.22	0.21	0.55	0.59	5.09
		min	0.05	0.10	0.00	5.50	0.49	0.31	1.27	12.94
		max	1.70	0.35	0.05	11.50	0.98	1.70	3.21	29.44
		count	16	16	7	8	8	8	8	8

C-5 Site-specific guideline values for MMP sites

Table C-9: Site-specific guideline values (GVs) used for comparison with water quality monitoring data. These GVs are used to calculate the annual condition version of the WQ Index for each water quality sampling location and were provided by the Reef Authority. GVs are derived from the Water Quality Guidelines for the Great Barrier Reef Marine Park (Great Barrier Reef Marine Park Authority, 2010, see Table B-1). Basin-level water quality objectives can be accessed online (Great Barrier Reef Marine Park Authority, Water quality guidelines for the Great Barrier Reef). Seasonal guideline values (i.e., wet vs. dry) are calculated as described in De'ath and Fabricius (2008). Guideline values for the Cape York region come from State of Queensland, (2020). See Appendix B for details on WQ Index calculation. DOF is direction of failure ('H' = high values fail, while 'L' = low values fail). Annual mean GVs are applied to annual mean values of monitoring data (and median GVs are applied to median data). Bold GVs are those applied to monitoring data.

Reef Authority group	Reef Authority sites	Measure	Water body	DOF	Annual Mean	Annual Median	Dry Median	Wet Median
30	ER01, AR01, PRN01, PRS01	Chl-*a* (μg L^{-1})	Enclosed Coastal waters	H				**0.70**
		NO_x (μg L^{-1})	Enclosed Coastal waters	H				**1.50**
		PN (μg L^{-1})	Enclosed Coastal waters					
		PO_4 (μg L^{-1})	Enclosed Coastal waters	H				**3.00**
		PP (μg L^{-1})	Enclosed Coastal waters					
		Secchi (m)	Enclosed Coastal waters	L				**3.00**
		TSS (mg L^{-1})	Enclosed Coastal waters	H				**4.00**
		Turbidity (NTU)	Enclosed Coastal waters	H		**10.00**		
40	KR01, KR02, BR01, NR01, NR02	Chl-*a* (μg L^{-1})	Enclosed Coastal waters	H				**0.70**
		NO_x (μg L^{-1})	Enclosed Coastal waters	H				**1.00**
		PN (μg L^{-1})	Enclosed Coastal waters					
		PO_4 (μg L^{-1})	Enclosed Coastal waters	H				**2.00**
		PP (μg L^{-1})	Enclosed Coastal waters					
		Secchi (m)	Enclosed Coastal waters	L				**1.50**
		TSS (mg L^{-1})	Enclosed Coastal waters	H				**6.00**
		Turbidity (NTU)	Enclosed Coastal waters	H		**11.00**		
50	ER02b, ER03, AR02b, AR03b, CI01, NR03, NR04, SR03, SR04, PRN02, PRN03, PRS02, PRS03, PRS2.5	Chl-*a* (μg L^{-1})	Open Coastal waters	H		0.36	**0.25**	**0.46**
		NO_x (μg L^{-1})	Open Coastal waters	H		0.35	**0.32**	**0.45**
		PN (μg L^{-1})	Open Coastal waters	H		18.00		**20.00**
		PO_4 (μg L^{-1})	Open Coastal waters	H		1.40	**1.86**	**0.93**
		PP (μg L^{-1})	Open Coastal waters	H		2.60		**3.00**
		Secchi (m)	Open Coastal waters	L	**10.00**			
		TSS (mg L^{-1})	Open Coastal waters	H		1.90		**1.70**
		Turbidity (NTU)	Open Coastal waters	H			**0.90**	**0.80**
60	AE04, ER05, NR05, SR05, SR06, PRN04, PRN05, PRN06, PRBB, PRS05	Chl-*a* (μg L^{-1})	Mid-shelf waters	H		**0.27**		
		NO_x (μg L^{-1})	Mid-shelf waters	H		**0.35**		
		PN (μg L^{-1})	Mid-shelf waters	H		**18.00**		

Reef Authority group	Reef Authority sites	Measure	Water body	DOF	Annual Mean	Annual Median	Dry Median	Wet Median
		PO_4 (µg L^{-1})	Mid-shelf waters	H		0.62		
		PP (µg L^{-1})	Mid-shelf waters	H		2.00		
		Secchi (m)	Mid-shelf waters	L	10.00			
		TSS (mg L^{-1})	Mid-shelf waters	H		1.50		
		Turbidity (NTU)	Mid-shelf waters	H		0.50		
70	NR06, ER06	Chl-*a* (µg L^{-1})	Offshore waters	H		0.26		
		NO_x (µg L^{-1})	Offshore waters	H		0.42		
		PN (µg L^{-1})	Offshore waters	H		16.00		
		PO_4 (µg L^{-1})	Offshore waters	H		0.39		
		PP (µg L^{-1})	Offshore waters	H		1.90		
		Secchi (m)	Offshore waters	L	17.00			
		TSS (mg L^{-1})	Offshore waters	H		0.50		
		Turbidity (NTU)	Offshore waters	H		0.50		
1	C1, C6, C8, RM1, RM4, RM8, TUL1	Chl-*a* (µg L^{-1})	Open Coastal waters	H	0.45		0.32	0.63
		NO_x (µg L^{-1})	Open Coastal waters	H		0.35		
		PN (µg L^{-1})	Open Coastal waters	H	20.00		16.00	25.00
		PO_4 (µg L^{-1})	Open Coastal waters	H		2.00		
		PP (µg L^{-1})	Open Coastal waters	H	2.80		2.30	3.30
		Secchi (m)	Open Coastal waters	L	10.00			
		TSS (mg L^{-1})	Open Coastal waters	H	2.00		1.60	2.40
		Turbidity (NTU)	Open Coastal waters	H		1.00		
2	RM9, RM10, TUL3, TUL4, TUL5, TUL6, TUL8, TUL9	Chl-*a* (µg L^{-1})	Open Coastal waters	H	0.45		0.32	0.63
		NO_x (µg L^{-1})	Open Coastal waters	H		0.35		
		PN (µg L^{-1})	Open Coastal waters	H	20.00		16.00	25.00
		PO_4 (µg L^{-1})	Open Coastal waters	H		2.00		
		PP (µg L^{-1})	Open Coastal waters	H	2.80		2.30	3.30
		Secchi (m)	Open Coastal waters	L	10.00			
		TSS (mg L^{-1})	Open Coastal waters	H	2.00		1.60	2.40
		Turbidity (NTU)	Open Coastal waters	H		1.00		
3	C4, C5, C11, RM2, RM3, RM5, RM6, RM7, TUL2	Chl-*a* (µg L^{-1})	Mid-shelf waters	H		0.30	0.32	0.63
		NO_x (µg L^{-1})	Mid-shelf waters	H		0.31		
		PN (µg L^{-1})	Mid-shelf waters	H		14.00	16.00	25.00
		PO_4 (µg L^{-1})	Mid-shelf waters	H		2.00		
		PP (µg L^{-1})	Mid-shelf waters	H		2.00	2.30	3.30

Reef Authority group	Reef Authority sites	Measure	Water body	DOF	Annual Mean	Annual Median	Dry Median	Wet Median
		Secchi (m)	Mid-shelf waters	L		**13.00**		
		TSS (mg L⁻¹)	Mid-shelf waters	H		1.20	**1.60**	**2.40**
		Turbidity (NTU)	Mid-shelf waters	H		**0.60**		
4	RM12, TUL11	Chl-*a* (µg L⁻¹)	Mid-estuarine waters	H		**2.00**		
		NO_x (µg L⁻¹)	Mid-estuarine waters	H		**15.00**		
		PN (µg L⁻¹)	Mid-estuarine waters					
		PO_4 (µg L⁻¹)	Mid-estuarine waters	H		**3.00**		
		PP (µg L⁻¹)	Mid-estuarine waters					
		Secchi (m)	Mid-estuarine waters	L		**1.50**		
		TSS (mg L⁻¹)	Mid-estuarine waters	H		**7.00**		
		Turbidity (NTU)	Mid-estuarine waters	H		**5.00**		
5	TUL7, TUL10	Chl-*a* (µg L⁻¹)	Lower estuarine waters	H		**1.10**		
		NO_x (µg L⁻¹)	Lower estuarine waters	H		**3.00**		
		PN (µg L⁻¹)	Lower estuarine waters					
		PO_4 (µg L⁻¹)	Lower estuarine waters	H		**3.00**		
		PP (µg L⁻¹)	Lower estuarine waters					
		Secchi (m)	Lower estuarine waters	L		**1.60**		
		TSS (mg L⁻¹)	Lower estuarine waters	H		**5.00**		
		Turbidity (NTU)	Lower estuarine waters	H		**4.00**		
6	BUR1, BUR2	Chl-*a* (µg L⁻¹)	Open Coastal waters	H		0.35	**0.32**	**0.63**
		NO_x (µg L⁻¹)	Open Coastal waters	H		**0.28**		
		PN (µg L⁻¹)	Open Coastal waters	H		12.00	**16.00**	**25.00**
		PO_4 (µg L⁻¹)	Open Coastal waters	H		**1.00**		
		PP (µg L⁻¹)	Open Coastal waters	H		2.20	**2.30**	**3.30**
		Secchi (m)	Open Coastal waters	L	**10.00**			
		TSS (mg L⁻¹)	Open Coastal waters	H		1.20	**1.60**	**2.40**
		Turbidity (NTU)	Open Coastal waters	H		**0.80**		
7	BUR3	Chl-*a* (µg L⁻¹)	Open Coastal waters	H	0.45		**0.32**	**0.63**
		NO_x (µg L⁻¹)	Open Coastal waters	H		**0.28**		
		PN (µg L⁻¹)	Open Coastal waters	H	20.00		**16.00**	**25.00**
		PO_4 (µg L⁻¹)	Open Coastal waters	H		**1.00**		
		PP (µg L⁻¹)	Open Coastal waters	H	2.80		**2.30**	**3.30**
		Secchi (m)	Open Coastal waters	L	**10.00**			
		TSS (mg L⁻¹)	Open Coastal waters	H	2.00		**1.60**	**2.40**

Reef Authority group	Reef Authority sites	Measure	Water body	DOF	Annual Mean	Annual Median	Dry Median	Wet Median
		Turbidity (NTU)	Open Coastal waters	H		**0.80**		
8	BUR4	Chl-*a* (µg L⁻¹)	Open Coastal waters	H		0.59	**0.32**	**0.63**
		NO_x (µg L⁻¹)	Open Coastal waters	H		**0.28**		
		PN (µg L⁻¹)	Open Coastal waters	H		17.00	**16.00**	**25.00**
		PO_4 (µg L⁻¹)	Open Coastal waters	H		**1.00**		
		PP (µg L⁻¹)	Open Coastal waters	H	2.80		**2.30**	**3.30**
		Secchi (m)	Open Coastal waters	L		**4.00**		
		TSS (mg L⁻¹)	Open Coastal waters	H		1.90	**1.60**	**2.40**
		Turbidity (NTU)	Open Coastal waters	H		**1.30**		
9	BUR5	Chl-*a* (µg L⁻¹)	Open Coastal waters	H		0.60	**0.32**	**0.63**
		NO_x (µg L⁻¹)	Open Coastal waters	H		**0.50**		
		PN (µg L⁻¹)	Open Coastal waters	H	20.00		**16.00**	**25.00**
		PO_4 (µg L⁻¹)	Open Coastal waters	H		**2.00**		
		PP (µg L⁻¹)	Open Coastal waters	H	2.80		**2.30**	**3.30**
		Secchi (m)	Open Coastal waters	L		**3.00**		
		TSS (mg L⁻¹)	Open Coastal waters	H		5.00	**1.60**	**2.40**
		Turbidity (NTU)	Open Coastal waters	H		**3.00**		
10	BUR6, BUR7	Chl-*a* (µg L⁻¹)	Open Coastal waters	H	0.45		**0.32**	**0.63**
		NO_x (µg L⁻¹)	Open Coastal waters	H		**1.00**		
		PN (µg L⁻¹)	Open Coastal waters	H		13.00	**16.00**	**25.00**
		PO_4 (µg L⁻¹)	Open Coastal waters	H		**2.00**		
		PP (µg L⁻¹)	Open Coastal waters	H		2.10	**2.30**	**3.30**
		Secchi (m)	Open Coastal waters	L	**10.00**			
		TSS (mg L⁻¹)	Open Coastal waters	H		1.20	**1.60**	**2.40**
		Turbidity (NTU)	Open Coastal waters	H	**2.00**			
11	BUR8, BUR9	Chl-*a* (µg L⁻¹)	Enclosed Coastal waters	H		**1.00**		
		NO_x (µg L⁻¹)	Enclosed Coastal waters	H		**4.00**		
		PN (µg L⁻¹)	Enclosed Coastal waters					
		PO_4 (µg L⁻¹)	Enclosed Coastal waters	H		**1.00**		
		PP (µg L⁻¹)	Enclosed Coastal waters					
		Secchi (m)	Enclosed Coastal waters	L		**1.50**		
		TSS (mg L⁻¹)	Enclosed Coastal waters	H		**2.00**		
		Turbidity (NTU)	Enclosed Coastal waters	H		**4.00**		
12	BUR10	Chl-*a* (µg L⁻¹)	Mid-shelf waters	H		0.33	**0.32**	**0.63**

Reef Authority group	Reef Authority sites	Measure	Water body	DOF	Annual Mean	Annual Median	Dry Median	Wet Median
		NO_x (µg L^{-1})	Mid-shelf waters	H		**0.28**		
		PN (µg L^{-1})	Mid-shelf waters	H		14.00	**16.00**	**25.00**
		PO_4 (µg L^{-1})	Mid-shelf waters	H		**1.00**		
		PP (µg L^{-1})	Mid-shelf waters	H		2.00	**2.30**	**3.30**
		Secchi (m)	Mid-shelf waters	L	**10.00**			
		TSS (mg L^{-1})	Mid-shelf waters	H		0.80	**1.60**	**2.40**
		Turbidity (NTU)	Mid-shelf waters	H		**0.50**		
13	BUR11, BUR12	Chl-*a* (µg L^{-1})	Open Coastal waters	H	0.45		**0.32**	**0.63**
		NO_x (µg L^{-1})	Open Coastal waters	H		**1.00**		
		PN (µg L^{-1})	Open Coastal waters	H	20.00		**16.00**	**25.00**
		PO_4 (µg L^{-1})	Open Coastal waters	H		**2.00**		
		PP (µg L^{-1})	Open Coastal waters	H	2.80		**2.30**	**3.30**
		Secchi (m)	Open Coastal waters	L	**10.00**			
		TSS (mg L^{-1})	Open Coastal waters	H	2.00		**1.60**	**2.40**
		Turbidity (NTU)	Open Coastal waters	H		**2.00**		
14	BUR13, BUR14, BUR15	Chl-*a* (µg L^{-1})	Enclosed Coastal waters	H		**1.00**		
		NO_x (µg L^{-1})	Enclosed Coastal waters	H		**4.00**		
		PN (µg L^{-1})	Enclosed Coastal waters					
		PO_4 (µg L^{-1})	Enclosed Coastal waters	H		**1.00**		
		PP (µg L^{-1})	Enclosed Coastal waters					
		Secchi (m)	Enclosed Coastal waters	L		**1.50**		
		TSS (mg L^{-1})	Enclosed Coastal waters	H		**2.00**		
		Turbidity (NTU)	Enclosed Coastal waters	H		**4.00**		
15	WHI1, WHI2, WHI3, WHI4, WHI5	Chl-*a* (µg L^{-1})	Open Coastal waters	H		0.36	**0.32**	**0.63**
		NO_x (µg L^{-1})	Open Coastal waters	H		**1.00**		
		PN (µg L^{-1})	Open Coastal waters	H	14.00		**16.00**	**25.00**
		PO_4 (µg L^{-1})	Open Coastal waters	H		**1.00**		
		PP (µg L^{-1})	Open Coastal waters	H		2.30	**2.30**	**3.30**
		Secchi (m)	Open Coastal waters	L	**10.00**			
		TSS (mg L^{-1})	Open Coastal waters	H		1.40	**1.60**	**2.40**
		Turbidity (NTU)	Open Coastal waters	H		**1.10**		
16	WHI6	Chl-*a* (µg L^{-1})	Enclosed Coastal waters	H		**1.30**		
		NO_x (µg L^{-1})	Enclosed Coastal waters	H		**4.00**		
		PN (µg L^{-1})	Enclosed Coastal waters					

Reef Authority group	Reef Authority sites	Measure	Water body	DOF	Annual Mean	Annual Median	Dry Median	Wet Median
		PO_4 (µg L^{-1})	Enclosed Coastal waters	H		**3.00**		
		PP (µg L^{-1})	Enclosed Coastal waters					
		Secchi (m)	Enclosed Coastal waters	L		**1.60**		
		TSS (mg L^{-1})	Enclosed Coastal waters	H		**5.00**		
		Turbidity (NTU)	Enclosed Coastal waters	H		**4.00**		
17	WHI7, WHI10	Chl-*a* (µg L^{-1})	Open Coastal waters	H	0.45		**0.32**	**0.63**
		NO_x (µg L^{-1})	Open Coastal waters	H		**0.25**		
		PN (µg L^{-1})	Open Coastal waters	H		18.00	**16.00**	**25.00**
		PO_4 (µg L^{-1})	Open Coastal waters	H		**2.00**		
		PP (µg L^{-1})	Open Coastal waters	H		2.10	**2.30**	**3.30**
		Secchi (m)	Open Coastal waters	L	**10.00**			
		TSS (mg L^{-1})	Open Coastal waters	H		1.60	**1.60**	**2.40**
		Turbidity (NTU)	Open Coastal waters	H	**2.00**			
18	WHI8, WHI11	Chl-*a* (µg L^{-1})	Open Coastal waters	H	0.45		**0.32**	**0.63**
		NO_x (µg L^{-1})	Open Coastal waters	H		**1.00**		
		PN (µg L^{-1})	Open Coastal waters	H	20.00		**16.00**	**25.00**
		PO_4 (µg L^{-1})	Open Coastal waters	H		**2.00**		
		PP (µg L^{-1})	Open Coastal waters	H	2.80		**2.30**	**3.30**
		Secchi (m)	Open Coastal waters	L	**10.00**			
		TSS (mg L^{-1})	Open Coastal waters	H	2.00		**1.60**	**2.40**
		Turbidity (NTU)	Open Coastal waters	H	**2.00**			
19	WHI9	Chl-*a* (µg L^{-1})	Open Coastal waters	H	0.45		**0.32**	**0.63**
		NO_x (µg L^{-1})	Open Coastal waters	H		**0.25**		
		PN (µg L^{-1})	Open Coastal waters	H		18.00	**16.00**	**25.00**
		PO_4 (µg L^{-1})	Open Coastal waters	H		**2.00**		
		PP (µg L^{-1})	Open Coastal waters	H		2.10	**2.30**	**3.30**
		Secchi (m)	Open Coastal waters	L	**10.00**			
		TSS (mg L^{-1})	Open Coastal waters	H		1.60	**1.60**	**2.40**
		Turbidity (NTU)	Open Coastal waters	H	**1.00**			
20	WHI10.1, WHI10.2	Chl-*a* (µg L^{-1})	Open Coastal waters	H	0.45		**0.32**	**0.63**
		NO_x (µg L^{-1})	Open Coastal waters	H		**1.00**		
		PN (µg L^{-1})	Open Coastal waters	H	20.00		**16.00**	**25.00**
		PO_4 (µg L^{-1})	Open Coastal waters	H		**2.00**		
		PP (µg L^{-1})	Open Coastal waters	H	2.80		**2.30**	**3.30**

Reef Authority group	Reef Authority sites	Measure	Water body	DOF	Annual Mean	Annual Median	Dry Median	Wet Median
		Secchi (m)	Open Coastal waters	L	**10.00**			
		TSS (mg L^{-1})	Open Coastal waters	H	2.00		**1.60**	**2.40**
		Turbidity (NTU)	Open Coastal waters	H			**2.00**	**12.00**
	FTZ1	Chl-*a* (µg L^{-1})	Mid-shelf waters	H		0.27	**0.32**	**0.63**
		NO_x (µg L^{-1})	Mid-shelf waters	H		**0.50**		
		PN (µg L^{-1})	Mid-shelf waters	H		12.00	**16.00**	**25.00**
		PO_4 (µg L^{-1})	Mid-shelf waters	H		**2.00**		
		PP (µg L^{-1})	Mid-shelf waters	H		1.90	**2.40**	**3.40**
		Secchi (m)	Mid-shelf waters	L		**12.00**		
		TSS (mg L^{-1})	Mid-shelf waters	H		0.40	**1.70**	**2.50**
		Turbidity (NTU)	Mid-shelf waters	H		**0.30**		
	FTZ2,FTZ3	Chl-*a* (µg L^{-1})	Open Coastal waters	H	0.45		**0.32**	**0.63**
		NO_x (µg L^{-1})	Open Coastal waters	H		**0.50**		
		PN (µg L^{-1})	Open Coastal waters	H	20.00		**16.00**	**25.00**
		PO_4 (µg L^{-1})	Open Coastal waters	H	**2.00**			
		PP (µg L^{-1})	Open Coastal waters	H	2.80		**2.40**	**3.40**
		Secchi (m)	Open Coastal waters	L	**10.00**			
		TSS (mg L^{-1})	Open Coastal waters	H	2.00		**1.70**	**2.50**
		Turbidity (NTU)	Open Coastal waters	H	**1.50**			
	FTZ4	Chl-*a* (µg L^{-1})	Open Coastal waters	H	0.45		**0.32**	**0.63**
		NO_x (µg L^{-1})	Open Coastal waters	H		**0.50**		
		PN (µg L^{-1})	Open Coastal waters	H		15.00	**16.00**	**25.00**
		PO_4 (µg L^{-1})	Open Coastal waters	H		**2.00**		
		PP (µg L^{-1})	Open Coastal waters	H		2.50	**2.30**	**3.30**
		Secchi (m)	Open Coastal waters	L		**10.00**		
		TSS (mg L^{-1})	Open Coastal waters	H		1.00	**1.60**	**2.40**
		Turbidity (NTU)	Open Coastal waters	H		**0.50**		
	FTZ5	Chl-*a* (µg L^{-1})	Open Coastal waters	H	0.45		**0.32**	**0.63**
		NO_x (µg L^{-1})	Open Coastal waters	H		**0.50**		
		PN (µg L^{-1})	Open Coastal waters	H	20.00		**16.00**	**25.00**
		PO_4 (µg L^{-1})	Open Coastal waters	H		**2.00**		
		PP (µg L^{-1})	Open Coastal waters	H	2.80		**2.40**	**3.40**
		Secchi (m)	Open Coastal waters	L	**10.00**			
		TSS (mg L^{-1})	Open Coastal waters	H	2.00		**1.70**	**2.50**
		Turbidity (NTU)	Open Coastal waters	H	**1.50**			

Reef Authority group	Reef Authority sites	Measure	Water body	DOF	Annual Mean	Annual Median	Dry Median	Wet Median
	FTZ6	Chl-*a* (µg L^{-1})	Enclosed Coastal waters	H		1.00		
		NO_x (µg L^{-1})	Enclosed Coastal waters	H		3.00		
		PN (µg L^{-1})	Enclosed Coastal waters	H				
		PO_4 (µg L^{-1})	Enclosed Coastal waters	H		3.00		
		PP (µg L^{-1})	Enclosed Coastal waters	H				
		Secchi (m)	Enclosed Coastal waters	L				
		TSS (mg L^{-1})	Enclosed Coastal waters	H				
		Turbidity (NTU)	Enclosed Coastal waters	H			7.00	15.00

C-6 Regional exposure assessments for waterbodies

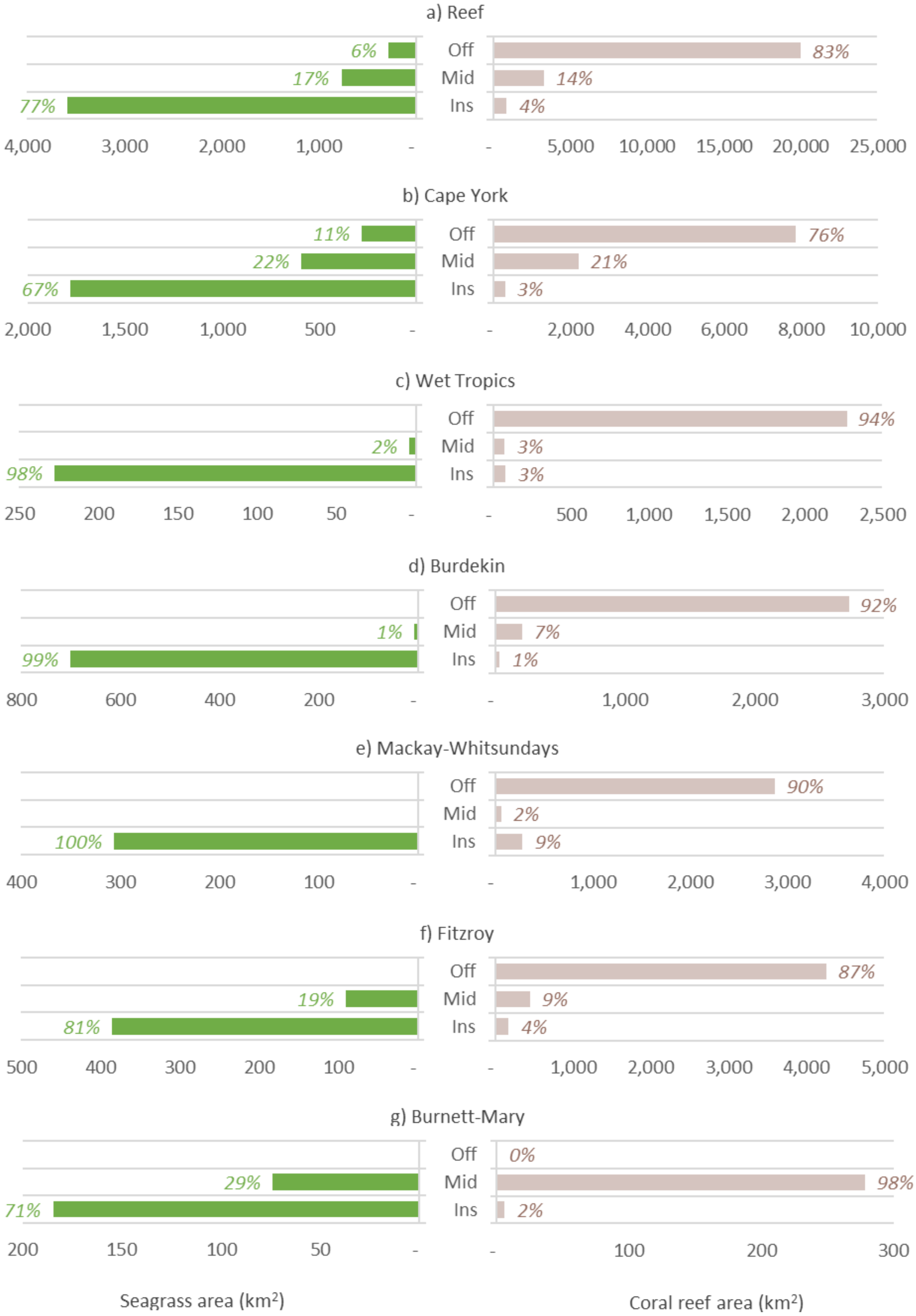


Figure C-3: Areas (in km^2 and represented as horizontal bars) of seagrass (left) and coral reefs (right) in the a) Reef and regional waterbodies; b) Cape York, c) Wet Tropics, d) Burdekin, e) Mackay-Whitsunday, f) Fitzroy, g) Burnett-Mary. Percentages of total Reef habitats or total regional habitats are indicated in italics.

Table C-10: Areas (km^2) (and percentages, %) of the Reef lagoon (total 348,839 km^2) and division by water bodies (WB) (enclosed coastal, EC; open coastal, OC; mid-shelf, Mid; and offshore, Off) affected by the Reef WT1–2 combined, and the 3 Reef water types individually during the current wet season and for a range of reference periods.

Water type	**Water body**	**Area of Reef affected in km² and %**									
		2023–24 wet season		**Long-term average**		**Average of coral recovery period (2012–2017)**		**Typical wet-year composite**		**Typical dry-year composite**	
		km²	% (%WB)	km²	% (%WB)	km²	% (%WB)	km²	% (%WB)	km²	% (%WB)
WT1+2	Reef	**68,303**	**20%**	**63,296**	**18%**	**58,870**	**17%**	**88,326**	**25%**	**42,047**	**12%**
	EC	6,364	2%	6,366	2%	7,826	2%	6,367	2%	6,366	2%
			(77%)		*(77%)*		*(95%)*		*(77%*		*(77%*
	OC	30,672	9%	33,955	10%	32,085	9%	34,765	10%	28,672	8%
			(93%)		*>99%*		*(97%)*		*>99%*		*(87%*
	Mid	21,426	6%	19,234	6%	16,296	5%	35,707	10%	6,566	2%
			(26%)		*(23%)*		*(20%)*		*(44%*		*(8%*
	Off	9,841	3%	3,741	1%	2,664	1%	11,488	3%	443	0%
			(4%)		*(2%)*		*(1%)*		*(5%*		*(0%*
WT1	Reef	**13,974**	**4%**	**10,791**	**3%**	**10,140**	**3%**	**19,856**	**6%**	**7,363**	**2%**
	EC	6,144	2%	6,018	2%	6,147	2%	6,199	2%	5,398	2%
			(75%)		*(73%)*		*(75%)*		*(75%*		*(65%*
	OC	7,241	2%	4,773	1%	3,989	1%	11,402	3%	1,965	1%
			(22%)		*(14%)*		*(12%)*		*(35%*		*(6%*
	Mid	574	0%	0	0%	4	0%	2,254	1%	0	0%
			(1%)		*(0%)*		*(0%)*		*(3%*		*(0%*
	Off	16	0%	0	0%	0	0%	0	0%	0	0%
			(0%)		*(0%)*		*(0%)*		*(0%*		*(0%*
WT2	Reef	**65,966**	**19%**	**59,410**	**17%**	**55,074**	**16%**	**82,931**	**24%**	**39,382**	**11%**
	EC	5,032	1%	5,118	1%	6,431	2%	5,490	2%	4,649	1%
			(61%)		*(62%)*		*(78%)*		*(67%*		*(56%*
	OC	30,637	9%	33,768	10%	31,894	9%	34,759	10%	28,461	8%
			(93%)		*>99%*		*(97%)*		*>99%*		*(86%*
	Mid	20,550	6%	17,031	5%	14,387	4%	32,193	9%	5,840	2%
			(25%)		*(21%)*		*(18%)*		*(39%)*		*(7%*
	Off	9,748	3%	3,493	1%	2,363	1%	10,489	3%	433	0%
			(4%)		*(2%)*		*(1%)*		*(5%)*		*(0%*
WT3	Reef	**213,491**	**61%**	**184,626**	**53%**	**165,582**	**47%**	**203,859**	**58%**	**135,874**	**39%**
	EC	253	0%	36	0%	91	0%	168	0%	31	0%
			(3%)		*(0%)*		*(1%)*		*(2%)*		*(0%*
	OC	28,114	8%	26,764	8%	25,620	7%	27,940	8%	25,874	7%
			(85%)		*(81%)*		*(78%)*		*(85%)*		*(78%*
	Mid	79,112	23%	75,136	22%	71,728	21%	79,609	23%	53,525	15%
			(96%)		*(92%)*		*(87%)*		*(97%)*		*(65%*
	Off	106,013	30%	82,691	24%	68,143	20%	96,142	28%	56,443	16%
			(48%)		*(37%)*		*(31%)*		*(43%)*		*(25%*

C-7 Pesticide monitoring results

Passive flow monitors

Results from the passive flow monitors (PFMs) used to estimate the in-situ flow velocities to which ED passive samplers were exposed ranged from 22.0 cm s^{-1} at Low Isles (for ED samplers deployed between March and April 2025) to 42.2 cm s^{-1} at Haughton River Mouth (for ED samplers deployed during January 2025) (Table A-2, Figure C-4). Average PFM-derived flow velocities across all sites was 29.5 ± 5.3 cm s^{-1} [Coefficient of variation (CV) = 18%] indicating relatively consistent water velocities observed across the deployment sites. Where PFMs were lost or empty, flow rates were estimated using the 100% gypsum loss rate (Table A-2). While PFMs are not an indication of total flow velocities within the aquatic system, they provide an estimate of the turbulence to which a passive sampler is exposed and allow for the empirical correction of chemical uptake rates for more accurate water concentration estimates from ED passive samplers.

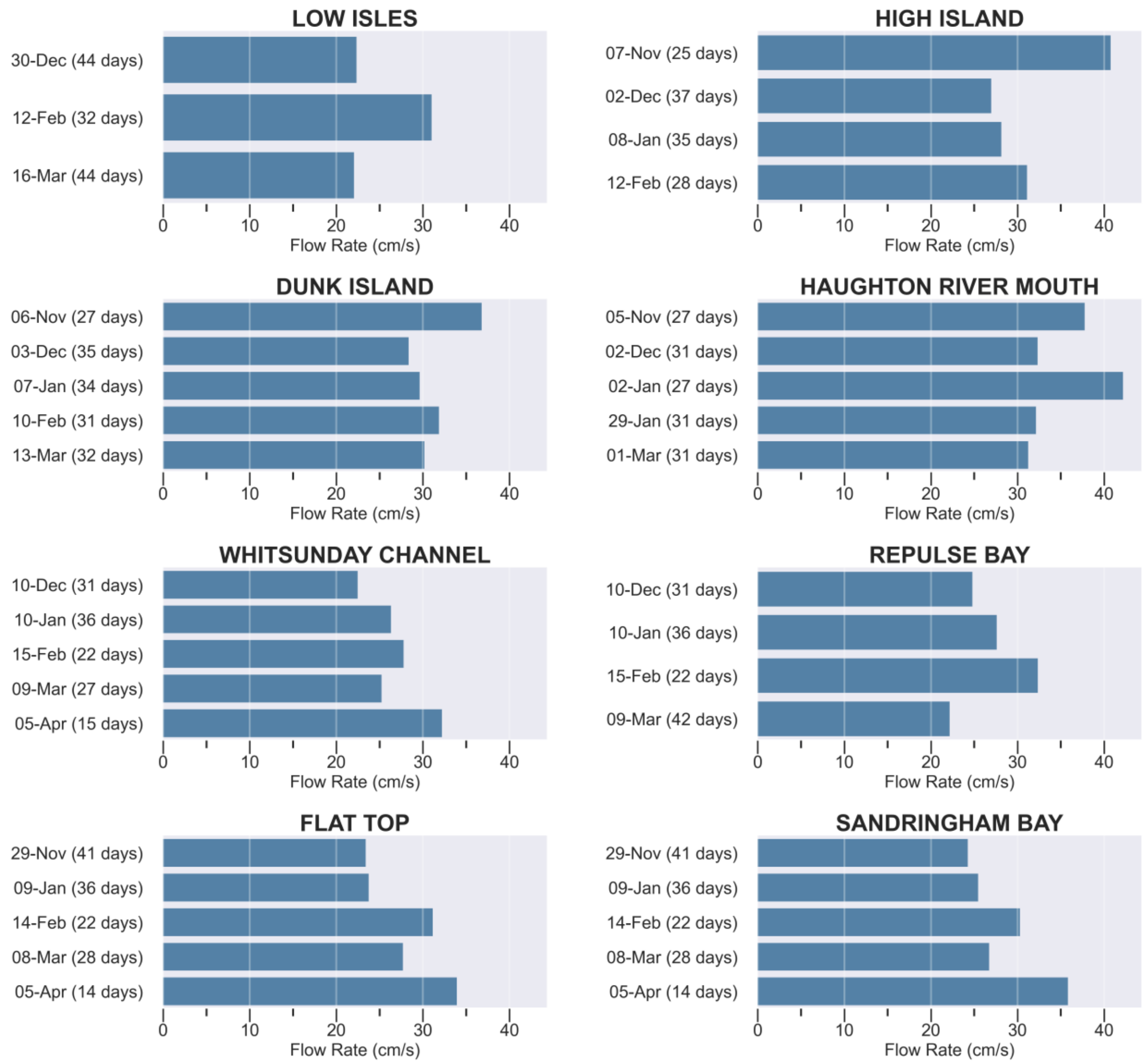


Figure C-4: Passive flow monitor (PFM) based water flow velocity estimations (cm s^{-1}) at the deployment sites. A minimum flow velocity of 3.4 cm s^{-1} is used to assess flow velocity using Passive Flow Monitors (PFMs).

Pesticide Risk Metric – Event grab samples

Table C-11: Pesticide Risk Metric (PRM) results (in %) for all event grab samples. Note some very low PRM results are presented in scientific notation.

Site Name	Station Name	Latitude	Date sampled	PSII Herbicide PRM	Other Herbicide PRM	Insecticide PRM
Green Island C11	WQR134	-16.77215	13/02/25	0.0452	0.4656	4.18E-11
Fitzroy Island coral site RM1	WQR131	-16.920283	13/02/25	0.0512	0.4718	1.23E-10
High Island Routine RM8 PEST	JCD437	-17.15843	25/02/25	0.0029	0.3992	0
High Island RM8	WQR128	-17.163328	13/02/25	0.0596	0.4445	6.33E-12
Russell Mulgrave river mouth mooring routine RM10	WQR124	-17.202233	25/02/25	0.1041	0.5083	1.11E-14
Russell-Mulgrave River mooring RM10	JCD439	-17.2027	12/02/25	0.0339	0.4077	7.95E-12
Russell Island Franklands RM7	WQR126	-17.227333	12/02/25	0.0050	0.2518	0
King Reef TUL1	JCF485	-17.785033	11/02/25	0.0937	1.0017	3.88E-08
East Clump Point TUL2	WQR117	-17.8904	11/02/25	0.0405	1.0779	4.70E-10
Dunk Island TUL3	WQR121	-17.9248	10/02/25	0.1407	1.0180	3.44E-07
South Mission Beach TUL4	JCF484	-17.93165	10/02/25	0.1384	0.9734	9.60E-08
Dunk Island routine TUL6Pest	JCD442	-17.94017	24/02/25	0.0814	0.5634	2.09E-11
Dunk Island South East TUL5	WQR118	-17.96	10/02/25	0.3045	1.1167	2.61E-05
Between Tam Oshanter and Timana TUL6	WQR120	-17.9753833	10/02/25	0.0739	0.9413	2.10E-08
Hull River mouth TUL7	JCF483	-17.997617	10/02/25	0.3601	1.1068	1.16E-05
Bedarra Island TUL8	WQR119	-18.014167	9/02/25	0.1991	1.0079	1.49E-06
TULLY RIVER MOUTH MOORING routine TUL10	JCD443	-18.0225	24/02/25	0.0280	0.5670	4.44E-14
Tully River Mouth mooring TUL10	WQR115	-18.023667	10/02/25	0.4378	1.1448	8.36E-05
Herbert 3	JCF482	-18.123017	9/02/25	0.0821	0.9698	2.41E-08
Herbert 2 - Britomart	JCF481	-18.2345	9/02/25	0.0017	0.2428	0
Herbert 1	JCF480	-18.431517	9/02/25	0.0058	0.3576	0
HALIFAX1 HAL1	JCF405	-18.4918	6/02/25	0.2751	1.5327	0.00253
HALIFAX2B HAL2B	JCF406	-18.5145	6/02/25	0.3336	1.4917	0.00891
HALIFAX 2X HAL2X	JCF407	-18.5367	6/02/25	0.4739	1.4944	0.00673
PELORUS BUR1	JCF417	-18.5413	13/02/25	0.1221	1.3761	7.08E-07
Pelorus / Orpheus Island BUR1	WQR112	-18.541633	9/02/25	0.0167	0.4105	1.55E-13
Pelorus BUR1	JCF400	-18.5428	6/02/25	0.3669	1.0609	0.00556
HALIFAX BAY HAL2	JCF408	-18.5447	6/02/25	0.3215	1.5394	0.00176
HALIFAX3 HAL3	JCF404	-18.6296	6/02/25	0.6187	1.5393	0.00176
HALIFAX 3 HAL3	JCF421	-18.63	13/02/25	0.0069	0.5832	0
Taylors Beach TAYB	JCF409	-18.6461	6/02/25	0.3651	1.0390	0.00292
HALIFAX HAL 4	JCF403	-18.6642	6/02/25	1.4823	1.5218	0.00144
HALIFAX BAY HAL5	JCF410	-18.7601	6/02/25	3.6156	1.6863	0.15843
PANDORA BUR2	JCF401	-18.8167	6/02/25	5.3683	1.8016	0.80354
PANDORA BUR2	JCF416	-18.8177	13/02/25	0.0015	0.3964	0
Pandora Reef BUR2	WQR110	-18.8182	8/02/25	0.1141	1.0446	1.75E-07

Site Name	Station Name	Latitude	Date sampled	PSII Herbicide PRM	Other Herbicide PRM	Insecticide PRM
HALIFAX HAVANA HAV	JCF420	-18.8547	13/02/25	0.0019	0.4194	0
HAVANA HAV	JCF402	-18.8547	6/02/25	2.1038	1.7267	0.03983
Halifax Bay 7 HAL7	JCF414	-18.87431	6/02/25	0.0076	1.0721	0
HALIFAX BAY 6 HAL6	JCF415	-18.9216	6/02/25	0.0318	1.0628	2.40E-12
Archeron BUR3	JCF419	-18.9922	13/02/25	0.0024	0.4592	0
GEOFFREY Bay BUR4	JCF413	-19.1573	13/02/25	0.0039	0.5537	0
Geoffrey Bay BUR4	WQR108	-19.157617	8/02/25	0.0097	0.6578	0
BURDEKIN EVENT_CAPE CLEVELAND BUR6	JCF422	-19.1898	14/02/25	0.0022	0.4377	0
Cleveland Bay BUR5	JCF418	-19.2327	13/02/25	0.0037	0.9445	2.22E-14
Haughton 2 BUR7	WQR107	-19.2825	7/02/25	0.0105	1.2283	0
BURDEKIN EVENT BUR7	JCF412	-19.2829	14/02/25	0.0053	0.6106	0
Yongala IMOS NRS BUR10	WQR106	-19.305817	7/02/25	0.0015	0.4181	0
BURDEKIN EVENT BUR8	JCF426	-19.3665	14/02/25	0.0097	1.1593	0
Burdekin event BUR8	JCF437	-19.3668	19/02/25	0.0067	0.5910	0
BURDEKIN EVENT	JCF425	-19.4107	14/02/25	0.0323	1.6648	1.24E-12
BURDEKIN EVENT BUR15	JCF425	-19.4107	15/02/25	0.0037	0.7335	0
BURDEKIN EVENT BUR12	JCF430	-19.5044	15/02/25	0.0126	1.5961	6.83E-08
BUR RIVER MOUTH MOORING BUR13	JCF411	-19.5876	15/02/25	0.0026	0.9668	0
Burdekin River mooring BUR13	WQR104	-19.587933	7/02/25	0.0056	0.4970	8.22E-13
Elliott River mouth/camp IAP-AMB3/4	nqbp	-19.84266	20/02/25	0.0007	0.2778	0
Euri Creek AP-AMB1	nqbp	-19.9047	20/02/25	0.0008	0.0022	0
Double Cone Island WHI1	WQR101	-20.1065	5/02/25	1.50E-08	0.0022	0
Pine Island WHI4	WQR099	-20.379783	5/02/25	0.0182	0.7888	0
Seaforth Island WHI5	WQR097	-20.4181	6/02/25	0.0083	0.2658	0
Repulse Islands dive mooring WHI7	WQR096	-20.576717	5/02/25	0.2419	1.4158	9.99E-05
O'Connell River WHI6	WQR094	-20.5782	5/02/25	0.4144	1.4985	5.66E-05
Slade Island MKY_AMB5	nqbp	-21.09257	20/02/25	0.0172	0.9154	0
Round Top Island MKY_AMB3B	nqbp	-21.17358	20/02/25	0.0218	0.9341	0

C-8 References

Cooper TF, Uthicke S, Humphrey C, Fabricius KE (2007). Gradients in water column nutrients, sediment parameters, irradiance and coral reef development in the Whitsunday Region, central Great Barrier Reef. Estuarine, Coastal and Shelf Science 74:458-470.

Cooper TF, Ridd PV, Ulstrup KE, Humphrey C, Slivkoff M, Fabricius KE (2008). Temporal dynamics in coral bioindicators for water quality on coastal coral reefs of the Great Barrier Reef. Marine and Freshwater Research 59:703-716.

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

Great Barrier Reef Marine Park Authority. Water quality guidelines for the Great Barrier Reef. Basin-level objectives for Wet Tropics, Townsville, and Mackay-Whitsundays regions. URL: http://www.gbrmpa.gov.au/our-work/threats-to-the-reef/declining-water-quality?a=1394. Accessed Jan 2019.

Great Barrier Reef Marine Park Authority (2010). Water Quality Guidelines for the Great Barrier Reef Marine Park. Revised Edition 2010. Great Barrier Reef Marine Park Authority, Townsville. 100pp.

State of Queensland (2020). Environmental Protection (Water and Wetland Biodiversity) Policy 2019: Environmental Values and Water Quality Objectives, Eastern Cape York Basins https://environment.des.qld.gov.au/management/water/policy/cape-york-eastern-basins.

APPENDIX D: SCIENTIFIC PUBLICATIONS AND PRESENTATIONS ASSOCIATED WITH THE PROGRAM, 2024–25

D-1 Publications

Reports and scientific publications

Gruber, R., Petus, C., Thompson, K., Thompson, A., McKenzie, L., Bove, U., Choukroun, S., Collier, C., Davidson, J., Elisei, G., Howley, C., James, C., Kaserzon, S., Lewis, S., Massuger, J., Mellors, J., Molinari, B., Moran, D., Mueller, J., O'Callaghan, M., Paxman, C., Tracey, D., Thompson, C., and Waterhouse, J. 2025. Great Barrier Reef Marine Monitoring Program Quality Assurance and Quality Control Manual 2023–24, Great Barrier Reef Marine Park Authority, Townsville, 175 pp.

Moran, D., Waterhouse, J., Petus, C., Howley, C., Lewis, S., Gruber, R., James, C., Logan, M., Bove, U., Brady, B., Choukroun, S., Connellan, K., Davidson, J., Mellors, J., O'Callaghan, M., O'Dea, C., Shellberg, J., Dick, E., Polglase, L., Tracey, D., Molinari, B., Zagorskis, I., 2025. Great Barrier Reef Marine Monitoring Program Inshore Water Quality Monitoring: Annual Report 2023–24. Great Barrier Reef Marine Park Authority, Townsville. 322 pp.

Thompson, K., Shiels, R., Beggs, C., Elisei, G., Paxman, C., Li, Y., Carswell, C., Xia, S., Prasad, P., Gallen, M., Reeks, T., Clokey, J., Marano, K., Kaserzon, S., 2025, Marine Monitoring Program Annual Report for Inshore Pesticide Monitoring: 2023–24. Report for the Great Barrier Reef Marine Park Authority, Great Barrier Reef Marine Park Authority, Townsville.

Data used for model validation and external investigations

During the 2024–25 year, MMP WQ data has been used by several external groups, including:

- Validation of the eReefs marine models for the Great Barrier Reef, led by Jenny Skerratt at CSIRO. An extensive list of resulting publications is available from: https://research.csiro.au/ereefs/models/further-reading/
- Incorporation of data into the IMOS Bio-Optical Database for validation of satellite imagery, led by Thomas Schroeder at CSIRO.
- Water quality data was provided to NRM technical officers at the Fitzroy Basin Association, the Mackay-Whitsunday-Isaac Healthy Rivers to Reef Partnership, the Dry Tropics Partnership for Healthy Waters, and the Wet Tropics Healthy Waterways Partnership to be used in preparation of the latest Regional Report Cards.
- Utilisation of the data in the review of the Great Barrier Reef Water Quality Targets led by C_2O Consulting and funded by the Australian and Queensland governments.
- Incorporation of the data in the update of the Great Barrier Reef Water Quality Spatial Management Priortisation (published report).
- Incorporation of MMP data into the underpinning synthesis reports and Regional Water Quality Strategy for the 6 NRM regions (to be released in 2026).

Related papers and reports – linking to MMP data or methods:

Dantra, A. (2024). Water quality influences spatial and temporal patterns in microbial communities at inshore sites of the Great Barrier Reef. Masters thesis, James Cook University.

Howley, C., Scobell, L., Albert-Mitchell, O., Shellberg, J., Rosendale, B., 2024. Cyclone Jasper Environmental Impact Technical Investigation and Community Engagement Report for the Cape York Peninsula Region: Annan & Bloomfield Catchments Focus. Report produced by

Cape York Water Partnership for the Queensland Government Department of Environment, Tourism, Science and Innovation.

Lønborg, C., Fuentes-Santos, I., Carreira, C., Amaral, V., Arístegui, J., Bhadury, P., et al. (2025). Dissolved organic carbon in coastal waters: Global patterns, stocks and environmental physical controls. Global Biogeochemical Cycles, 39, e2024GB008407. https://doi.org/10.1029/2024GB008407

Lønborg, C., Carreira, C., Abril, G., Agustí, S., Amaral, V., Andersson, A., . . . Álvarez-Salgado, X. A. (2024). A global database of dissolved organic matter (DOM) concentration measurements in coastal waters (CoastDOM v1). Earth Syst. Sci. Data, 16(2), 1107-1119. doi:10.5194/essd-16-1107-2024.

Puignou Lopez, O. Lewis, S.E. James, C.S. Davis, A.M. Mackay, S.J. 2025. Hydrology of the Great Barrier Reef catchment area along a latitudinal gradient: Implications for estimating discharge. Journal of Hydrology: Regional Studies 61, 102603.

Shellberg, J., Howley, C., Carlin, G., Saunders, A., Sycamore, W., Gibson, B., Dick, E., Morris, R., 2025. Empirical Fine Sediment Loads Exported to the Great Barrier Reef Lagoon from the Annan and Endeavour River: 2015-2024. Cape York Water Partnership, Cooktown.

Terzin, M., Robbins, S.J., Bell, S.C. et al. Gene content of seawater microbes is a strong predictor of water chemistry across the Great Barrier Reef. Microbiome 13, 11 (2025). https://doi.org/10.1186/s40168-024-01972-0

Waterhouse J, Star M, Molinari B, Sambrook K, VanderGragt M, Leigh C, Sutcliffe T, Smith R, Choukroun S, Tracey D, Lewis S (2025) Decision support framework for management options to maintain and improve water quality in the Great Barrier Reef catchment area. Analysis of key spatial factors impacting water quality and the condition of wetlands, corals and seagrass in the Great Barrier Reef. Commonwealth of Australia and Queensland Government.

D-2 Presentations

Davidson J, Moran D. MMP updates provided at quarterly meeting between AIMS and Manbarra Elders Council. Meeting held at AIMS, 4 November 2025.

Grant C. Meeting between AIMS Indigenous Partnerships Team staff and representatives from Gia and Ngaro sea claim to build relationships for future collaborations. Meeting held in-person at Airlile Beach, 22 May 2025.

Gruber R. and MMPWQ teams. Inshore water quality: 2024–25 condition and long-term trends. Presentation at MMP Symposium in person and over Teams. Mercure, Townsville QLD. 25 November 2025.

Gruber R. Inshore water quality: 2024–25 condition and long-term trends. Presented to QLD Department of State Development, Infrastructure and Planning. Site visit at AIMS, Townsville, 12 Nov 2025.

Gruber R. Inshore water quality: 2024–25 condition and long-term trends. AIMS All-Colleagues webinar, 11 Nov 2025.

Gruber R. “Threats to Great Barrier Reef must be 'tackled simultaneously' after back-to-back bleaching, experts say”. Interview with Baz Ruddick for ABC online, 3 September 2025: https://www.abc.net.au/news/2025-09-03/great-barrier-reef-recovery-water-quality/105724044.

Gruber R. GBR inshore water quality: 2023–24 results and 2025 wet season. Presented to the Independent Chair Reef 2050 Advisory Committee (Annabelle Bennett), Office of the GBR, and DETSI staff. Site visit at AIMS, Townsville, QLD, 1 July 2025.

Gruber R. Marine Monitoring Program for Inshore Water Quality: 2023–24 condition and long-term trends. Paddock to Reef Burdekin Regional Water Quality Science Forum. AIMS, Townsville, QLD, 15 May 2025.

Gruber R. GBR Inshore water quality: 2023–24 results and 2025 wet season. Presented to Healthy Waters Partnership (DCCEEW, DETSI/OGBR, and NRM staff). Site visit at AIMS, Townsville, QLD, 9 May 2025.

Gruber R. Inshore water quality: 2023–24 results and 2025 wet season. AIMS all-staff webinar, online via Teams, 15 April 2025.

Gruber R, Waterhouse J, and Thompson A. Meeting with Manbarra Traditional Owners to introduce the MMP Water Quality and Coral programs and request FPIC for monitoring activities. Meeting held in-person at AIMS, 5 March 2025.

Howley, Shellberg, Polglase et al. Marine Monitoring Program Cyclone Jasper event sampling: Cape York. Reef Authority Science Seminar, Townsville 5 September 2024 (Townsville).

Howley et al. Marine Monitoring Program Inshore Water Quality: Cape York 2024–25. MMP Annual Symposium 13 November 2024 (Townsville).

Howley, Shellberg, Albert-Mitchell. Environmental Impacts of Cyclone Jasper in the Cape York region. March-July 2024. This was part of a series of presentations funded by Commonwealth & DESI DRFA, including overview of details collected via MMP Inshore WQ monitoring team, but no specific MMP data. CYWP Presentation Series: Cyclone Jasper Environmental Impacts (Cooktown, Bloomfield, HopeVale, Jabalbina Yalanji Aboriginal Corp, Waymburr-Gamaay Aboriginal Corp, Rossville & Wallaby Creek Regen Festival).

Moran D, Davidson J, Waterhouse J, McKenzie L, Simbolo R. Meeting with Girringun TUMRA Steering Committee to introduce MMP monitoring programs in Gulngay and Nywaigi sea country and to seek consent. Meeting held in Cardwell, 16 September 2025.

Moran D, Davidson J, Waterhouse J, Simbolo R. Combined meeting with GMY and Gunggandji Rangers and staff to introduce MMP monitoring programs in their respective sea country areas and discuss consent from Gunggandji and GMY Tradtional Owners. Meeting held at Gunggandi TUMRA Ranger Base in Yarrabah, 11 September 2025.

Moran D, Lewis S. When the Rivers Roared: GBR inshore water quality and 2024–25 wet season flooding. Presented to Reef Authority staff at Great Barrier Reef Marine Park Authority Science Series. Online via Teams, 1 September 2025.

Moran D, Simbolo R. Meeting with Yirrganydji TUMRA coordinator Melanie Mitchell to discuss MMP water quality monitoring in Yirrganydji sea country. Meeting held online, 11 August 2025.

Moran D. Provided a flyer to Darumbal Enterprises representatives outlining 2023–24 MMP water quality results for the Fitzroy Region. Sent 7 August 2025.

Moran D. Provided a flyer to Woppaburra TUMRA representatives outlining 2023–24 MMP water quality results for the Fitzroy Region. Sent 7 August 2025.

Moran D. GBR inshore water quality: 2023–24 results and 2025 wet season. Presented to the QLD Shadow Minister for Environment, Science, Innovation and Climate Change (Hon Leanne Linard MP) and staff. Site visit at AIMS, Townsville, QLD, 18 June 2025.

Moran D. Meeting between Karl Mangelsdorf and Daniel Moran to discuss MMP water quality and coral monitoring in Jabalbina (Eastern Kuku Yalanji) sea country. Meeting held online, 29 May 2025.

Moran D, Thompson A, and Davidson J. Meeting with GMY Rangers (Gunggandji Mandingalbay-Yidinji Peoples PBC) to introduce the MMP Water Quality and Coral programs and build relationships for future FPIC discussions. Meeting held in-person at AIMS, 27 May 2025.

Thompson K, Shiels R, Elisei G, Paxman C, Lei Li S, Li Y, Carswell C, Xia S, Prasad P, Gallen M, Reeks T, Clokey JE, Jekimovs LJ, Marano K, Kaserzon S. Marine Monitoring Program Inshore Water Quality: 2024–25 Pesticide monitoring. MMP Annual Symposium 13 November 2024 (Townsville).

Waterhouse, Howley, Petus, Lewis, Mellors, James, O'Callaghan. Marine Monitoring Program Cyclone Jasper event sampling: Wet Tropics. Reef Authority Science Seminar, Townsville 5 September 2024 (Townsville).

Waterhouse, Petus, Lewis, Mellors, James, O'Callaghan, Choukroun, Molinari. Marine Monitoring Program Inshore Water Quality: Wet season drivers & remote sensing products 2024–25. MMP Annual Symposium 13 November 2024 (Townsville).

Waterhouse et al. Marine Monitoring Program Overview 2023–24. Mackay Whitsunday Paddock to Reef Forum, 1 May 2025 (Mackay).

D-3 Media releases

TropWATER Media Release, 30 January 2024. Dual Cyclones: Unravelling the flood plume impact on Great Barrier Reef. Picked up by over 80 media outlets around the world. Jane Waterhouse provided interviews to 4 local and regional radio stations, 2 TV stations, and other media outlets including The Guardian and the Townsville Bulletin.

CYWP Newsletter "The Stream- Cyclone Jasper Special Edition".

TropWATER media release, 27 February 2025. Flood plume reaches offshore reefs in Great Barrier Reef. https://www.tropwater.com/post/flood-plume-reaches-offshore-reefs-in-great-barrier-reef