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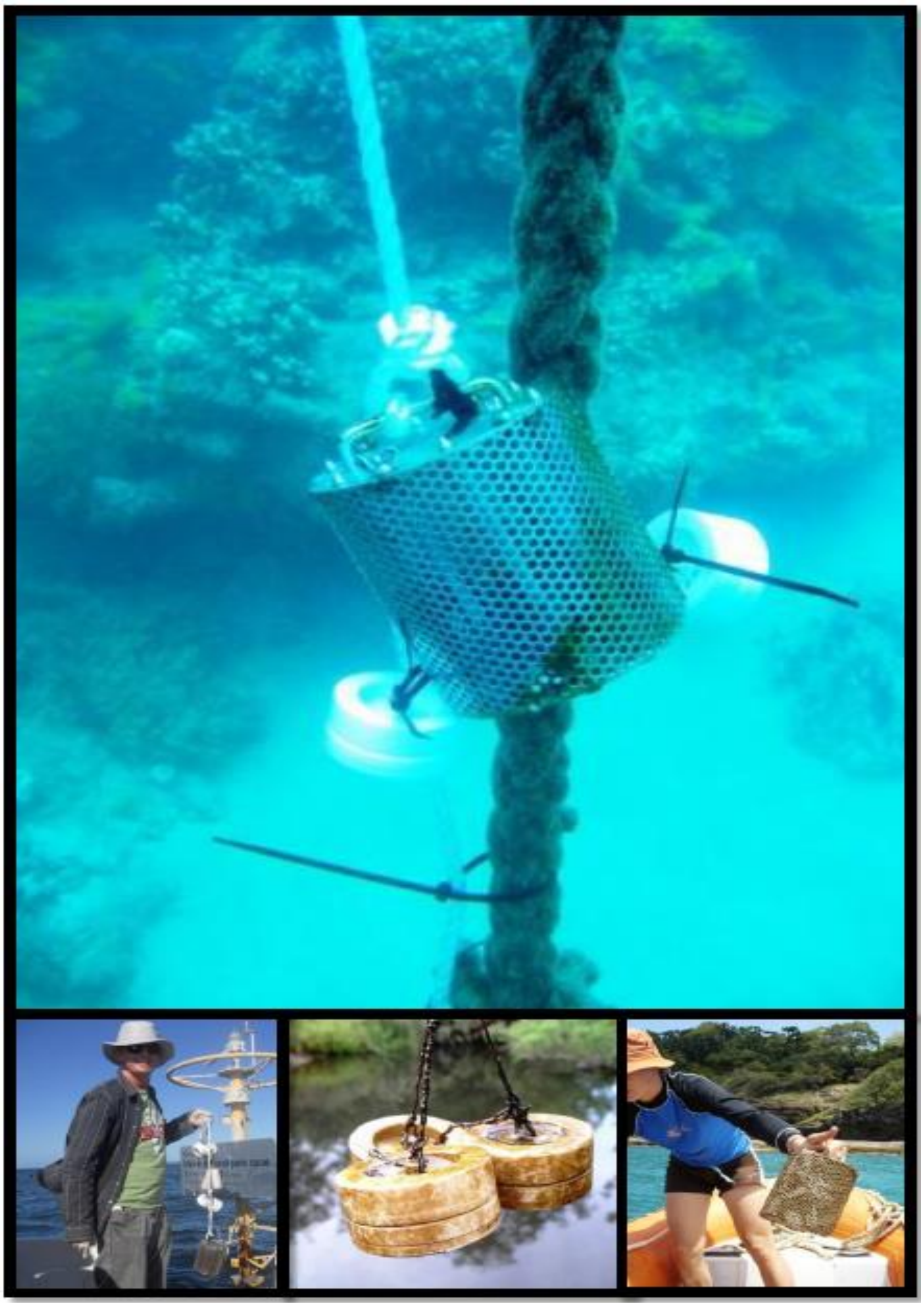

Pesticide monitoring in inshore waters of the Great Barrier Reef using both time-integrated and event monitoring techniques (2012 - 2013)

September 2013

Prepared for – The Program Manager, The Great Barrier Reef Marine Park Authority

Project Teams –

- **Inshore Marine Water Quality Monitoring**

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Report should be cited as –

Gallen, C., Devlin, M., Paxman, C., Banks, A., Mueller, J. (2013) Pesticide monitoring in inshore waters of the Great Barrier Reef using both time-integrated and event monitoring techniques (2012 - 2013). The University of Queensland, The National Research Centre for Environmental Toxicology (Entox).

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Acknowledgements

Other contributors to this work include-

- Carol Honchin of the GBRMPA for her work on the PSII-HEq Index in 2010.
- Britta Schaffelke and staff of the Australian Institute of Marine Sciences for the assessment of long term discharge data.
- Steve Carter and Vince Alberts of Queensland Health Forensic and Scientific Services for the analysis and reporting of pesticide data for the project.
- Adam Thom and Alex Shanahan of the School of Geography, Planning and Environmental Management, University of Queensland for mapping project support (mapping).
- The early work of David Haynes, Joelle Prange and Deb Bass of the GBRMPA in establishing and managing this monitoring program.

These routine monitoring activities have been undertaken in some form since 2005. Entox therefore acknowledges the significant contribution of past staff–
Dr Karen Kennedy, Andrew Dunn, Dr Michael Bartkow, Dr Tatiana Komarova, Dr Melanie Shaw, Anita Kapernick, Jake O'Brien, Kristie Thompson

The assistance of the numerous volunteers who have deployed passive samplers is gratefully acknowledged –

Whitsunday Moorings	Hamilton Island Enterprises	Great Barrier Reef Marine Park Authority
Mission Beach/ Dunk Island Water Taxi	Ingham Travel	Australian Centre for Tropical and Freshwater Research
Sarina Bait Supplies	Frankland Island Cruise & Dive	North Keppel Island Environmental Education Centre
Jace Services	Reef Safari Diving	Cairns Dive Centre (Fitzroy Island)
Reef Fleet Terminal	Orpheus Island Research Station	Australian Institute of Marine Science
Quicksilver Connections	Big Cat Green Island	Fitzroy Island Resort

In particular Entox thanks the GBRMPA Program Manager Katherine Martin and the GBRMPA Regional coordinators for the role they have played in managing and facilitating this monitoring program throughout the years: -
Carolyn Thompson, Cath McLean, Phil Laycock, Warwick Sheldon

About the Reef Rescue Marine Monitoring Program –
The Reef Rescue Marine Monitoring Program is a water quality and ecosystem health long-term monitoring program in the Great Barrier Reef lagoon to track the effectiveness of the Reef Rescue Plan. This project is supported by the Great Barrier Reef Marine Park Authority, through funding from the Australian Government's Caring for Our Country.

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Acronyms

ANZECC	Australian and New Zealand Environment and Conservation Council
APVMA	Australian Pesticides and Veterinary Medicines Authority
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
C_W	Concentration in water
DEET	*N*,*N*-Diethyl-*meta*-toluamide
EC_{20}	20 % maximal effective concentration is observed
EC_{50}	50 % maximal effective concentration is observed
ED	Empore Disk™ passive sampler
Entox	National Research Centre for Environmental Toxicology
ENSO	El-Nińo Southern Oscillation
GBR	Great Barrier Reef
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GC-MS	Gas Chromatography-Mass Spectrometry
GPC	Gel Permeation Chromatography
IWL	Interim working level
K_{OW}	Octanol-water partition coefficient
LC-MS	Liquid Chromatography-Mass Spectrometry
LOD	Limit of Detection
LOR	Limit of Reporting
MMP	Reef Rescue Marine Monitoring Program
NATA	National Association of Testing Authorities
PDMS	Polydimethylsiloxane passive sampler
PFM	Passive/Plaster Flow Monitor
PSII-HEq	Photosystem II -Herbicide Equivalent Concentration
PTFE	Polytetrafluoroethylene : Common brand name - Teflon
QHFSS	Queensland Health Forensic & Scientific Services
RWQPP	Reef Water Quality Protection Plan
SDB-RPS	Poly(styrenedivinylbenzene) copolymer – reverse phase sulfonated
SPMD	Semi-permeable Membrane Devices

1 EXECUTIVE SUMMARY

In 2012-2013, Entox carried out monitoring activities utilising a combination of passive sampling and grab sampling techniques in the Great Barrier Reef Marine Park as part of the Reef Rescue Marine Monitoring Program (MMP). The MMP was implemented under the Reef Water Quality Protection Plan (RWQPP) 2003 (which was further updated in 2009 and 2013) to evaluate trends in water quality status in the Great Barrier Reef (GBR) and the impact on key ecosystems. The goal of the updated 2013 Reef Plan is to ensure that by 2020, the quality of water entering the reef has no detrimental impact on the health and resilience of the Great Barrier Reef. Further specific water quality targets to meet this goal are outlined including a minimum reduction in end-of-catchment pesticide loads of 60 % by 2018 (Anon, 2013). Monitoring was conducted within two components of the MMP; ***Inshore Marine Water Quality Monitoring*** and the ***Assessment of Terrestrial Run-off Entering the Reef***. The key objectives of these components were to assess the temporal and spatial trends in water quality (i.e. pesticides) at fixed inshore GBR sites and the exposure to organic pollutants delivered to the reef lagoon during flood events in the wet season.

Long-term trends in pesticide exposure were monitored using passive sampling techniques at twelve fixed sites located in four Natural Resource Management (NRM) regions (Wet Tropics, Burdekin, Mackay Whitsunday and Fitzroy). These sites stretch approximately 1000 km down the Queensland coast from Low Isles in the Wet Tropics region, the northernmost site, through to North Keppel Island, in the Fitzroy region being the southernmost site. Three of the twelve sites (Cape Cleveland, Pioneer Bay and Sarina Inlet) are located on the mainland, whilst the remaining nine sites are located on inshore islands of the GBR, extending up to approximately 25 km offshore. Polar passive samplers that target relatively hydrophilic herbicides were deployed bimonthly during the dry season (May 2012 – October 2012) and monthly at every fixed site during the wet season (November 2012 – April 2013). Non-polar passive samplers that target relatively hydrophobic pesticides were deployed monthly during the wet season at selected sites only, with the exception of Normanby Island which had both sampler types deployed year-round. Exposure to pesticides from terrestrial run-off entering the reef lagoon was assessed using 1 L grab samples collected in the Cape York, Wet Tropics,Burdekin and Fitzroy regions, along transects extending from eight major Rivers during the wet season.

The land adjacent to the GBR has undergone significant agricultural development in the past 100 years, with approximately 76 % of the land now used for agricultural activities (DSITIA, 2012a). Photosystem II (PSII) herbicides have been identified as priority chemicals for monitoring in the GBR due to their heavy usage in GBR catchments and their previous detection in both grab and passive samplers. Unlike other water quality indicators such as *chlorophyll a* and turbidity that are present naturally in the environment at low levels and can be enhanced by anthropogenic activities, the presence of herbicides in inshore waters is a direct indicator of the influence of human activities, such as agricultural practices, on this world heritage ecosystem.

The mode of action of PSII herbicides is to inhibit photosynthesis and thus, exposure to these herbicides poses a risk to photosynthetic organisms such as seagrass, corals, algae and aquatic plant life. The concentrations of these herbicides within the present MMP report are expressed both as water concentrations (ng L^{-1}) PSII herbicide equivalent concentrations (PSII-HEq) (also in ng L^{-1}), which incorporate both the potency and abundance of individual PS-II herbicides relative to the reference PSII herbicide diuron. The PSII-HEq Index was developed as an indicator of the potential for PSII inhibition caused by the additive effects of mixtures of herbicides. The risk of PSII inhibition may be underestimated when concentrations of herbicides are considered individually rather than as part of a more complex mixture. The index consists of five Categories which range from Category 1 (> 900 ng.L^{-1}), which represents the highest risk of exposure (above the 99 % species protection trigger value derived for the reference PSII herbicide diuron (GBRMPA 2010), to Category 5 (≤10 ng.L^{-1}), which represents concentrations below which no published PSII inhibition effects have been observed.

In this report, additional reporting parameters are the maximum PSII-HEq concentration (PSII-HEq Max) within each monitoring year and the average PSII-HEq during the wet season (PSII-HEq Wet Avg) at each site.

These parameters have been selected to provide a simple means of highlighting temporal trends in herbicide exposure, where PSII-HEq Max shows the maximum risk of exposure to PSII herbicides, and PSII HEq Av shows the average risk of exposure to herbicides (during the wet season) of the current monitoring year. The temporal profile for the PSII-HEq Max at each of the routine monitoring sites since monitoring commenced is provided in Figure 1. The PSII herbicide diuron continues to be the dominant contributor to PSII-HEq at all sites due to its abundance and potency as a PSII inhibitor.

The PSII-HEq Max and PSII-HEq Wet Avg for 2012-2013 are provided in Tables 1 and 2, which summarises key results from the routine monitoring and terrestrial run-off programs respectively. For routine monitoring sites where long-term, time-integrated monitoring with passive sampling occurred, these reporting parameters are compared to those obtained since sampling commenced at the site (typically 2005-2006 unless otherwise stated) using ratios (Table 1). In this current monitoring year, the PSII-HEq Max for each of the twelve routine passive sampling sites ranged from Category 3 to 5. The PSII-HEq Max of grab samples collected in the terrestrial run-off assessment also ranged from Category 3 to 5 (Table 2). Where non-PSII herbicides (i.e. metolachlor, imidacloprid) or industrial chemicals (galaxolide) have been detected, these are also indicated in Table 1 together with the maximum concentrations detected.

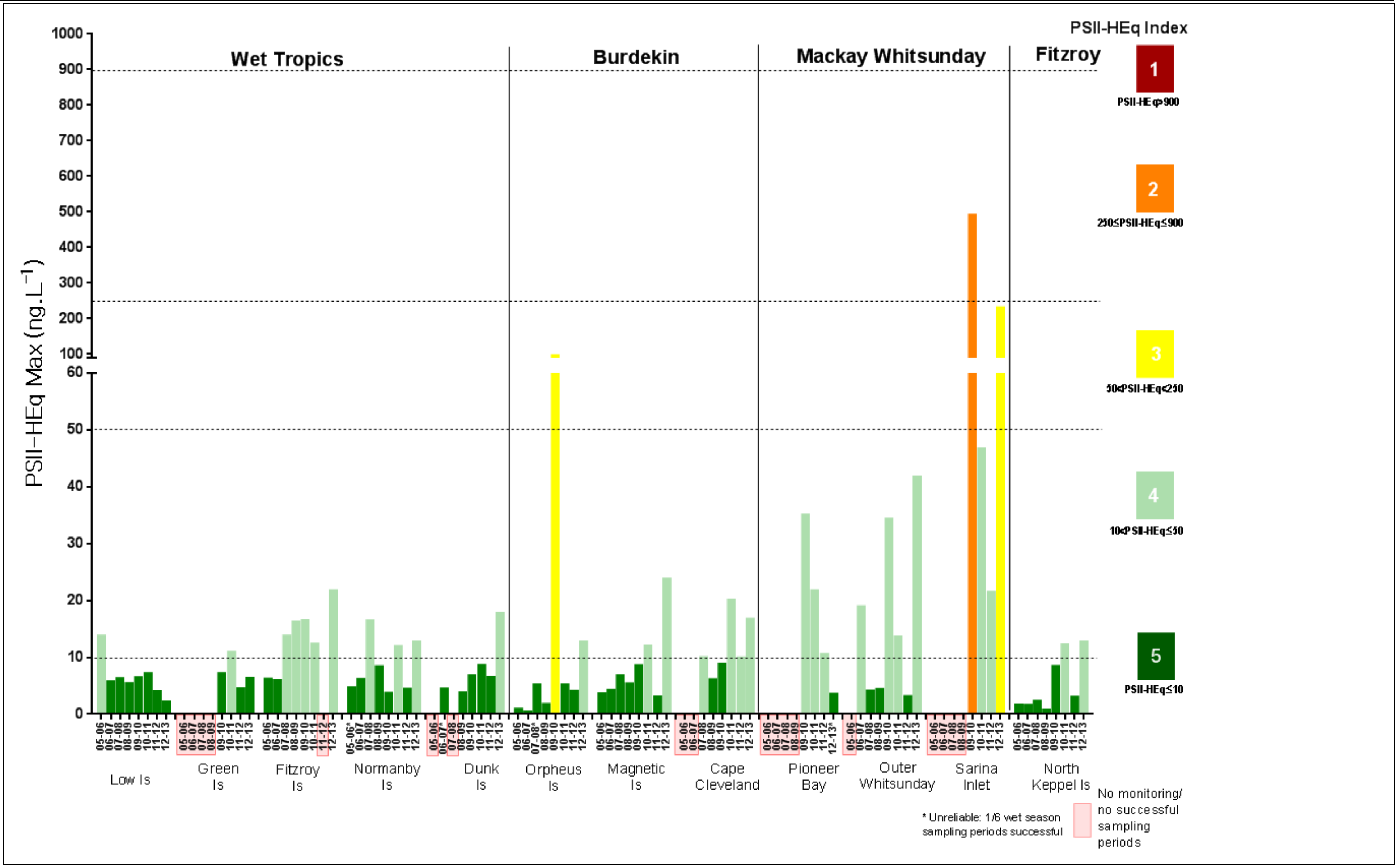

Figure 1 The temporal trends in PSII-HEq Max at routine monitoring sites in inshore waters of the GBR determined using time-integrative sampling

1.1 Key findings for the 2012-2013 monitoring year

A wide range of PSII herbicides, other pesticides and industrial chemicals were frequently detected at pesticide monitoring sites in 2012-2013 using grab and passive sampling techniques. Tebuthiuron was the only herbicide (with an individual guideline to assess against), detected using passive samplers at concentrations which exceeded Water Quality Guidelines (ANZECC and ARMCANZ 2000; GBRMPA 2010) at North Keppel Island. Most notably, diuron was detected at the majority of sites in the Wet Tropics, Burdekin and Mackay Whitsunday regions in greater abundance than in the previous monitoring year, with average increases of 2.2, 3.7 and 12 times respectively.

A. Routine monitoring sites:

The most abundant and frequently detected PSII herbicides in each region were:

- **Wet Tropics** – diuron (maximum concentration of 19.0 ng.L^{-1} at Fitzroy Island), atrazine (maximum concentration of 6.5 ng.L^{-1} maximum at Fitzroy Island) and hexazinone (maximum concentration of 3.8 ng.L^{-1} at Dunk Island)
- **Burdekin** – atrazine (maximum concentration of 28 ng.L^{-1} at Cape Cleveland), diuron (maximum concentration of 21 ng.L^{-1} maximum at Magnetic Island), and hexazinone (maximum concentration of 1.9 ng.L^{-1} at Orpheus Island)
- **Mackay Whitsunday** – diuron (maximum concentration of 203 ng.L^{-1} at Sarina Inlet), hexazinone (maximum concentration of 51 ng.L^{-1} at Sarina Inlet) and atrazine (maximum concentration of 32 ng.L^{-1} at Sarina Inlet)
- **Fitzroy** – tebuthiuron (maximum of 57 ng.L^{-1}), atrazine (maximum concentration of 8.1 ng.L^{-1}) and diuron (maximum concentration of 5.6 ng.L^{-1})

With the exception of a single detection of tebuthiuron at North Keppel Island (maximum of 57 ng.L^{-1}), none of these maximum concentrations exceeded the Water Quality Guideline values for 99% species protection. Other non PSII herbicides were also detected at routine monitoring sites (terbutryn, imidacloprid, imazapic and metolachlor), with metolachlor regularly detected at all sites.

The trends in the reporting parameters PSII-HEq Max and PSII-HEq Wet Avg during the 2012-2013 monitoring year were:

- **Wet Tropics –**Low Isles and Green Island were the only sites where the PSII-HEq Max remained a Category 5 from the previous monitoring year, whereas Dunk Island and Normanby Island increased from a Category 5 to 4 (note that no sampling occurred at Fitzroy Island in 2011-12). When compared to the earliest monitoring data collected at these sites, the PSII-HEq Max values of Fitzroy Island, Dunk Island and Normanby Island all increased (from Category 5 to 4) whilst Low Isles showed a decrease and Green Island remained stable. The PSII-HEq Wet Avg of Dunk Island and Normanby Island when compared to 2011-2012, indicated a higher risk of exposure to PSII herbicides during the wet season.
- **Burdekin –** The PSII-HEq Max and PSII-HEq Wet Avg increased at Orpheus Island and Magnetic Island from a Category 5 to 4 (Cape Cleveland remained a Category 4) when compared to the previous monitoring year. This was also the case since monitoring commenced at each site. Wet Avg values also increased from both the previous monitoring year and since monitoring commenced.
- **Mackay Whitsunday –** The PSII-HEq Max increased substantially at both Outer Whitsunday and Sarina Inlet from the previous monitoring year reaching a high Category 4 and Category 3 respectively. Similarly the PSII-HEq Wet Avg also increased to Category 4 and 3 respectively from the previous year. Only one successful sampling period occurred at Pioneer Bay this year.
- **Fitzroy –** Both PSII-HEq Max (Category 4) and the PSII-HEq Wet Avg at North Keppel Island have increased in 2012-2013, compared to both the previous monitoring year and since monitoring commenced (Category 5).

Table 1 Key findings of routine monitoring sites in 2012-2013

NRM Region	Site Name	Sampler Type	Sampling Mode	PSII-Heq Max	Ratio to Year sampling commenced[a]	PSII-Heq Wet Avg	Ratio to Year sampling commenced[a]	Other Pesticides detected	Max Concentration (ng.L^{-1})	GBRMPA Guideline Exceedances (ng.L^{-1})
Wet Tropics	Low Isles	ED	TI	2.5	0.18	1.6	0.29	Metolachlor	0.03	
	Green Island	ED	TI	6.6	0.89	3.9	2.3	Metolachlor	0.13	
								Terbutryn	0.05	
		PDMS	TI					Galaxolide	0.06	
	Fitzroy Island	ED	TI	22	3.4	16	4.7	Metolachlor	0.25	
								Imidacloprid	0.08	
		PDMS								
	Normanby Island	ED	TI	13	2.6	5.3	1.1	Metolachlor	0.11	
								Terbutryn	0.18	
								Imidacloprid	0.14	
		PDMS	TI					Galaxolide	0.18	
	Dunk Island	ED	TI	18	4.4	8.9	2.9	Metolachlor	0.29	
								Imazapic	0.01	
								Imidacloprid	1.4	
		PDMS	E					Metolachlor	6.8	
Burdekin	Orpheus Island	ED	TI	13	11	7.6	10.0	Metolachlor	0.36	
								Imidacloprid	0.18	
	Magnetic Island	ED	TI	24	6.1	11.0	2.7	Metolachlor	0.3	
								Terbutryn	0.17	
		PDMS	E					Metolachlor	6.0	
	Cape Cleveland	ED	TI	17	1.7	9.5	1.5	Metolachlor	1.1	
		PDMS	E					Metolachlor	6.3	
Mackay Whitsunday	Pioneer Bay	ED	TI	3.8		-		Terbutryn	0.19	
	Outer Whitsunday	ED	TI	42	2.2	14	1.9	Metolachlor	0.58	
		PDMS	TI					Galaxolide	0.08	
	Sarina Inlet	ED	TI	234	0.47	44	0.75	Metolachlor	2.4	
								Imidacloprid	1.9	
Fitzroy	North Keppel Island	ED	TI	13	6.8	3.9	2.3	Metolachlor	6.4	
		ED	TI					Tebuthiuron		57

TI = Time Integrated sampling; E = Equlibrium phase sampling; The reporting parameters PSII-HEq Max and Wet Avg are colour coded according to PSII-HEq Index Categories (refer Figure 1); Ratios of these time-integrated reporting parameters are to the same parameters in the previous monitoring year (2011-2012) and the year in which sampling commenced [a]Routine sampling commenced in 2005 for all sites except Dunk Island (2008-09), Green Island and Sarina Inlet (2009-10), Cape Cleveland (2007-08) and Outer Whitsunday (2006-07); Note that only one sampling period was successful at Pioneer Bay, and results are therefor unreliable

Terrestrial Run-Off (flood plumes)

- No herbicides were detected in 1 L grab samples collected at several sites located in Princess Charlotte Bay (extending from the Normanby River), in the Cape York region.
- No herbicides were detected in 1 L grab samples collected at sites located near the Barron and Russell-Mulgrave River mouths in the Wet Tropics.
- Diuron (140 ng.L^{-1}), atrazine, hexazinone and imidacloprid were each detected in a single sample collected on a transect extending from the Tully River mouth in the Wet Tropics region, the highest concentration of all grab samples collected.
- On a transect extending north of the Herbert River in the Wet Tropics region, diuron (12 ng.L^{-1}) was detected in a single sample only at Channel North.
- On a transect extending south of the Herbert River in the Wet Tropics region, diuron (maximum concentration 33ng.L^{-1}), and simazine (maximum concentration 22 ng.L^{-1}) were detected in grab samples with diuron detected in all samples.
- On a transect extending from the Mary River in the Fitzroy region, diuron (18 ng.L^{-1}) and atrazine (11 ng.L^{-1}) were detected in a single sample, located closest to the river mouth

Table 2 Key findings of terrestrial run-off component in 2012-2013

NRM Region	Transect	Site Name	Sampler Type	PSII-Heq Max	Other Pesticides detected	Max Concentration (ng. L^{-1})	GBRMPA Guideline Exceedances
Cape York	Normanby River	Princess Charlotte Bay (approx 15 km from Normanby River mouth)	GRAB	n.d.			
		Princess Charlotte Bay (approx 7 km from Normanby River mouth)	GRAB	n.d.			
		Princess Charlotte Bay (approx 6 km from Normanby River mouth)	GRAB	n.d.			
		Normanby River mouth 1 (approx 3 km from Normanby River mouth)	GRAB	n.d.			
		Normanby River mouth 2 (approx 4 km from Normanby River mouth)	GRAB	n.d.			
		Princess Charlotte Bay (approx 12 km from Normanby River mouth)	GRAB	n.d.			
		Bizant River mouth (approx 3 km from Bizant River mouth)	GRAB	n.d.			
		North Kennedy River mouth 2 (approx 5 km from North Kennedy River mouth)	GRAB	n.d.			
		North Kennedy River mouth 1 (approx 4 km from North Kennedy River mouth)	GRAB	n.d.			
		Princess Charlotte Bay (approx 18 km from North Kennedy River mouth)	GRAB	n.d.			
		Princess Charlotte Bay (approx 37 km from Normanby River mouth)	GRAB	n.d.			
		Princess Charlotte Bay - near Blackwood Island (approx 18 km from Normanby River mouth)	GRAB	n.d.			
Wet Tropics	Barron River	Barron River mouth	GRAB	n.d.			
	Russell-Mulgrave River	Russell-Mulgrave River mouth	GRAB	n.d.			
	Tully River	Sisters Island - South (approx 30 km from Tully River mouth)	GRAB	n.d.			
		Tully River mouth	GRAB	n.d.			
		Bedarra Island (approx 9 km from Tully River mouth)	GRAB	n.d.			
		Tully - mid (approx 8 km from Tully River mouth)	GRAB	160	Imidacloprid	20	
	Herbert River Northern	Channel North - approx 36 km from Herbert River mouth	GRAB	12			
		Goold Island - approx 50 km from Herbert River mouth	GRAB	n.d.			
	Herbert River Southern	Herbert River mouth 1	GRAB	26			
		Herbert River mouth 2	GRAB	33			
		Seymour River mouth	GRAB	29			
		Channel South (approx 5 km from Herbert River mouth)	GRAB	16			
Burdekin	Burdekin River	Palm Island - South (approx 130 km from Burdekin River mouth, approx 36 km from Ross River mouth)	GRAB	93			
		Burdekin River mouth	GRAB	n.d.			
Fitzroy	Mary River	Mary River mouth	GRAB	20			
		Mary River transect 1 (approx 20 kim from Mary River mouth)	GRAB	n.d.			
		Mary River transect 2 (approx 28 km from Mary River mouth)	GRAB	n.d.			
		Mary River transect 3 (approx 52 km from Mary River mouth)	GRAB	n.d.			
		Mary River transect 4 (approx 68 km from Mary River mouth)	GRAB	n.d.			

2 INTRODUCTION

The World Heritage Great Barrier Reef Marine Park covers an area of 344,400 km^2 and spans 2,300 km along the Queensland coast, Eastern Australia. The reef is the largest living structure on Earth, and it supports a rich and diverse ecosystem of marine organisms, including many endangered species. Coral reefs worldwide are exposed to multiple simultaneous stressors including shipping, destructive fishing practices, destructive weather, effects of climate change and the delivery of anthropogenic pollutants (sediments, nutrients, pesticides and other chemicals) from sewerage, aquaculture, urban and agricultural sources (Brodie et al. 2012).

The declining quality of water entering the GBR lagoon has been identified as a key threat to the reef's continued ability to adapt to change and withstand these multiple stressors, whether they be local (e.g. a cyclone) or the global impacts of climate change (such as ocean acidification and rising sea temperature) (Furnas, 2003; Hoegh-Guldberg et al 2007; Brodie et al 2008; Brodie and Waterhouse 2009; De'ath et al 2009; Packett et al 2009; van Dam et al 2010). Approximately 76 % of the land in the GBR catcment area (adjacent to the reef) is used for agricultural activities (including sugar cane, beef grazing, horticulture, cropping, pastures and cotton) (Smith et al 2012). Nutrients, sediments and agricultural chemicals from these adjacent catchments are introduced into the inshore waters of the reef in river run-off during the wet season, and are often at elevated concentrations for extended periods of time (Devlin and Scaffelke, 2009). Exposure to pesticides from these adjacent catchments poses a direct threat to the inshore waters of the GBR.

The contaminants assessed as an indicator of water quality, either routinely or during flood events were pesticides (insecticides, herbicides and fungicides). The objective of the routine monitoring component of the MMP is to monitor long-term temporal and spatial trends in water quality (i.e. pesticide concentrations) at twelve fixed sites across four Natural Resource Management (NRM) regions - Wet Tropics, Burdekin, Mackay Whitsunday and Fitzroy. This monitoring has been conducted for between four to eight years at these locations. The focus of the terrestrial run-off component in 2012-2013 was to profile the pollutant of flood plumes from catchments extending the full length of the GBR (from the Cape York to Burnett-Mary region) which cover diverse land uses.

3 METHODOLOGY

Routine water quality monitoring at fixed sites was conducted using passive sampling techniques. These samplers accumulate chemicals into a sorbing material from water via passive diffusion. The passive sampling techniques which are utilized in this component of the MMP include:

- SDB-RPS Empore™ Disk (ED) based polar passive samplers for relatively hydrophilic organic chemicals with relatively low octanol-water partition coefficients ($logK_{OW}$) such as the PSII herbicides (example: diuron).
- Polydimethylsiloxane (PDMS) and Semipermeable Membrane Devices (SPMDs) non-polar passive samplers for organic chemicals which are relatively more hydrophobic (higher $log\ K_{OW}$) such as chlorpyrifos.

Terrestrial run-off assessments conducted during the wet season have used 1 L grab water sampling only. Full details regarding these methodologies have been described in the *Reef Rescue Marine Monitoring Program: Quality Assurance/Quality Control Methods and Procedures Manual 2011* (GBRMPA 2011) and in previous reports (Kennedy et al. 2011; Kennedy et al. 2010a;).

Figures 2 and 3 show the typical configuration of polar and non-polar samplers together with PFMs. Typically, samplers are deployed on a rope or chain using shackles or cable ties from either a buoy or fixed point such as a jetty or pontoon. It is recommended that the samplers sit in the middle of the water column or are at a level where they are not exposed at low tide, without resting on the bottom. The transportation lid on the EDs are removed and replaced with a deployment ring which holds a protective mesh in place. The caps of PFMs are also removed (except in the dry season where flow-limiting caps are deployed). Once the samplers are attached to the rope or chain they are lowered into the water, shaking to remove any air bubbles. The date of deployment is then recorded by the volunteer. Upon retrieval, samplers are removed from the water, shaking to remove excess debris and water. The cage is detached from the rope or chain and re-sealed in a tin. The EDs and PFMs are also detached and the lids of the PFMs replaced. The ED is filled with water from the site to prevent drying and the transportation lids screwed on. The sampler set is then refrigerated until being returned to Entox in an esky packed with ice bricks.

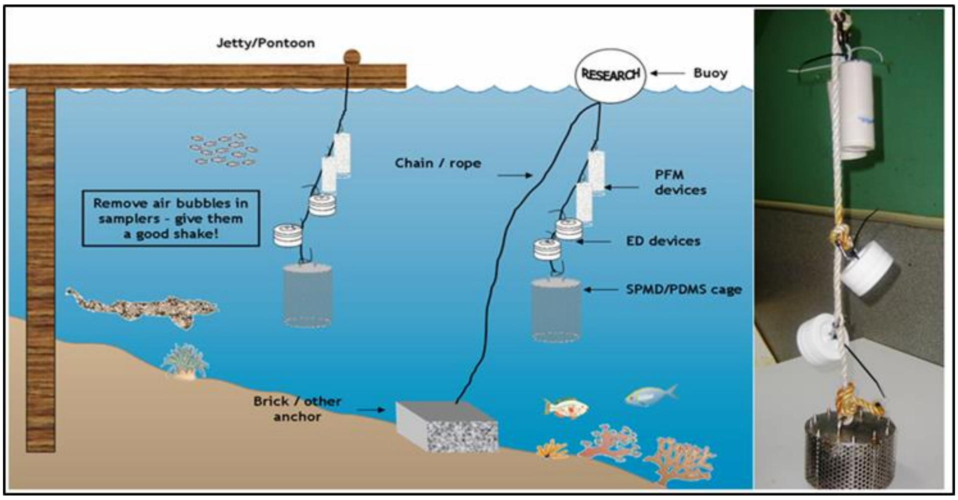

Figure 2 Typical configuration of passive samplers

The participation of volunteers (Table 3) from various community groups, agencies and tourist operations is a key feature of the routine pesticide monitoring program and integral to the success of maintaining the program in often remote locations. These volunteers assist by receiving, deploying, retrieving and returning the passive samplers to Entox for subsequent extraction and analysis. This active participation of volunteers within the program is made possible by training from GBRMPA and/or Entox staff in Standard Operating Procedures to ensure a high level of continuous sampling and high quality usable data is obtained from these deployments.

Figure 3 Deployment of passive samplers in the field

3.1 Target Chemicals and Limits of Reporting

The pesticides targeted for analysis using the different sampling techniques and the limits of reporting (LOR) are indicated in Appendix A, Table 16. This list of target chemicals was derived at the commencement of the MMP through consultation with GBRMPA based on the following criteria: pesticides detected in recent studies, those recognised as a potential risk, analytical affordability, pesticides within the current analytical capabilities of Queensland Health Forensic and Scientific Services (QHFSS) and those likely to be accumulated within one of the passive sampling techniques (i.e. that exist as neutral species and are not too polar).The limits of reporting (LOR) for the LCMS and GCMS instrument data have been defined by Queensland Health Forensic and Scientific Services laboratory as follows: The LORs are determined by adding a very low level of analyte to a matrix and injecting 6-7 times into the analytical instrument. The standard deviation of the resultant signals is obtained and a multiplication factor of 10 is applied to obtain the LOR.

All empore disc sampler extracts (routine monitoring) and grab samples (terrestrial run-off assessment) were routinely analysed using liquid chromatography mass spectrometry on the (ABSciex 4000 QTrap LCMSMS) run in positive analysis mode (Appendix A, Table 17). This excludes the analysis of several hydrophilic pesticides such as 2,4-D, MCPA, mecoprop, and picloram, detected in negative analysis mode only. PDMS and SPMD sampler extracts are analysed for pesticides using gas chromatography mass spectrometry (GCMS). While priority chemicals are targeted using SPMDs and PDMS in this MMP (Appendix A, Table 18), a broader suite of organic chemicals including other pesticides and industrial chemicals are also simultaneously measured (Appendix A, Table 18).

3.2 Sampling Sites

Passive samplers were routinely deployed at twelve inshore GBR sites in 2012-2013, including three sites that were only incorporated into the MMP in 2009-2010 (refer to Figure 4). These sites were Green Island in the Wet Tropics region and Pioneer Bay and Sarina Inlet in the Mackay Whitsunday region. Low Isles, Green Island, Dunk Island, Magnetic Island, Pioneer Bay, Hamilton Island and Sarina Inlet are also seagrass monitoring sites within the MMP.

3.3 Routine Sampling Periods

The monitoring year for routine pesticide sampling is from May 2012 to April 2013. The year is arbitrarily divided into “Dry 12” (May 2012 to October 2012) and “Wet 12-13” (November 2012 – April 2013) sampling periods for reporting purposes. Within each dry season deployment period, samplers are typically deployed for two months (maximum of three deployment periods each monitoring year) and within each wet season deployment period, samplers are typically deployed for one month (maximum of six deployment periods within each monitoring year). The maximum number of samples which should be obtained from each location within each monitoring year is nine. Table 3 indicates the numbers of passive sampler sets sent to each location, successfully deployed and returned to Entox.

Table 3 Sampling return record for the 2012-2013 monitoring year

NRM Region	Site Name	No of samplers sent	No of samplers deployed and returned	Comments
Wet Tropics	Low Isles	7	6	Lost mooring twice
	Green Island	8	8	One over-deployment
	Fitzroy Island	8	5	Several volunteer changes
	Normanby Island	9	9	
	Dunk Island	9	9	New volunteers Sept 2012, lost 1 ED sampler
Burdekin	Orpheus Island	9	8	One over-deployment
	Magnetic Island	9	9	
	Cape Cleveland	9	9	
Mackay Whitsunday	Pioneer Bay	9	1	Communication issues with the volunteer, numerous samplers unaccounted for or returned unused
	Outer Whitsunday	10	8	Double deployment Sep/Oct, 2 over-deployments, 2 sampler sets not accounted for
	Sarina Inlet	8	7	Two over-deployments
Fitzroy	North Keppel Island	9	9	

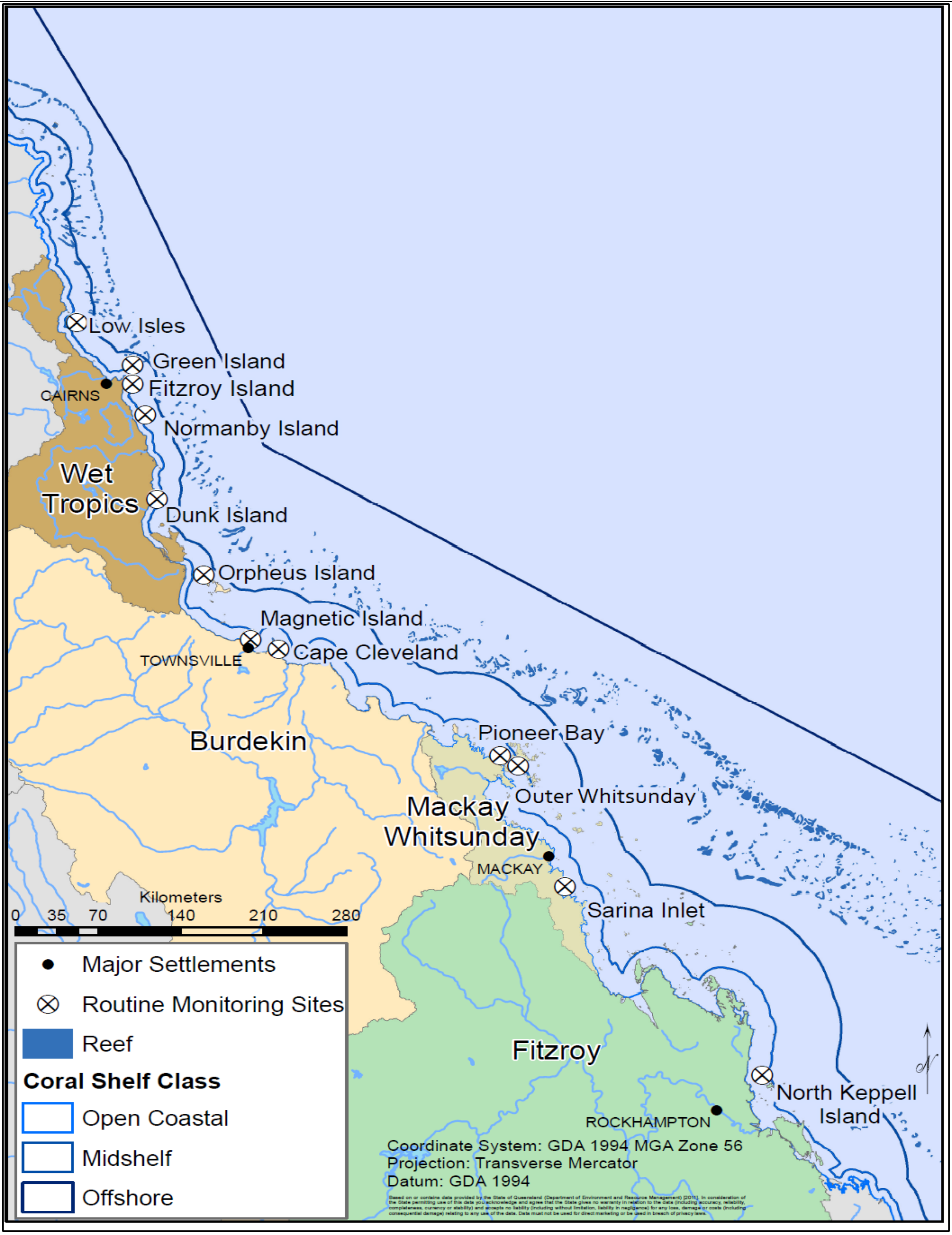

Figure 4 Locations of current inshore GBR routine monitoring sites where time-integrated sampling of pesticides occurred in 2012-2013

(Source – Adam Thom and Alex Shanahan, School of Geography, Planning and Environmental Management, the University of Queensland)

3.4 Types of samplers deployed for routine sampling for the Assessment of Water Quality

The types of samplers deployed at each site are indicated in Table 4 below. All twelve sites are routinely monitored in both the dry and wet periods using EDs, while six of these sites have additional PDMS samplers deployed during the wet season - three sites located in the Wet Tropics region, two in the Burdekin region and one in the the Mackay Whitsunday region. Normanby Island (located in the Wet Tropics) is the only site which is monitored year-round using PDMS in both the dry and wet period. SPMDs are also deployed at this site only. The sampling records and results for each routine monitoring site are provided in Appendix D, Tables 23-27, 29-35.

Table 4 The types of passive samplers deployed at each routine monitoring site in 2012-2013

Region	Site	EDs (polar)		PDMS (non-polar)		SPMD (non-polar)	
		Dry	Wet	Dry	Wet	Dry	Wet
Wet Tropics	Low Isles	✓	✓	×	×	×	×
	Green Island	✓	✓	×	✓	×	×
	Fitzroy Island	✓	✓	×	✓	×	×
	Normanby Island	✓	✓	✓	✓	✓	✓
	Dunk Island	✓	✓	×	✓	×	×
Burdekin	Orpheus Island	✓	✓	×	×	×	×
	Magnetic Island	✓	✓	×	✓	×	×
	Cape Cleveland	✓	✓	×	✓	×	×
Mackay - Whitsunday	Pioneer Bay	✓	✓	×	×	×	×
	Outer Whitsunday	✓	✓	×	✓	×	×
	Sarina Inlet	✓	✓	×	×	×	×
Fitzroy	North Keppel Island	✓	✓	×	×	×	×

3.5 Sampling for the Assessment of Terrestrial Run-Off by Region in the Wet Season

3.5.1 Flood plume sampling

A total of thirty-two 1 L grab samples were collected to monitor terrestrial run-off from eight rivers in four NRM regions (Cape York, Wet Tropics, Burdekin and Fitzroy) during flood plume events in the 2012-2013 wet season (refer to Table 5). No passive samplers were deployed in this component of the MMP. Further details for these samples including the date and time of collection, co-ordinates and results for individual herbicides detected are provided in Appendix E, Table 36.

Table 5 The number and timing of grab samples collected to assess terrestrial run-off during the 2012-2013 wet season

Region	Transect	Site Name	Date
Cape York	Normanby River	Princess Charlotte Bay	30-Jan-13
		Princess Charlotte Bay	31-Jan-13
		Normanby River mouth	31-Jan-13
		Bizant River mouth	31-Jan-13
		North Kennedy River mouth	31-Jan-13
		Princess Charlotte Bay	01-Feb-13
		Samples collected 3, 4 and 5 days following peak event	
Wet Tropics	Barron River	Barron River mouth	03-Feb-13
		Samples collected 10 days following peak event	
	Russell-Mulgrave River	Russell-Mulgrave River mouth	03-Feb-13
		Samples collected 9 days following peak event	
	Tully River	Sisters Island South	11-Nov-12
		Baseline dry season sample	
		Tully River mouth/ Bedarra Island	15-Jan-13
		Sample collected 13 days following first flush event	
		Tully mid (between Goold and Bedarra Island)	27-Jan-13
		Sample collected 3 days following first flush event	
	Herbert River North	Channel North/ Goold Island	16-Jan-13
		Samples collected prior to major peak	
		Channel North	25-Mar-13
		Samples collected at the peak of small event, following one major event and two small events in the month prior	
	Herbert River South	Herbert River mouth 2/ Channel South	17-Jan-13
		Samples collected prior to major peak	
		Seymour River mouth/ Herbert River mouth 1	25-Mar-13
		Samples collected at the peak of small event, which followed one major event and two smaller events in the month prior	
Burdekin	Burdekin	Palm Island - South	13-Mar-13
		Burdekin River mouth	17-Mar-13
		Samples collected following event on 7 March, the second major event of the wet season	
Fitzroy	Mary River	Mary River mouth/ Mary transect 1	8-Feb-13
		Mary River transect 2,3 and 4	9-Feb-13
		Samples collected 9 and 10 days following first flush	

3.6 Water Quality Guideline Trigger Values

In order to interpret the potential significance of measured concentrations, these were compared with available Water Quality Guideline Trigger Values (Guidelines). Guidelines have been developed by both the GBRMPA (GBRMPA 2010) and as part of the National Water Quality Management Strategy for fresh and marine waters (ANZECC and ARMCANZ 2000). A selection of relevant Guidelines and Interim Working Levels (IWLs) for priority chemicals identified in the MMP, are provided in Appendix A, Tables 19.

Conservative guidelines which are protective of 99 % of species are the most suitable for water bodies such as the GBR World Heritage Area, which is classified as having outstanding natural value and no change in the indicators of biological diversity beyond the natural variation is recommended (ANZECC and ARMCANZ 2000; GBRMPA 2010). In certain cases, only freshwater guidelines (ANZECC and ARMCANZ) or “low reliability” Guidelines or “interim working levels” (IWLs) rather than marine water quality Guideline values are available for assessing the concentrations of specific chemicals. In many cases, no Guideline values are available to assess the concentrations of specific chemicals detected in this current monitoring year.

3.7 Calculation of PSII-Herbicide Equivalent Concentrations (PSII-HEq)

In this report, PSII herbicide concentrations ($ng.L^{-1}$) are also expressed as PSII herbicide equivalent concentrations (PSII-HEq) (also in $ng.L^{-1}$). PSII-HEq values were derived using relative potency factors (REP) for each individual PSII herbicide with respect to a reference PSII herbicide diuron.

A given PSII herbicide with an REP of 1, is equally as potent as diuron. If it is more potent than diuron it will have a REP of >1, while if it is less potent than diuron it will have an REP of <1. To calculate the PSII-HEq concentration of a given grab or passive sample, it is assumed that these herbicides act additively (Escher et al. 2006; Muller et al. 2008; Magnusson et al. 2010). The PSII-HEq ($ng.L^{-1}$) is therefore the sum of the individual REP-corrected concentrations of each individual PSII herbicide (Ci, $ng.L^{-1}$) detected in each sample using Equation 1.

$$\textbf{PSII-HEq} = \sum C_i \times REP_i \qquad \textbf{Equation 1}$$

REP values for the chemicals of interest were obtained from relevant laboratory studies (Table 6). For the initial determination of REP consensus values, average values from studies obtained using corals, Phaeodactylum and Chlorella were used (different organisms were not weighted). The PSII-HEq concentrations in this report were then predicted using these mean preliminary consensus REP values giving equal weight to EC_{50} and EC_{20} values. These initial consensus values were developed and applied to determine PSII-HEq since the baseline reporting year 2008-09 and have not been updated for the sake of consistency. However it should be acknowledged that as more data continues to be published (Magnusson et al. 2010), it is likely that these values would benefit from review and updating in the future to include not only more data for these chemicals but also additional PSII herbicides that are detected in GBR waters such as bromacil and terbutryn.

Table 6 Relative potency factors (REP) for PSII herbicides and selected transformation products

PSII Herbicides	Relative potency (range)			Relative potency (mean based on various EC values)			
	Zooxanthellae (Corals) [a]	P. tricornutum [bcd]	C. vulgaris [bde]	Zooxanthellae (Corals) [a]	P. tricornutum [bcd]	C. vulgaris [bde]	Mean/ Preliminary consensus [a] REP
Diuron (reference)	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Ametryn	1.2-1.35	0.94	0.9 -2.7	1.28	0.94	1.71	**1.31**
Atrazine	0.05-0.06	0.1-0.4	0.15 -0.3	0.05	0.22	0.21	**0.16**
Desethyl-atrazine			0.01-0.2			0.105	**0.11**
Desisopropyl-atrazine			0.003			0.003	**0.003**
Flumeturon			0.04			0.04	**0.04**
Hexazinone	0.2-0.26	0.27-0.82	0.17-0.95	0.23	0.46	0.44	**0.38**
Prometryn			1-1.1			1.05	**1.05**
Simazine	0.02	0.03-0.05	0.02-0.26	0.02	0.04	0.14	**0.07**
Tebuthiuron	0.01	0.07	0.11-0.2	0.01	0.07	0.15	**0.08**
Terbuthylazine			0.3			0.3	**0.3**

[a](Jones and Kerswell 2003);[b] (Muller et al. 2008); [c] (Bengtson-Nash et al. 2005); [d] (Schmidt 2005); [e] Macova et al., unpublished data (Entox); [f]Based on a preliminary summary of available data when derived in 2009 - it should be noted that bromacil (routinely analysed for since 2009-2010) and terbutryn (beginning to be routinely analysed for from the end of 2010-2011) are also PSII herbicides and not currently incorporated into PSII-HEq estimates (no REP). Similarly while terbuthylazine does have a REP it is not a target chemical in the analysis of EDs, but is part of the GCMS pesticide screen for PDMS. The herbicides which contribute to PSII-HEq in this report are shaded.

3.8 PSII Herbicide Index

To interprete the PSII-herbicide data reported as PSII-HEq, the PSII Herbicide Index has been compiled (with the GBRMPA) as an indicator of PSII inhibition to report against across the MMP (Table 7). This index uses published scientific evidence with respect to the effects of the reference PSII herbicide diuron (summarized for each index category in Appendix, Table 20-21). These index criteria have been slightly modified from those indicated in the baseline reporting year 2008-2009 (Kennedy et al. 2010b). Note that an increase in the concentrations of herbicides detected, which translates to an increase in PSII-HEq, can subsequently result in a decline in Index category (for e.g. Category 5 to Category 4).

Table 7 PSII-Herbicide Equivalent Index developed as an indicator for reporting of PSII herbicides across the Reef Rescue Marine Monitoring Program

Category	Concentration ($ng.L^{-1}$)	Description
5	PSII-HEq ≤ 10	No published scientific papers that demonstrate any effects on plants or animals based on toxicity or a reduction in photosynthesis. The upper limit of this category is also the detection limit for pesticide concentrations determined in field collected water samples
4	10 < PSII-HEq ≤ 50	Published scientific observations of reduced photosynthesis for two diatoms.
3	50 < PSII-HEq < 250	Published scientific observations of reduced photosynthesis for two seagrass species and three diatoms.
2	250 ≤ PSII-HEq ≤ 900	Published scientific observations of reduced photosynthesis for three coral species.
1	PSII-HEq > 900	Published scientific papers that demonstrate effects on the growth and death of aquatic plants and animals exposed to the pesticide. This concentration represents a level at which 99 per cent of tropical marine plants and animals are protected, using diuron as the reference chemical.

For categories 2 – 4:

- The published scientific papers indicate that this reduction in photosynthesis is reversible when the organism is no longer exposed to the pesticide;
- Detecting a pesticide at these concentrations does not necessarily mean that there will be an ecological effect on the plants and animals present;
- These categories have been included as they indicate an additional level of stress that plants and animals may be exposed to in the Marine Park. In combination with a range of other stressors (e.g. sediment, temperature, salinity, pH, storm damage, and elevated nutrient concentrations) the ability of these plant and animal species to recover from impacts may be reduced.

Classifying the data generated in this MMP into Index categories provides an indication of the additive effects of PSII herbicides on plants, animals or algae, based on the concentrations and relative potencies of the individual herbicides detected. The Index can quickly indicate the extent of PSII inhibition encountered at a given site (and its potential consequences), and a rapid indication of the duration (i.e. length of deployment periods) and/or frequency that a site is exposed to elevated levels of PSII herbicides.

4 RESULTS

4.1 GBR-wide Summary 2012 -2013

Similarly to the previous wet season, 2012-2013 was not subject to the severity of weather events and extreme flooding seen in 2010-2011. Table 8 shows the comparison between the long-term median discharge from major rivers in the four NRM regions, and the total discharge for the current monitoring year. Long-term median discharge figures were provided by Shaffelke et al (2011). Historical annual discharge of major rivers influencing routine monitoring sites are provided in Appendix C, Table 22.

The ratio of freshwater discharge in 2012-2013 to the long-term median ranged from 0.5 – 3.1 (Table 8), compared to 1.0 – 3.0 in the previous monitoring year (Bentley et al, 2012). Notably, the major rivers from the Mackay Whitsunday region south, had the three greatest flows of 2.2 – 3.1 times the long-term median discharge .

Table 8 Comparison of long-term median flows in major rivers with total discharge of 2012-2013

NRM Region	River	Long-term median discharge (ML)	Total Discharge 2012-2013 (ML)	Ratio to long-term median discharge
Wet Tropics	Daintree	727,872	694,048	1.0
	Barron	604,729	297,555	0.5
	Russell-Mulgrave	1,944,726	1,455,801	0.7
	North Johnstone	1,746,102	1,478,171	0.8
	South Johnstone	820,304	584,344	0.7
	Tully	3,056,169	2,334,035	0.8
	Herbert	3,067,947	2,775,345	0.9
Burdekin	Burdekin	5,982,681	3,417,924	0.6
Mackay Whitsunday	Proserpine	17,140	37,411	2.2
	O'Connell	205,286	109,094	0.5
	Pioneer	355,228	912,117	2.6
Fitzroy	Fitzroy	2,754,600	8,532,353	3.1

*River discharge data compiled by Michelle Devlin. (Data Source Department of Environment and Resource Management, Stream Gauging Network). Long-term median flow data was determined from the commencement of river monitoring up to the year 2000. Long-term median water year is from October 1st to September 30th the following year.

The flow graphs of the major rivers located close to routine monitoring sites within the four NRM regions are presented in Appendix F, Figures 28 - 32. The PSII-HEq concentrations detected using passive samplers are presented in relation to these flow events. The difference in the number and intensity of flow peaks between the current and previous monitoring years (2010 – 2011, which experienced flooding and extreme weather) is clearly observed. Despite these lower flow peaks, the PSII-HEqs of deployed samplers exceeded the previous monitoring year (2011-2012) at most sites (excluding Low Isles, Pioneer Bay and Fitzroy Island). Typically, periods of high river flow coincided with increased PSII-HEq concentrations.

Tebuthiuron was the only herbicide with an individual Guideline to assess against which exceeded its Guideline value in routine passive sampling (57 ng.L^{-1} at North Keppel Island in the Fitzroy region). This is only the second Guideline exceedance recorded since monitoring commenced, with the previous exceedance also being tebuthiruon at North Keppel Island (20 ng.L^{-1}) in 2010-2011. The PSII herbicides detected at inshore reef locations in the current monitoring year were ametryn, atrazine, bromacil (detected twice only), desethyl atrazine, desisopropyl atrazine, diuron, hexazinone, prometryn, simazine and tebuthiuron. The most frequently detected and highest concentration herbicides in this current monitoring year were diuron (maximum concentration of 203 ng.L^{-1} at Sarina Inlet in the Mackay Whitsunday region), atrazine (maximum concentration of 32 ng.L^{-1} at Sarina Inlet) and hexazinone (maximum concentration of 52 ng.L^{-1} at Sarina Inlet). Metolachlor was also detected with a high frequency in this current monitoring year, albeit at relatively low concentrations (maximum concentration 2.4 ng.L^{-1}).

Notably, despite the lack of large flow events in the major rivers when compared to previous monitoring years, several herbicides (ametryn, desethyl atrazine and simazine) were detected with greater frequency (although at relatively low concentrations) in all regions. The maximum concentrations of each individual herbicide measured in EDs at routine sites from the commencement of sampling to the current monitoring year are presented in Figure 5. The ranges of concentrations of individual herbicides detected at each site, and the proportion of sampling periods that the herbicide was detected (% detects), are summarised in Appendix G, Tables 23 - 35.

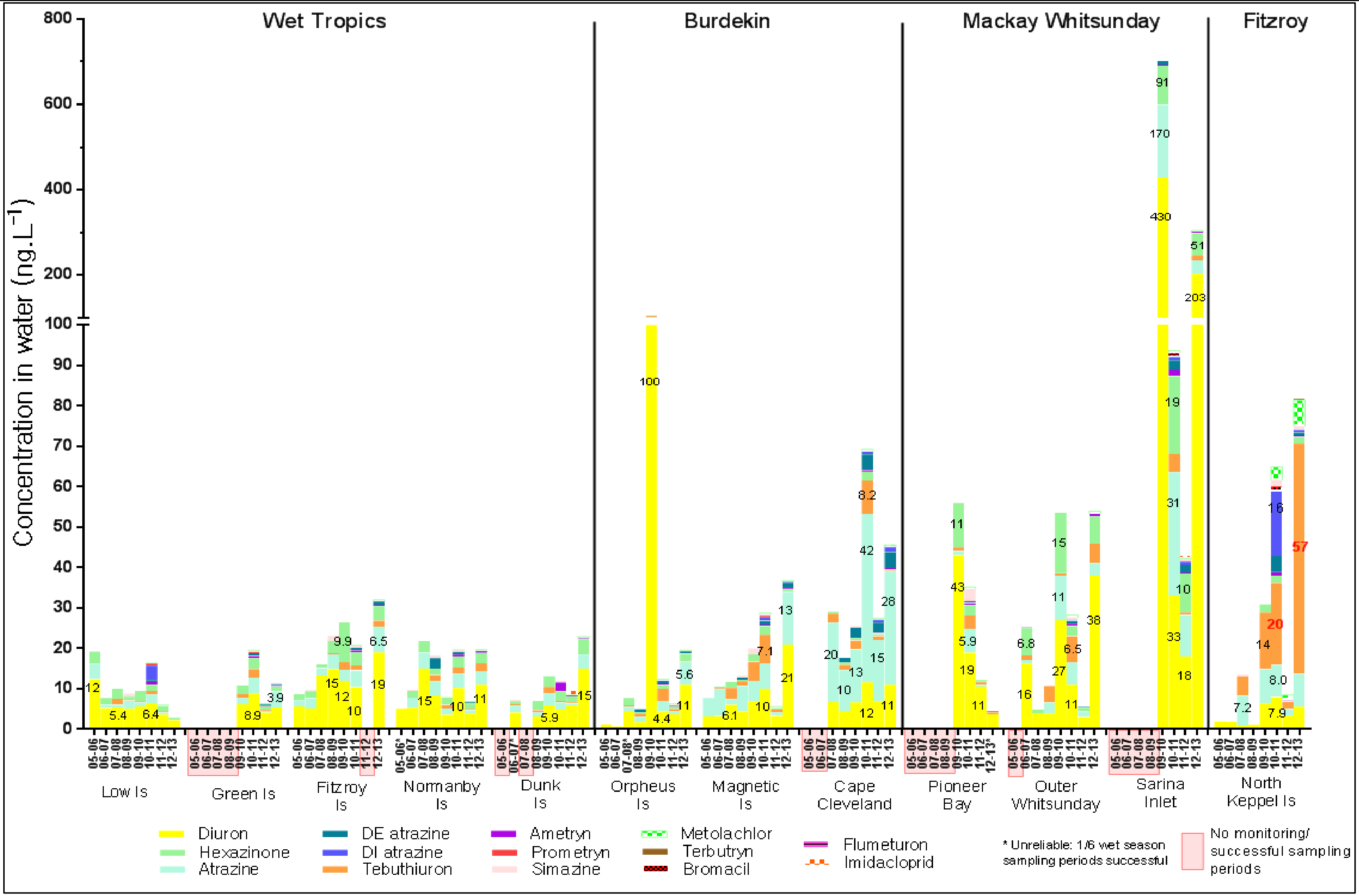

Figure 5 Maximum concentrations of each individual herbicide at routine monitoring sites from the commencement of sampling to 2012-2013

There was a clear increase in the maximum concentrations of herbicides detected at nine of the twelve routine monitoring sites (with the exception of Low Isles, Fitzroy Island and Pioneer Bay) when compared to the previous monitoring year (Figure 5). The greatest increases were observed in the Mackay Whitsundays and Fitzroy regions. When compared to the year in which monitoring commenced at each site, the majority of sites show an increase in the maximum concentrations of herbicides (with the exceptions of the Low Isles and Green Island which show either a decrease or no real change, and Pioneer Bay in which only one sampling period was successful, and results are therefore unreliable) (refer to Figure 5).

Figure 6 presents the PSII-HEq Max values for each site since monitoring commenced until 2012-2013. Since monitoring commenced, 33 % of PSII-HEq Max values in the Wet Tropics were Category 4. When compared to the previous monitoring year, atrazine and diuron were detected in greater abundance in the Wet Tropics, by average factors of 8.4 and 2.2 respectively (excluding Fitzroy Island). The frequency of detection of ametryn, desethyl atrazine and simazine have also increased (although concentrations remain low) by an average factor of 2 when compared to the previous monitoring year (Bentley et al, 2012).

Since monitoring commenced in the Burdekin region, 32 % of PSII-HEq Max values were Category 4 on the PSII-HEq Index with a single instance of a Category 3. Increases in the maximum concentrations of herbicides were detected at all sites, with the most significant increase observed at Magnetic Island. Similarly to the Wet Tropics, the abundance of atrazine and diuron increased when compared to the previous monitoring year by average factors of 7.7 and 3.7 respectively. The frequency of detection of ametryn and desethyl atrazine also increased approximately two-fold to 100 % and 84 % of samplers respectively. For the previous three years, Cape Cleveland has had the highest maximum concentration of herbicides in this region.

Since monitoring commenced, 60 % of PSII-HEq Max values in the Mackay Whitsunday region were classified as Category 4, with a further 13 % categorized as either Category 2 or 3. Prior to this year, all sites in this region showed the most significant decreases in herbicide concentrations (most notably diuron) between 2009 - 2012. Sarina Inlet remains the most 'at risk' site with the most frequent detections of herbicides (ametryn, atrazine, desethyl atrazine, diuron, hexazinone, simazine and tebuthiuron detected in 100 % of samplers) and the highest PSII-HEq Max (234 $ng.L^{-1}$) of all routine monitoring sites.

Since monitoring commenced, 29 % of PSII-HEq Max values at North Keppel Island were Category 4 on the PSII-HEq Index. The most noticeable change in the herbicide concentration profile occurred at this site, when compared to the previous monitoring year with large increases in the concentrations of metolachlor (factor of 7.1) and tebuthiuron (factor of 30) observed. Tebuthiuron was detected at levels which exceeded the Guideline values by almost three times (Figure 5). Ametryn, desethyl atrazine and simazine were detected in greater frequency (average factor of 2.1) in this monitoring year compared to the previous year, with ametryn, atrazine, desethyl atrazine, diuron, simazine and tebuthiuron detected in 100 % of samplers.

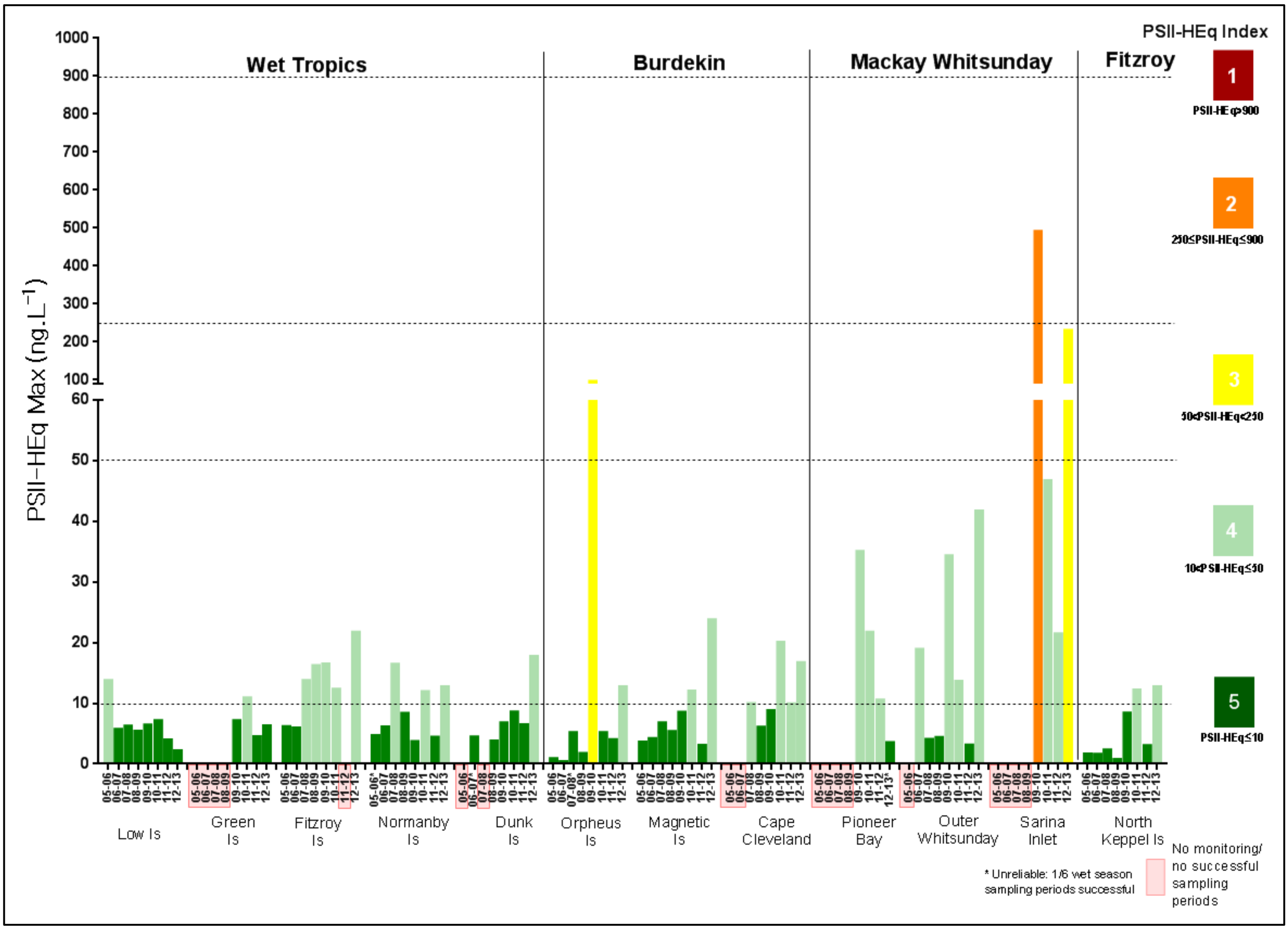

Figure 6 PSII-HEq Max at each site since monitoring commenced to 2012-2013

In 2012-2013, the PSII-HEq Max for the regions ranged from 2.5 – 22 $ng.L^{-1}$ in the Wet Tropics, 13 – 24 $ng.L^{-1}$ in the Burdekin Region, 42 – 234 $ng.L^{-1}$ in the Mackay Whitsunday (excluding Pioneer Bay) and was 13 $ng.L^{-1}$ in the Fitzroy region. These values indicate maximum PSII-HEq Index Categories of 4 or 5 for the Wet Tropics, Burdekin and Fitzroy regions, and Category 3 and 4 in the Mackay Whitsunday region. The majority of sites in all regions showed a significant increase in PSII-HEq Max compared to the previous monitoring year, with the increase the most apparent in the Mackay Whitsunday region. In this current monitoring year, Sarina Inlet in the Mackay Whitsunday region, for the fourth consecutive year had the highest PSII-HEq Max of 234 $ng.L^{-1}$. Five sites had PSII-HEq Max values that were the highest since monitoring commenced.

Grab sampling assessing terrestrial run-off was conducted in four NRM regions – Cape York, Wet Tropics, Burdekin and Fitzroy regions. Sampling was undertaken on transects extending from eight major rivers in these regions – the Normanby River (Cape York), the Barron, Russell-Mulgrave and Tully Rivers (Wet Tropics), the Herbert and Burdekin Rivers (Burdekin) and the Mary River (Fitzroy). Further details for the grab samples including date and time of collection, co-ordinates and results for individual herbicides detected are provided in Appendix E, Tables 36.

4.2 Cape York region

4.2.1 Normanby River transect

Twelve grab samples were collected from the 30th of January 2013 to the 1st of February 2013, between 3 to 5 days after a flow event in the Normanby River. No herbicides were found at detectable levels in any samples, indicating a Category 5 risk of exposure on the PSII-HEq Index. Figure 7 shows the timing of the grab samples collected and the PSII-HEq Index Category indicated of each sample in relation to the mean daily flow of the Normanby River. Passive sampling and grab sampling conducted in this region in previous years have also indicated a Category 5 on the PSII-HEq Index.

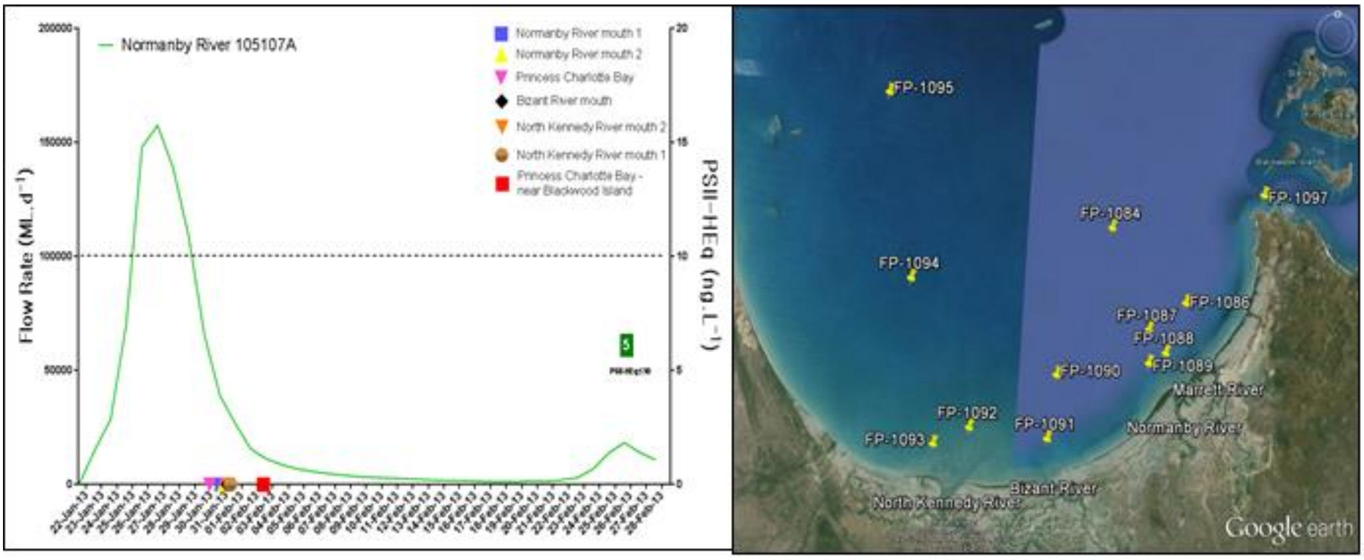

Figure 7 Timing and location of grab samples taken on the Normanby River transect, Cape York, during 2012-2013

4.3 Wet Tropics Region

4.3.1 Routine monitoring sites

The Wet Tropics region encompasses 8 catchment areas, covering approximately 2.2 million hectares (ABS, 2013). Approximately 44 % of land is set aside as conservation and natural environment areas, however beef cattle grazing (30 % of total land use) and sugar cane (7% of total land use) are the primary agricultural activities (DSITIA, 2012b). Routine sampling sites in the Wet Tropics region in 2012-2013 were at Low Isles, Green Island, Fitzroy Island, Normanby Island and Dunk Island (Figure 8). Low Isles, Fitzroy Island and Normanby Island have been monitored since 2005 while Dunk Island has been monitored routinely since 2008 (once in 2007) and Green Island since 2009. Due to various staffing and weather issues, Fitzroy Island had only two successful deployments in the wet season and one in the dry season, and Low isles had only two sucessful wet season deployments and one in the dry season.

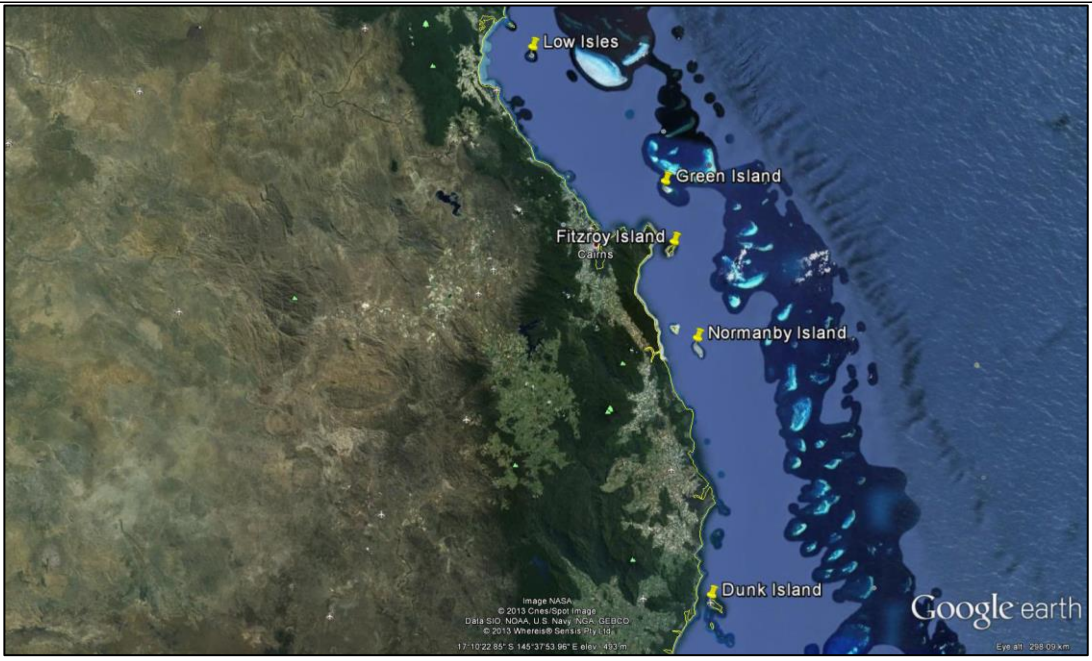

Figure 8 Location of routine monitoring sites in the Wet Tropics region

The historical concentrations of individual herbicides detected at these sites are indicated in Appendix G, Figures 33 - 37. Results for this region in 2012-2013, typically showed that concentrations of PSII herbicides either met or exceeded concentrations detected in the previous monitoring year (with the exception of Low Isles). Concentrations of herbicides increased despite flows of major rivers below the long-term median. The PSII-HEq concentrations detected at each site in relation to the flow of the nearest influencing river are presented in Appendix F, Figure 28 –29.

PSII herbicides (and transformation products) detected in the Wet Tropics region in 2012-2013 using EDs include ametryn, atrazine, desethyl atrazine, desisopropyl atrazine, diuron, hexazinone, simazine, prometryn and tebuthiuron. The range and frequency of the detected PSII-HEq concentrations for each routine site in this region are provided in Appendix D, Table 23 - 27. The most frequently detected PSII herbicides in the Wet Tropics were (from highest to lowest) diuron (detected in 100 % of samplers; maximum concentration 19 ng.L^{-1} at Fitzroy Island), hexazinone (detected in 98 % of samplers; 3.8 ng.L^{-1} at Dunk Island) and atrazine (detected in 98 % of samplers; 6.5 ng.L^{-1} at Fitzroy Island). Metolachlor and imidacloprid were also frequently detected in EDs at all sites at low concentrations (<2.0 ng.L^{-1}). When compared to the previous monitoring year, ametryn, desethyl atrazine and simazine were detected with almost double the frequency (increasing to 95 %, 52 % and 70 % of samplers).

Table 9 Summary statistics for the PSII-HEq Max and Wet Season Average (ng.L^{-1}) since the commencement of monitoring until 2012-2013 in the Wet Tropics.

		PSII-HEq									
Site		**2012-13**	**2011-12**	**2010-11**	**2009-10**	**2008-09**	**2007-08**	**2006-07**	**2005-06**	**Ratio to previous monitoring year**	**Ratio to Year sampling commenced[a]**
Low Isles	Wet Avg	1.6	2.1	4.4	1.9	2.1	3.9	2.5	5.6	**0.76**	**0.29**
	Max	**2.5**	**4.2**	**7.4**	**6.7**	**5.7**	**6.6**	**6.0**	**14**	**0.59**	**0.18**
Green Island	Wet Avg	3.9	1.9	5.7	1.7	-	-	-	-	**2.0**	**2.3**
	Max	**6.6**	**4.8**	**11**	**7.4**	-	-	-	-	**1.4**	**0.89**
Fitzroy Island	Wet Avg	16	-	8.8	5.1	5.7	5.3	2.6	3.3	**-**	**4.7**
	Max	**22**	-	**13**	**17**	**16**	**14**	**6**	**7**	**-**	**3.4**
Normanby Island	Wet Avg	5.3	1.8	6.2	1.9	2.6	10.6	3.7	*5.0*	**2.9**	**1.1**
	Max	**13**	**4.7**	**12**	**4.0**	**8.6**	**17**	**6.4**	***5.0***	**2.8**	**2.6**
Dunk Island	Wet Avg	8.9	3.4	8.8	4.4	3.0	-	*4.7*	-	**2.6**	**3.0**
	Max	**18**	**6.8**	**8.8**	**7.1**	**4.1**	-	***4.7***	-	**2.7**	**4.4**

Wet Avg are the averages indicated for PSII-HEq for the wet season sampling periods only. [a] The ratio of PSII-HEq Wet Avg and PSII-HEq Max in the current year with respect to the year sampling commenced was 2005, except at Green Island which was only monitored from 2009-2010, and Dunk Island 2008-2009. Block colours indicate the maximum PSII-Heq Index category for that year. Values in italics indicate a single measurement for that year

Table 9 presents the PSII-HEq Max and Wet Avg values since monitoring commenced at each site. PSII-HEq Max values at Green Island, Dunk Island and Normanby Island increased between 1.4 and 2.7 times when compared to the previous monitoring year. Since monitoring commenced, the PSII-HEq Max values at Fitzroy Island, Normanby Island and Dunk Island have increased by factors of 2.6 (Normanby Island) to 4.4 (Dunk Island). The PSII-HEq Max values in 2012-2013 ranged from Category 4 - 5 on the PSII-HEq Index. Grab sampling conducted as part of the terrestrial run-off assessment (flood plume sampling) at various rivers detected a wide range of concentrations from no detections (Category 5) to 160 ng.L^{-1} (Category 3) on the Tully River transect.

Seasonal average PSII-HEq values are indicated for each routine site in the Wet Tropics region across all monitoring years in Figure 9. Average wet season PSII-HEqs have increased at three sites by factors ranging from 2.0 at Green Island to 2.9 at Normanby Island, when compared to the previous reporting year (Table 9) (Fitzroy Island is excluded as no sampling occurred in 2011-2012). Since monitoring commenced, Wet Avg values have increased at all sites (except the Low Isles) by a factor of 1.1 (Normanby Island) to 3.0 (Dunk Island).

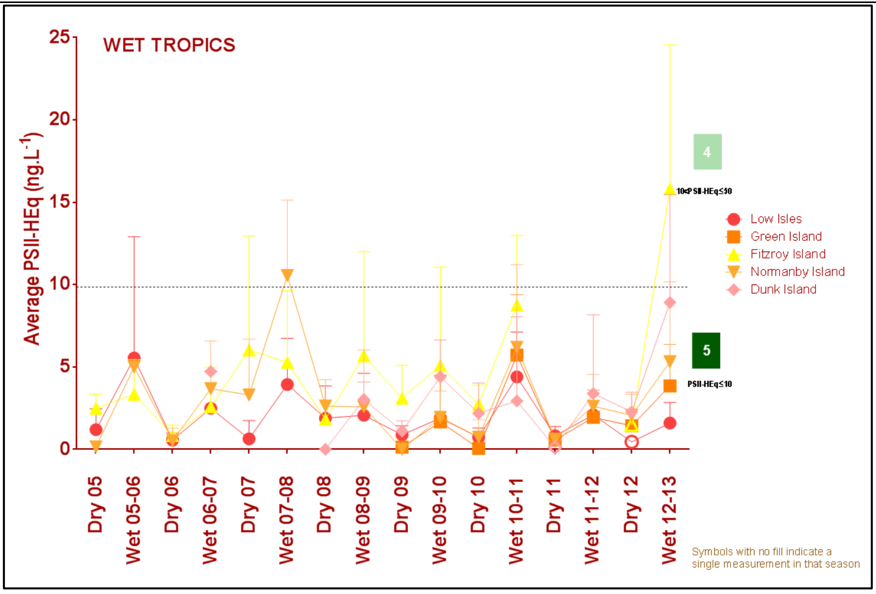

Figure 9 Seasonal average PSII-HEq for Wet Tropics sites since routine monitoring commenced

Other non PSII herbicides imidacloprid, imazapic, terbutryn and metolachlor were also analysed. Imidacloprid was also routinely analysed in grab samples collected from transects, but was only detected once at Tully mid at a concentration of 20 ng.L^{-1}.

Pesticide results obtained using PDMS samplers in the region are summarised in Appendix D, Table 23 – 27 with metolachlor (detected once at Dunk Island) and the polycyclic musk galaxolide (Green Island, Fitzroy Island and Normanby Island) detected. The metolachlor results represent equilibrium concentration estimates and are typically higher than the time-averaged estimates obtained using EDs. No pesticides or herbicides exceeded the GBRMPA Guidelines (GBRMPA 2010) at any of the Wet Tropics sites.

4.3.2 Barron and Russell-Mulgrave River transect

Single grab samples were collected from both the Barron River and Russell-Mulgrave River mouths on the 3rd of February 2013. Figure 10 shows the location and timing of the grab samples collected and the PSII-HEq Index Category indicated of each sample in relation to the mean daily flow. No herbicides were detected in either sample, indicating a Category 5 on the PSII-HEq Index.

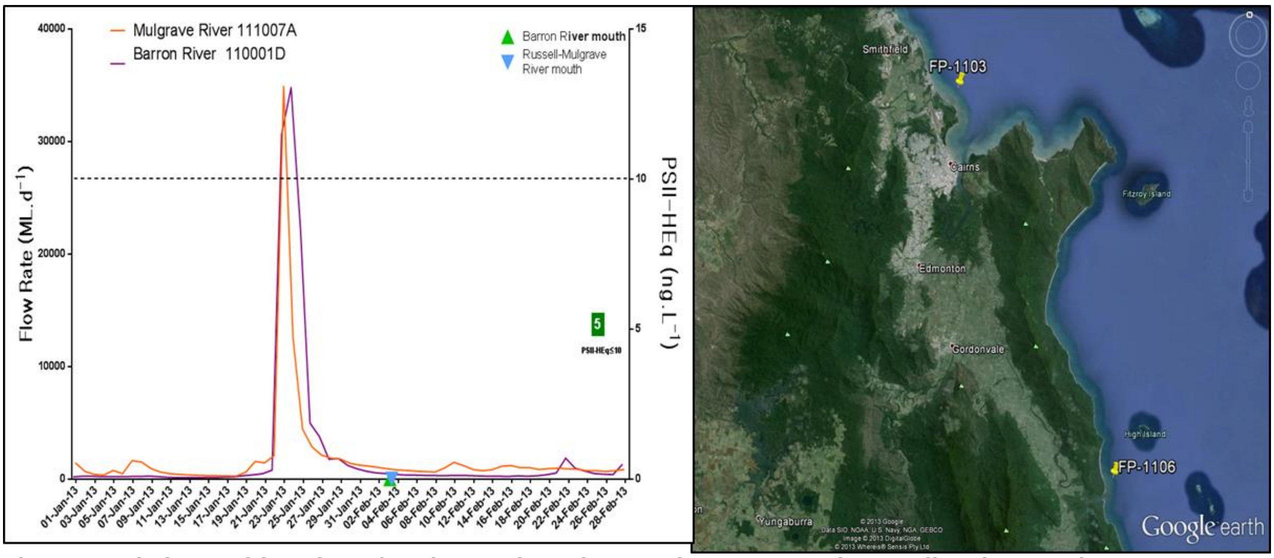

Figure 10 Timing and location of grab samples taken on the Barron and Russell-Mulgrave River transects, Wet Tropics, during 2012-2013

4.3.3 Tully River transect

A total of four grab samples were collected at four sites (Tully River mouth, Bedarra Island, Sisters Island south and Tully mid) on a transect which extended up to 30 km from the Tully River mouth between 11 November 2012 and 27 January 2013. Figure 11 shows the timing of grab samples collected and the PSII-HEq Index Category indicated of each sample in relation to the mean daily flow of the Tully and Herbert Rivers. PSII herbicides were detected in only a single sample (collected at the Tully mid site) with atrazine (31 ng.L^{-1}), diuron (140 ng.L^{-1}) and hexazinone (41 ng.L^{-1}) detected. The concentration of diuron detected at this site was the greatest of all grab samples collected in the terrestrial run-off component and indicated a Category 3 on the PSII-HEq Index.

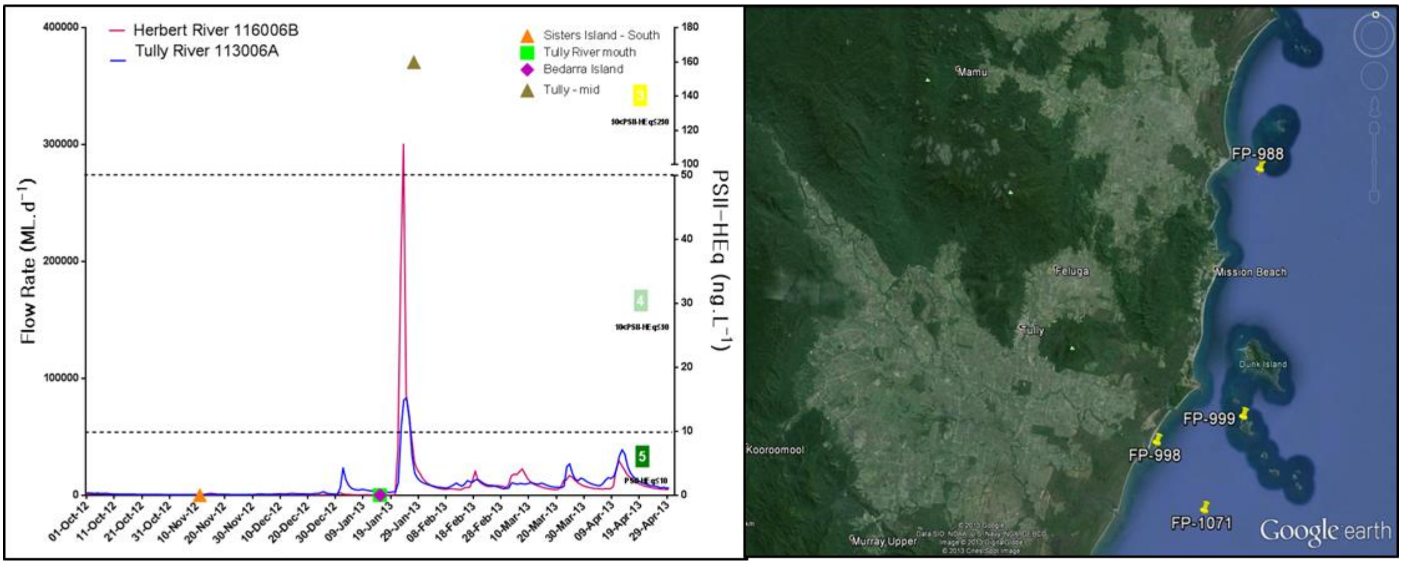

Figure 11 Timing and location of grab samples taken on the Tully River transect, Wet Tropics, during 2012-2013

4.3.4 Dickson Inlet Case Study

The Port Douglas area is part of the Mossman River catchment, the smallest of the GBR catchments. The predominant land use of the catchment is for natural parks and state forests, with only 8% of the area used for agricultural activities (primarily sugarcane farming) (ABS, 2013).The Douglas Local Marine Advisory Committee has been undertaking monitoring (freshwater grab sampling) in the catchments of Port Douglas (specifically Dickson Inlet) for several years, following concerns of fish declines and fish kills in the area. Diuron and benomyl have been detected in low concentrations at one of the town's urban stormwater outlets. As a small case study to contribute to the knowledge of transport of herbicides in small catchments in the GBR, passive samplers were placed in Crees Creek upstream of Port Douglas in the freshwater reaches of Dickson Inlet and in the marine section of Dickson Inlet (Figure 12).

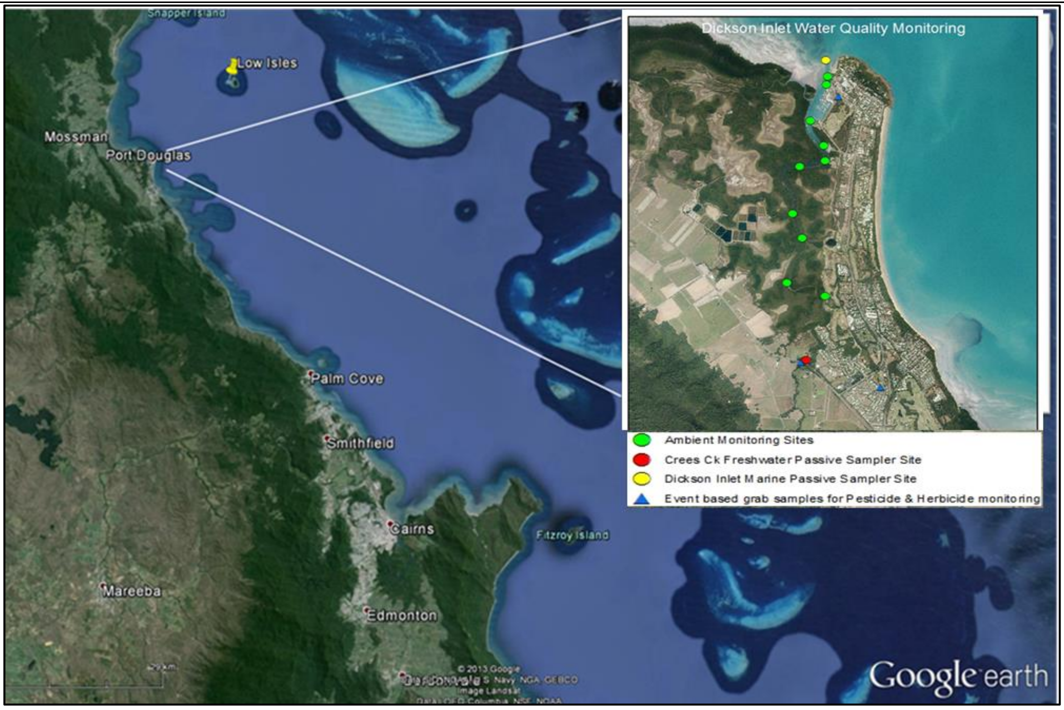

Figure 12 Location of passive samplers deployed for the Dickson Inlet case study

The aim of the case study was to collect herbicide presence/absence information and event-based concentrations of herbicides and pesticides during the first flush event during the wet season, in the middle of the wet season and towards the end of the wet season. The addition of a passive sampler at the mouth of the inlet was expected to provide some correlation with data that has been collected at the routine monitoring site at Low Isles. Both polar (ED) and non-polar (PDMS) were deployed at both locations. Table 10 outlines the locations and duration of deployment periods.

Table 10 Location and timing of Dickson Inlet passive samplers

Location	Deployment Period	Days Deployed
Dickson Inlet	21 Dec 2012 – 11 Jan 2013	21
	27 Feb 2013 – 2 Apr 2013	34
Crees Creek	27 Feb 2013 – 2 Apr 2013	34

Figure 13 presents the concentrations of PSII herbicides detected. Individual concentrations of herbicides and pesticides detected are in Appendix D, Table 28.

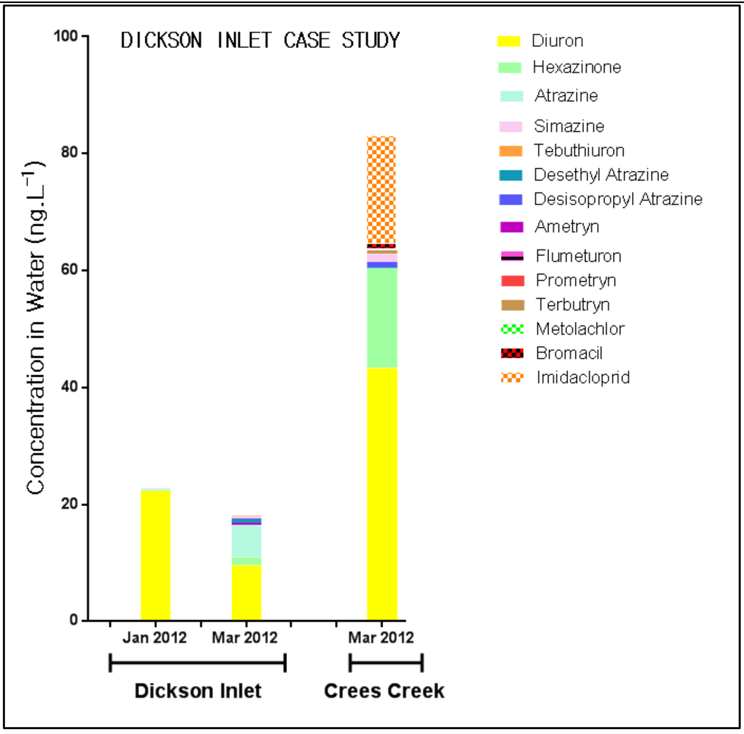

Figure 13 Concentrations of PSII herbicides detected at Dickson Inlet sites (ng.L^{-1})

PSII herbicides (and transformation products) detected in the Dickson Inlet area using EDs include ametryn, atrazine, desethyl atrazine, desisopropyl atrazine, diuron, hexazinone, simazine, prometryn, and tebuthiuron. Non PSII herbicides also detected were bromacil and terbutryn (both single detections), metolachlor and imidacloprid. Diuron was detected in all three deployment periods ranging from 9.5 to a maximum of 43 ng.L^{-1} at Crees Creek. Simazine, hexazinone and imidacloprid all reached their maximum concentrations (2.8, 17 and 18 ng.L^{-1} respectively) at the Crees Creek location. The PSII-HEq concentrations of all three deployment periods were Category 4 on the PSII Index, reaching a maximum of 49.7 ng.L^{-1} at the Crees Creek location, which is bordering on Category 3.

Pesticide results obtained using PDMS samplers are summarised in Appendix D, Table 23 – 27 with the polycyclic musk galaxolide and the insecticide pendimethalin both detected once at the Dickson Inlet site. No pesticides or herbicides exceeded the GBRMPA Guidelines (GBRMPA 2010) during any of the deployments.

4.4 Burdekin Region

4.4.1 Routine monitoring sites

The Burdekin region spans five catchments and covers 14 million hectares, of which 90 % is used for agricultural purposes, with grazing primarily inland and some sugar cane and horticulture along the coast (ABS, 2013; DSITIA, 2012c). Routine sampling sites in the Burdekin region in 2012-2013 were Orpheus Island, Magnetic Island and Cape Cleveland (Figure 14). Orpheus and Magnetic Island have been monitored since 2005, while Cape Cleveland has been monitored since 2007. The historical concentrations of individual PSII herbicides and other non-PSII indexed herbicides at these sites are indicated in Appendix G, Figure 38 - 40. All three sites have an excellent sampling record in 2012-2013 with only one over-deployment at Orpheus Island.

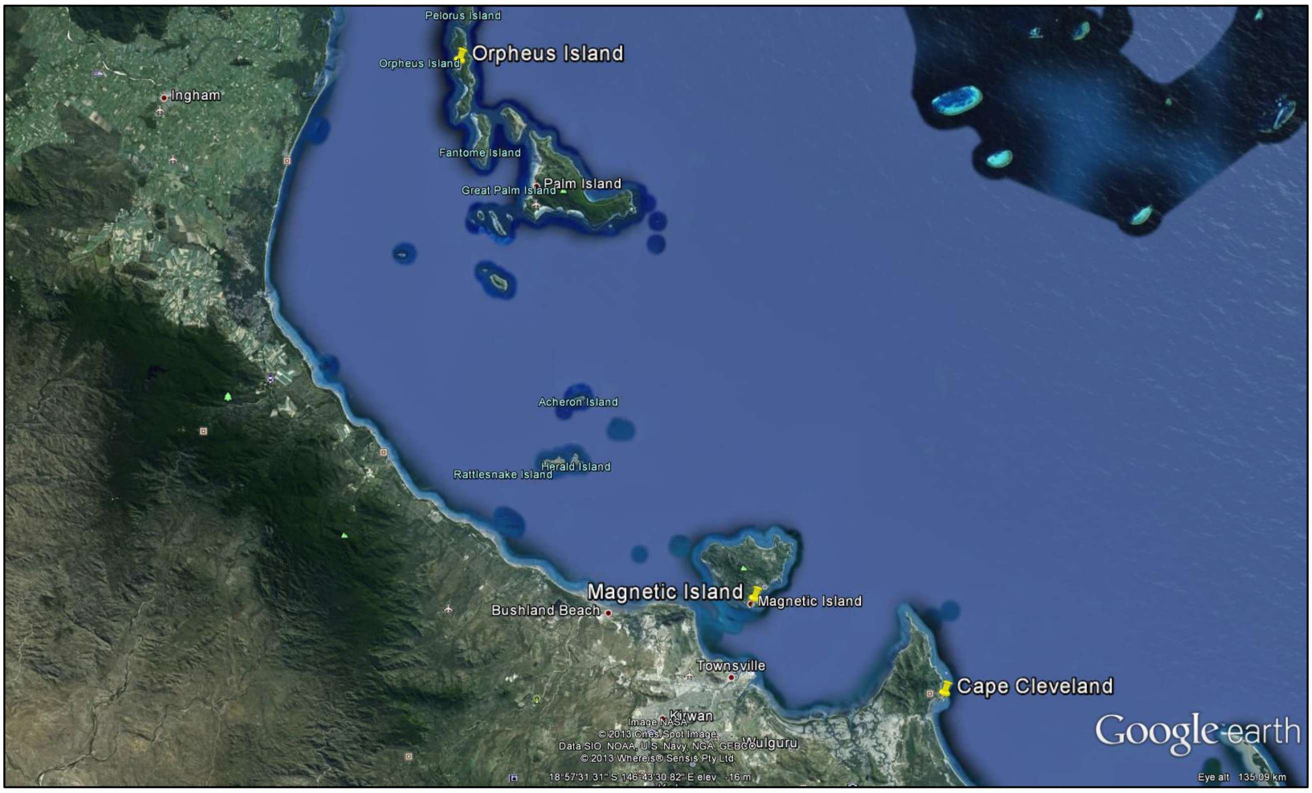

Figure 14 Location of routine monitoring sites in the Burdekin region

PSII herbicides (and transformation products) detected at routine sites in this region include ametryn, atrazine, desethyl atrazine, desisopropyl atrazine, diuron, hexazinone, simazine and tebuthiruon. The non PSII herbicide metolachlor was frequently detected at all sites and bromacil, terbutryn and imidacloprid were detected in a single sample each. The range and frequency of the detected PSII herbicide concentrations for each routine site in this region are provided in Appendix D, Table 27 -29.

The most frequently detected PSII herbicides in this region were atrazine (100 % detection; maximum concentration 28 ng.L^{-1} at Cape Cleveland), diuron (detected in 100 % of samplers; maximum concentration 21 ng.L^{-1} at Magnetic Island), tebuthiuron (detected in 100 % of samplers; maximum concentration 3.7 ng.L^{-1}) and ametryn (detected in 100 % of samplers; maximum concentration 0.53 ng.L^{-1}). Atrazine and atrazine breakdown products typically dominate the herbicide profile at Magnetic Island and Cape Cleveland, rather than diuron.

Table 11 presents the PSII-HEq Max and Wet Avg values since monitoring commenced at each site. The PSII-HEq Max values increased at all sites when compared to the previous monitoring year (factors of 1.7 to 7.1 at Cape Cleveland and Magnetic Island respectively) and also since monitoring commenced (factors of 1.7 to 11 at Cape Cleveland and Orpheus Island respectively). The PSII-HEq Max values in 2012-2013 ranged from Category 4 - 5 on the PSII-HEq Index. Cape Cleveland has the highest maximum concentrations of each of the dominant herbicides in this region however Magnetic Island had the highest PSII-HEq maximum for the region (PSII-HEq Max 24 ng.L^{-1}) due to a higher proportion of diuron detected.

Table 11 Summary statistics for the PSII-HEq Max and Wet Season Average (ng.L^{-1}) since the commencement of monitoring until 2012-2013 in the Burdekin region.

Site		PSII-HEq 2012-13	2011-12	2010-11	2009-10	2008-09	2007-08	2006-07	2005-06	Ratio to previous monitoring year	Ratio to Year sampling commenced[a]
Orpheus Island	Wet Avg	7.6	1.6	4.2	2.4	0.59	*5.4*	0.38	0.76	**4.7**	**10.0**
	Max	13	4.3	5.4	100	2	*5.4*	0.67	1.2	**3.0**	**11**
Magnetic Island	Wet Avg	11	3.0	6.8	3.4	2.3	4.2	2.2	3.9	**3.6**	**2.7**
	Max	24	3.4	12	8.8	5.6	7.1	4.5	3.9	**7.1**	**6.2**
Cape Cleveland	Wet Avg	9.5	4.4	11	3.2	2.3	6.1	-	-	**2.1**	**1.5**
	Max	17	10	20	9.1	6.3	10	-	-	**1.7**	**1.7**

Wet Avg are the averages indicated for PSII-HEq for the wet season sampling periods only [a] The ratio of PSII-HEq Wet Avg and PSII-HEq Max in the current year with respect to the year sampling commenced was 2005-2006, except for Cape Cleveland which was 2007-2008. Block colours indicate the maximum PSII-Heq Index category for that year.

Seasonal average PSII-HEq values are indicated for each routine site in the region across all monitoring years in Figure 15. Average wet season PSII-HEq increased at all sites by factors ranging from 2.1 at Cape Cleveland to 4.7 at Orpheus Island when compared to the previous monitoring year (Table 10). Since monitoring commenced, Wet Avg values have also increased significantly at Orpheus Island (factor of 10) and moderately at Magnetic Island and Cape Cleveland (2.7 and 1.5 respectively), indicating an increased risk of exposure to PSII herbicides during the wet season.

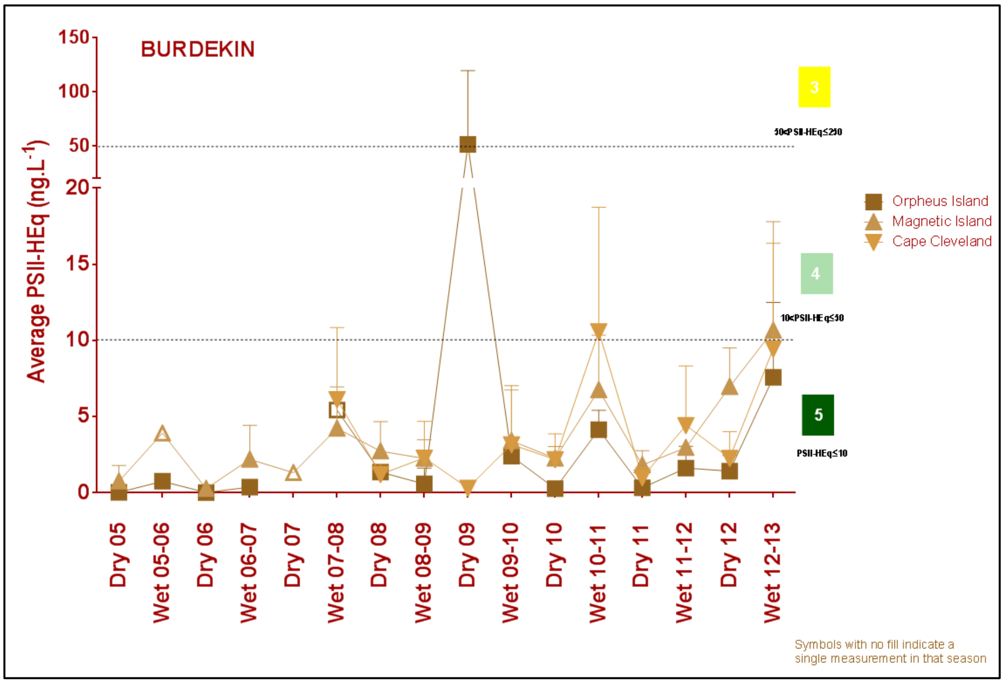

Figure 15 Seasonal average PSII-HEq for Burdekin sites since routine monitoring commenced

Metolachlor was detected using EDs at all sites including all samplers deployed at Magnetic Island, however the maximum concentration was < 1ng.L^{-1}.

Pesticide results obtained using PDMS samplers at Cape Cleveland and Magnetic Island are summarised in Appendix D, Table 29 - 31 with metolachlor the only pesticide detected at both sites. No herbicides or pesticides were detected in concentrations that met or exceeded GBRMPA Guidelines.

4.4.2 Herbert River transects

Seven grab samples were collected between 16 January 2013 and 25 March 2013 at sites located on two transects extending approximately 50 km north and 5 km south-east from the Herbert River mouth. The location and timing of the grab samples collected and the PSII-HEq Index Category indicated of each sample in relation the the mean daily flow of the Herbert River are presented in Figure 16 and 17 below.

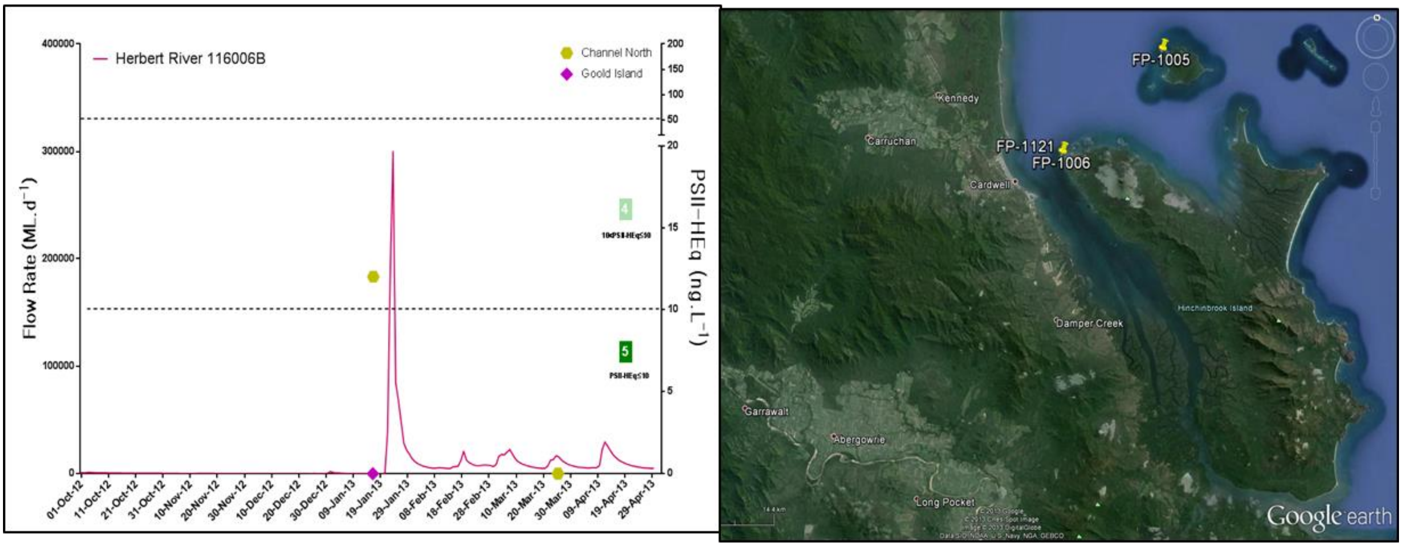

Figure 16 Timing and location of grab samples taken on the Herbert River North transect, Wet Tropics, during 2012-2013

Diuron (12 ng.L^{-1}) was the only herbicide detected on the northern transect, detected once at the Channel North site on the 16th of January 2013. A sample collected from Goold Island on the same day did not detect any herbicides, suggesting the flood plume in this instance had not extended to that site.

Diuron (15 – 33 ng.L^{-1}) was detected in all four samples collected on the southern transect on the 17th of January and 25th of March 2013. Simazine was found only in samples collected on the 17th of January 2013 at the Herbert River mouth 2 and Channel South sites. The risk of exposure to herbicides indicated from the grab samples ranged from mid Category 4 to Category 5 on the PSII-HEq Index.

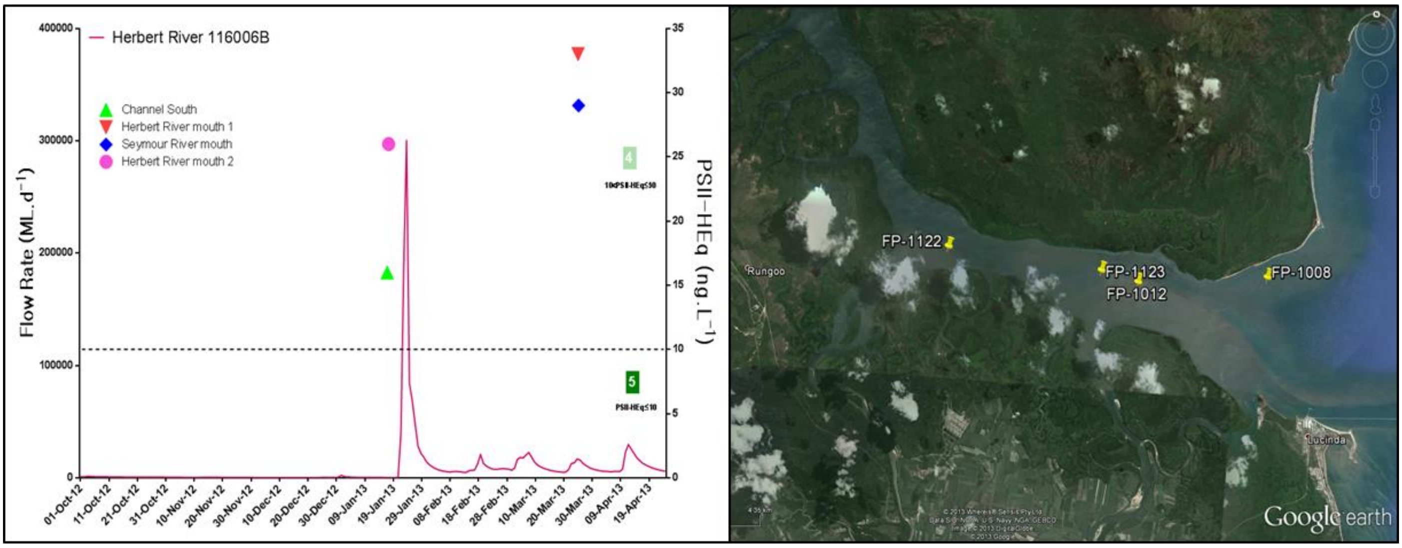

Figure 17 Timing and location of grab samples taken on the Herbert River South transect, Wet Tropics, during 2012-2013

4.4.3 Burdekin River transect

Two grab samples were collected from two sites located in the Burdekin region, 6 and 10 days after the second major event of the wet season. Figure 18 shows the timing of grab samples collected and the PSII-

HEq Index Category indicated of each sample in relation to the mean daily flow of the Burdekin River. No herbicides were detected in a grab sample collected in the Burdekin River mouth on the 13th of March 2013. A sample collected at Palm Island south detected the second highest levels of diuron in the terrestrial run-off component (82 ng.L^{-1}) as well as atrazine (28 ng.L^{-1}) and hexazinone (19 ng.L^{-1}) indicating a Category 3 on the PSII-HEq Index.

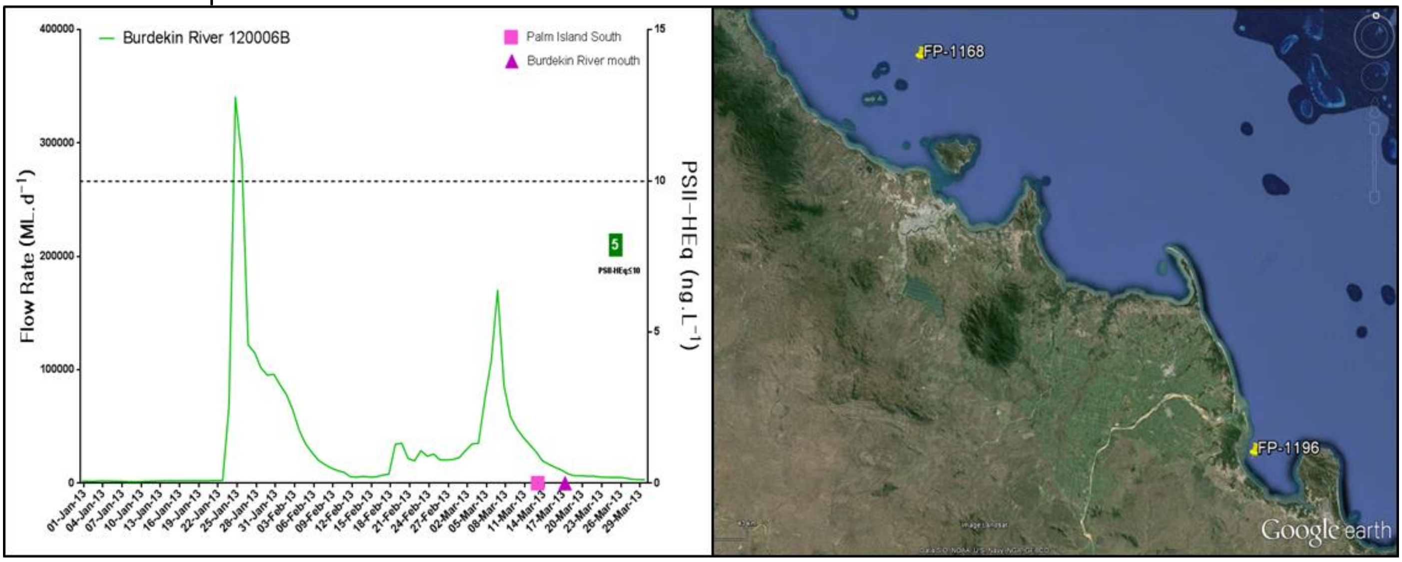

Figure 18 Timing and location of grab samples taken on the Burdekin River transect, Burdekin, during 2012-2013

4.5 Mackay Whitsunday Region

4.5.1 Routine monitoring sites

The Mackay Whitsunday region is the smallest NRM region, spanning 4 catchments at an area of approximately 900,000 hectares (ABS, 2013). This region is dominated by the sugar cane industry, with 18% of the land use (DSITIA, 2012d). Routine sampling sites in the Mackay Whitsunday region in 2012-2013 were Pioneer Bay, Outer Whitsunday (Hamilton Island) and Sarina Inlet (Figure 19). Outer Whitsunday has been monitored since 2006 while the Pioneer Bay and Sarina Inlet sites were established in 2009. The historical concentrations of individual PSII herbicides and other non-PSII indexed pesticides at these sites are indicated in Appendix G, Figure 41 - 43. Both Outer Whitsunday and Sarina Inlet had relatively successful sampling periods, with two over-deployments at each site. Unfortunately, Pioneer Bay had only a single deployment completed for this monitoring year.

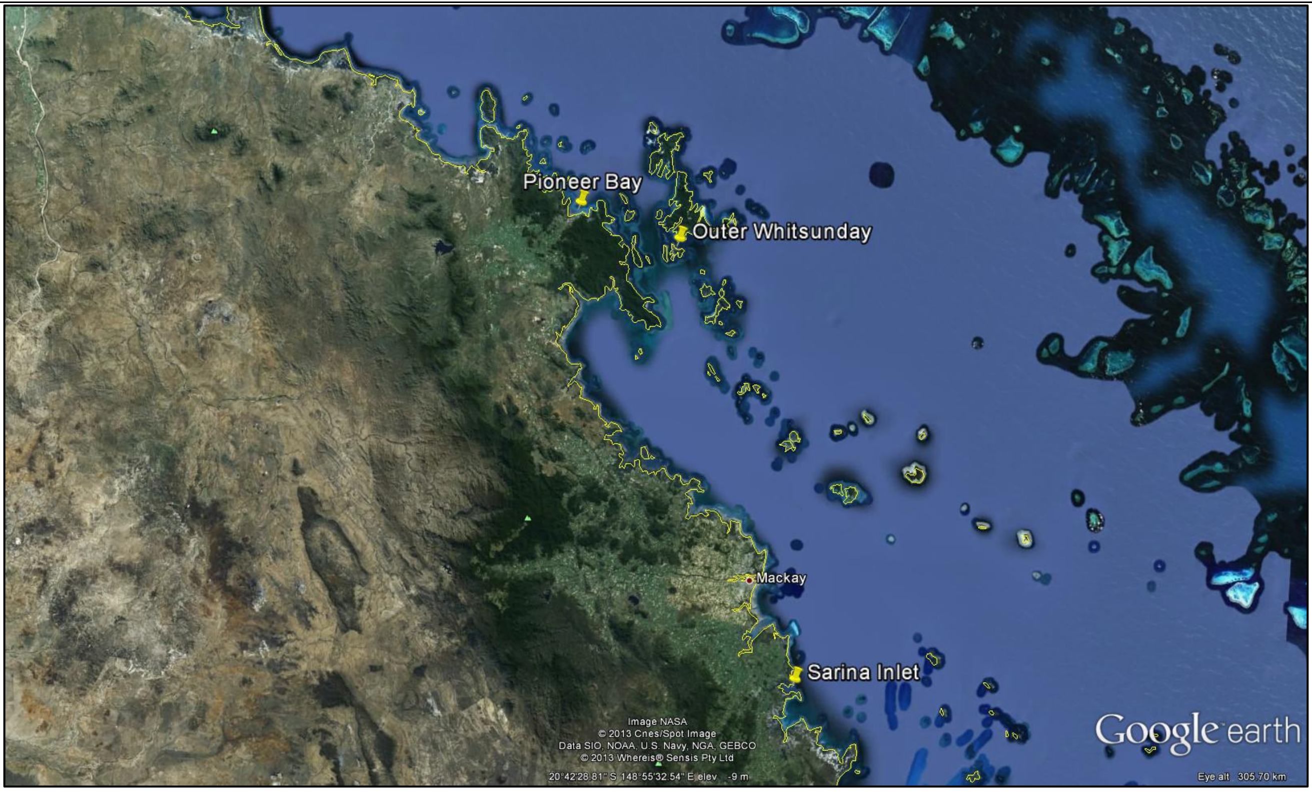

Figure 19 Location of routine monitoring sites in the Mackay Whitsunday region

PSII herbicides (and transformation products) detected at routine sites in this region include ametryn, atrazine, desethyl atrazine, desisopropyl atrazine (single detection), diuron, hexazinone, simazine, prometryn and tebuthiuron. The range and frequency of the detected PSII herbicide concentrations for each routine site in this region are provided in Appendix D, Table 32 - 34. The most abundant and frequently detected PSII herbicides in this region are diuron (detected in 100 % of samplers; maximum concentration 203 ng.L^{-1} at Sarina Inlet), atrazine (detected in 100 % of samplers; maximum concentration 32 ng.L^{-1} at Sarina Inlet) and hexazinone (detected in 100 % of samplers; maximum concentration 51 ng.L^{-1} at Sarina Inlet). The frequency of detection of ametryn, desethyl atrazine and simazine all increased approximately two-fold when compared to the previous monitoring year.

Sarina Inlet has the highest concentration of diuron of any other routine site and subsequently, it also has the highest PSII-HEq Max of 234 ng.L^{-1}, which is a high Category 3 risk of herbicide exposure on the PSII-HEq Index, and is the second highest PSII-HEq Max recorded since monitoring commenced. Table 12 presents the PSII-HEq Max and Wet Avg values since monitoring commenced at each site. The PSII-HEq Max at Outer Whitsunday (42 ng.L^{-1}) is the highest recorded for that site since monitoring commenced. The PSII-HEq Max values at both Outer Whitsunday and Sarina Inlet increased significantly (factors of 12 and 11 respectively) from the previous monitoring year. PSII-HEq comparisons are unreliable for Pioneer Bay, since only one sampling period was successful this year. Since monitoring began, the Max value has increased at Outer Whitsunday, and decreased at Sarina Inlet (despite the increase in the current monitoring year.) The Mackay Whitsunday region historically has recorded the highest PSII-HEq Max values ranging from Category 5 to Category 2.

Table 12 Summary statistics for the PSII-HEq Max and Wet Season Average (ng.L^{-1}) since the commencement of monitoring until 2012-2013 in the Mackay Whitsunday region

Site		PSII-HEq								Ratio to previous monitoring year	Ratio to Year sampling commenced[a]
		2012-13	2011-12	2010-11	2009-10	2008-09	2007-08	2006-07	2005-06		
Pioneer Bay	Wet Avg	-	7.9	12	29	-	-	-	-	**-**	**-**
	Max	*3.8*	11	22	43	-	-	-	-	**0.35**	**0.09**
Outer Whitsunday	Wet Avg	14	1.4	9.2	13	*0*	4.2	7.5	-	**10**	**1.9**
	Max	42	3.4	14	35	4.7	4.3	19	-	**12**	**2.2**
Sarina Inlet	Wet Avg	85	12	22	114	-	-	-	-	**6.9**	**0.75**
	Max	234	22	47	495	-	-	-	-	**11**	**0.47**

Wet Avg are the averages indicated for PSII-HEq for the wet season sampling periods only [a] These are the ratio of PSII-HEq Wet Avg and PSII-HEq Max in the current year with respect to the first monitoring year for Sarina Inlet and Pioneer Bay – 2009-2010, and 2006-2007 at Outer Whitsunday due to the unreliable sampling record in the baseline reporting year (08-09) Block colours indicate the maximum PSII-Heq Index category for that year

Seasonal average PSII-HEq values are indicated for each routine site in the region across all monitoring years in Figure 20. The PSII-HEq Wet Avg have increased significantly at Outer Whitsunday and Sarina Inlet (factors of 10 and 6.9 respectively), when compared to the previous monitoring year. However, since monitoring began, the Wet Avg values at Outer Whitsunday increased by a smaller degree (factor 1.9) and actually decreased at Sarina Inlet. Discharges in both the Pioneer and Proserpine Rivers in the Mackay Whitsunday region (which influence passive sampling sites) were both greater than 2 times the long-term median.

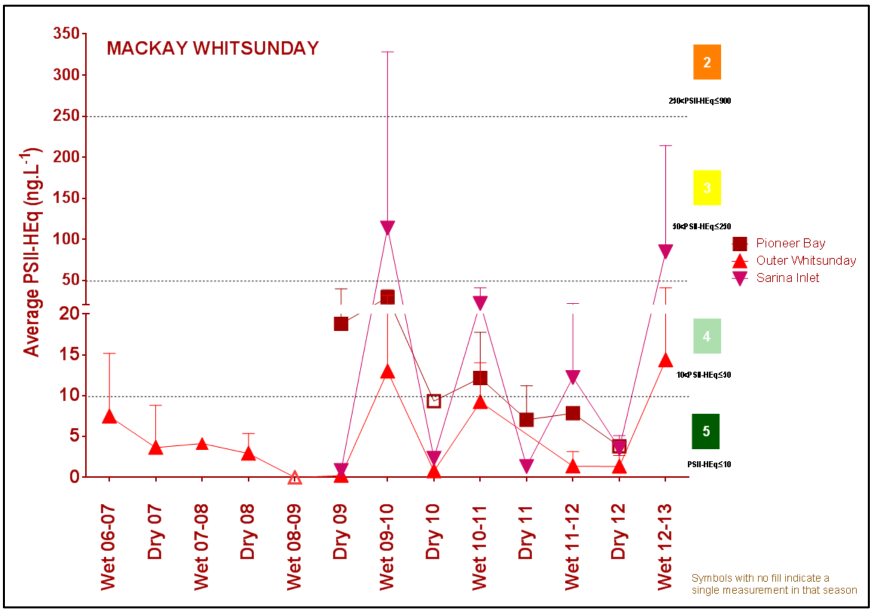

Figure 20 Seasonal average PSII-HEq for Mackay Whitsunday sites since routine monitoring commenced

Metolachlor was also detected using EDs at all sites at concentrations <1 ng.L^{-1}. Pesticide results obtained using PDMS samplers at Outer Whitsunday are summarised in Table 33, with galaxolide the only pesticide detected. There were no exceedances of GBRMPA Guidelines (GBRMPA 2010) for any herbicides detected in the Mackay Whitsunday region in 2012-2013.

4.6 Fitzroy Region

4.6.1 Routine monitoring sites

The Fitzroy region spans 6 catchments and covers an area of 15.6 million hectares (ABS, 2013). Beef cattle grazing is the most prevalent industry (78 % of the land use), with broad acre cropping (5 % of the land use) and cotton also common (DSITIA, 2012e). The only routine monitoring site in the Fitzroy region is at North Keppel Island (Figure 21). This site has been monitored since 2005 although it has had broken periods of sampling in some years. The historical concentrations of individual PSII herbicides and other non-PSII indexed pesticides at this site are indicated in Appendix G, Figure 44.

Figure 21 Location of routine monitoring sites in the Fitzroy region

PSII herbicides (and transformation products) detected at this site in 2012-2013 include ametryn, atrazine, desethyl atrazine, desisopropyl atrazine, diuron, hexazinone, simazine, prometryn, tebuthiuron and bromacil (detected once only). The PSII herbicides detected with the greatest frequency were tebuthiuron (detected in 100 % of samplers; maximum concentration 57 ng.L^{-1}), atrazine (detected in 100% of samplers; maximum concentration 8.1 ng.L^{-1}) and diuron (detected in 100 % of samplers; maximum concentration 5.6 ng.L^{-1}). Tebuthurion and atrazine typically dominate the PSII herbicide profile at this site which is similar to sites in the Burdekin region such as Cape Cleveland and Magnetic Island. The concentration range and frequency of detection for these herbicides at North Keppel Island in 2012-2013 are provided in Appendix D, Table 35. Similarly to other regions, the frequency in which ametryn, desethyl atrazine and simazine were detected increased approximately two-fold when compared to the previous monitoring year.

The PSII-HEq Max for 2012-2013 at North Keppel Island was 13 ng.L^{-1} indicating a Category 4 risk of herbicide exposure on the PSII-HEq Index. This is an increase by a factor of 3.8 when compared to the the previous monitoring year. Table 13 presents the PSII-HEq Max and Wet Avg values since monitoring commenced at each site. The Wet Avg value has also increased by a factor of 3.2 from the previous monitoring year and also since monitoring commenced.

Table 13 Summary statistics for the PSII-HEq Max and Wet Season Average (ng.L^{-1}) since the commencement of monitoring until 2012-2013 in the Fitzroy region

Site		PSII-HEq								Ratio to previous monitoring year	Ratio to Year sampling commenced[a]
		2012-13	2011-12	2010-11	2009-10	2008-09	2007-08	2006-07	2005-06		
North Keppel Island	Wet Avg	3.9	1.7	4	4.1	0.73	1.9	0.94	1.7	**2.3**	**2.3**
	Max	**13**	**3.4**	**12**	**8.7**	**1.1**	**2.6**	**1.9**	**1.9**	**3.8**	**1.5**

Wet Avg are the averages indicated for PSII-HEq for the wet season sampling periods only; In 2008-2009 North Keppel Island PSII HEq maximum was derived from 4 dry season sampling periods and 2 wet season sampling period, the average for the wet season is therefore from only two sampling periods. Block colours indicate the maximum PSII-Heq Index category for that year.

Seasonal average PSII-HEq values are indicated for North Keppel Island Figure 22. The PSII-HEq Wet Avg has been consistently Category 5 since monitoring commenced.

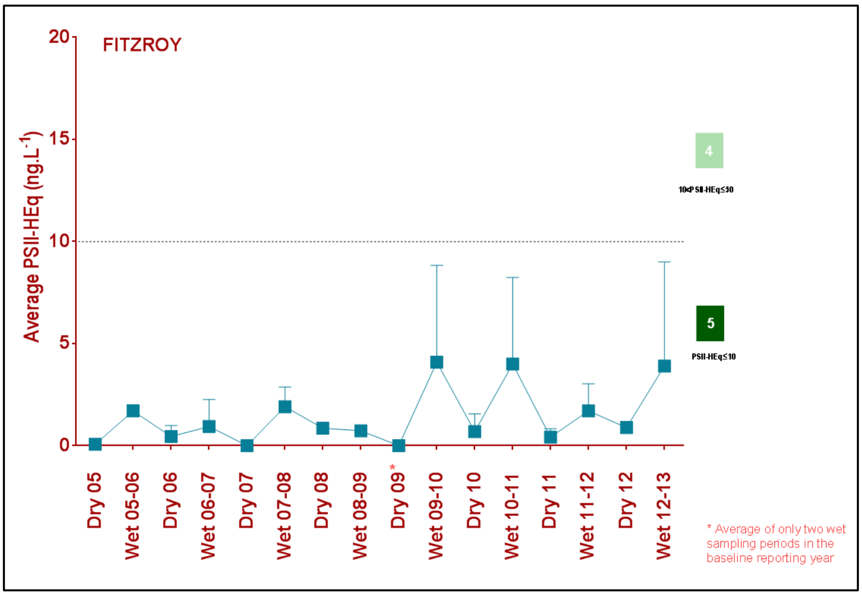

Figure 22 Seasonal average PSII-HEq for North Keppel Island in the Fitzroy region since routine monitoring commenced

The herbicide metolachlor was also detected in routine sampling at North Keppel Island. Bromacil was detected once at a concentration of 0.11 ng.L^{-1}. No PDMS sampling is undertaken at North Keppel Island. Tebuthiuron (57 ng.L^{-1}) was the only exceedance of the GBRMPA Guideline in 2012-2013.

4.6.2 Mary River transect

Five grab samples were collected from five sites in a transect that extended approximately 68 km from the Mary River mouth on the 8th and 9th of February 2013. Figure 23 shows the timing of grab samples collected and the PSII-HEq Index Category indicated of each sample in relation to the mean daily flow of the Mary River. Atrazine (11 ng.L^{-1}) and diuron (18 ng.L^{-1}) were the only herbicides detected in a single sample collected from the Mary River mouth on the 8th of February, 9 days after the first flush event, indicating a Category 4 on the PSII-HEq Index.

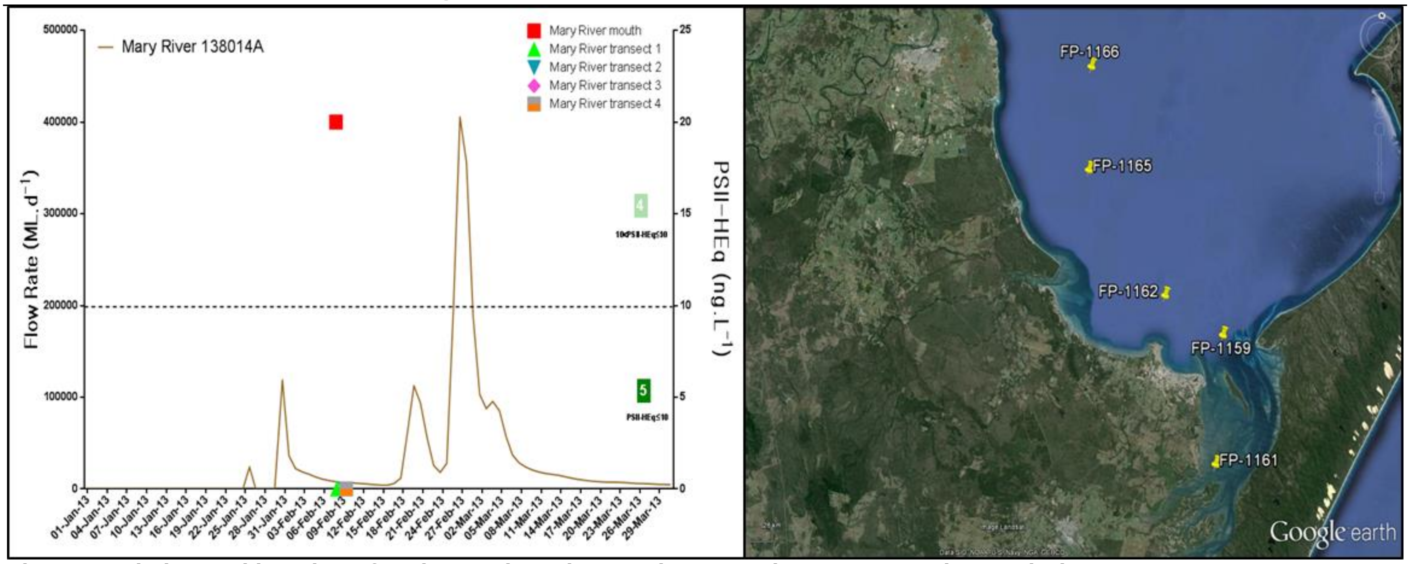

Figure 23 Timing and location of grab samples taken on the Mary River transect, Fitzroy, during 2012-2013

5 DISCUSSION

In the 2012-2013 monitoring year overall, Queensland experienced a decrease in rainfall when compared to the previous two years (Appendix C, Figure 27) with the El-Nińo-Southern Oscillation (ENSO) currently neutral and predicted to remain so for the rest of 2013 producing comparatively drier conditions (BOM, 2013). Rainfall for much of the Wet Tropics and Burdekin regions was typically average or below average, however the Mackay Whitsunday and Fitzroy regions experienced rainfall that either met or exceeded the average by 150 % in some areas (Appendix C, Figure 27). As a result of the decreased rainfall in the northern regions, there was a subsequent decrease in the total discharge of freshwater from rivers to 0.4 – 0.9 the long-term median discharge. The higher rainfall in the Mackay Whitsunday and Fitzroy regions was reflected in river discharge that exceeded the long-term median by factors of 2.2 – 3.1 (Table 8) and were the three highest flows recorded for GBR rivers this monitoring year. Figure 24 shows the total annual discharge of major rivers into the GBR. The historical discharge of major GBR rivers influencing passive sampler sites are presented in Appendix F, Figures 28- 32 The PSII-HEq of each deployment period since monitoring commenced is plotted with respect to the mean daily flow rate of the closest major river and the PSII-HEq Index Category for each passive sampler deployment indicated.

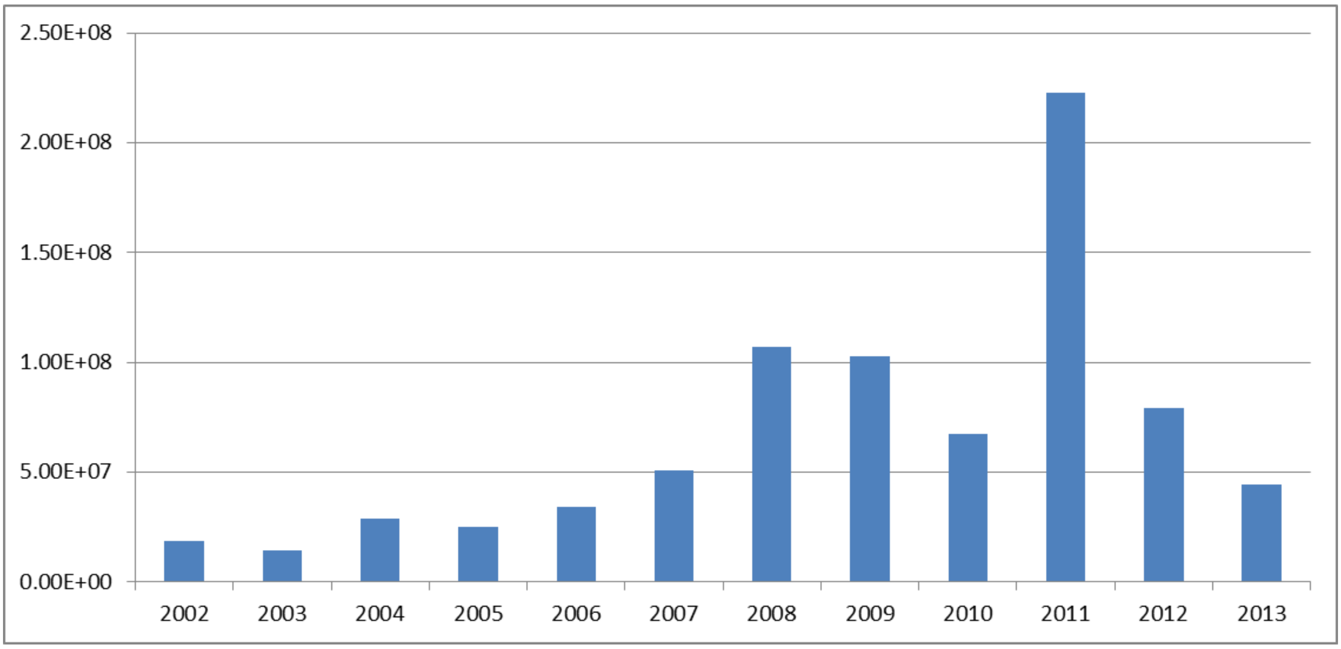

Figure 24 Total annual discharge of major rivers into the inshore waters of the GBR (ML)

Data provided by Michelle Devlin (unpublished). The water year is considered October 1st to September 30th the following year, and thus the discharge for the current year remains incomplete.

Despite the drier conditions in several regions, an increase in the concentrations and frequency of detection of many PSII herbicides was observed at almost all sites when compared to the previous monitoring year. Most notably, compared to the previous monitoring year, concentrations of diuron and atrazine were significantly greater. From November 2011 until 30 November 2012, the use of most diuron products was suspended by the APVMA while it completed a review of the environmental and human health impacts of diuron, and an investigation into the contamination of the marine environment. Following the review period, from November 2012 onwards the use of most diuron products was reaffirmed however, with significant changes to their use including certain crop restrictions, strict 'no spray' windows, buffer zones to prevent spray drift, in addition to region-specific and season-specific restrictions for use on sugarcane in Queensland (APVMA, 2013). A search of registered diuron products on the APVMA website yielded 16 products for antifouling, 20 products for use as algacides and 60 registered as herbicides registered for use in Queensland. The increase in the frequency of detection of many PSII herbicides may have been in response to the diuron suspension, where other herbicides were used as a diuron alternative/ replacement.

Table 14 presents the average concentration of diuron during the wet season at each routine monitoring site from 2009 – 2013. The factor decrease compares the average concentrations of diuron prior to the suspension in 2009-10 to the average concentrations in the wet season of 2011-12 during the suspension period. Concentrations of diuron decreased at seven sites by of factors ranging between 1.6 (Low Isles) – 9.8 (Sarina Inlet). Following the lifting of this suspension period, in 2012-2013 the average wet season concentration of diuron increased in all regions by average factors of 2.2 (Wet Tropics) – 6.0 (Mackay Whitsunday). Whilst the decreases in diuron concentration observed in 2011-2012 coincide with the suspension period, they may also in part be due to the possible 'exhaustion' of diuron from the catchments, due to the major flooding in the previous year, 2010-2011. With the more stringent conditions of use, this MMP will be able to inform whether the direct regulatory activity of diuron results in a decrease in the risk of exposure to PSII herbicides for inshore waters of the GBR.

Table 14 Average wet season concentration of diuron 2009 – 2013 (ng.L^{-1})

NRM Region	Site	2009-2010	2010-2011	2011-2012	2012-2013	Factor decrease: 2009-10/ 2011-12	Factor increase: 2011-12/ 2012-13
Wet Tropics	Low Isles	2.5	3.8	1.6	1.2	1.6	0.8
	Green Island	1.7	4.1	1.7	3.7	1	2.2
	Fitzroy Island	4.1	7.2	-	15	-	-
	Normanby Island	2	4.8	2.1	4.4	0.95	2.1
	Dunk Island	3.7	*4.8*	*6*	7.7	0.62	1.3
	Regional average	**2.8**	**4.9**	**2.9**	**6.4**	**0.97**	**2.2**
Burdekin	Orpheus Island	1.9	3	1.4	6.6	1.4	4.7
	Magnetic Island	3.5	5.3	2.7	8.7	1.3	3.2
	Cape Cleveland	2.4	6.2	3.8	6.8	0.63	1.8
	Regional average	**2.6**	**4.8**	**2.6**	**7.4**	**0.99**	**2.8**
Mackay Whitsunday	Pioneer Bay	27	11	7	-	3.9	-
	Outer Whitsunday	10	8	1.2	16	8.3	13.3
	Sarina Inlet	97	14	9.9	56	9.8	5.7
	Regional average	**45**	**11**	**6**	**36**	**7.4**	**6.0**
Fitzroy	North Keppel Island	6	1.2	1.5	4.2	4	2.8
	Regional average	**6**	**1.2**	**1.5**	**4.2**	**4**	**2.8**

Results in italics are less reliable as only one deployment period occurred in that year.

When trying to identify trends in herbicide exposure over time, it is important to consider the multiple factors driving that change. It can be difficult to ellucidate meaningful trends and assess the progress of Reef Plan (Anon 2009) when concurrent changes in pesticide application, river discharge and rainfall occur simultaneously. Quite often, the necessary data needed to interpret these changes (such as pesticide application rates and river loads) are not available. For example, an increase in the concentration of a pesticide detected at a routine monitoring site may not necessarily reflect that greater amounts of pesticides were applied, but perhaps are a result of rainfall that closely followed the pesticide application, flushing a greater proportion of the applied pesticide into waterways. Additionally, the locations of samplers are at varying proximity to river mouths, and thusly some may be influenced by flood plumes from more than one river. All of these factors make it difficult to quantitatively assess the link between improved land management practises as a direct result of Reef Resue initiatives and changes in water quality to gain a true understanding of the input of herbicides into the system. However, despite this, the trends in herbicide concentrations measured at routine monitoring sites give an 'absolute' measure of pesticide exposure at that location.

The use of passive samplers in this MMP is unsuitable for herbicide loads estimation. However, the PSII herbicide profiles detected with the passive samplers confirms the composition profiles of loads data that has been estimated by other agencies. Annual loads have been estimated for major GBR rivers for 2010-2011. Loads data for more recent years is still not yet available. In 2010-2011 the Barratta Creek located in the Wet Tropics region showed the greatest annual load of atrazine in the Wet Tropics region of 290 kg (Turner et al, 2013). Routine monitoring sites located nearby include Cape Cleveland (maximum concentration 42 ng.L^{-1}) and Magnetic Island which both show a dominance of atrazine in their PSII herbicide profiles. Annual loads of tebuthiuron were the highest in the Burdekin River (810 kg) and Fitzroy

River (6000 kg) (Turner et al, 2013). The routine monitoring sites influenced by these rivers also showed the greatest concentrations of tebuthiuron with maximum concentrations of 8.2 $ng.L^{-1}$ and 20 $ng.L^{-1}$ detected at Cape Cleveland and North Keppel Island respectively, and typically have the highest of tebuthiuron of all routine monitoring sites.

Historically, there appears to be a clear link between extreme wet weather events and an increased risk of exposure to PSII herbicides delivered by river discharge in the GBR (Kennedy et al 2012a; Kennedy et al 2012b). However, these fluctuations in discharge can obscure the true changes in pesticide usage and improvements in land management practices. Figure 25 shows the total annual discharge of selected GBR rivers from 2000 to 2013, and most notably, the significant reduction in annual discharge between 2010-2011 and 2011-2012.

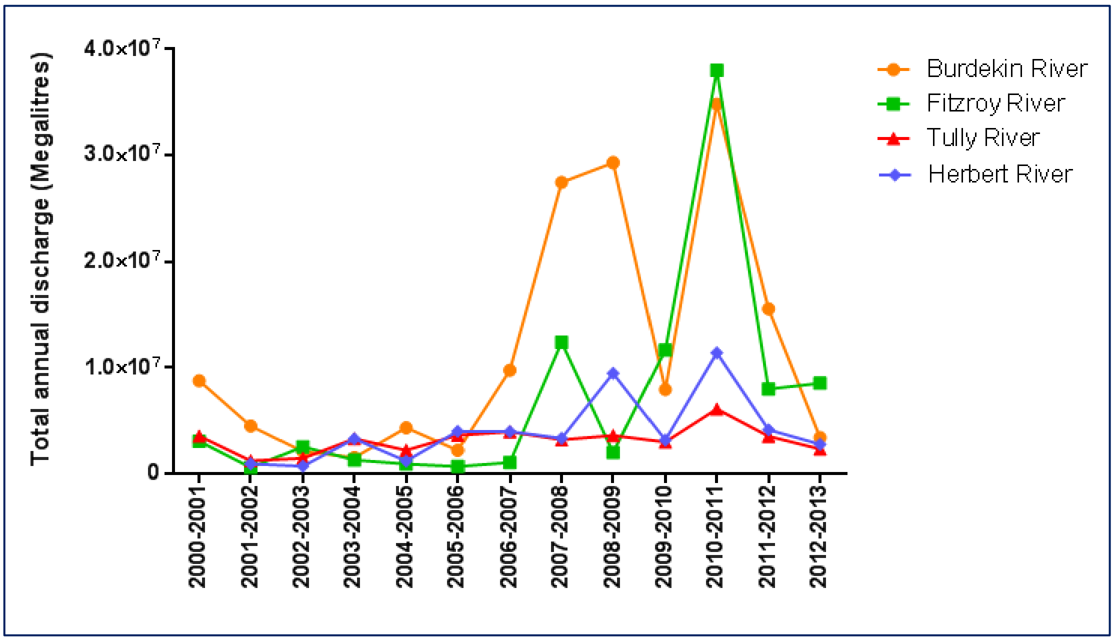

Figure 25 Total annual discharge of selected rivers in adjacent catchments to the GBR
Discharge data provided by Michelle Devlin (unpublished). The water year is considered October 1st to September 30th the following year

A summary of the PSII-HEq Max for routine monitoring sites in 2012-2013 is indicated in Figure 26. The relative contributions of individual PSII herbicides to these equivalent concentrations (which account for the relative potency of each) are indicated. Similarly, to previous monitoring years, the Mackay Whitsundays is the most risk at region for exposure to PSII herbicides.

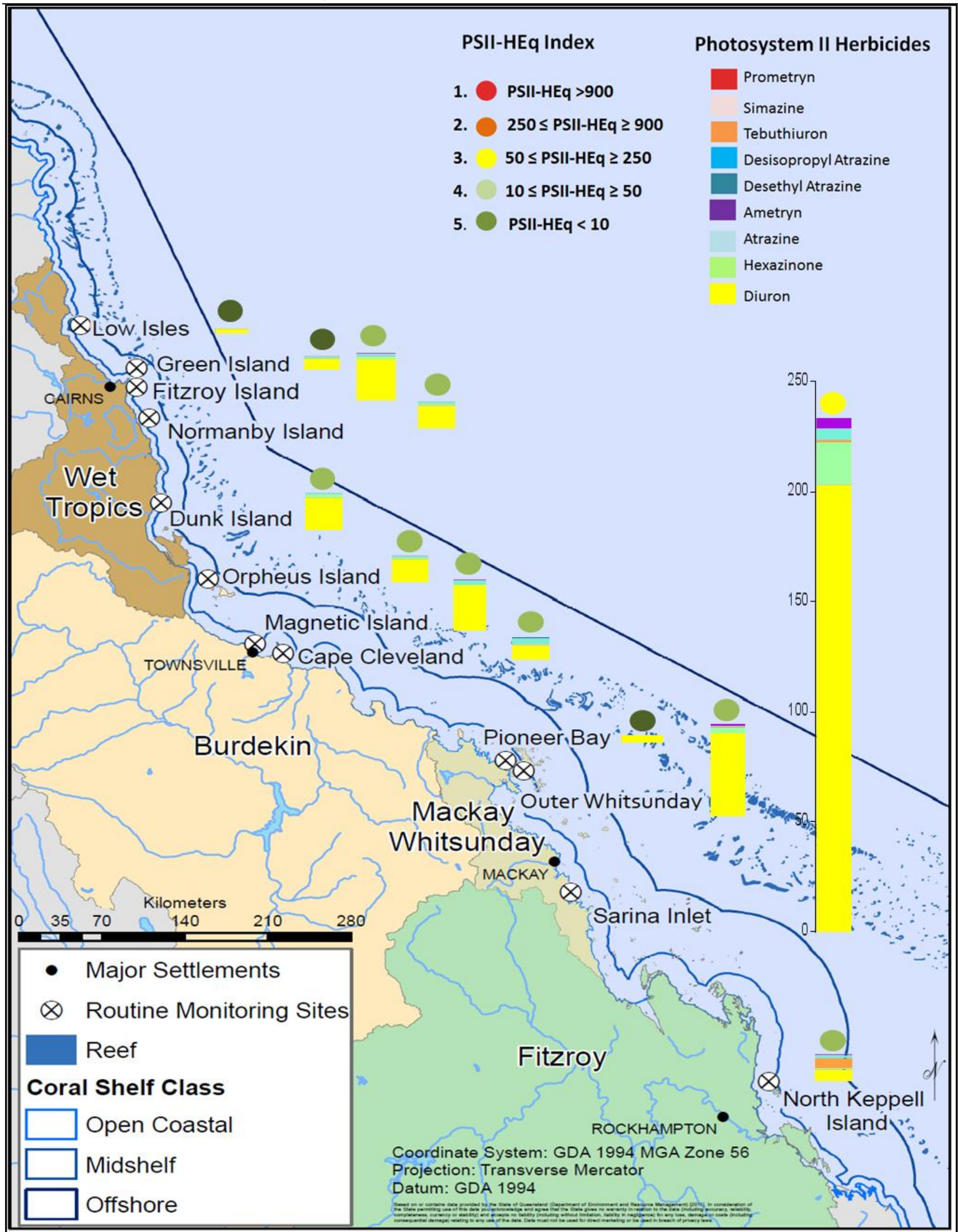

Figure 26 PSII-HEq Max (ng.L^{-1}) with the PSII-HEq Index of each value indicated for each routine site 2012-2013 (Source – Modification of original map provided by Adam Donovan and Alex Shanahan, School of Geography, Planning and Environmental Management, The University of Queensland). Note that Pioneer Bay had only one successful sampling period in 2012-2013

The total area of GBR waters impacted by flood plumes has been investigated as part of this MMP (Devlin et al, 2012). Using true colour classification, the surface extent and frequency of flood plumes in the GBR was determined for the previous monitoring year. Whilst the data for this current year is not yet available to us, considering river discharge was in a similar range to 2011-2012 (Appendix C, Table 22), we expect the flood plume extent to be similar. The proportion of surface area of each region affected by a high to very high (>10 flood plumes per year) frequency of flood plumes ranged from 22 % (Wet Tropics) to 33 % (Mackay Whitsunday) (Devlin et al, 2012), which is equivalent to 5790 km^2 and 13 871 km^2 respectively. Almost 100 % of seagrass beds in the GBR are located in these high to very high impact areas, with the largest areas of seagrass beds impacted in the Cape York (2355 km^2) and Burdekin (581 km^2) region. The regions with the largest areas of coral impacted by high to very high frequency flood plumes were located in Cape York and Mackay Whitsunday. Despite the large proportion of Cape York being impacted by flood waters, minimal agriculture (particularly sugarcane) in the region means that the risk of PSII herbicide exposure is low (Anon, 2011; Brodie et al. 2013b), which is also reflected in passive samplers deployed in this region previously.

The results clearly show the wide range of variation in PSII herbicide profiles between regions (such as the atrazine dominance seen in the Burdekin region, and the tebuthiuron dominance in the Fitzroy region) and also within regions (such as Orpheus Island and Cape Cleveland in the Burdekin region). The variation in the PSII herbicide profiles between sites and regions reflects differences in land use on the adjacent catchment area with concentrations influenced by factors such as surface run-off, rainfall, land clearing and urban development. Such regional variability can also be affected by the proximity of samplers to major rivers (and the degree of impact from river run-off) and whether the consistent deployment of samplers captured peaks in concentrations during the wet season. Sites within the same region can also be influenced by the run-off delivered by different major rivers, and thus their profiles can vary dramatically (as seen at the diuron-dominated site Orpheus Island (likely more influenced by the Herbert River) and the atrazine-dominated site Cape Cleveland (likely more influenced by the Haughton River and Barratta Creek), both of which are located in the Burdekin region.

Table 15 summarises the major land uses in the GBR catchment (reproduced from DSITIA, 2012a). A land use map of the GBR catchment is in Appendix H, Figure 45. The largest single land use within the GBR catchment is cattle grazing for beef production (76 % of total land use), with other major uses including sugar cane cropping, plantation forestry and horticulture (DSITIA, 2012a; Brodie et al, 2001). Sugar cane farming is clustered heavily along the Tully River (Wet Tropics region), Burdekin River (Burdekin region) and Pioneer River (Mackay-Whitsunday region) (Lewis et al, 2009), with 18 % of the Mackay Whitsunday region alone used for sugar cane farming (DSITIA, 2012b; DSITIA, 2012c). The herbicide residues detected in the greatest abundance in this MMP (diuron, atrazine and hexazinone) are consistent with the applications of the sugar cane industry (Bainbridge et al, 2009) with atrazine additionally used in grains cropping (Lewis et al, 2009). Historically the Burdekin and Fitzroy catchments have seen the highest concentrations of tebuthiuron detected of all regions since monitoring commenced, exceeding guideline values twice at North Keppel Island. These catchments are extensively used for cattle grazing, and tebuthiruon is heavily used to control woody plants on grazing land (Lewis et al, 2009; Brodie et al, 2001).

Table 15 Major land uses of the regions within the GBR

Region	Major Land Uses	%
Cape York^	Grazing	50
	Conservation and protected areas	25
	Other uses	20
Wet Tropics	Conservation and natural environments	44
	Grazing native vegetation	31
	Dryland cropping and plantations- sugarcane	6.8
	Production forestry	6.5
Burdekin	Grazing native vegetation	90
	Conservation and natural environments	6
	Dryland cropping and plantations	0.9
	Irrigated cropping and plantations- sugarcane	0.75
Mackay Whitsunday	Grazing native vegetation	52
	Conservation and natural environments	20
	Irrigated cropping and plantations- sugarcane	18
	Production forestry	10
Fitzroy	Grazing native vegetation	78
	Production forestry	6
	Conservation and natural environments	8
	Dryland cropping and plantations	5
GBR Summary*	Grazing native vegetation	76
	Conservation and natural environments	10
	Production forestry	5
	Dryland cropping and plantations	3.6

Reproduced from DSITIA, 2013a-e; ^ Cape York Land uses were obtained from 2009 Regional Report Card (Anon, 2011); * Excludes Cape York.

There is a general trend of increased risk of exposure to PSII herbicides in sites located in the Burdekin – Fitzroy regions in comparison to the Wet Tropics, which has also been seen in previous monitoring years. This may be partly due to the decreasing proportion of land that is set aside as conservation areas and resource protection (44% in the Wet Tropics compared to an average of 11% for the Burdekin - Fitzroy regions (DSITIA, 2012b-e)) and an increasing proportion that is used for agricultural purposes (only 37 % of the land in the Wet Tropics region is utlilised for agriculture, compared to 56 % - 87 % in the other regions (ABS, 2013)). In addition, the southern regions experienced higher than average rainfall during this monitoring year (Appendix C, Figure 27), creating the potential for higher amounts of herbicides transported in agricultural run-off combined with above median river discharge (Table 8). Whilst concentrations of pesticides typically coincide with periods of high river discharge (Appendix F, Figures 28 – 35), concentrations do not necessarily relate soley to river flow, as the application of herbicides relative to rainfall events and land management practises will also increase chemical losses from adjacent catchments (Davis et al. 2013; Masters et al. 2013).

The sites located in the Mackay Whitsundays region have encountered the greatest risk of exposure to herbicides over a number of years, with concentrations detected that have been shown to inhibit photosynthesis in some species of coral and seagrass (Category 2 and 3 on the PSII Herbicide Index) (Flores et al. 2013). Sarina Inlet has consistently had the highest frequencies and concentrations of PSII herbicides detected, most likely related to the density of sugarcane farming in such proximity to the coast, with sugarcane cropping identified as contributing 90% of the modelled PSII herbicide loads into the GBR lagoon (ref land use map and Davis et al 2011; Brodie et al. 2013). Furthermore, 34% of the Plane Creek catchment (adjacent to the Sarina Inlet site) was used for sugarcane farming (ABS, 2013). Based on a risk assessment of the six most dominant PSII herbicides, the Mackay Whitsundays region has recently been identified as having the highest risk of toxic effects to coral reefs and seagrasses and the reduction of pesticides in this region is a management priority (Brodie et al. 2013b).

Diuron was the dominant contributor to the PSII-HEq Max at every routine site. Diuron contributes an average of 84 % to the PSII-Max in the Wet Tropics, 79 % in the Burdekin and Mackay Whitsundays (excluding Pioneer Bay) and 43 % at North Keppel Island in the Fitzroy. The contribution of diuron remains relatively consistent between the sites within the Wet Tropics (82 % - 88 %) but varies more widely within the Burdekin region (65 % at Cape Cleveland to 88 % at Magnetic Island) and Mackay Whitsunday region (70 % at Outer Whitsunday to 87 % at Sarina Inlet).

In the Wet Tropics, the contributions of atrazine to PSII-HEq Max ranged from <1 % to 9 %. The contribution of hexazinone was relatively consistent averaging 7 % across all Wet Tropics sites. In the Burdekin region the contributions were highly variable, with atrazine contributing up to 27 % at Cape Cleveland and only up to 9 % at other sites. Atrazine has previously been found to be a dominant herbicide in rivers discharging in the Burdekin region (Davis et al. 2008). The contribution of hexazinone to PSII-HEq Max was also variable ranging from < 1 % to 5.5 % at Orpheus Island, which typically reflects the herbicide profile of the Wet Tropics.

The contribution of hexazinone in the Mackay Whitsunday region averaged 7 % (excluding Pioneer Bay). A maximum contribution of 2 % of atrazine was seen at Sarina Inlet. 10 % of the PSII-HEQ Max was from atrazine at North Keppel Island, an increase from 1 % the previous monitoring year. Tebuthiruon was detected at the highest concentration since monitoring commenced and contributed 35 % to the PSII-HEq Max at North Keppel Island. The contribution of ametryn across all sites in all regions was low, averaging 2 %. Simazine, desethyl atrazine and desisopropyl atrazine all contributed ≤ 1% to these maxima in all regions.

6 SUMMARY

Pesticide monitoring activities in four NRM regions undertaken in 2012-2013 have included routine monitoring at twelve fixed sites using polar passive samplers (at all sites) and non-polar passive samplers (at selected sites). Terrestrial run-off from eight major rivers was monitored during the wet season in four NRM regions utilising grab sampling techniques.

Passive sampling in the routine monitoring component of the program showed that diuron continued to be the dominant PSII herbicide detected in all four NRM regions. Due to its potency, it was also the major contributing PSII herbicide to the PSII-HEq Max concentrations at each site. Also observed at the routine monitoring sites in 2012-2013, were the increasing frequency of detection of herbicides such as ametryn, desethyl atrazine and simazine in all regions when compared to the previous monitoring year. The PSII-HEq Max values of nine of the twelve routine monitoring sites increased by factors of 1.4 to 12 when compared to the previous monitoring year. Similarly, the Wet Avg values of the same nine sites increased by factors from 2 to 10 when compared to the previous monitoring year, indicating that in general, exposure to PSII herbicides was elevated across this wet season. This was despite a decrease in the volume of river discharge that was delivered into inshore reef waters during the current wet season when compared to the previous monitoring years.

PSII-HEq Max indicated by passive samplers deployed at routine sites were Category 4 or 5 on the PSII-HEq Index in all regions, with the exception of Sarina Inlet (Category 3). Tebuthiuron was the only herbicide with a GBRMPA guideline that exceeded its guideline value in this current monitoring year at North Keppel Island. Diuron was also the dominant herbicide detected in grab samples collected in the wet season to monitor terrestrial run off with PSII-HEq values ranging from n.d. (Category 5) to 160 $ng.L^{-1}$ (Category 3).

Despite most sites detecting relatively low levels of PSII herbicides, low level chronic exposure to PSII herbicides may still have a profound effect on this fragile ecosystem (Pennington et al, 2001; Cantin et al, 2007). In particular, the compound effects of simultaneous stressors on key organisms on the reef including the effects of global climate change (increasing sea temperatures, ocean acidification), an increase in the severity and frequency of damaging weather events such as cyclones, and increase in the frequency of flood events are not fully understood. In view of these multiple driving factors for change, interpreting trends remains difficult, but is essential when ascertaining whether improving or declining water quality is driven by land management practices or is an artefact of weather conditions.

7 FUTURE OUTLOOK AND RECOMMENDATIONS

The 2013 review of the MMP will assist in determining whether the current program design delivers relevant results that help to address the goals of the Reef Plan. The review process presents the opportunity to incorporate knowledge gained since the inception of the MMP into the future of the program, and assist in identifying new research priorities. A concurrent statistical review of the long-term data sets collected from each sub-program over the past 9 years will test the appropriateness and sensitivity of measured water quality indicators to describe condition and trend, highlight relationships between environmental drivers and coral/ seagrass and water quality data, illuminate knowledge gaps and evaluate uncertainties. Furthermore, the long-term data sets collected which have primarily focused on the state and trends of physical, chemical and biological parameters, are of significant depth to provide insight into impacts on ecosystem health, and prioritise management action.

A number of workshops over the past year have discussed changes in program design to prioritise high risk regions (areas of coral and seagrass vulnerability, high sediment or pesticide loads), as identified by the recent GBR risk assessment and Scientific Concensus Statement (Brodie et al. 2013). Alignment to other programs (such as the Paddock to Reef and End-of-Catment Loads) based on specific case studies will provide a holistic view of management practice adoption, paddock scale monitoring, catchment monitoring and marine monitoring that will improve information on the impacts of key pollutants on critical ecosystems.

Collaboration and integration with other MMP sub-programs is central to providing a comprehensive and robust program that is capable of identifying key indicators of water quality, and integrating water quality data with ecosystem health. More specifically, in order to assess the level of impact of pesticides on marine ecosystems, it is crucial for the data generated from this MMP to be linked with that of seagrasses and corals, organisms that are directly affected by PSII herbicides. As a result, some routine pesticide monitoring sites may be re-located nearer to those that monitor seagrass, corals and other water quality parameters. Monitoring an area as vast and complex as the GBR remains a challenge however long-term monitoring programs are essential in protecting such a valuable ecosystem.

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9 APPENDIX A: COMPLETE ANALYTE LIST FOR LCMS AND GCMS ANALYSIS

Table 16. Pesticides specified under the MMP for analysis with different sampling techniques together with the limits of reporting ($ng.L^{-1}$)

Pesticide	Description	LOR			
		SPMD	PDMS	ED[a]	GRAB
Bifenthrin	Pyrethroid insecticide		<1		
Fenvalerate	Pyrethroid insecticide		<0.5		
Bromacil[b]	PSII herbicide-uracil			<0.04 - 2	<10
Tebuthiuron	PSII herbicide-thiadazolurea		<25	<0.04 - 2	<10
Terbutryn[c]	PSII herbicides-methylthiotriazine			<0.04 – 0.4	<10
Flumeturon	PSII herbicide-phenylurea		<30	<0.08 - 2	<10
Ametryn	PSII herbicide-methylthiotriazine		<10	<0.04 – 2	<10
Prometryn	PSII herbicide-methylthiotriazine		<5	<0.04 - 2	<10
Atrazine	PSII herbicide-chlorotriazine		<10	<0.04 - 2	<10
Propazine	PSII herbicide-chlorotriazine		<10		
Simazine	PSII herbicide-chlorotriazine		<30	<0.04 - 2	<10
Hexazinone	PSII herbicide- triazinone		<25	<0.04 - 2	<10
Desethylatrazine	PSII herbicide breakdown product (also active)			<0.04 - 2	<10
Desisopropylatrazine	PSII herbicide breakdown product (also active)		<25	<0.08 - 2	<10
Diuron	PSII herbicide - pheynylurea		<25	<0.04 - 2	<10
Oxadiazon	Oxadiazolone herbicide		<0.5		
Chlorfenvinphos	Organophosphate insecticide		<2		
Chlorpyrifos	Organophosphate insecticide	<0.03	<0.5		
Diazinon	Organophosphate insecticide	<5	<5		
Fenamiphos	Organophosphate insecticide		<5		
Prothiophos	Organophosphate insecticide	<0.09	<0.5		
Chlordane	Organochlorine insecticide	<0.1	<0.5		
DDT	Organochlorine insecticide	<0.08	<0.5		
Dieldrin	Organochlorine insecticide	<0.2	<0.5		
Endosulphan	Organochlorine insecticide	<1.9	<5		
Heptachlor	Organochlorine insecticide	<0.07	<0.5		
Lindane	Organochlorine insecticide	<0.5	<5		
Hexachlorobenzene	Organochlorine fungicide	<0.09	<0.5		
Imidacloprid[c]	Nicotinoid insecticide			<0.04 - 4	<10
Trifluralin	Dintiroaniline		<0.5		
Pendimethalin	Dinitroaniline herbicide	<0.4	<0.5		
Propiconazole	Conazole fungicide		<2		
Tebuconazole	Conazole fungicide		<5		
Metolachlor	Chloracetanilide herbicide		<10	<0.04 - 2	<10
Propoxur	Carbamate insecticide		<25		

[a] Prior to 2011-2012, ED sample extracts were routinely analysed on the API 300 LCMS, LOR ranges reflect both changes in sampling rates under event (no membrane) and routine configurations (with membrane) and differences in sensitivities on the different instruments for an assumed 30-day deployment period; [b]Bromacil was included in the list of target analytes from 2009-2010; [c]Imidacloprid and terbutryn were routinely analysed in this monitoring year.

Table 17 LCMS Analyte List for Positive Mode

Ametryn
Atrazine
Bromacil
Clethodim[a]
Clomazone[a]
Cynazine[a]
Desethyl Atrazine
Desisopropyl Atrazine
Diuron
Ethametsulfuron methyl[a]
Flumeturon
Flusilazole[a]
Hexazinone
Imazapic[a]
Imazethapyr[a]
Imidacloprid
Metolachlor
Mesosulfuron methyl[a]
Napropamide[a]
Prometryn
Propachlor[a]
Propazin-2-hydroxy[a]
Sethoxydim[a]
Simazine
Sulfosulfuron[a]
Tebuthiuron
Terbuthylazine[a]
Terbuthylazine desethyl[a]
Terbutryn
Trifloxysulfuron-sodium[a]

[a] Not routinely analysed in 2011-2012

Table 18 GCMS analyte list for PDMS extracts with cells shaded grey to indicate chemicals which are not calibrated within the fraction collected during gel permeation (size exclusion) chromatography of extracts and cells shaded blue to indicated industrial chemicals/personal care products which may be detected but are not reported along with pesticides in the MMP results

ACEPHATE	DICHLORVOS	METHAMIDOPHOS
ALDRIN	DICLOFOP METHYL	METHIDATHION
AMETRYN	DICOFOL o,p	METHOMYL
AMITRAZ	DICOFOL p,p bd	METHOPRENE
ATRAZINE	DIELDRIN	METHOXYCHLOR
AZINPHOS ETHYL	DIMETHOATE	METOLACHLOR
AZINPHOS METHYL	DIMETHOMORPH E,Z	METRIBUZIN
BENALAXYL	DIOXATHION	MEVINPHOS z+E
BENDIOCARB	DISULFOTON	MOLINATE
BIFENTHRIN	Diuron bd	MONOCROTOPHOS
BIORESMETHRIN	ENDOSULFAN alpha	MUSK KETONE
BITERTANOL	ENDOSULFAN beta	MUSK XYLENE
BROMACIL	ENDOSULFAN ETHER	NICOTINE
BROMOPHOS ETHYL	ENDOSULFAN LACTONE	NONACHLOR cis
CADUSAPHOS	ENDOSULFAN SULPHATE	NONACHLOR trans
CAPTAN	ENDRIN	OMETHOATE
CARBARYL	ENDRIN ALDEHYDE	OXADIAZON
CARBOPHENOTHION	ETHION	OXYCHLOR
CHLORDANE cis	ETHOPROP	OXYDEMETON METHYL
CHLORDANE trans	ETRIMIPHOS	OXYFLUORFEN
CHLORDENE	FAMPHUR	PARATHION ETHYL
CHLORDENE EPOXIDE	FENAMIPHOS	PARATHION METHYL
CHLORDENE, 1-HYDROXY	FENCHLORPHOS	PENDIMETHALIN
CHLORDENE, 1-OH-2,3-EPOXY	FENITROTHION	PERMETHRIN isomers
CHLORFENVINPHOS e+Z	FENTHION ETHYL	PHENOTHRIN isomers
CHLOROTHALONIL	FENTHION METHYL	PHORATE
CHLORPYRIFOS	FENVALERATE isomers	PHOSMET
CHLORPYRIFOS ME	FIPRONIL	PHOSPHAMIDON peak1 **200**
CHLORPYRIFOS OXON	FLUAZIFOP BUTYL	PHOSPHAMIDON peak2 **800**
COUMAPHOS	FLUOMETURON	PHOSPHATE TRI-n-BUTYL
CYFLUTHRIN isomers	FLUVALINATE isomers	PIPERONYL BUTOXIDE
CYHALOTHRIN isomers	FURALAXYL	PIRIMICARB
CYPERMETHRIN isomers	GALOXOLIDE	PIRIMIPHOS METHYL
DCPP isomers	HALOXYFOP 2-EtOEt	PROCYMIDONE
DDD o,p	HALOXYFOP METHYL	PROFENOPHOS
DDD p,p	HCB	PROMETRYN
DDE o,p	HCH-a	PROPAGITE
DDE pp	HCH-b	PROPANIL
DDT o,p	HCH-d	PROPAZINE
DDT p,p	HEPTACHLOR	PROPICONAZOL isomers
DEET	HEPTACHLOR EPOXIDE	PROPOXUR
DELTAMETHRIN isomers	HEXAZINONE	PROTHIOPHOS
DEMETON-S-METHYL	IPRODIONE	PYRAZAPHOS
DESETHYLATRAZINE	ISOPHENOPHOS	ROTENONE
DESISOPROPYLATRAZINE *900*	LINDANE (HCH-g)	SIMAZINE
DIAZINON	MALATHION	SULPROFOS
DICHLOROANILINE 3,4	METALAXYL	TCEP
TEBUTHIURON TEBUCONAZOLE		
TCPP		
TEMEPHOS		
TEP		
TERBUPHOS		

TERBUTHYLAZINE		
TERBUTRYN		
TETRACHLORVINPHOS		
TETRADIFON		
TETRAMETHRIN isomers		
THIABENDAZOLE		
TONALID		
TRANSFLUTHRIN		
TRIADIMEFON		
TRIADIMENOL ISOMERS		
TRIALLATE		
TRIFLURALIN		
VINCLOZALIN		

Table 19 Water quality guideline trigger valuesavailable for specific pesticides (ng.L^{-1})

Chemical	GBRMPA[a]		ANZECC and ARMCANZ[b]	
	ng.L^{-1}	Notes	ng.L^{-1}	Notes
Dinitroaniline Herbicides				
Trifluralin			**2600**	**99% species protection; Freshwater**
Organophosphate Pesticides				
Chlorpyrifos	**0.5**	**99% species protection; High reliability**	**0.5**	**99% species protection; Marine water**
	9	**95% species protection; High reliability**	**9**	**95% species protection; Marine water**
			0.04	**99% species protection; Fresh water**
			10	**95% species protection; Fresh water**
Choracetanilide herbicides				
Metolachlor			**20***	**Low reliability; Fresh water**
			20*	**Low reliability; Marine water**
Triazine or Triazinone Herbicides				
Atrazine	**600**	**99% species protection; Moderate reliability**	**700**	**99% species protection; Fresh water**
	1400	**95% species protection; Moderate reliability**	**1300**	**95% species protection; Fresh water**
Hexazinone	**1200**	**Low reliability**		
Simazine	**200**	**99% species protection; Low reliability**	**200**	**99% species protection; Fresh water**
			3200	**95% species protection; Fresh water**
Ametryn	**500**	**99% species protection; Moderate reliability**		
	1000	**95% species protection; Moderate reliability**		
Urea Herbicides				
Diuron	**900**	**99% species protection; Moderate reliability**	**200 ***	**Low reliability ; Fresh water**
	1600	**95% species protection; Moderate reliability**	**200 ***	**Low reliability ; Marine water**
Tebuthiuron	**20**	**99% species protection; Low reliability**	**20**	**99% species protection; Fresh water**
			2200	**95% species protection; Fresh water**
Transformation Product				
3,4-dichloroaniline			**85000**	**99% species protection; Marine water**

[a] Sourced from Table 26 & Table 27 of the Water Quality Guidelines for the Great Barrier Reef Marine Park 2010 (GBRMPA 2010) ; [b] Sourced from Table 3.4-1 of the ANZECC and ARMCANZ Guidelines (ANZECC and ARMCANZ 2000); “*” indicates values which are Interim Working Levels rather than Guidelines as indicated in Chapter 8.3.7 Volume 2 of the ANZECC and ARMCANZ Guidelines.

10 APPENDIX B – SUPPORING LITERATURE FOR THE DEVELOPMENT OF THE PSII-HEQ INDEX

Table 20 Scientific publications indicating the effect concentrations and the end-points for the reference PSII herbicide diuron used to define specific PSII-HEq Index categories as an indicator for reporting purposes

Category	PSII-HEq Range (ng.L^{-1})	Description	Supporting Literature with Respect to the Reference Chemical Diuron				
			Species	Effects Concentration (ng.L^{-1})	Endpoint	Toxicity measure	Reference
5	HEq ≤ 10	No published scientific papers that demonstrate any effects on plants or animals based on toxicity or a reduction in photosynthesis. The upper limit of this category is also the detection limit for pesticide concentrations determined in field collected water samples.					
4	10 < HEq ≤ 50	Published scientific observations of reduced photosynthesis for two diatoms.	**Diatoms**				
			D. tertiolecta	50	↓photosynthesis	LOEC	Bengston Nash *et al* 2005
			N. closterium	50	Sensitivity	LOEC	Bengston Nash *et al* 2005
3	50 < HEq < 250	Published scientific observations of reduced photosynthesis for two seagrass species and three diatoms.	**Seagrass**				
			H. ovalis	100	↓photosynthesis	LOEC	Haynes et al 2000
			Z. capriconi	100	↓photosynthesis	LOEC	Haynes et al 2000
			Diatoms				
			N. closterium	100	Sensitivity	IC10	Bengston Nash *et al* 2005
			P. tricornutum	100	Sensitivity	IC10	Bengston Nash *et al* 2005
			D. tertiolecta	110	↓photosynthesis	IC10	Bengston Nash *et al* 2005
2	250≤ HEq ≤ 900	Published scientific observations of reduced photosynthesis for three coral species.	**Coral - Isolated zooxanthellae**				
			S. pistillata	250	↓photosynthesis	LOEC	Jones *et al* 2003
			Coral - Adult colonies				
			A. formosa	300	↓photosynthesis	LOEC	Jones & Kerswell, 2003
			S. hystrix	300	↓photosynthesis	LOEC	Jones *et al* 2003
			S. hystrix	300	↓photosynthesis	LOEC	Jones & Kerswell, 2003
1	HEq > 900	Published scientific papers that demonstrate effects on the growth and death of aquatic plants and animals exposed to the pesticide. This concentration represents a level at	**Seagrass**				
			Z. capriconi	1000	↓photosynthesis	LOEC	Chesworth *et al* 2004
			Z. capriconi	5000	↓growth	LOEC	Chesworth *et al* 2004
			Z. capriconi	10000	↓photosynthesis	LOEC	Macinnis-Ng & Ralph, 2004
			C. serrulata	10000	↓photosynthesis	LOEC	Haynes *et al* 2000b

Category	PSII-HEq Range (ng.L^{-1})	Description	Supporting Literature with Respect to the Reference Chemical Diuron				
			Species	**Effects Concentration (ng.L^{-1})**	**Endpoint**	**Toxicity measure**	**Reference**
		which 99 per cent of tropical marine plants and animals are protected, using diuron as the reference chemical.	**Coral - Isolated zooxanthellae**				
			M. mirabilis	1000	↓C^{14} incorporation	LOEC	Owen *et al* 2003
			F. fragum	2000	↓C^{14} incorporation	LOEC	Owen *et al* 2003
			D. strigosa	2000	↓C^{14} incorporation	LOEC	Owen *et al* 2003
			Larvae				
			A. millepora	300	↓ Metamorphosis	LOEC	Negri *et al* 2005
			Coral recruits				
			P. damicornis	1000	↓ photosynthesis	LOEC	Negri *et al* 2005
			P. damicornis	10000	Loss of algae	LOEC	Negri *et al* 2005
			Coral - Adult colonies				
			A. formosa	1000	↓ photosynthesis	LOEC	Jones *et al* 2003
			P. cylindrica	1000	↓ photosynthesis	LOEC	Jones *et al* 2003
			M. digitata	1000	↓ photosynthesis	LOEC	Jones *et al* 2003
			S. hystrix	1000	↓ photosynthesis	LOEC	Jones *et al* 2003, Jones 2004
			A. millepora	1000	↓ photosynthesis	LOEC	Negri *et al* 2005
			P. damicornis	1000	↓ photosynthesis	LOEC	Negri *et al* 2005
			S. hystrix	2300	↓ photosynthesis	EC50	Jones *et al* 2003
			A. formosa	2700	↓ photosynthesis	EC50	Jones & Kerswell, 2003
			M. digitata	10000	Loss of algae	LOEC	Jones *et al* 2003
			P. damicornis	10000	Loss of algae	LOEC	Negri *et al* 2005
			S. hystrix	10000	Loss of algae	LOEC	Jones 2004
			P. cylindrica	10000	GPP* rate, GPP to respiration ration, effective quantum yield	LOEC	Råberg *et al* 2003
			Macro Algae				
			H. banksii	1650	↓ photosynthesis	EC50	Seery *et al* 2006
			Red Algae				
			P. onkodes	2900	↓ photosynthesis	LOEC	Harrington *et al* 2005
			Diatoms				
			Navicula sp	2900	↓ photosynthesis	IC50 Acute, 6 m	Magnusson *et al* 2006
			P. tricornutum	3300	↓ photosynthesis	I50	Schreiber *et al* 2002
			Mangroves				
			A. marina	1100	Health	NOEC	Duke *et al* 2003, 2005
			A. marina	1500	Reduced health	LOEC	Duke *et al* 2003, Bell & Duke 2005
			A. marina	2000	Dieback/ absence	Mortality	Duke et al 2003, Bell & Duke 2005
			A. marina	1500	Reduced health	LOEC	Duke *et al* 2003, Bell & Duke 2005

ANZECC (Australian and New Zealand Environment and Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand) (2000). *Australian and New Zealand guidelines for fresh and marine water* *quality.* National Water Quality Management Strategy. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

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Additionally the following marine data is an excerpt from the Australian Pesticides and Veterinary Medicines Authority (APVMA 2005), Volume I and II as preliminary findings for diuron. Effects concentrations are reported in µg.L^{-1}. This data set has also been used in the derivation of Category 1 of the PSII-HEq Index.

Table 21 Preliminary effects of diuron in marine organisms

Organisms and comments	Toxicity (ug.L^{-1}) test substance (95% CL)	Year reported	US EPA category
Fish			
M. cephalus (striped mullet) tech. (95%) static	6300 (NR) 48h, acute	1986	S
C. variegates (Sheephead minnow) 99% active constituent; static	6700 (NR) 96h, acute NOEC = 3600	1986	Core
Invertebrates			
M. bahia (Mysid shrimp) 99% active constituent; static	LC50 = 110 96h, acute NOEC = 1000	1987	Core
M. bahia (Mysid shrimp) 96.8% active constituent; early life stage; static	28d LOEC = 110 560 NOEC = 270	1992	Core
P. aztecus (Brown shrimp) 95% active constituent; flow through	LC50 = 1000 48h acute	1986	S
C. virginica (Eastern oyster) 96.8% active constituent; flow through	EC50 = 4800 96h, acute NOEC = 2400	1991	Core
C. virginica (Eastern oyster) 96.8% active constituent; flow through	EC50 = 3200 96h acute	1986	Core
Algae			
D. tertiolecta 95% active constituent; static	EC50 = 20 240h chronic	1986	S
Platmonas sp 95% active constituent; static	EC50 = 17 72h chronic	1986	S
P. cruentum (red algae) 95% active constituent; static	EC50 = 24 72h chronic	1986	S
M. lutheri 95% active constituent; static	EC50 = 18 72h chronic	1986	S
I. galbana 95% active constituent; static	EC50 = 10 72h chronic	1986	S
Marine diatoms			
N. incerta 95% active constituent; static	EC50 = 93 72h chronic	1986	S
N. closterium 95% active constituent; static	EC50 = 50 72h chronic	1986	S
P. tricornutum 95% active constituent; static	EC50 = 10 240h chronic	1986	S
S. amphoroides 95% active constituent; static	EC50 = 31 72h chronic	1986	S
T. fluviatilis 95% active constituent; static	EC50 = 95 72h chronic	1986	S
C.nana 95% active constituent; static	EC50 = 39 72h chronic	1986	S
A. exigua 95% active constituent; static	EC50 = 31 72h chronic	1986	S

11 APPENDIX C - ANNUAL FRESHWATER DISCHARGE (ML) FOR RIVERS INFLUENCING ROUTINE MONITORING SITES

Table 22 Annual freshwater discharge of rivers influencing routine monitoring sites (ML)

Region	River	Long-term median	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Wet Tropics	Daintree 108002A	727,872		132,216	1,429,195	489,927	1,252,971	715,190	873,694		1,215,914	1,654,757	998,710	694,048
	Barron 110001D	604,729	165,896	113,639	950,207	383,440	745,781	413,328	1,606,907	772,722	500,756	1,924,506	774,595	297,555
	Mulgrave 111007A	751,149	183,890	333,262	1,132,755		937,024	738,709	930,657	670,019	680,091	1,422,790	1,083,092	1,455,801
	Russell 111101D	1,193,577	433,936	615,927	1,345,241	990,735	1,280,589	1,281,621	1,088,458	1,130,682	1,221,231	1,806,202	1,290,488	
	North Johnstone 112004A	1,746,102	657,456	819,663	2,304,375	1,447,193	2,155,313	2,071,610	1,858,252	1,925,821	1,825,452	3,551,393	2,023,900	1,478,171
	South Johnstone 112101B	820,304	345,067	311,763		542,835	1,014,727	886,683	794,698	1,019,195	709,887	1,673,604	941,983	584,344
	Tully 113006A	3,074,666	1,208,802	1,442,044	3,283,940	2,200,706	3,624,289	3,949,123	3,195,153	3,596,264	3,087,403	6,094,549	3,535,675	2,334,035
	Herbert 116001F	3,067,947	929,944	688,778	3,303,805	1,186,808	3,990,498	3,985,721	3,337,660	9,468,229	3,167,698	11,419,015	4,131,993	2,775,345
Burdekin	Burdekin 120006B	5,982,681	4,485,315	2,092,834	1,516,191	4,328,245	2,199,744	9,768,935	27,502,704	29,951,685	7,947,563	34,602,113	15,568,159	3,417,924
Mackay Whitsunday	Proserpine 122005A	17,140	19,969	18,583	10,350	23,782	20,393	44,740	76,447	65,556	52,341	349,085	51,926	37,411
	O'Connell 124001B	145,351	85,202	23,236		75,989	84,267	168,513	229,994	165,637	313,605	574,154	278,370	109
	Pioneer 125007A	355,228	218,366	111,589	44,939	196,084	72,633	716,235	1,300,252	822,925	1,180,449	3,044,648	1,312,054	912,117
Fitzroy	Fitzroy 130005A	2,754,600	581,373			921,670	680,627	1,057,441	12,046,873	2,028,795	11,666,996	38,058,960	7,993,273	8,532,353
Burnett Mary	Burnett 136007A	n/a	106,888	523,464	221,477	136,959	69,506	29,880	17,155	23,138	1,034,804	7,081,587	584,670	

Table provided by Schaffelke, B. Shaded cells highlight years for which river flow exceeded the median annual flow as estimated from available long-term time series for each river (LT median; from earliest available records to September 2000): yellow= 1.5 to 2-times LT median, orange= 2 to 3-times LT median, red= >3-times LT median. Discharge data were supplied by the Queensland Department of Natural Resources and Mines (gauging station codes given after river names). Missing values represent years for which >15% of daily flow estimates were not available.

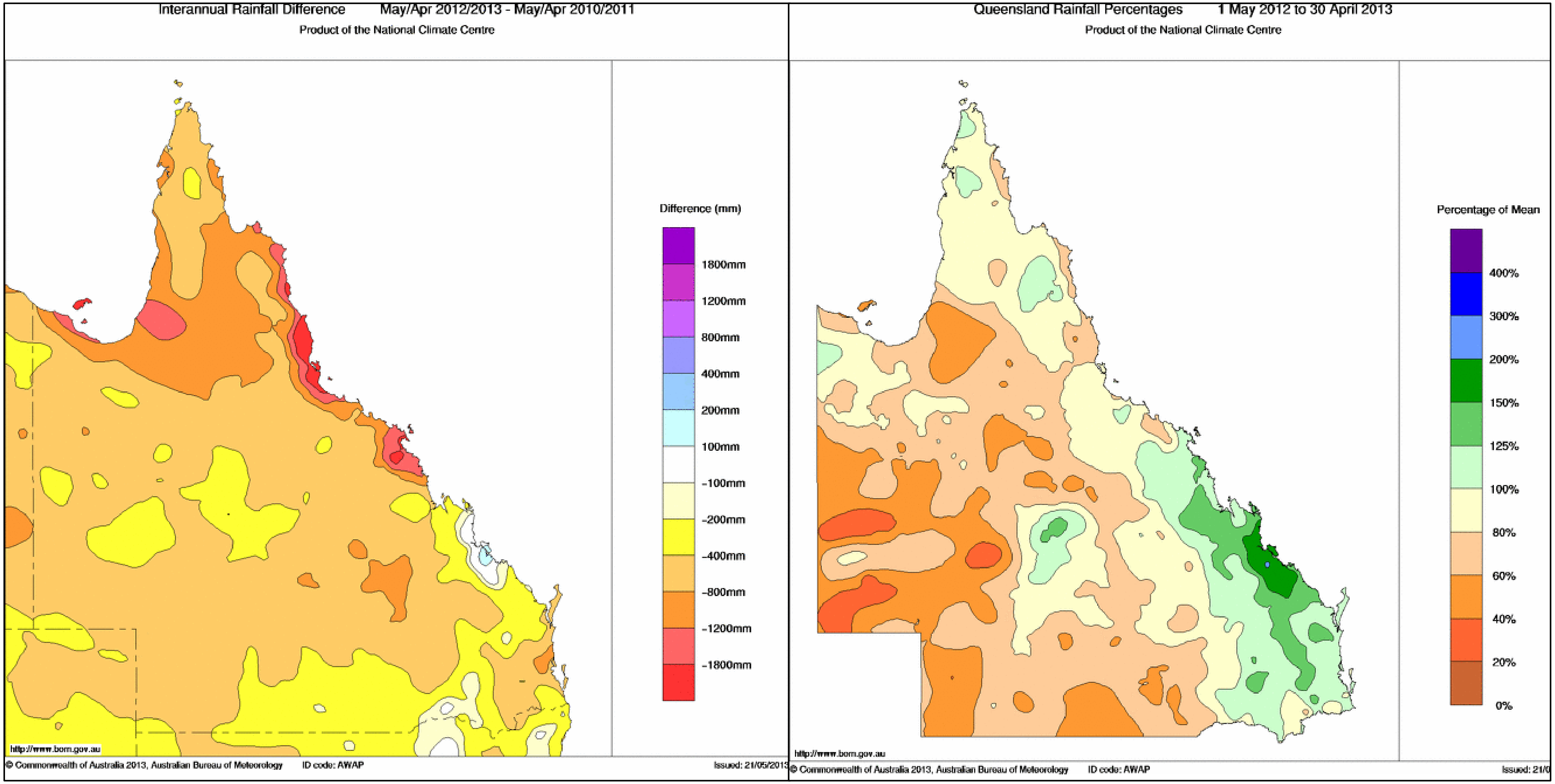

Figure 27 Queensland rainfall statistics. 2 year interannual rainfall difference May 2010/2011-May 2012/2013 (left) and rainfall percentages 1 May 2012 – 30 April 2013 (right) Figures provided by Bureau of Meteorology

12 APPENDIX D – ROUTINE MONITORING – INDIVIDUAL SITE RESULTS

Table 23 Low Isles, Wet Tropics region – Concentration in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutryn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May-12																					
Jun-12																					
Jul-12																					
Aug-12																					
Sep-12	24-Aug-12	11-Nov-12	ED	0.01	0.04	n.d.	n.d.	0.41	n.d.	0.04	n.d.	n.d.	0.01	0.45	n.d.	n.d.	n.d.	n.d.	n.d.		
Oct-12																					
Nov-12	11-Nov-12	10-Dec-12																			
Dec-12	10-Dec-12	11-Jan-13	ED	0.01	0.10	n.d.	n.d.	0.7	n.d.	0.05	n.d.	0.02	0.01	0.73	n.d.	n.d.	0.01	n.d.	n.d.		
Jan-13	11-Jan-13	15-Feb-13	ED	0.03	0.12	n.d.	n.d.	2.2	n.d.	0.46	n.d.	0.02	0.01	2.5	n.d.	n.d.	0.03	n.d.	n.d.		
Feb-13	15-Feb-13	02-Jun-13																			
Jun-13																					
ED Summary																					
Samples (n)				3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
Detects (n)				3	3	0	0	3	0	3	0	2	3	3	0	0	2	0	0		
% Detects				100	100	0	0	100	0	100	0	67	100	100	0	0	67	0	0		
Minimum concentration				0.01	0.04	n.d.	0.00	0.41	n.d.	0.04	n.d.	0.02	0.01	0.45	n.d.	n.d.	0.01	n.d.	n.d.		
Average concentration				0.02	0.09	n.d.	-	1.1	n.d.	0.18	n.d.	-	0.01	1.2	n.d.	n.d.	0.02	n.d.	n.d.		
Maximum concentration				0.03	0.12	n.d.	0.00	2.2	n.d.	0.5	n.d.	0.02	0.01	2.5	n.d.	n.d.	0.03	n.d.	n.d.		
Max/ min ratio				3.0	3.0	-	-	5.4	-	11.5	-	-	1.0	5.6	-	-	3.0	-	-		

[a] Photosystem II herbicides but not currently included in the index *Galaxolide and tonalid are detected in non-polar samplers only. Concentrations are time-integrated estimates.

Table 24 Green Island, Wet Tropics region – Concentration in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutryn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May-12	05-May-12	02-Jul-12	ED	0.02	0.54	0.08	n.d.	1.3	n.d.	0.34	n.d.	0.08	0.06	1.50	n.d.	0.05	n.d.	n.d.	n.d.		
Jun-12																					
Jul-12	02-Jul-12	29-Aug-12	ED	0.01	0.06	n.d.	n.d.	2.3	n.d.	0.09	n.d.	n.d.	0.01	2.40	n.d.	n.d.	0.01	n.d.	n.d.		
Aug-12						n.d.															
Sep-12	29-Aug-12	08-Dec-12	ED	0.02	n.d.	n.d.	n.d.	0.38	n.d.	0.01	n.d.	n.d.	0.01	0.41	n.d.	n.d.	n.d.	n.d.	n.d.		
Oct-12																					
Nov-12																					
Dec-12	08-Dec-12	15-Jan-13	ED	0.02	0.11	n.d.	n.d.	0.59	n.d.	n.d.	0.01	0.05	n.d.	0.7	n.d.	n.d.	n.d.	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.06	n.d.
Jan-13	15-Jan-13	04-Feb-13	ED	0.04	0.43	0.04	n.d.	3.0	n.d.	0.42	n.d.	0.09	0.02	3.3	n.d.	n.d.	0.05	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Feb-13	04-Feb-13	03-Mar-13	ED	0.03	0.32	0.03	n.d.	2.2	n.d.	0.31	n.d.	0.07	0.02	2.5	n.d.	n.d.	0.04	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Mar-13	03-Mar-13	02-Apr-13	ED	0.06	3.9	0.41	0.15	5.4	n.d.	1.2	n.d.	0.10	0.09	6.6	n.d.	n.d.	n.d.	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Apr-13	02-Apr-13	12-May-13	ED	0.11	1.5	0.12	n.d.	5.3	n.d.	1.3	n.d.	0.04	1.40	6.2	n.d.	n.d.	0.13	n.d.	0.17		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
ED Summary																					
Samples (n)				8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8		
Detects (n)				8	7	5	1	8	0	7	1	6	7	8	0	1	4	0	1		
% Detects				100	88	63	13	100	0	88	0	75	88	100	0	0	50	0	13		
Minimum concentration				0.01	0.06	0.03	0.15	0.38	n.d.	0.01	0.01	0.04	0.01	0.41	n.d.	n.d.	0.01	0.00	0.17		
Average concentration				0.04	0.98	0.15	-	2.6	n.d.	0.52	-	0.07	0.23	2.9	n.d.	n.d.	0.06	-	-		
Maximum concentration				0.11	3.9	0.41	0.15	5.4	n.d.	1.30	0.01	0.10	1.40	6.6	n.d.	n.d.	0.13	0.00	0.17		
Max/ min ratio				11.0	65.0	13.7	-	14.2	-	130.0	-	2.5	140.0	16.1	-	-	13.0	-	-		
PDMS Summary																					
Samples (n)				5		5	5		5	5	5	5	5				5			5	5
Detects (n)				0		0	0		0	0	0	0	0				0			2	0
% Detects				0		0	0		0	0	0	0	0				0			40	0
Minimum concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.06	n.d.
Average concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			-	n.d.
Maximum concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.06	n.d.
Max/ min ratio				-		-	-		-	-	-	-	-				-			-	-

[a] Photosystem II herbicides but not currently included in the index; *Galaxolide and tonalid are detected in non-polar samplers only. Concentrations are time-integrated estimates.

Table 25 Fitzroy Island, Wet Tropics region – Concentration in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutyrn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May-12			ED																		
Jun-12																					
Jul-12			ED																		
Aug-12																					
Sep-12	05-Sep-12	04-Nov-12	ED	0.02	0.19	n.d.	n.d.	1.4	n.d.	0.12	n.d.	n.d.	0.02	1.5	n.d.	n.d.	0.02	n.d.	n.d.		
Oct-12																					
Nov-12	04-Nov-12	04-Dec-12	ED																		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Dec-12	04-Dec-12	14-Mar-13	ED	0.06	1.8	0.20	n.d.	9	n.d.	1.0	n.d.	0.18	0.01	9.6	n.d.	n.d.	0.08	n.d.	0.08		
Mar-13			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Mar-13	14-Mar-13	03-May-13	ED	0.30	6.5	0.74	n.d.	19	n.d.	3.7	n.d.	0.15	1.5	22	n.d.	n.d.	0.25	n.d.	n.d.		
Apr-13			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.09	n.d.
ED Summary																					
Samples (n)				3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
Detects (n)				3	3	2	0	3	0	3	0	2	3	3	0	0	3	0	1		
% Detects				100	100	67	0	100	0	100	0	67	100	100	0	0	100	0	33		
Minimum concentration				0.02	0.19	0.20	n.d.	1.40	n.d.	0.12	n.d.	0.15	0.01	1.5	n.d.	n.d.	0.02	n.d.	0.08		
Average concentration				0.13	2.83	0.47	n.d.	9.8	n.d.	1.61	n.d.	0.17	0.51	11	n.d.	n.d.	0.12	n.d.	-		
Maximum concentration				0.30	6.5	0.74	n.d.	19.0	n.d.	3.70	n.d.	0.18	1.50	22	n.d.	n.d.	0.25	n.d.	0.08		
Max/ min ratio				15.0	34.2	3.7	-	13.6	-	30.8	-	1.2	150.0	14.7	-	-	12.5	-	-		
PDMS Summary																					
Samples (n)				3		3	3		3	3	3	3	3				3			3	3
Detects (n)				0		0	0		0	0	0	0	0				0			1	0
% Detects				0		0	0		0	0	0	0	0				0			33	0
Minimum concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.09	n.d.
Average concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			-	n.d.
Maximum concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.09	n.d.
Max/ min ratio				-		-	-		-	-	-	-	-				-			-	-

[a] Photosystem II herbicides but not included in the index at this stage; [*] Galaxolide and tonalid are detected in non-polar samplers only. Concentrations are time-integrated estimates.

Table 26 Normanby Island, Wet Tropics region – Concentration in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutyrn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May-12	05-May-12	21-Jul-13	ED	0.10	1.1	0.03	n.d.	2.9	n.d.	0.71	n.d.	n.d.	0.15	3.5	n.d.	0.18	n.d.	n.d.	n.d.		
Jun-12			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.18	n.d.
			SPMD	Samplers lost																	
Jul-12	21-Jul-13	31-Aug-13	ED	0.05	0.34	0.07	n.d.	0.93	n.d.	0.10	n.d.	0.06	0.02	1.1	n.d.	n.d.	n.d.	n.d.	n.d.		
Aug-12			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.04	n.d.
			SPMD	Samplers lost																	
Sep-12	31-Aug-13	02-Nov-13	ED	0.37	0.25	n.d.	n.d.	1.0	n.d.	0.11	0.05	0.03	0.01	1.6	n.d.	n.d.	0.07	n.d.	n.d.		
Oct-12			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.04	n.d.
			SPMD	Samplers lost																	
Nov-12	02-Nov-13	22-Dec-12	ED	0.01	0.10	0.02	n.d.	0.4	n.d.	0.04	n.d.	0.04	0.01	0.5	n.d.	n.d.	0.01	n.d.	0.05		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
			SPMD	Samplers lost																	
Dec-12	22-Dec-12	18-Jan-13	ED	0.42	1.2	0.06	n.d.	1.2	n.d.	0.22	0.01	0.07	0.01	2.0	n.d.	n.d.	0.11	n.d.	0.14		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
			SPMD	Samplers lost																	
Jan-13	18-Jan-13	08-Feb-13		ALL SAMPLERS LOST																	
Feb-13	08-Feb-13	02-Mar-13	ED	0.04	1.4	0.14	n.d.	5.1	n.d.	1.1	n.d.	0.09	0.01	5.8	n.d.	n.d.	0.06	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
			SPMD	Samplers lost																	
Mar-13	02-Mar-13	26-Apr-13	ED	0.07	2.2	0.20	n.d.	4.5	n.d.	1.1	n.d.	0.04	0.35	5.4	n.d.	n.d.	0.07	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
			SPMD	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Apr-13	26-Apr-13	03-May-13	ED	0.11	3.4	0.48	n.d.	11.0	n.d.	2.5	n.d.	0.11	1.9	13	n.d.	n.d.	0.16	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
			SPMD	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
ED Summary																					
Samples (n)				8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8		
Detects (n)				8	8	7	0	8	0	8	2	7	8	5	0	1	5	0	2		
% Detects				100	100	88	0	100	0	100	25	88	100	63	0	13	63	0	25		
Minimum concentration				0.01	0.10	0.02	n.d.	0.40	n.d.	0.04	0.01	0.03	0.01	0.45	n.d.	n.d.	0.01	n.d.	0.05		
Average concentration				0.15	0.74	0.07	n.d.	3.4	n.d.	0.74	0.03	0.06	0.31	4.1	n.d.	n.d.	0.08	n.d.	0.10		
Maximum concentration				0.42	3.40	0.48	n.d.	11.0	n.d.	2.5	0.05	0.11	1.90	13	n.d.	n.d.	0.16	n.d.	0.14		
Max/ min ratio				42.0	34.0	24.0	-	27.5	-	62.5	-	3.7	190.0	28.9	-	-	16.0	-	-		
PDMS Summary																					
Samples (n)				7		7	7		7	7	7	7	7				7			7	7
Detects (n)				0		0	0		0	0	0	0	0				0			3	0
% Detects				0		0	0		0	0	0	0	0				0			43	0
Minimum concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.04	n.d.
Average concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.09	n.d.
Maximum concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.18	n.d.
Max/ min ratio				-		-	-		-	-	-	-	-				-			4.5	-

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only. Concentrations are time-integrated estimates.

Table 27 Dunk Island, Wet Tropics region – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutryn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May-12	23-Apr-12	29-May-12	ED	0.01	0.26	0.04	n.d.	1.20	n.d.	0.33	n.d.	n.d.	0.24	1.4	n.d.	n.d.	0.02	0.01	n.d.		
Jun-12	29-May-12	12-Jul-12	ED	0.06	0.22	n.d.	n.d.	3.00	n.d.	0.78	0.01	n.d.	0.07	3.4	n.d.	0.10	n.d.	n.d.	n.d.		
Jul-12																					
Jul-12	12-Jul-12	29-Aug-12	ED	0.07	0.11	n.d.	n.d.	2.82	n.d.	0.57	n.d.	0.03	0.09	3.2	n.d.	n.d.	0.19	n.d.	n.d.		
Aug-12																					
Sep-12	29-Aug-12	04-Nov-12	ED	0.27	0.40	0.08	n.d.	0.58	n.d.	0.14	0.01	n.d.	0.02	1.1	n.d.	n.d.	0.05	n.d.	n.d.		
Oct-12																					
Nov-12	04-Nov-12	15-Dec-12	ED	0.02	0.11	n.d.	n.d.	0.41	n.d.	0.08	n.d	0.01	0.01	0.49	n.d.	n.d.	0.02	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Dec-12	15-Dec-12	09-Jan-13	ED																		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			0.04	n.d.
Jan-13	09-Jan-13	04-Feb-13	ED	0.11	0.29	n.d.	n.d.	11	n.d.	2.0	n.d.	0.02	0.01	12	n.d.	n.d.	0.29	n.d.	1.4		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Feb-13	04-Feb-13	15-Mar-13	ED	0.19	3.4	0.07	n.d.	15	n.d.	3.8	n.d.	0.06	0.11	18	n.d.	n.d.	0.28	n.d.	0.26		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Mar-13	15-Mar-13	8-Apr-13	ED	0.09	1.1	0.03	n.d.	5.2	n.d.	1.1	n.d.	n.d.	0.14	5.9	n.d.	n.d.	0.07	n.d.	0.49		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Apr-13	8-Apr-13	14-May-13	ED	0.14	0.73	n.d.	n.d.	6.7	n.d.	2.1	n.d.	n.d.	1.9	8.2	n.d.	n.d.	0.22	n.d.	0.21		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				6.8			n.d.	n.d.
ED Summary																					
Samples (n)				9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9		
Detects (n)				9	9	4	0	9	0	9	2	4	9	9	0	1	8	1	4		
% Detects				100	100	44	0	100	0	100	0	44	100	100	0	11	89	11	44		
Minimum concentration				0.01	0.11	0.03	n.d.	0.41	n.d.	0.08	0.01	0.01	0.01	0.49	n.d.	0.10	0.02	0.01	0.21		
Average concentration				0.11	0.74	0.06	n.d.	5.10	n.d.	1.21	0.01	0.03	0.29	6.0	n.d.	0.10	0.14	0.01	0.59		
Maximum concentration				0.27	3.40	0.08	n.d.	15.00	n.d.	3.80	0.01	0.06	1.90	18	n.d.	0.10	0.29	0.01	1.40		
Max/ min ratio				27.0	30.9	2.7	-	36.6	-	47.5	-	-	190.0	36.7	-	-	14.5	-	-		
PDMS Summary																					
Samples (n)				6		6	6		6	6	6	6	6				6			6	6
Detects (n)				0		0	0		0	0	0	0	0				1			1	0
% Detects				0		0	0		0	0	0	0	0				17			17	0
Minimum concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				6.80			0.04	n.d.
Average concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				-			-	n.d.
Maximum concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				6.80			0.04	n.d.
Max/ min ratio				-		-	-		-	-	-	-	-				-			-	-

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only and concentrations are time-integrated estimates. Metolachlor has been detected in a single PDMS deployment in April 2013,and the concentration of 6.8 ng.L^{-1} is an equilibrium estimate.

Table 28 Dickson Inlet case study, Wet Tropics – Concentrations in water (ng.L^{-1})

	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
Site	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutryn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Pendimethalin*
Dickson Inlet	21-Dec-12	11-Jan-13	ED	0.03	0.13	n.d.	n.d.	21.00	n.d.	0.12	n.d.	0.12	0.01	21	n.d.	n.d.	0.02	n.d.	n.d.		
			PDMS	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.	0.13	n.d.
	27-Feb-13	02-Apr-13	ED	0.43	5.50	0.54	0.17	9.5	n.d.	1.50	0.01	0.41	0.06	12.00	n.d.	n.d.	0.12	n.d.	0.17		
			PDMS	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.20
Crees Creek	27-Feb-13	02-Apr-13	ED	0.02	0.08	0.09	1.90	43.0	n.d.	17.00	n.d.	2.80	n.d.	43.0	0.89	0.61	0.09	n.d.	18.00		
			PDMS	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and pendimethalin are detected in non-polar samplers only and concentrations are time-integrated estimates

Table 29 Orpheus Island, Burdekin region – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutyrn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May-12	04-May-12	07-Jul-12	ED	0.05	0.68	0.03	n.d.	2.00	n.d.	0.53	n.d.	0.01	0.07	2.60	n.d.	n.d.	n.d.	n.d.	n.d.		
Jun-12																					
Jul-12	07-Jul-12	29-Aug-12	ED	0.03	0.33	0.04	n.d.	0.81	n.d.	0.15	n.d.	0.02	0.04	0.97	n.d.	n.d.	0.07	n.d.	n.d.		
Aug-12			ED																		
Sep-12	29-Aug-12	04-Nov-12	ED	0.04	0.47	0.08	n.d.	0.54	n.d.	0.11	n.d.	0.04	0.04	0.72	n.d.	n.d.	0.07	n.d.	n.d.		
Oct-12																					
Nov-12	04-Nov-12	01-Dec-12	ED	0.02	0.17	n.d.	n.d.	1.00	n.d.	n.d.	n.d.	0.04	0.01	1.1	n.d.	n.d.	0.03	n.d.	n.d.		
Dec-12	01-Dec-12	05-Feb-13	ED	0.05	1.7	0.13	n.d.	5.1	n.d.	0.89	n.d.	0.13	0.01	5.8	n.d.	n.d.	0.09	n.d.	0.18		
Jan-13																					
Feb-13	05-Feb-13	02-Mar-13	ED	0.12	5.6	0.56	n.d.	11	n.d.	1.9	n.d.	0.13	0.10	13	n.d.	n.d.	0.15	n.d.	n.d.		
Mar-13	02-Mar-13	06-Apr-13	ED	0.09	2.4	0.20	n.d.	5.1	n.d.	1.00	n.d.	0.02	0.12	6.0	n.d.	n.d.	0.06	n.d.	n.d.		
Apr-13	06-Apr-13	06-May-13	ED	0.22	0.89	n.d.	n.d.	11	n.d.	2.9	n.d.	n.d.	3.7	12	n.d.	n.d.	0.36	n.d.	n.d.		
ED Summary																					
Samples (n)				8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8		
Detects (n)				8	8	6	0	8	0	7	0	7	8	8	0	0	7	0	1		
% Detects				100	100	75	0	100	0	88	0	88	100	100	0	0	88	0	13		
Minimum concentration				0.02	0.17	0.03	n.d.	0.54	n.d.	0.11	n.d.	0.01	0.01	0.72	n.d.	n.d.	0.03	n.d.	0.18		
Average concentration				0.08	1.53	0.17	n.d.	4.6	n.d.	1.07	n.d.	0.06	0.51	5.3	n.d.	n.d.	0.12	n.d.	-		
Maximum concentration				0.22	5.60	0.56	n.d.	11.0	n.d.	2.90	n.d.	0.13	3.70	13	n.d.	n.d.	0.36	n.d.	0.18		
Max/ min ratio				11.0	32.9	18.7	-	20.4	-	26.4	-	13.0	370.0	18.1	-	-	12.0	-	-		

[a] Photosystem II herbicides but not included in the index at this stage. *Galaxolide and tonalid are detected in non-polar samplers only and concentrations are are time-integrated estimates.

Table 30 Magnetic Island, Burdekin Region – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insecticides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutryn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May-12	05-May-12	03-Jul-12	ED	0.06	1.90	0.29	n.d.	9.2	n.d.	0.64	n.d.	0.12	0.14	9.9	n.d.	0.17	n.d.	n.d.	n.d.		
Jun-12																					
Jul-12	03-Jul-12	27-Aug-12	ED	0.12	2.50	0.48	0.12	5.0	n.d.	0.28	n.d.	0.10	0.11	5.3	n.d.	n.d.	0.30	n.d.	n.d.		
Aug-12																					
Sep-12	27-Aug-12	02-Nov-12	ED	0.06	0.53	0.02	n.d.	5.40	n.d.	0.14	n.d.	0.03	0.12	5.70	n.d.	n.d.	0.20	n.d.	n.d.		
Oct-12																					
Nov-12	02-Nov-12	19-Dec-12	ED	0.03	0.51	0.07	n.d.	5.5	n.d.	0.06	0.01	0.03	0.03	5.7	n.d.	n.d.	0.04	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Dec-12	19-Dec-12	13-Jan-13	ED	0.03	0.81	0.15	0.05	5.1	n.d.	0.05	n.d.	0.08	0.68	5.4	n.d.	n.d.	0.04	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Jan-13	13-Jan-13	09-Feb-13	ED	0.21	13	1.40	0.23	21	n.d.	0.46	0.01	0.11	0.16	24	n.d.	n.d.	0.19	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Feb-13	09-Feb-13	04-Mar-13	ED	0.11	11	1.40	0.42	8.6	n.d.	0.38	n.d.	0.10	0.27	11	n.d.	n.d.	0.16	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Mar-13	04-Mar-13	02-Apr-13	ED	0.04	2.1	0.30	0.08	5.3	n.d.	0.45	n.d.	0.05	0.14	5.9	n.d.	n.d.	0.03	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Apr-13	02-Apr-13	21-May-13	ED	0.15	4.2	0.56	0.12	9.9	n.d.	2.1	n.d.	0.08	2.50	12	n.d.	n.d.	0.26	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				6.00			n.d.	n.d.
ED Summary																					
Samples (n)				9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9		
Detects (n)				9	9	9	6	9	0	9	2	9	9	8	0	1	8	0	0		
% Detects				100	100	100	67	100	0	100	0	100	100	89	0	11	89	0	0		
Minimum concentration				0.03	0.51	0.02	0.05	5.00	n.d.	0.05	n.d.	0.03	0.03	5.30	n.d.	0.17	0.03	n.d.	n.d.		
Average concentration				0.09	4.06	0.52	0.17	8.3	n.d.	0.51	n.d.	0.08	0.46	9.4	n.d.	-	0.15	n.d.	n.d.		
Maximum concentration				0.21	13.0	1.40	0.42	21.0	n.d.	2.10	n.d.	0.12	2.50	24.0	n.d.	0.17	0.30	n.d.	n.d.		
Max/ min ratio				7.0	25.5	70.0	8.4	4.2	-	42.0	-	4.0	83.3	4.5	-	-	10.0	-	-		
PDMS Summary																					
Samples (n)				6		6	6		6	6	6	6	6				6			6	6
Detects (n)				0		0	0		0	0	0	0	0				1			0	0
% Detects				0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0				16.7			0.0	0.0
Minimum concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				6.0			n.d.	n.d.
Average concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				-			n.d.	n.d.
Maximum concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				6.0			n.d.	n.d.
Max/ min ratio				-		-	-		-	-	-	-	-				-			-	-

[a] Photosystem II herbicides but not included in the index at this stage; [*]*Galaxolide and tonalid are detected in non-polar samplers only and concentrations are time-integrated estimates. Metolachlor has been detected in one PDMS deployment and theconcentration of 6 ng.L^{-1} is an equilibrium estimate.

Table 31 Cape Cleveland, Burdekin Region – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutryn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May-12	03-May-12	03-Jul-12	ED	0.20	2.30	0.32	n.d.	3.2	n.d.	0.80	n.d.	0.06	0.15	4.2	0.21	0.51	n.d.	n.d.	n.d.		
Jun-12																					
Jul-12	03-Jul-12	03-Sep-12	ED	0.45	0.65	n.d.	n.d.	0.98	n.d.	0.24	n.d.	n.d.	0.13	1.8	n.d.	n.d.	1.10	n.d.	n.d.		
Aug-12																					
Sep-12	03-Sep-12	05-Nov-12	ED	0.06	0.32	n.d.	n.d.	0.65	n.d.	0.12	n.d.	n.d.	0.08	0.83	n.d.	n.d.	0.33	n.d.	n.d.		
Oct-12																					
Nov-12	05-Nov-12	03-Dec-12	ED	0.08	0.57	0.11	n.d.	0.46	n.d.	0.06	0.01	0.08	0.02	0.70	n.d.	n.d.	0.06	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Dec-12	03-Dec-12	02-Jan-13	ED	0.10	0.51	0.1	n.d.	0.8	n.d.	0.10	n.d.	n.d.	0.04	1.1	n.d.	n.d.	0.09	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Jan-13	02-Jan-13	13-Feb-13	ED	0.41	28	4.0	1.10	11	n.d.	0.27	0.01	0.16	0.18	17	n.d.	n.d.	0.46	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				6.00			n.d.	n.d.
Feb-13	13-Feb-13	06-Mar-13	ED	0.53	20	2.6	n.d.	9.2	n.d.	0.48	n.d.	0.13	0.38	14	n.d.	n.d.	0.29	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Mar-13	06-Mar-13	08-Apr-13	ED	0.39	5.1	1.2	0.27	11	n.d.	2.2	n.d.	0.07	0.40	13	n.d.	n.d.	0.16	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				n.d.			n.d.	n.d.
Apr-13	08-Apr-13	13-May-13	ED	0.33	2.2	0.13	n.d.	8.6	n.d.	2.5	n.d.	0.05	2.4	11	n.d.	n.d.	0.39	n.d.	n.d.		
			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				6.30			n.d.	n.d.
ED Summary																					
Samples (n)				9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9		
Detects (n)				9	8	7	2	9	0	9	2	6	9	9	1	1	5	0	0		
% Detects				100	89	78	22	100	0	100	22	67	100	100	11	11	56	0	0		
Minimum concentration				0.06	0.32	0.11	0.27	0.46	n.d.	0.06	n.d.	0.05	0.02	0.70	n.d.	n.d.	0.06	0.00	n.d.		
Average concentration				0.27	4.0	0.7	0.27	4.4	n.d.	0.75	n.d.	0.09	0.42	7.1	0.2	n.d.	0.35	-	n.d.		
Maximum concentration				0.53	15	4.0	1.10	11.0	n.d.	2.50	n.d.	0.16	2.40	17	n.d.	n.d.	1.10	0.00	n.d.		
Max/ min ratio				8.8	47.4	36.4	4.1	23.9	-	41.7	-	3.2	120.0	24.3	-	-	18.3	-	-		
PDMS Summary																					
Samples (n)				6		6	6		6	6	6	6	6				6			6	6
Detects (n)				0		0	0		0	0	0	0	0				1			0	0
% Detects				0		0	0		0	0	0	0	0				17			0	0
Minimum concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				6.30			n.d.	n.d.
Average concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				-			n.d.	n.d.
Maximum concentration				n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				6.3			n.d.	n.d.
Max/ min ratio				-		-	-		-	-	-	-	-				-			-	-

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only and concentrations are are time-integrated estimates. Metolachlor has been detected in two PDMS deployments, the concentrations are equilibrium estimates.

Table 32 Pioneer Bay, Mackay Whitsunday – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutyrn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
Jun-12	03-Jun-12	16-Sep-12	ED	0.02	0.07	n.d.	n.d.	3.7	n.d.	0.10	n.d.	n.d.	0.38	3.8	n.d.	0.19	n.d.	n.d.	n.d.		
Jul-12																					
Aug-12																					
Sep-12																					
Sep-12				Sampler not returned																	
Oct-12																					
Nov-12				Sampler not returned																	
Dec-12																					
Jan-13				Sampler not returned																	
Feb-13																					
Mar-13				Sampler not returned																	
Apr-13				Sampler not returned																	
ED Summary																					
Samples (n)				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
Detects (n)				1	1	0	0	1	0	1	0	0	1	1	0	1	0	0	0		
% Detects				100	100	0	0	100	0	100	0	0	100	100	0	0	0	0	0		
Minimum concentration				0.02	0.07	n.d.	n.d.	3.7	n.d.	0.10	n.d.	n.d.	0.38	3.8	n.d.	0.19	n.d.	n.d.	n.d.		
Average concentration				-	-	n.d.	n.d.	-	n.d.	-	n.d.	n.d.	-		n.d.	-	n.d.	n.d.	n.d.		
Maximum concentration				0.02	0.07	n.d.	n.d.	3.7	n.d.	0.10	n.d.	n.d.	0.38	3.8	n.d.	0.19	n.d.	n.d.	n.d.		
Max/ min ratio				-	-	-	-	-	-	-	-	-	-		-	-	-	-	-		

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only and concentrations are are time-integrated estimates.

Table 33 Outer Whitsunday, Mackay Whitsunday region – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutyrn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May-12	05-May-12	27-Jul-12	ED	0.06	2.84	0.37	n.d.	2.44	n.d.	0.37	0.01	0.15	1.11	3.3	n.d.	n.d.	n.d.	n.d.	n.d.		
Jun-12																					
Jul-12																					
Aug-12	27-Jul-12	31-Aug-12		0.03	0.34	n.d.	n.d.	0.93	n.d.	0.11	0.01	0.02	0.51	1.1	n.d.	n.d.	n.d.	n.d.	n.d.		
Sep-12	31-Aug-12	01-Oct-12	ED	0.01	0.33	0.06	n.d.	0.50	n.d.	0.06	n.d.	0.03	0.16	0.61	n.d.	n.d.	0.04	n.d.	n.d.		
Oct-12	01-Oct-12	03-Nov-12	ED	0.02	0.17	n.d.	n.d.	0.30	n.d.	n.d.	n.d.	n.d.	0.04	0.36	n.d.	n.d.	0.02	n.d.	n.d.		
Nov-12	03-Nov-12	03-Dec-12	ED	0.01	0.07	n.d.	n.d.	0.32	n.d.	0.03	0.01	n.d.	0.02	0.37	n.d.	n.d.	0.01	n.d.	n.d.		
			PDMS																		
Dec-12	03-Dec-12	05-Feb-13	ED	0.01	0.13	0.03	n.d.	0.25	n.d.	0.02	n.d.	0.03	0.01	0.30	n.d.	n.d.	0.01	n.d.	n.d.		
Jan-13			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.		n.d.		n.d.			n.d.	n.d.
Feb-13	05-Feb-13	04-Mar-13	ED	0.61	3.2	0.06	n.d.	38	n.d.	6.8	n.d.	n.d.	4.7	42	n.d.	n.d.	0.58	n.d.	0.32		
			PDMS	7.9		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.		n.d.		n.d.			0.08	n.d.
Mar-13	04-Mar-13	05-May-13	ED	0.11	1.0	0.12	n.d.	2.0	n.d.	0.53	n.d.	0.07	3.7	2.8	n.d.	n.d.	0.39	n.d.	n.d.		
Apr-13			PDMS	n.d.		n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.		n.d.		4.6			n.d.	n.d.
ED Summary																					
Samples (n)				8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8		
Detects (n)				8	8	5	0	8	0	7	3	5	8	8	0	0	7	0	1		
% Detects				100	100	63	0	100	0	88	0	63	100	100	0	0	88	0	13		
Minimum concentration				0.01	0.07	0.03	n.d.	0.25	n.d.	0.02	n.d.	0.02	0.01	0.30	n.d.	n.d.	0.01	n.d.	0.32		
Average concentration				0.11	1.01	0.13	n.d.	5.6	n.d.	1.13	n.d.	-	1.29	6.4	n.d.	n.d.	0.18	n.d.	-		
Maximum concentration				0.61	3.2	0.37	n.d.	38.0	n.d.	6.80	n.d.	0.15	4.70	42	n.d.	n.d.	0.58	n.d.	0.32		
Max/ min ratio				61	46	12	-	152	-	340	-	-	470	140	-	-	58	-	-		
PDMS Summary																					
Samples (n)				3	3	3	3		3	3	3	3	3				3			3	3
Detects (n)				1	0	0	0		0	0	0	0	0				1			1	0
% Detects				0	0	0	0		0	0	0	0	0				33			0	0
Minimum concentration				7.9	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				4.60			0.08	n.d.
Average concentration				-	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				-			-	n.d.
Maximum concentration				7.9	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.				4.60			0.08	n.d.
Max/ min ratio				-	-	-	-		-	-	-	-	-				-			-	-

[a] Photosystem II herbicides but not included in the index at this stage; [*]*Galaxolide and tonalid are detected in non-polar samplers only and concentrations are are time-integrated estimates. Metoloachlor was detected in one PDMS deployment and the concentration of 4.6 ng.L^{-1} is an equilibrium estimate.

Table 34 Sarina Inlet, Mackay Whitsunday region – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutryn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May-12	06-May-12	11-Jul-12	ED	0.04	1.1	0.15	n.d.	1.30	n.d.	0.34	0.01	0.11	0.96	1.8	n.d.	n.d.	n.d.	n.d.	n.d.		
Jun-12																					
Jul-12	11-Jul-12	27-Aug-12	ED	0.06	2.2	0.46	0.18	3.2	n.d.	1.2	0.01	0.16	0.71	4.2	n.d.	n.d.	0.18	n.d.	n.d.		
Aug-12																					
Sep-12	27-Aug-12	09-Nov-12	ED	0.09	2.30	0.43	n.d.	3.70	n.d.	1.00	0.01	0.15	0.63	4.7	n.d.	n.d.	0.26	n.d.	n.d.		
Oct-12																					
Nov-12	09-Nov-12	06-Dec-12	ED	0.05	0.8	0.14	n.d.	2.1	n.d.	0.5	0.01	0.17	0.25	2.5	n.d.	n.d.	0.09	n.d.	n.d.		
Dec-12	06-Dec-12	17-Jan-13	ED	0.26	6.4	0.6	n.d.	15	n.d.	6.1	0.01	0.14	0.30	19	n.d.	n.d.	0.14	n.d.	0.36		
Jan-13	17-Jan-13	18-Apr-13	ED	3.8	32	0.22	n.d.	203	n.d.	51	n.d.	0.09	12.00	234	n.d.	n.d.	2.40	n.d.	1.90		
Feb-13																					
Mar-13																					
Apr-13																					
ED Summary																					
Samples (n)				6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6		
Detects (n)				6	6	6	1	6	0	6	5	6	6	6	0	0	5	0	2		
% Detects				100	100	100	17	100	0	100	83	100	100	100	0	0	83	0	33		
Minimum concentration				0.04	0.84	0.14	0.18	1.30	n.d.	0.34	0.01	0.09	0.25	1.80	n.d.	n.d.	0.09	n.d.	0.36		
Average concentration				0.72	7.5	0.33	-	38.1	n.d.	10.0	0.01	0.14	2.48	44.4	n.d.	n.d.	0.61	n.d.	1.13		
Maximum concentration				3.80	32	0.6	0.18	203	n.d.	51.0	0.01	0.17	12.00	234	n.d.	n.d.	2.40	n.d.	1.90		
Max/ min ratio				95.0	38.1	4.3	-	156.2	-	150.0	-	1.9	48.0	130.0	-	-	26.7	-	5.3		

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only and concentrations are are time-integrated estimates.

Table 35 North Keppel Island, Fitzroy Region – Concentrations in water (ng.L^{-1})

Sampling Period	Deployment Dates		Sampler Type	PSII Herbicides (Included in Index)										PSII-HEq (ng/L)	Other Herbicides (Not indexed)				Insectides and other		
	START	END		Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Flumeturon	Hexazinone	Prometryn	Simazine	Tebuthiuron		Bromacil[a]	Terbutyrn[a]	Metolachlor	Imazapic	Imidacloprid	Galaxolide*	Tonalid*
May-12	15-May-12	10-Jul-12	ED	0.02	0.32	0.05	n.d.	0.72	n.d.	0.05	n.d.	0.16	0.11	0.8	n.d.	n.d.	n.d.	n.d.	n.d.		
Jun-12																					
Jul-12	10-Jul-12	07-Sep-12	ED	0.01	0.26	0.06	0.09	0.55	n.d.	0.07	n.d.	1.4	5.20	1.2	n.d.	n.d.	0.06	n.d.	n.d.		
Aug-12																					
Sep-12	07-Sep-12	10-Nov-12	ED	0.01	0.17	0.04	0.05	0.31	n.d.	0.03	n.d.	0.71	2.4	0.61	n.d.	n.d.	0.02	n.d.	n.d.		
Oct-12																					
Nov-12	10-Nov-12	10-Dec-12	ED	0.03	0.21	0.04	n.d.	0.71	n.d.	n.d.	0.01	0.06	0.69	0.86	n.d.	n.d.	0.03	n.d.	n.d.		
Dec-12	10-Dec-12	29-Jan-13	ED	0.01	0.28	0.04	n.d.	0.9	n.d.	0.03	n.d.	0.10	0.35	1.0	n.d.	n.d.	0.03	n.d.	n.d.		
Jan-13																					
Feb-13	29-Jan-13	11-Feb-13	ED	0.45	8.1	0.67	0.58	5.6	n.d.	1.6	0.06	0.95	57.0	13	n.d.	0.41	6.40	n.d.	n.d.		
Feb-13	11-Feb-13	13-Mar-13	ED	0.44	2.8	0.22	0.09	5.1	n.d.	0.83	0.10	0.14	2.9	7.0	0.26	0.08	1.30	n.d.	n.d.		
Mar-13	13-Mar-13	23-Apr-13	ED	n.d.	1.1	0.23	n.d.	1.4	n.d.	0.25	n.d.	0.1	0.77	1.8	n.d.	n.d.	0.76	n.d.	n.d.		
Apr-13	23-Apr-13	02-May-13	ED	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	n.d.	n.d.	n.d.	n.d.	n.d.		
ED Summary																					
Samples (n)				9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9		
Detects (n)				7	8	8	4	8	0	7	3	8	8	9	1	2	7	0	0		
% Detects				78	89	89	44	89	0	78	33	89	89	100	11	22	78	0	0		
Minimum concentration				0.01	0.17	0.04	0.05	0.31	n.d.	0.03	0.01	0.06	0.11	0.00	0.26	0.08	0.02	n.d.	n.d.		
Average concentration				0.14	1.65	0.17	0.20	1.90	n.d.	0.41	0.06	0.45	8.68	2.9	-	0.25	1.23	n.d.	n.d.		
Maximum concentration				0.45	8.1	0.67	0.58	5.6	n.d.	1.60	0.10	1.40	57.0	13	0.26	0.41	6.40	n.d.	n.d.		
Max/ min ratio				45.0	47.5	16.8	11.6	18.0	-	53.3	10.0	23.3	518.2		-	-	320.0	-	-		

[a] Photosystem II herbicides but not included in the index at this stage; *Galaxolide and tonalid are detected in non-polar samplers only and concentrations are are time-integrated estimates.

13 APPENDIX E – TERRESTRIAL RUN-OFF ASSESMENT- RESULTS

Table 36 Concentrations in water (ng.L^{-1}) measured at various locations using 1 L grab samples during terrestrial run-off events during the wet season

								PSII Herbicides (Included in Index)											Other Herbicides (Not indexed)				Other
Catchment	Transect	Date	Time	Site Name	Location	Latitude	Longtitude	Ametryn	Atrazine	DE Atrazine	DI Atrazine	Diuron	Fluometuron	Hexazinone	Prometryn	Simazine	Tebuthiuron	PSII-HEq (ng.L^{1})	Bromacil	Terbutyrn	Metolachlor	Imazapic	Imidacloprid
Cape York	Normanby River	30-Jan-13	16:00:00	FP-1084	Princess Charlotte Bay	-14.287567	144.07155	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		30-Jan-13	17:30:00	FP-1086	Princess Charlotte Bay	-14.34135	144.139717	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		31-Jan-13	07:30:00	FP-1087	Princess Charlotte Bay	-14.364383	144.109033	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		31-Jan-13	08:10:00	FP-1088	Normanby River mouth 1	-14.3812	144.12495	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		31-Jan-13	09:02:00	FP-1089	Normanby River mouth 2	-14.390083	144.110817	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		31-Jan-13	10:47:00	FP-1090	Princess Charlotte Bay	-14.40435	144.0313	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		31-Jan-13	11:45:00	FP-1091	Bizant River mouth	-14.45435	144.026617	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		31-Jan-13	12:55:00	FP-1092	North Kennedy River mouth 2	-14.450167	143.958183	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		31-Jan-13	13:50:00	FP-1093	North Kennedy River mouth 1	-14.464817	143.927633	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		31-Jan-13	15:10:00	FP-1094	Princess Charlotte Bay	-14.337833	143.89965	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		31-Jan-13	16:40:00	FP-1095	Princess Charlotte Bay	-14.195333	143.870917	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		01-Feb-13	11:45:00	FP-1097	Princess Charlotte Bay - near Blackwood Island	-14.253367	144.201917	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Wet Tropics	Barron River	03-Feb-13	08:59:00	FP-1103	Barron River Mouth	-16.84835	145.7732	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
	Russell-Mulgrave River	03-Feb-13	12:59:00	FP-1106	Russell-Mulgrave River mouth	-17.205516	145.9782	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
	Tully River	11-Nov-12	14:21:00	FP-988	Sisters Island South	-17.7868	146.14025	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		15-Jan-13	12:28:00	FP-998	Tully River mouth	-18.028667	146.060683	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		15-Jan-13	13:28:00	FP-999	Bedarra Island	-18.000267	146.142017	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		27-Jan-13	11:10:00	FP-1071	Tully Mid (between Goold and Bedarra Island)	-18.083483	146.111283	n.d.	31	n.d.	n.d.	140	n.d.	41	n.d.	n.d.	n.d.	160	n.d.	n.d.	n.d.	n.d.	20
	Herbert River - North	16-Jan-13	15:18:00	FP-1006	Channel North	-18.245567	146.06845	n.d.	n.d.	n.d.	n.d.	12	n.d.	n.d.	n.d.	n.d.	n.d.	12	n.d.	n.d.	n.d.	n.d.	n.d.
		16-Jan-13	14:25:00	FP-1005	Goold Island	-18.158417	146.150317	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		25-Mar-13	11:50:00	FP-1121	Channel North	-18.2456	146.067783	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
	Herbert River - South	17-Jan-13	11:54:00	FP-1012	Herbert River mouth 2	-18.497317	146.284117	n.d.	n.d.	n.d.	n.d.	24	n.d.	n.d.	n.d.	22	n.d.	26	n.d.	n.d.	n.d.	n.d.	n.d.
		17-Jan-13	08:50:00	FP-1008	Channel South	-18.493667	146.317817	n.d.	n.d.	n.d.	n.d.	15	n.d.	n.d.	n.d.	17	n.d.	16	n.d.	n.d.	n.d.	n.d.	n.d.
		25-Mar-13	13:00:00	FP-1122	Seymour River mouth	-18.492733	146.233917	n.d.	n.d.	n.d.	n.d.	29	n.d.	n.d.	n.d.	n.d.	n.d.	29	n.d.	n.d.	n.d.	n.d.	n.d.
		25-Mar-13	13:20:00	FP-1123	Herbert River mouth 1	-18.495317	146.27435	n.d.	n.d.	n.d.	n.d.	33	n.d.	n.d.	n.d.	n.d.	n.d.	33	n.d.	n.d.	n.d.	n.d.	n.d.
Burdekin	Burdekin River	13-Mar-13	10:20:00	FP-1168	Palm Island - South	-18.94308	146.72116	n.d.	28	n.d.	n.d.	82	n.d.	19	n.d.	n.d.	n.d.	93	n.d.	n.d.	n.d.	n.d.	n.d.
		17-Mar-13	08:27:00	FP-1196	Burdekin River mouth	-19.7481	147.6311	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fitzroy	Mary River	08-Feb-13	12:47:00	FP-1161	Mary River mouth	-25.416833	152.941167	n.d.	11	n.d.	n.d.	18	n.d.	n.d.	n.d.	n.d.	n.d.	20	n.d.	n.d.	n.d.	n.d.	n.d.
		08-Feb-13	11:17:00	FP-1159	Mary River transect 1	-25.231	152.93	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		09-Feb-13	07:05:00	FP-1162	Mary River transect 2	-25.18562	152.82085	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		09-Feb-13	08:45:00	FP-1165	Mary River transect 3	-25.01999	152.66315	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		09-Feb-13	09:36:00	FP-1166	Mary River transect 4	-24.86995	152.64804	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

14 APPENDIX F – MEAN FLOW RATES IN MAJOR RIVERS VS PSII-HEQ OF PASSIVE SAMPLERS

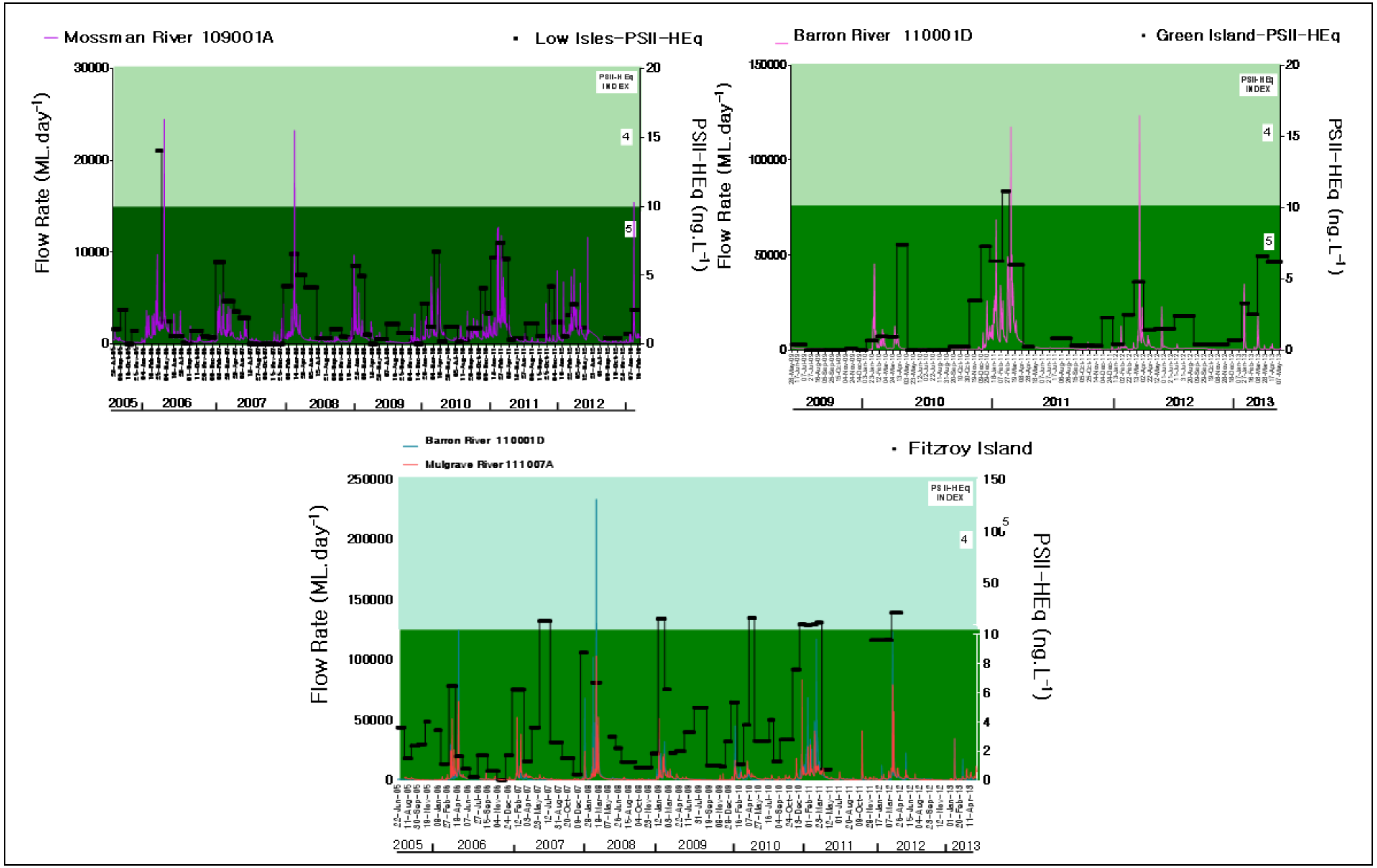

Figure 28 Temporal trends in PSII-HEq with respect to flow rate of rivers influencing passive sampler sites in the Wet Tropics region since monitoring commenced

(Flow data provided by Department of Environment and Resource Management, Stream Gauging Network)

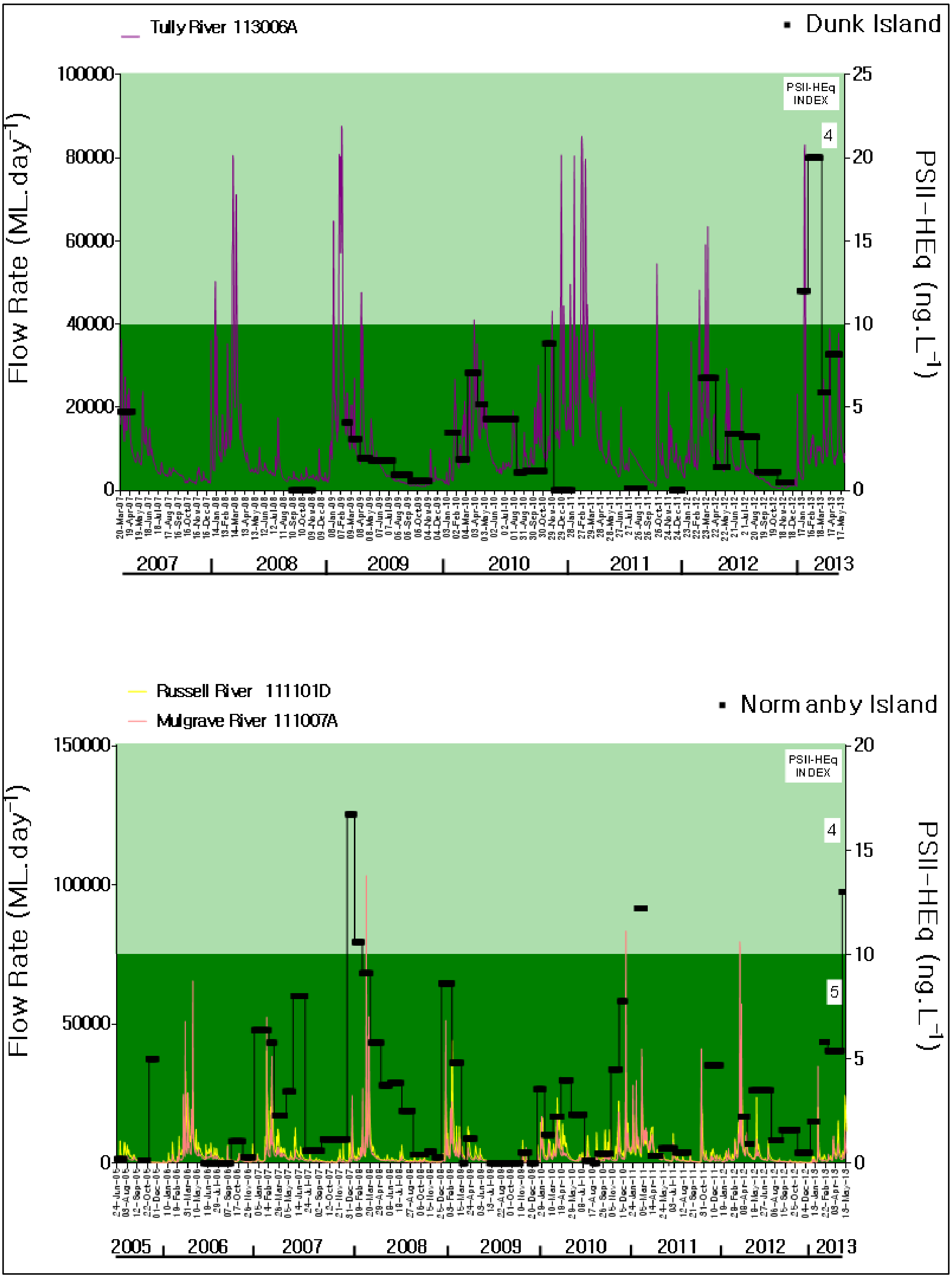

Figure 29 Temporal trends in PSII-HEq with respect to flow rate of rivers influencing passive sampler sites in the Wet Tropics region since monitoring commenced
(Flow data provided by Department of Environment and Resource Management, Stream Gauging Network)

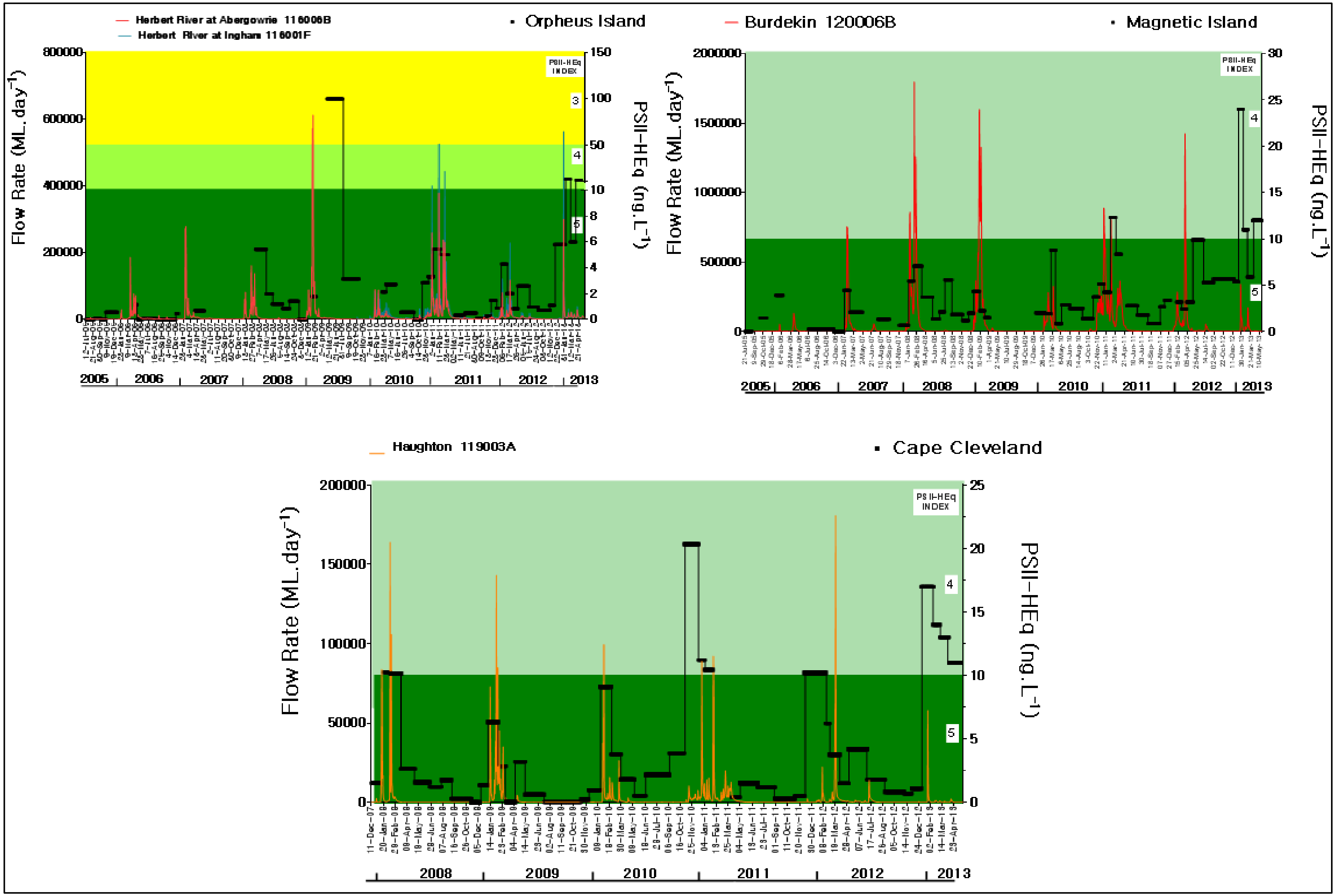

Figure 30 Temporal trends in PSII-HEq with respect to flow rate of rivers influencing passive sampler sites in the Burdekin region since monitoring commenced

(Flow data provided by Department of Environment and Resource Management, Stream Gauging Network)

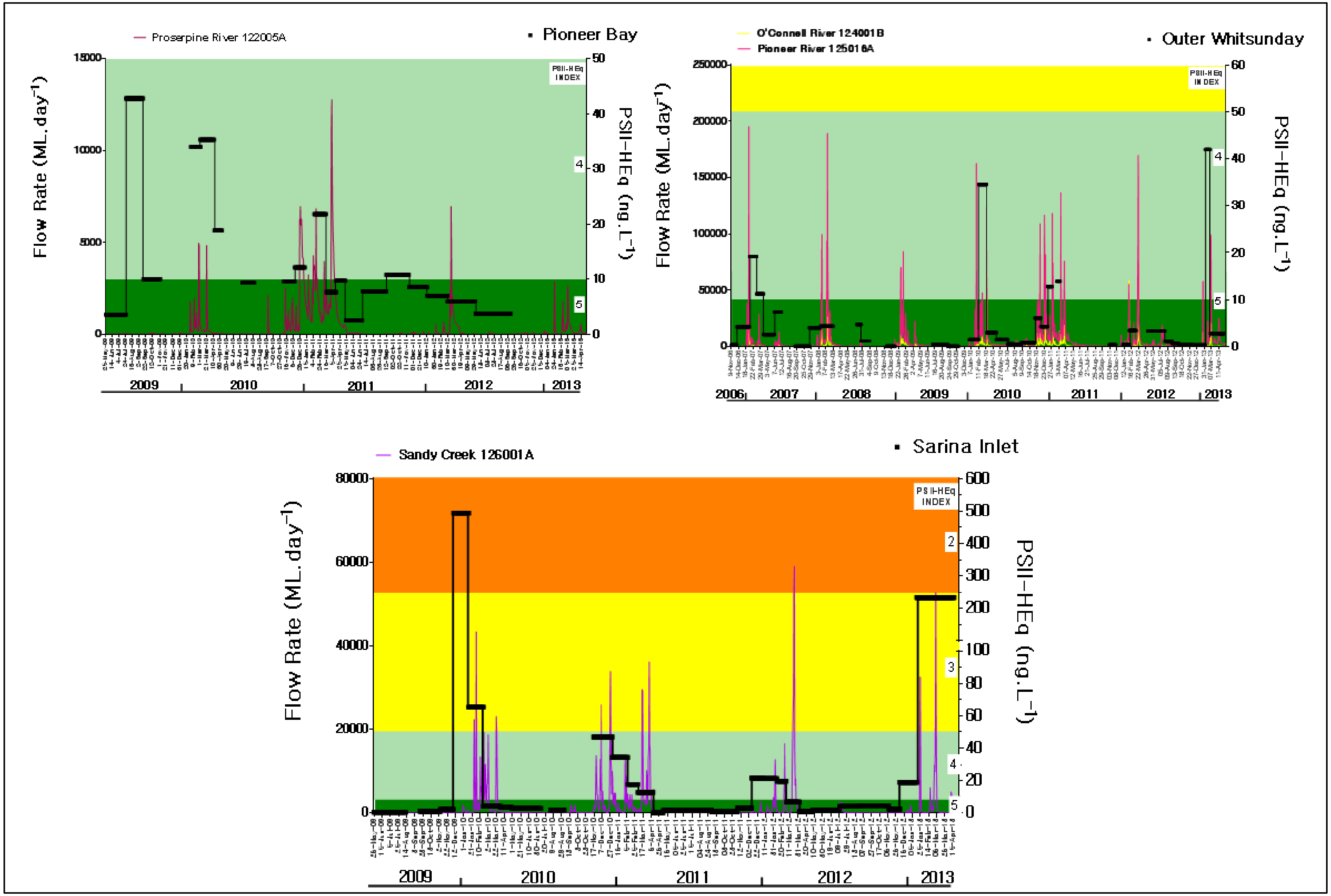

Figure 31 Temporal trends in PSII-HEq with respect to flow rate of rivers influencing passive sampler sites in the Mackay Whitsunday region since monitoring commenced

(Flow data provided by Department of Environment and Resource Management, Stream Gauging Network)

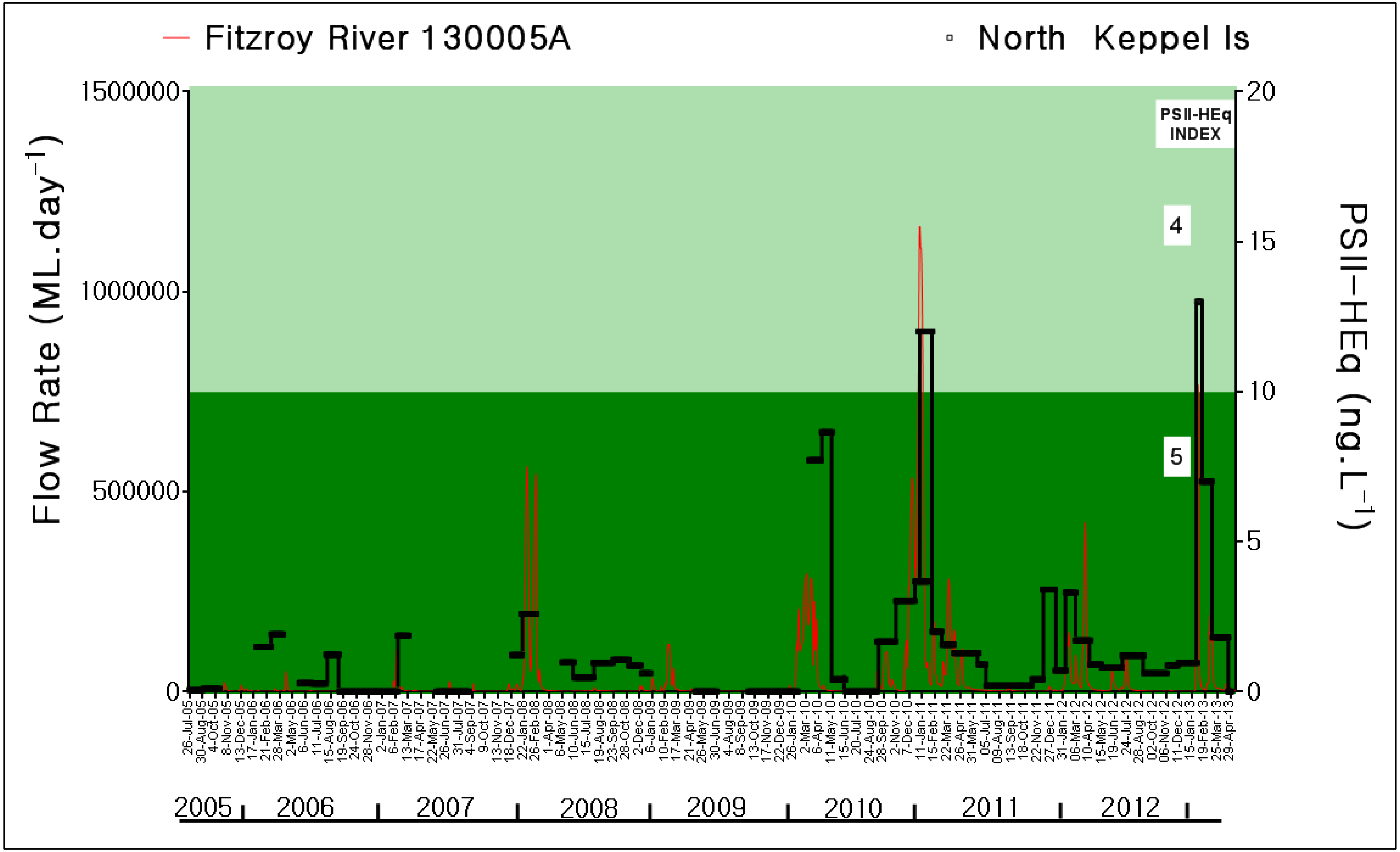

Figure 32 Temporal trends in PSII-HEq with respect to flow rate of rivers influencing passive sampler sites in the Fitzroy region since monitoring commenced (Flow data provided by Department of Environment and Resource Management, Stream Gauging Network)

15 APPENDIX G – HISTORICAL CONCENTRATION PROFILES AT ROUTINE MONITORING SITES

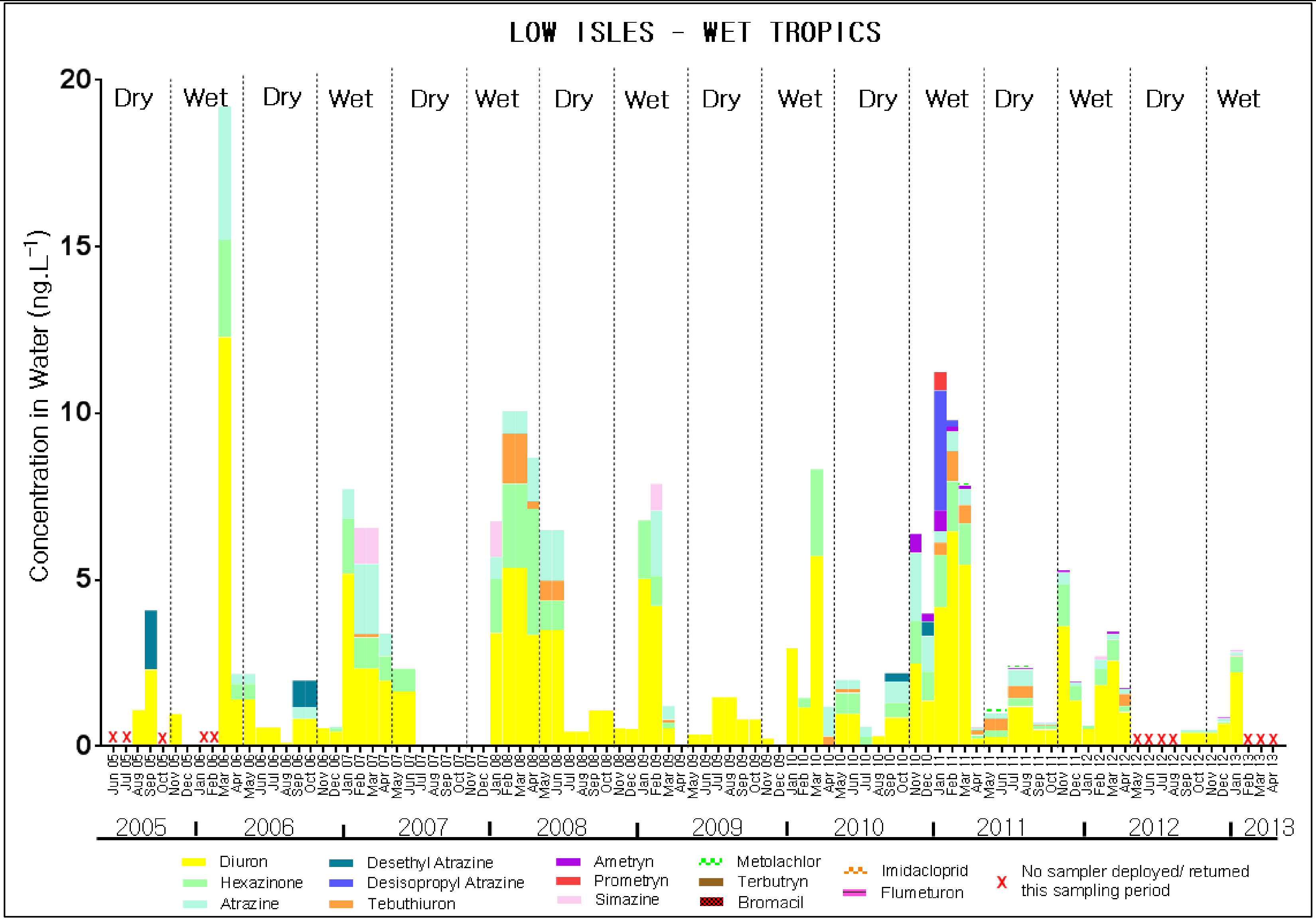

Figure 33 Temporal concentration profiles of individual herbicides at Low Isles in the Wet Tropics region

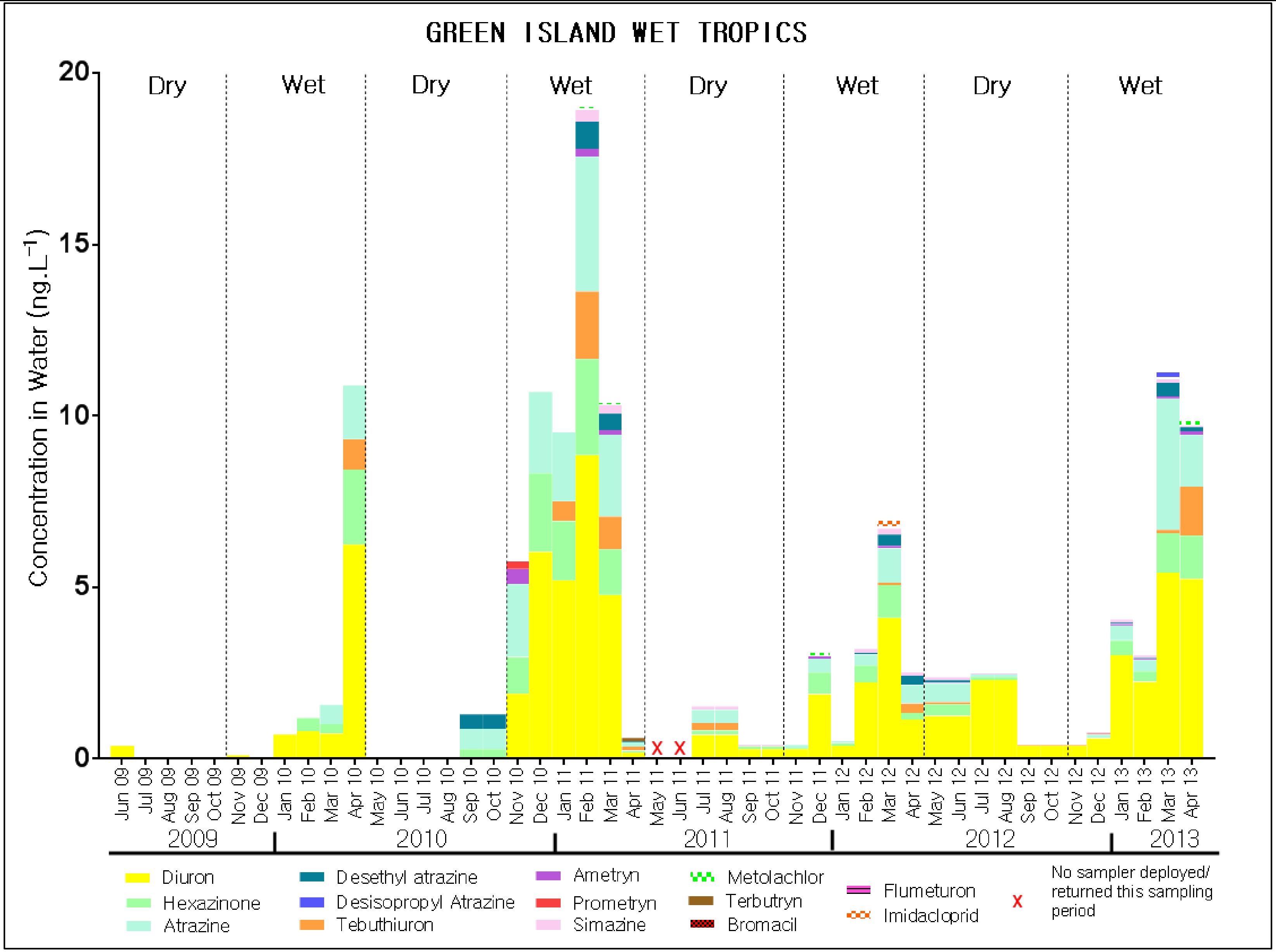

Figure 34 Temporal concentration profiles of individual herbicides at Green Island in the Wet Tropics region

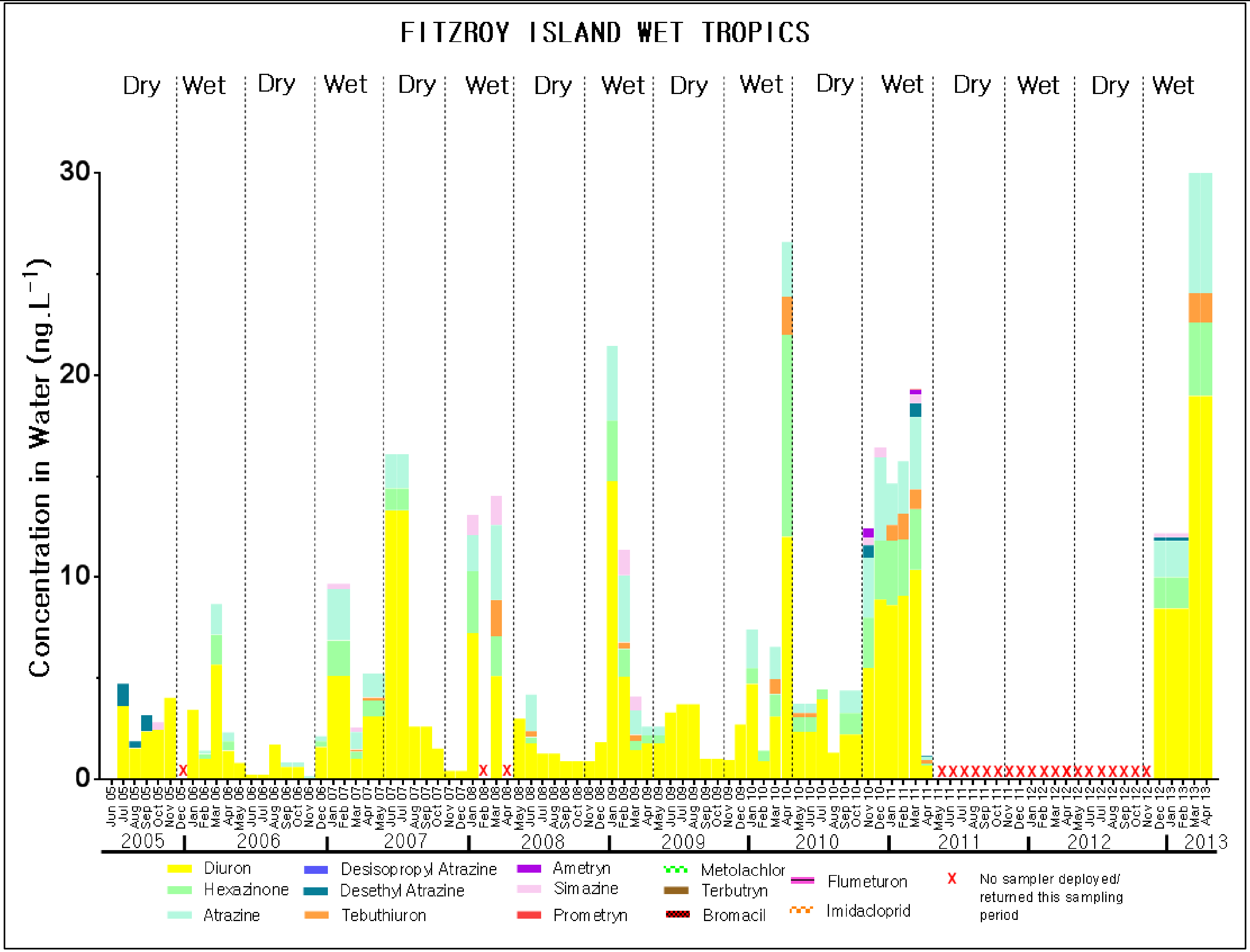

Figure 35 Temporal concentration profiles of individual herbicides at Fitzroy Island in the Wet Tropics region

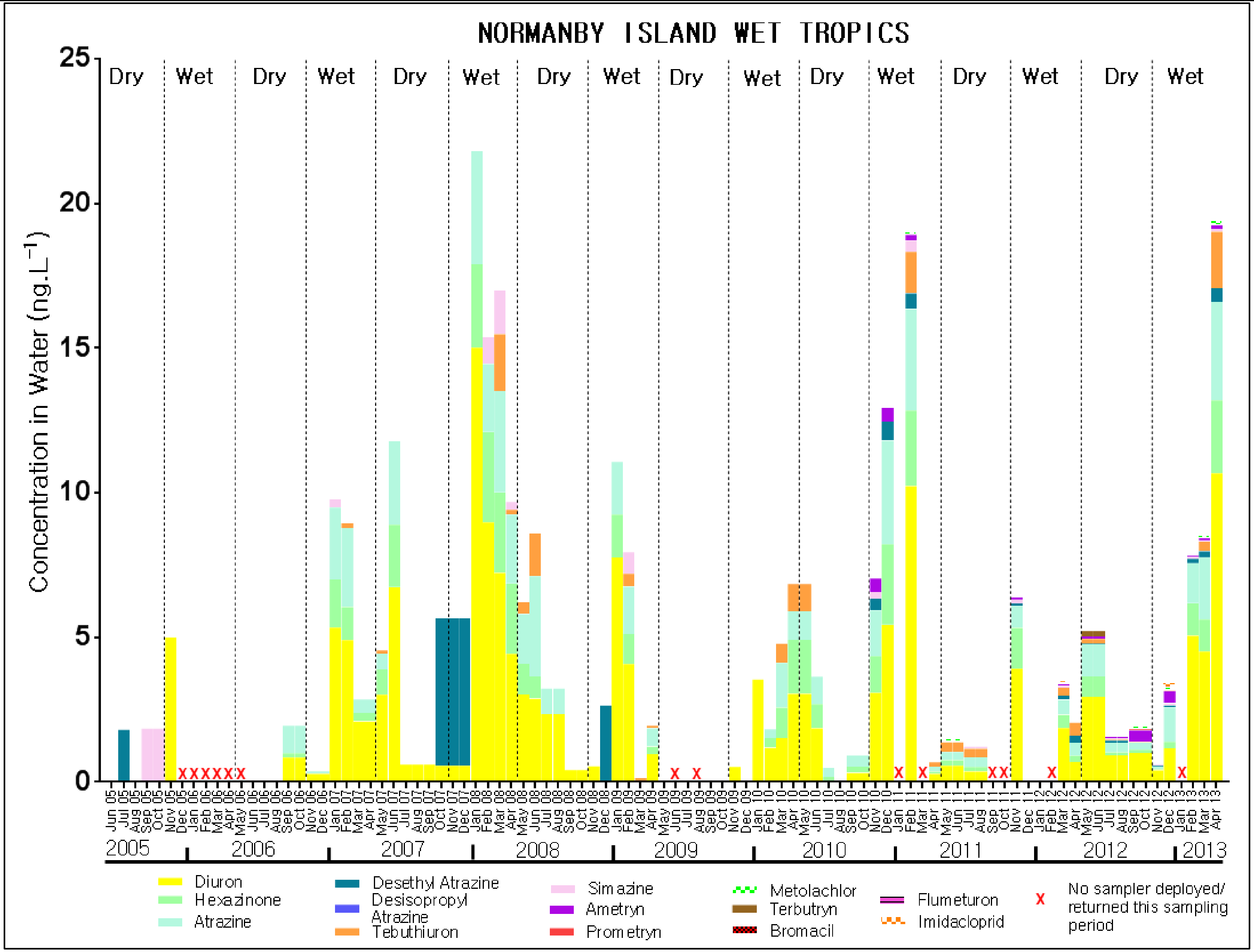

Figure 36 Temporal concentration profiles of individual herbicides at Normanby Island in the Wet Tropics region

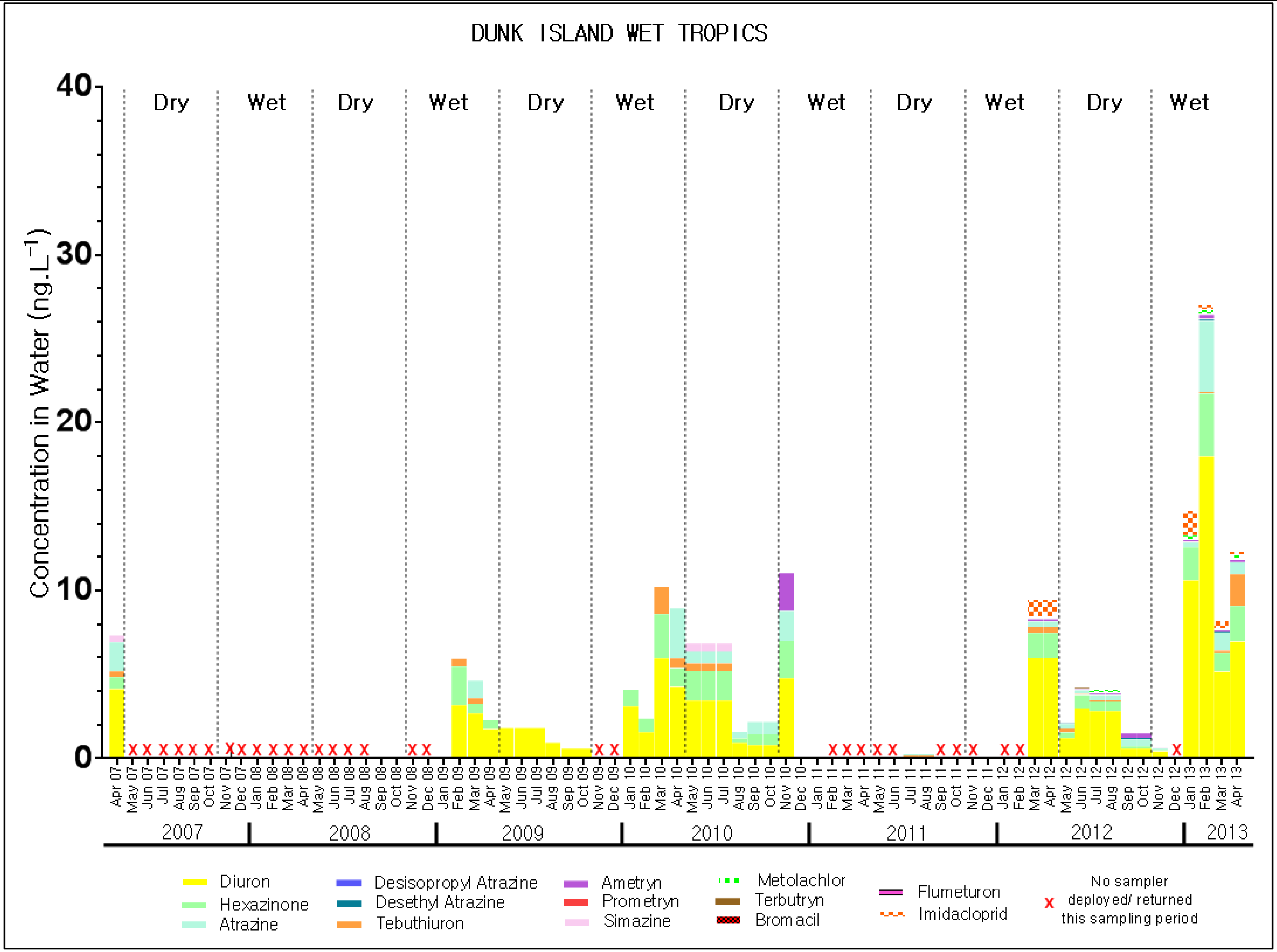

Figure 37 Temporal concentration profiles of individual herbicides at Dunk Island in the Wet Tropics region

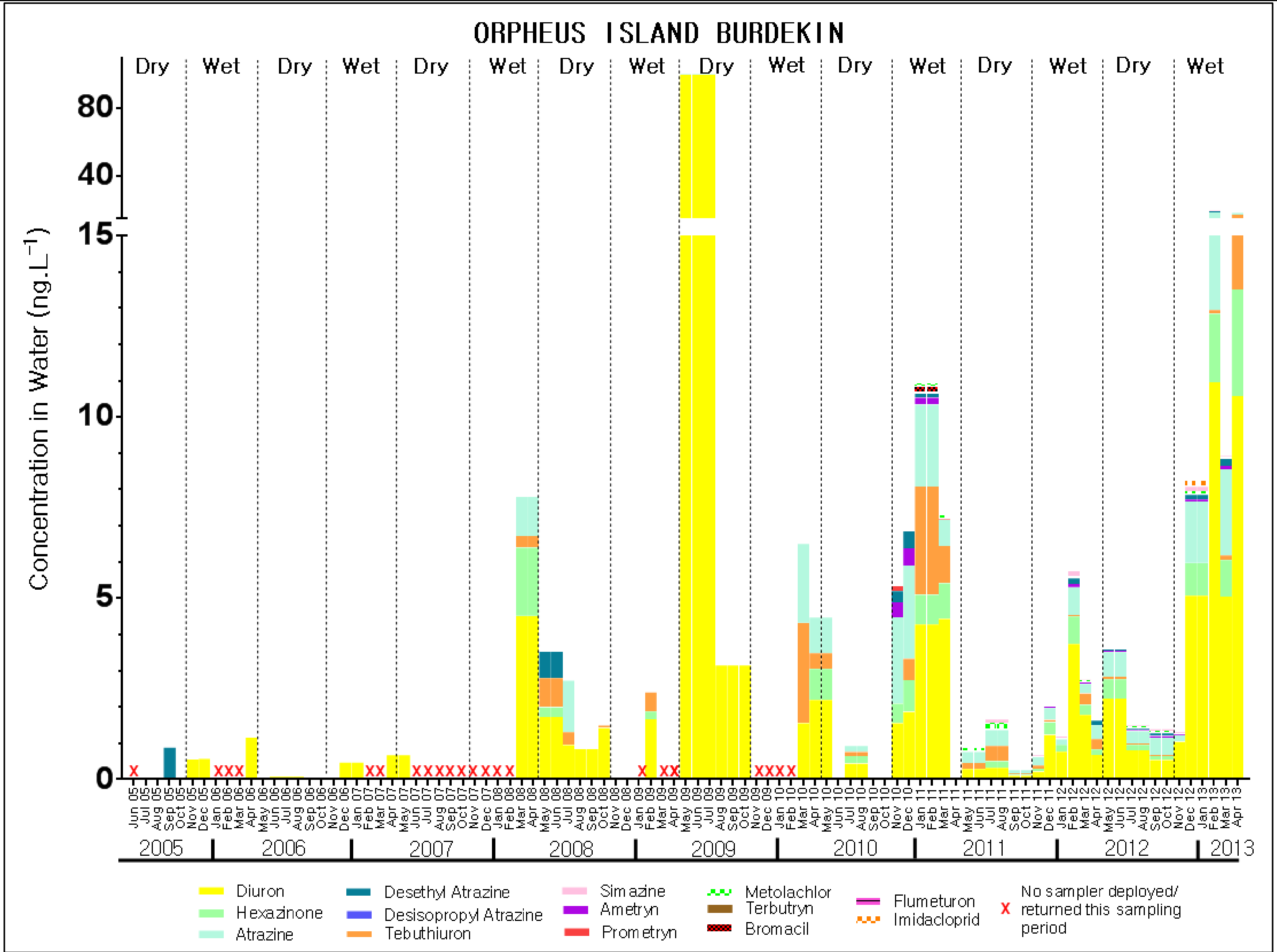

Figure 38 Temporal concentration profiles of individual herbicides at Orepheus Island in the Burdekin region

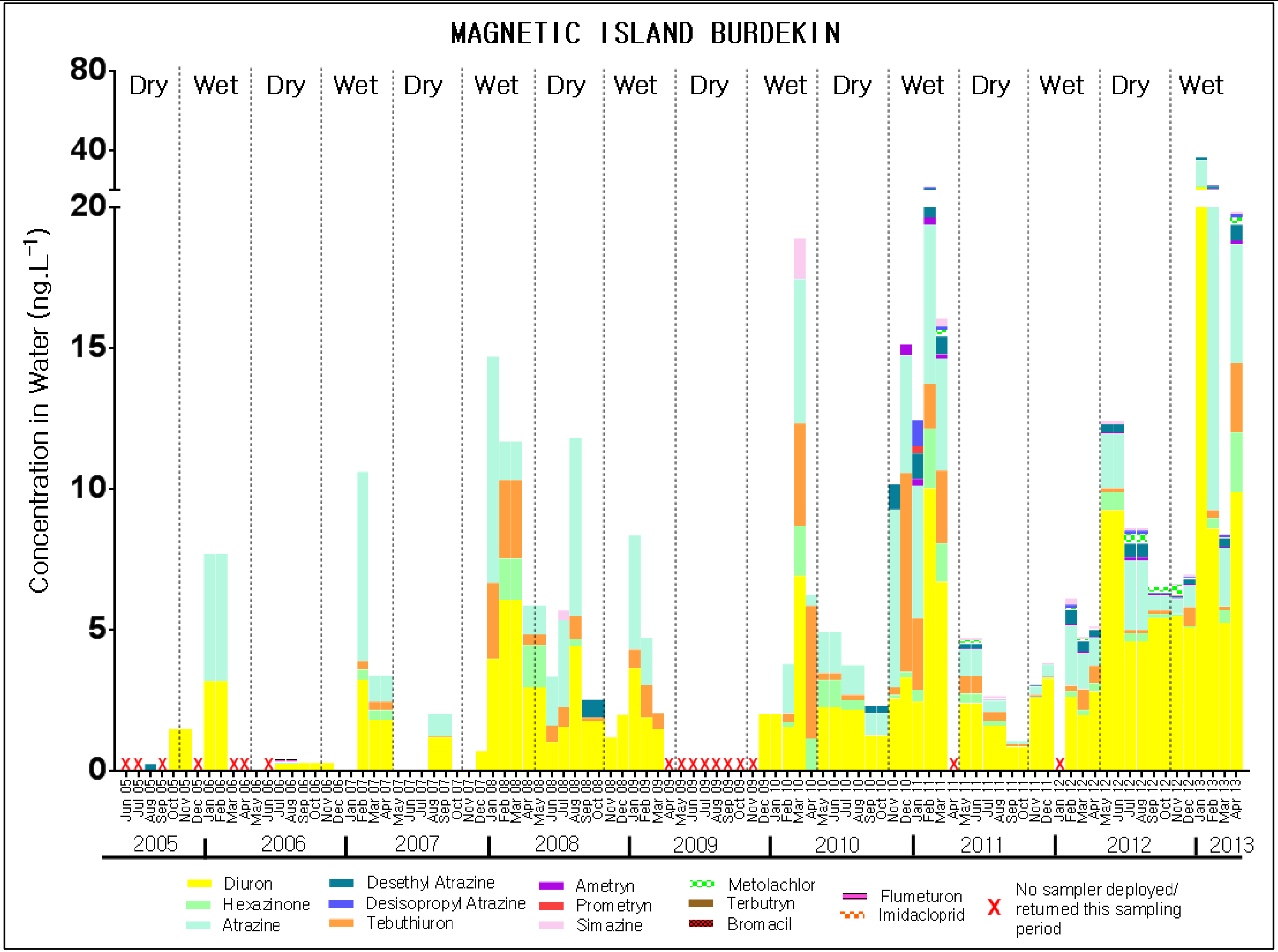

Figure 39 Temporal concentration profiles of individual herbicides at Magnetic Island in the Burdekin region

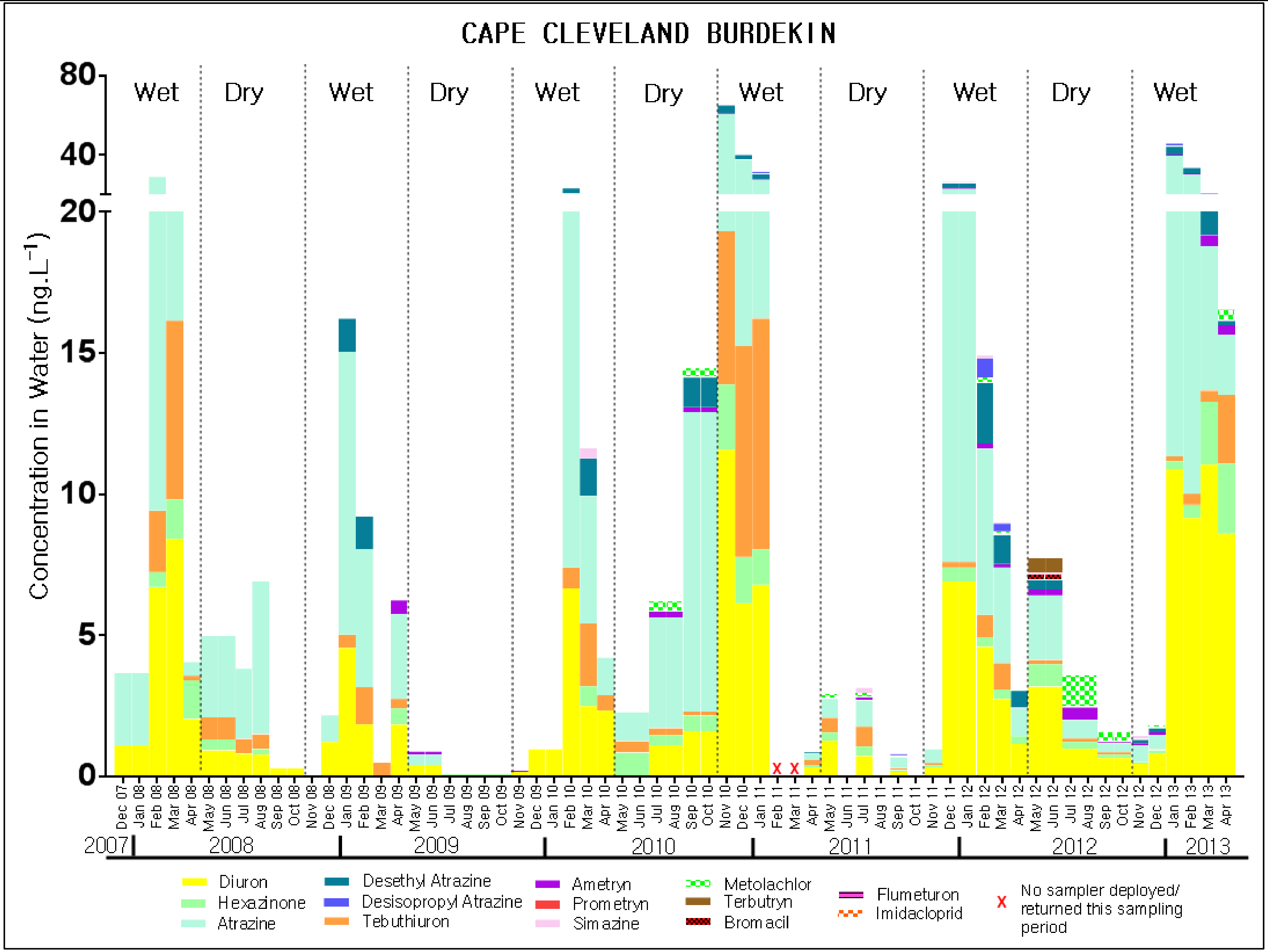

Figure 40 Temporal concentration profiles of individual herbicides at Cape Cleveland in the Burdekin region

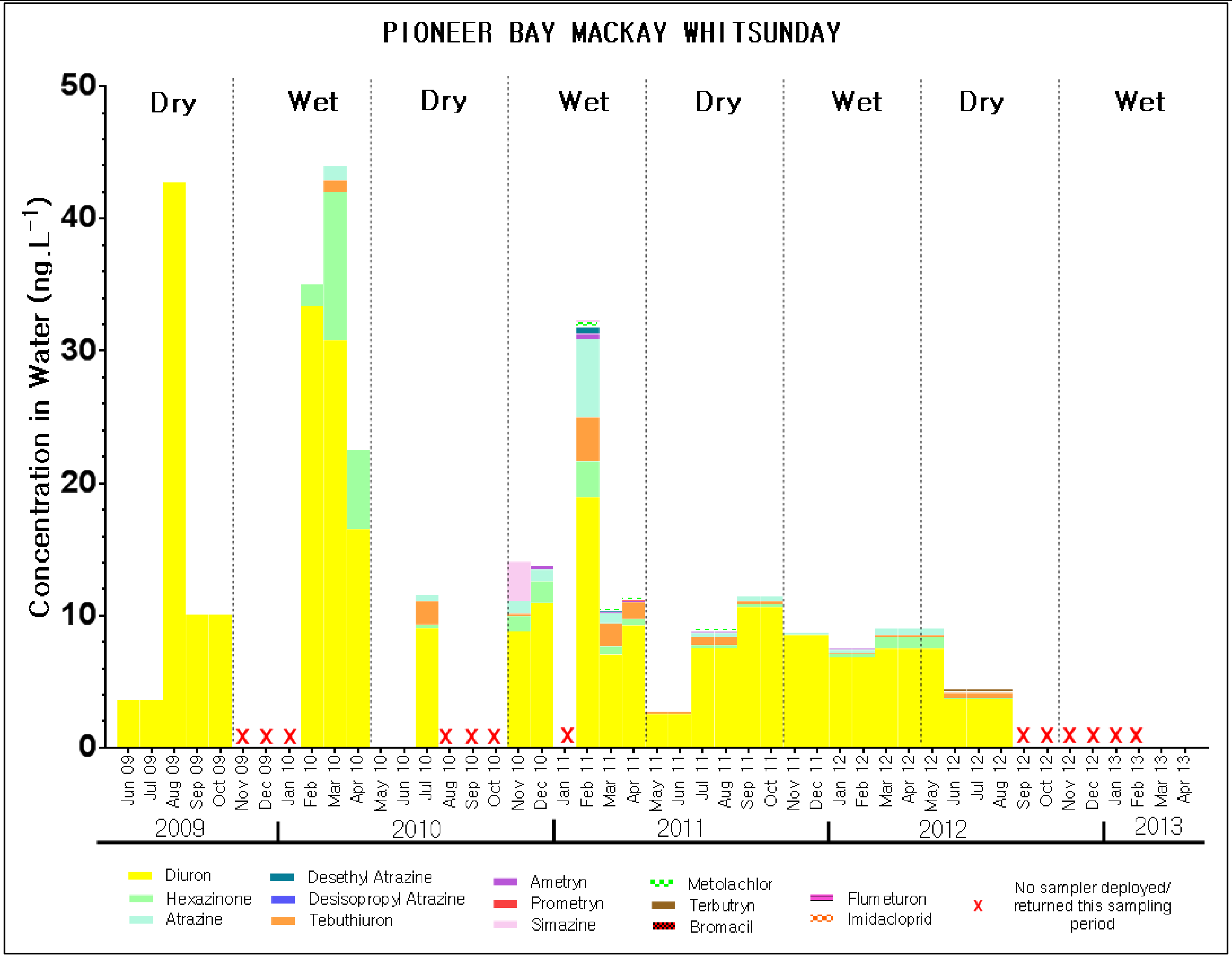

Figure 41 Temporal concentration profiles of individual herbicides at Pioneer Bay in the Mackay Whitsunday region

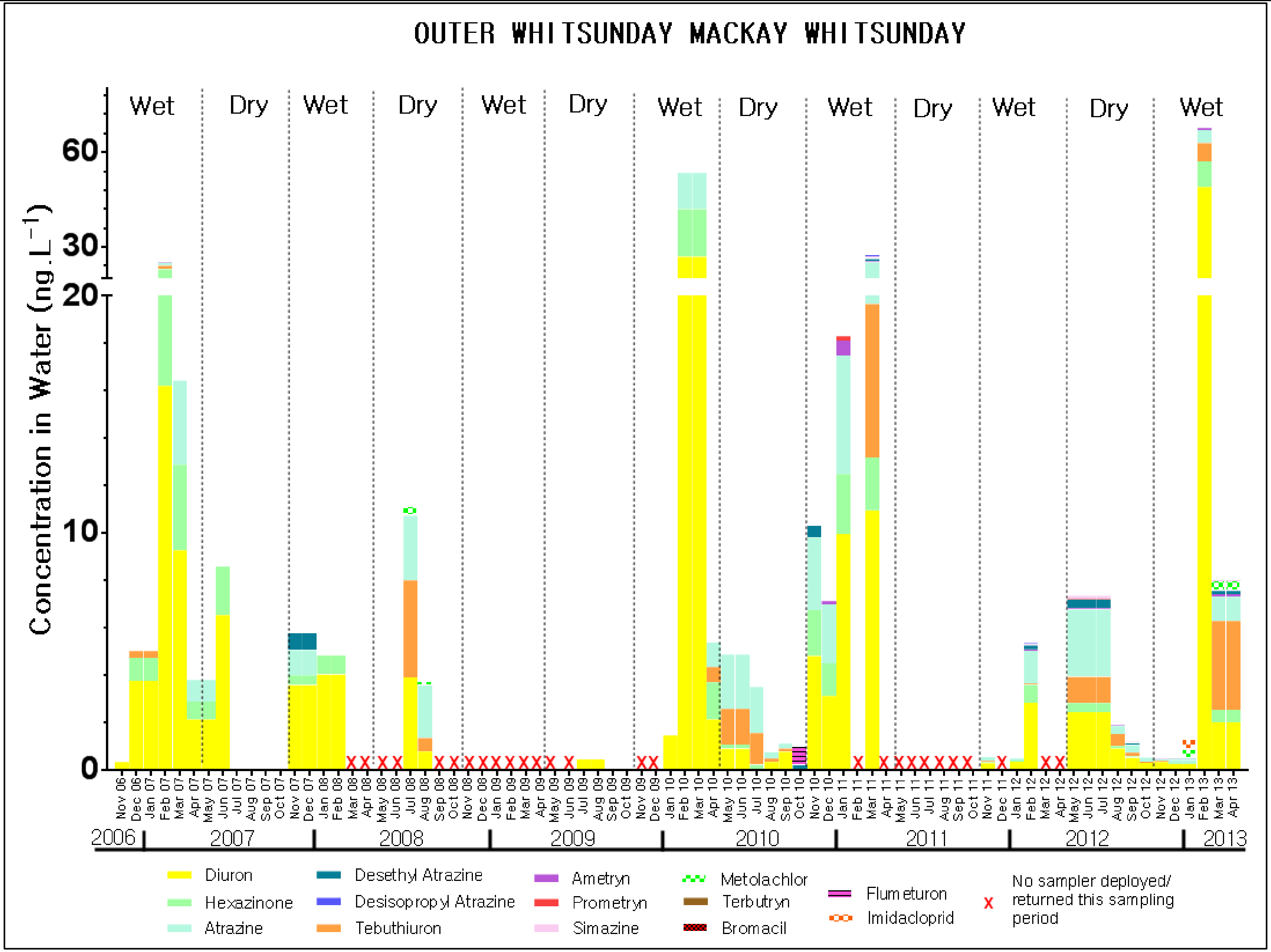

Figure 42 Temporal concentration profiles of individual herbicides at Outer Whitsunday in the Mackay Whitsunday region

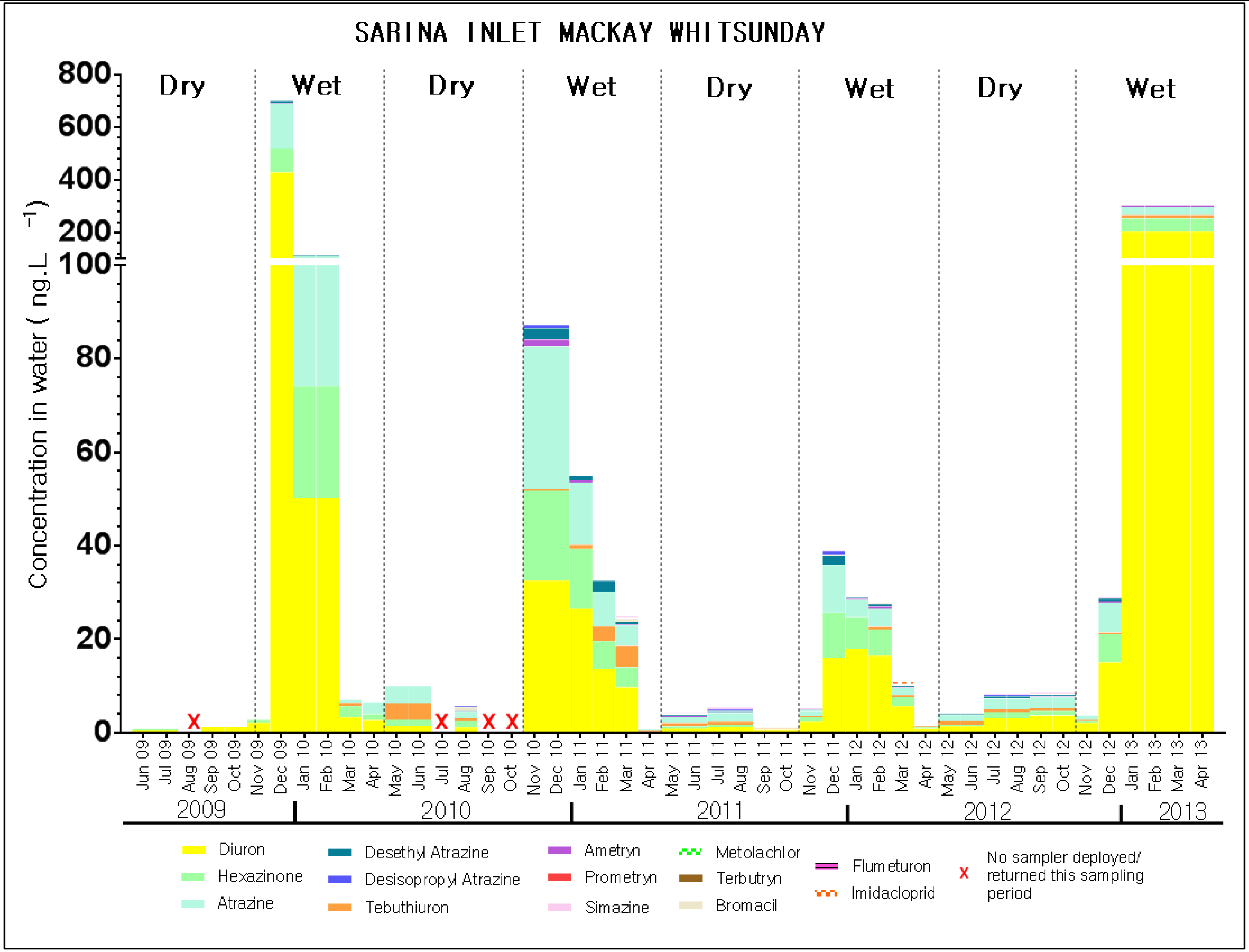

Figure 43 Temporal concentration profiles of individual herbicides at Sarina Inlet in the Mackay Whitsunday region

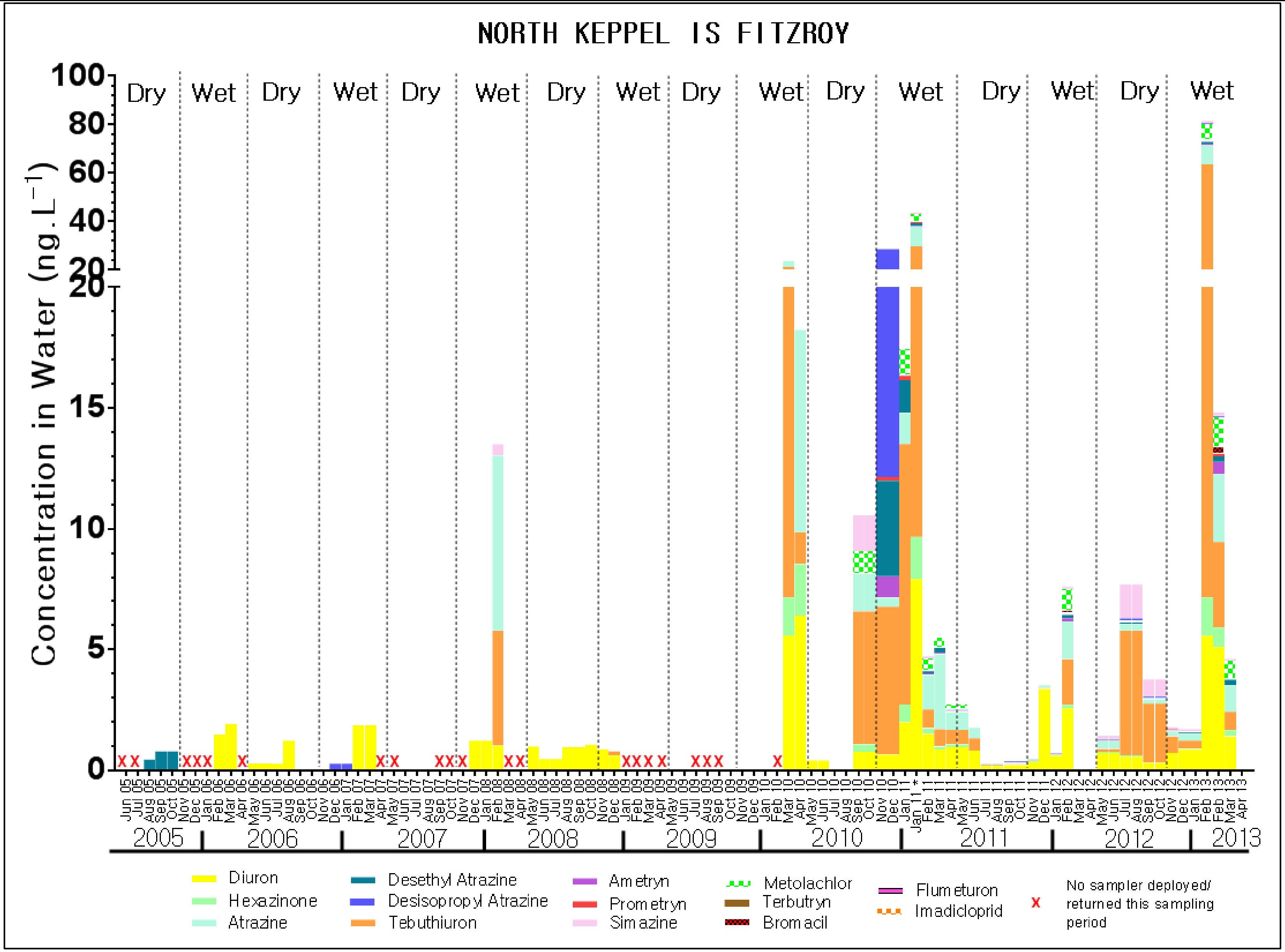

Figure 44 Temporal concentration profiles of individual herbicides at North Keppel Island in the Fitzroy region

16 APPENDIX H - LAND USE MAP OF THE GBR CATCHMENTS ADJACENT TO ROUTINE MONITORING SITES

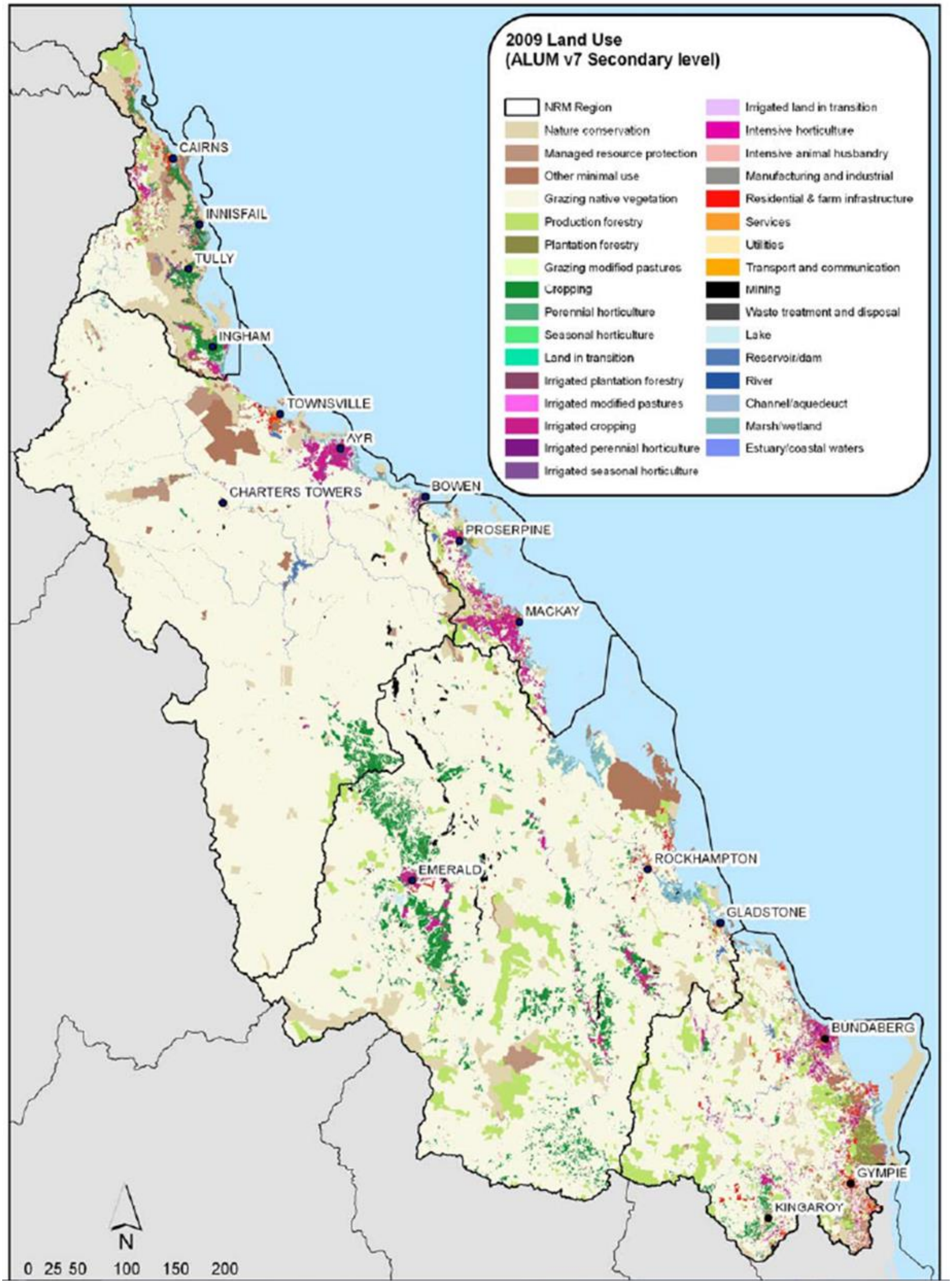

Figure 45 Land Use Map of the GBR catchment – 2009. Map obtained from DSITIA, 2012a