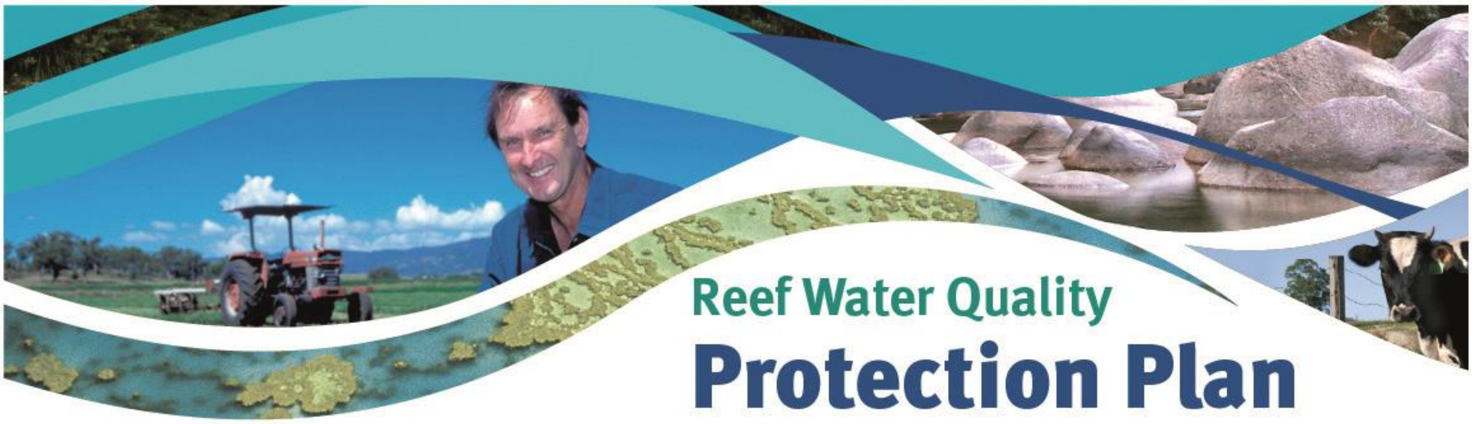

Total suspended solids, nutrient and pesticide loads (2012–2013) for rivers that discharge to the Great Barrier Reef

Great Barrier Reef Catchment
Loads Monitoring 2012–2013

Australian Government

Queensland
Government

Prepared by

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April 2015

Executive summary

Diffuse pollutant loads discharged from rivers of the east coast of Queensland have contributed to a decline in water quality in the Great Barrier Reef lagoon. This decline in water quality is known to directly impact the health of the Great Barrier Reef and its ecosystems. The Reef Water Quality Protection Plan 2009 (Reef Plan 2009) and the revised Reef Water Quality Protection Plan 2013, aim to halt and reverse the decline in water quality and enhance the resilience of the Great Barrier Reef to other threatening processes (e.g. coral bleaching, ocean acidification, disease, climate change and overfishing) by improving land management practices. Only Reef Plan 2009 is pertinent to the current report.

Reef Plan 2009 is underpinned by pollutant reduction targets measured against the baseline (anthropogenic) load reported in the Reef Water Quality Protection Plan First Report 2009. These reduction targets include a 20 per cent reduction in anthropogenic load of total suspended solids by 2020; a 50 per cent reduction in anthropogenic load of nutrients (nitrogen and phosphorus) by 2013; and a 50 per cent reduction in photosystem II inhibiting herbicides[1] by 2013.

Progress towards the Reef Plan 2009 targets is measured through the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (Paddock to Reef Program) which is jointly funded by the Australian and Queensland governments. The Paddock to Reef Program includes catchment scale water quality monitoring of pollutant loads entering the Great Barrier Reef lagoon which is implemented through the Great Barrier Reef Catchment Loads Monitoring Program.

The monitoring data generated by this program provides a point of truth to validate loads predicted by catchment models. The loads predicted by the catchment models are used to report annually on progress towards the Reef Plan 2009 targets, as part of the annual Reef Report Card (e.g. the Report Card 2012 and 2013).

Pollutant loads are calculated annually by the Great Barrier Reef Catchment Loads Monitoring Program in the following natural resource management regions and priority catchments:

- Cape York region – Normanby catchment
- Wet Tropics region – Barron, Johnstone, Tully and Herbert catchments
- Burdekin region – Burdekin and Haughton catchments
- Mackay Whitsunday region – Plane and Pioneer catchments
- Fitzroy region – Fitzroy catchment
- Burnett Mary region – Burnett catchment

This report presents monitored annual loads and yields of pollutants based on monitoring data from the 2012–2013 monitoring year (i.e., 1 July 2012 to 30 June 2013).

Total rainfall across the priority reef catchments for the 2012–2013 monitoring year was generally average to slightly below average in the Cape York, Wet Tropics and Burdekin regions and average to above average

[1] Photosystem II inhibitor herbicides are those herbicides that exert toxicity to plants by inhibiting the photosystem II component of photosynthesis. The priority herbicides for this program are ametryn, total atrazine, diuron, hexazinone and tebuthiuron.

in the Mackay Whitsunday region. Following very dry conditions during the first six months, the Fitzroy and Burnett Mary regions received very high rainfall associated with Ex-Tropical Cyclone Oswald in late-January which contributed to them receiving above average to very much above average annual rainfall over the 2012–2013 monitoring year.

During the 2012–2013 monitoring year, discharge in all rivers of the Cape York, Wet Tropics and Burdekin Dry Tropics regions was below the long-term mean with exceedence probabilities ranging from 50 per cent in Barratta Creek in the Haughton catchment to 78 per cent in the Barron catchment. Annual river discharge in all other catchments was very much above average with exceedence probabilities in the Mackay Whitsunday and Fitzroy regions in the range of 22 percent to 28 per cent. In the Burnett catchment exceptionally high rainfall associated with Ex-Tropical Cyclone Oswald resulted in the highest maximum recorded flow and highest annual recorded discharge. The annual discharge of the Burnett River during the 2012-2013 monitoring year was five times higher than the long-term mean annual discharge with an exceedence probability of only three per cent. The periods of highest discharge during 2012–2013 were:

- Late January – All catchments with major flooding in the Fitzroy and Burnett catchments and
- Early March – Barron, Burdekin, Pioneer, Plane and Fitzroy catchments.

Ten end-of-system and fifteen sub-catchment sites were monitored for total suspended solids and nutrients during the 2012–2013 monitoring year. Photosystem II inhibiting pesticides were also monitored at eight end-of-system sites and two sub-catchment sites. This is the first year that monitored annual loads have been reported for the Bowen River. The installation of an automated water quality monitoring trailer and direct engagement of staff employed by the Burdekin Bowen Integrated Floodplain Management Advisory Board enabled the regular collection of water samples during both ambient and flood conditions.

During 2012–2013, the monitored catchments generated approximately 9.6 million tonnes of total suspended solids, approximately 34,000 tonnes of nitrogen, and approximately 9400 tonnes of phosphorus. A major flood event in the Burnett catchment following Ex-Tropical Cyclone Oswald resulted in the highest monitored annual loads of total suspended solids and total nitrogen at all end-of-system sites during the 2012–2013 monitoring year. The combined loads of the Burdekin, Fitzroy and Burnett catchments, accounted for at least 90 per cent of the total suspended solids (8.7 million tonnes) and total phosphorus loads (8500 tonnes) and 78 per cent of the monitored annual total nitrogen load (approximately 27,000 tonnes).

The monitored annual load of the five priority photosystem II inhibiting herbicides (ametryn, total atrazine, diuron, hexazinone and tebuthiuron) during the 2012–2013 monitoring year was approximately 10,000 kilograms. The total monitored annual priority photosystem II inhibiting herbicide loads exported past the end-of-system monitoring sites were (from largest to smallest): 5100 kilograms of tebuthiuron, 2600 kilograms of total atrazine, 1900 kilograms of diuron, 440 kilograms of hexazinone and 100 kilograms of ametryn. These reported monitored annual loads do not include monitored annual loads of pesticides from the Johnstone catchment as sample collection at this catchment was insufficient for the calculation of pesticide loads during the monitoring year.

Total atrazine and diuron were detected at all monitored catchments; ametryn was detected at all catchments except in the Fitzroy and hexazinone was detected at all catchments except the Burdekin. The Pioneer and Burnett catchments contributed the largest monitored annual loads of ametryn (28 kilograms and 27 kilograms, respectively) and Barratta creek in the Haughton catchment contributed the largest monitored annual load of total atrazine (520 kilograms). The Tully catchment contributed the largest load of diuron (570 kilograms) and hexazinone (130 kilograms). Consistent with previous monitoring years, the Fitzroy catchment contributed the largest load of tebuthiuron (5000 kilograms). In addition, this report, for the first time, presents the loads of all the pesticides that were detected in the monitored catchments (Appendix A).

Yields (the load divided by the monitored surface area of the catchment) were calculated to compare the rate of pollutant delivery between catchments. The highest monitored annual yield at the end-of-system sites of total suspended solids was in the Burnett catchment, total nitrogen in the Tully catchment and total phosphorus in Sandy Creek in the Plane catchment. The Johnstone and Pioneer catchments also produced high monitored annual yields of total suspended solids, total nitrogen and total phosphorus. The Barron and Herbert catchments also produced high monitored annual yields of total suspended solids during the 2012–2013 monitoring year. Conversely, the lowest monitored annual yields of total suspended solids were produced by Barratta Creek in the Haughton catchment and the Normanby catchment, and the lowest total nitrogen and total phosphorus yields occurred in the Fitzroy and Burdekin catchments.

In 2012–2013, the largest monitored annual land use yield (the load divided by the total surface area of land-uses where the pesticide is registered for use) of ametryn was in the Burnett catchment, total atrazine in Barratta Creek in the Haughton catchment, diuron and hexazinone in the Tully catchment and tebuthiuron in the Fitzroy catchment.

This is the final technical report to be released by the Great Barrier Reef Catchment Loads Monitoring Program under Reef Plan 2009. The Paddock to Reef Integrated Monitoring, Modelling and Reporting Program was reviewed in 2013. This resulted in decommissioning several sub-catchment sites where the modellers felt the catchment models were of sufficient accuracy and establishing end-of-system sites to provide loads data for new catchments and better alignment of freshwater and marine monitoring. The loads and yields data contained in this report complement the existing data collected over the previous six years to validate the catchment models which are used to monitor progress against the water quality improvement targets.

The program has ensured continuous improvement through the implementation of a quality management system including the delivery of specialist training to regional staff. Further, the installation of automated sampling equipment has improved sample coverage during large flood events as demonstrated by the water quality data available for the calculation of loads in the remote Bowen catchment monitoring site and the collection of water samples during the Burnett River flood in January 2013.

The continuity of the data made available through the Great Barrier Reef Catchment Loads Monitoring Program continues to provide a critical data resource for the effective management of Queensland natural resources.

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1 Introduction

The Great Barrier Reef World Heritage Area is located off the north-east coast of Australia and is recognised as the largest coral reef ecosystem in the world (Furnas 2003; Rayment 2003). It is widely acknowledged that the Great Barrier Reef is at significant risk from degraded water quality caused by pollutants exported from catchments adjacent to the Great Barrier Reef (Wachenfeld et al. 1998; State of Queensland and Commonwealth of Australia 2003; Brodie et al. 2008; DPC 2008; Hunter and Walton 2008; Brodie et al. 2009; Packett et al. 2009; Brodie et al. 2010; Brodie et al. 2013a; Brodie et al. 2013b; Schaffelke et al. 2013). In order to improve water quality entering from these catchments, the Queensland and Australian Governments cooperatively initiated the Reef Water Quality Protection Plan 2009 (Reef Plan) with the short-term goal to halt and reverse the decline in water quality entering the Great Barrier Reef lagoon by 2013 (DPC 2009a).

The Paddock to Reef Integrated Monitoring, Modelling and Reporting (Paddock to Reef) Program measures progress towards Reef Plan goals and targets. The Paddock to Reef program is a joint collaboration involving the Australian and Queensland Governments, industry, regional natural resource management bodies and research organisations (DPC 2009b). It is a world-leading approach to integrate data and information on management practices, catchment indicators, water quality and the health of the Great Barrier Reef.

To assist in evaluating progress towards the water quality targets of Reef Plan, the Great Barrier Reef Catchment Loads Monitoring Program was implemented to monitor and report on loads of total suspended solids and nutrients in 11 priority catchments and loads of pesticides in eight priority catchments under the Paddock to Reef program.

Evidence of elevated anthropogenic loads of total suspended solids, nutrients and pesticides exported to the Great Barrier Reef lagoon since European settlement has been reported extensively over recent years (e.g. Nicholls 1988; Eyre 1998; Wachenfeld et al. 1998; Fabricius et al. 2005; Hunter and Walton 2008; Packett et al. 2009; Brodie et al. 2010; DPC 2011; Kroon et al. 2011; Smith et al. 2012; Turner et al. 2012; Kroon et al. 2013; Turner et al. 2013; Wallace et al. 2014). Kroon et al. (2013) estimated that since European settlement the mean annual load of total suspended solids exported to the Great Barrier Reef lagoon has increased by 5.5 times, total nitrogen has increased by 5.7 times and total phosphorus has increased by 8.9 times. Photosystem II inhibiting herbicides were not present before European settlement. The majority of pollutant loads are generated during the wet season as runoff during flood events from catchments adjacent to the Great Barrier Reef (Nicholls 1988; Eyre 1998; Smith et al. 2012; Turner et al. 2012; Kroon et al. 2013; Turner et al. 2013; Wallace et al. 2014).

Thirty-five catchments flow into the Great Barrier Reef lagoon, and cover an area of approximately 424,000 square kilometres. These catchments extend from the tropics to the subtropics over 1500 kilometres of Queensland’s east coastline (DPC 2011). Across the study area, there are substantial climatic differences within and between catchments, with highly variable rainfall, hydrology and geology. These factors contribute to the high variability in estimated discharge volume and total suspended solids, nutrient and pesticide loads between catchments and years (Furnas et al. 1997; Devlin and Brodie 2005; Joo et al. 2012; Smith et al. 2012; Turner et al. 2012; Turner et al. 2013; Wallace et al. 2014).

Of these 35 catchments, 11 catchments were monitored by the Great Barrier Reef Catchment Loads Monitoring Program in 2012–2013. The 11 catchments were selected based on inputs from the regional National Action Plan for Salinity and Water Quality Program officers, the Great Barrier Reef Marine Park Authority and the Australian Centre for Tropical Freshwater Research (DERM 2011a). The 11 priority monitored catchments and the natural resource management regions in which they occur are:

- Cape York region – Normanby catchment
- Wet Tropics region – Barron, Johnstone (including North Johnstone and South Johnstone rivers), Tully and Herbert catchments
- Burdekin region – Burdekin and Haughton catchments
- Mackay Whitsunday region – Plane and Pioneer catchments
- Fitzroy region – Fitzroy catchment
- Burnett Mary region – Burnett catchment

Grazing is the largest single land use within the Great Barrier Reef catchments (DPC 2011), with other significant land uses being conservation, forestry, sugarcane, horticulture and other cropping. In the Cape York region, the Normanby catchment is dominated by grazing and large amount of land set aside for conservation in State protected areas. In the Wet Tropics the main land uses are grazing in the west, sugarcane on the coastal flood plains and small areas of horticulture. Large areas of the Wet Tropics region are also set aside for conservation purposes in the Wet Tropics World Heritage Area. Land use in the Burdekin region is dominated by grazing with irrigated sugarcane, horticulture and cropping located in the lower Burdekin and Haughton catchments. Within the Mackay Whitsunday region the Pioneer and Plane catchments are dominated by grazing. This region also contains relatively large areas of sugarcane cultivation along the coastline and areas for nature conservation. Grazing, dry land cropping, irrigated cotton and mining are the dominant land uses within the Fitzroy region. Land use within the Burnett Mary region is a mixture of grazing, dairy, horticulture, sugarcane and other cropping (DPC 2011).

This report is the seventh publication from the Great Barrier Reef Catchment Loads Monitoring Program, and fourth annual technical report in this series. The current report presents annual loads and yields (the load per unit area) from 11 priority reef catchments for total suspended solids, nutrients and from nine catchments for pesticides in 2012–2013. These loads have been calculated using the same methods in each of the technical reports issued under the Paddock to Reef Program. Previous reports of the Great Barrier Reef Catchment Loads Monitoring Program have presented loads for the period 2006–2009 (Joo et al. 2012), 2009–2010 (Turner et al. 2012), 2010–2011 (Turner et al. 2013), 2011–2012 (Wallace et al. 2014). Smith et al. (2012) examined pesticide loads and assessed the toxicity and potential implications of mixtures of pesticides. Smith et al. (2014) recently reported the concentrations and loads of alternate pesticides in monitored Great Barrier Reef catchments and compared the relative toxicity of these chemicals to the primary photosystem II inhibiting herbicides which have been the focus of landuse management change under Reef Plan 2009 (DPC 2009b; 2013c).

The scope of this report is confined to the estimation and reporting of loads and yields exported from the monitored area of each catchment and as such these pollutant loads do not represent the total load discharged to the Great Barrier Reef lagoon[2]. This report does not link land uses, regions or soil erosion processes (e.g. gullies, channel/bank or hill-slope erosion) to loads or yields of total suspended solids or nutrients but does present land use yields of pesticides. The reported loads are estimated from monitoring data, which provides a point of truth to validate the modelled catchment loads. The loads predicted by the catchment models are used to report on progress towards water quality targets in the annual Reef Plan Report Card (DPC 2011; DPC 2013a; DPC 2013b; DPC 2014). No modelled loads are presented in this report.

[2] Not all catchments that drain to the Great Barrier Reef lagoon were monitored. In addition, the end-of-system monitoring sites are not located at the mouth of the river or creek (refer to Section 2.1) and this unmonitored portion of the catchment or sub-catchment may contribute, remove or degrade total suspended solids, nutrients and pesticides.

2 Methods

2.1 Monitoring sites

Eleven priority catchments were identified for monitoring under the Paddock to Reef Program (DPC 2011; Carroll et al. 2012). Monitoring sites were established at existing Queensland Government stream gauging stations (Figure 2.1 and Table 2.1). Sites are classified as either end-of-system or sub-catchment sites. End-of-system sites are defined as sites located at the lowest point in a river or creek, which does not have tidal influence and the volume of water passing that point, can be accurately gauged. Sub-catchment sites are located on rivers that have different drainage basins to the major river for those catchments. Sub-catchment sites were selected to provide specific water quality data on various land uses or on a geographical region for enhanced validation of catchment models.

Ten end-of-system sites and 15 sub-catchment sites were selected to monitor total suspended solids and nutrients (Table 2.2), while eight end-of-system sites and two sub-catchment site were selected to monitor photosystem II inhibiting pesticides (Table 2.2). All selected sites are fixed monitoring locations of the Great Barrier Reef Catchment Loads Monitoring Program to allow collection of data over multiple years. Summary information on each monitoring site including its gauging station identification, location, whether it is an end-of-system or sub-catchment site, the surface area of each catchment or sub-catchment and the area monitored is provided in Table 2.1.

Between 1 July 2012 and 30 June 2013 monitoring was undertaken at 25 sites located in the 11 priority catchments (Figure 2.1 and Table 2.1). These 25 sites have remained as fixed monitoring sites since commencement of the Great Barrier Reef Catchment Loads Monitoring Program in 2009.

Monitoring at some sites was constrained during the 2012–2013 monitoring year, limiting the analysis and reporting of data for these catchments. Further details are provided in Section 3.2 and Section 3.3.

2.2 Rainfall

Rainfall data were obtained from the Commonwealth of Australia, Bureau of Meteorology National Climate Centre data archive (BoM 2013a). These data were synthesised using ArcGIS to create maps of Queensland to display total annual rainfall and annual rainfall deciles during the 2012–2013 monitoring year.

2.3 Water quality sampling

Water samples were collected according to methods outlined in the Environmental Protection (Water) Policy Monitoring and Sampling Manual (DERM 2010). Water quality samples were collected between 1 July 2012 and 30 June 2013. Two different sampling methods were used to collect water samples, depending on equipment availability and suitability for use at each site. The two methods used were manual grab sampling and automatic sampling using refrigerated pump samplers. The specific methods employed at each site are shown in Table 2.2.

Figure 2.1 Map indicating the natural resource management regions, catchments and sites where the Great Barrier Reef Catchment Loads Monitoring Program monitored in 2012–2013.

Table 2.1 Summary information on sites monitored as part of the Great Barrier Reef Catchment Loads Monitoring Program between 1 July 2012 and 30 June 2013. Text in bold are end-of-system sites and the corresponding data, all others are sub-catchment sites.

NRM region	Catchment	Gauging station	River and site name	Type of site#	Site location		Total catchment surface area (km^2)	Monitored surface area (km^2)	Per cent of catchment monitored
					Latitude	Longitude			
Cape York	**Normanby**	**105107A**	**Normanby River at Kalpowar Crossing**	**EoS**	**-14.91850**	**144.21000**	**24,399**	**12,934**	**53**
Wet Tropics	**Barron**	**110001D**	**Barron River at Myola**	**EoS**	**-16.79983**	**145.61211**	**2188**	**1945**	**89**
	Johnstone	112004A	North Johnstone River at Tung Oil$	S-C	-17.54564	145.93253	2325	925	40
		112101B	South Johnstone River at Upstream Central Mill$	S-C	-17.60889	145.97906		400	17
	Tully	**113006A**	**Tully River at Euramo**	**EoS**	**-17.99214**	**145.94247**	**1683**	**1450**	**86**
		113015A	Tully River at Tully Gorge National Park	S-C	-17.77260	145.65025		482	29
	Herbert	**116001F**	**Herbert River at Ingham**	**EoS**	**-18.63275**	**146.14267**	**9844**	**8581**	**87**
Burdekin	**Haughton**	**119101A**	**Barratta Creek at Northcote**	**EoS**	**-19.69228**	**147.16879**	**4051**	**753**	**19**
	Burdekin	**120001A**	**Burdekin River at Home Hill**	**EoS**	**-19.64361**	**147.39584**	**130,120**	**129,939**	**99**
		120002C	Burdekin River at Sellheim	S-C	-20.00778	146.43694		36,290	28
		120301B	Belyando River at Gregory Development Road	S-C	-21.53323	146.85961		35,411	27
		120302B	Cape River at Taemas	S-C	-20.99956	146.42712		16,074	12
		120310A	Suttor River at Bowen Development Road	S-C	-21.52075	147.04267		10,758	8
		120205A	Bowen River at Myuna	S-C	-20.58333	147.60000		7104	5
Mackay Whitsunday	**Pioneer**	**125013A**	**Pioneer River at Dumbleton Pump Station**	**EoS**	**-21.14407**	**149.07528**	**1572**	**1485**	**94**
	Plane	**126001A**	**Sandy Creek at Homebush**	**EoS**	**-21.28306**	**149.02278**	**2539**	**326**	**13**
Fitzroy	**Fitzroy**	**1300000**	**Fitzroy River at Rockhampton**	**EoS**	**-23.38111**	**150.51691**	**142,552**	**139,159**	**98**
		130401A	Isaac River at Yatton	S-C	-22.66583	149.11695		19,720	14
		130206A	Theresa Creek at Gregory Highway	S-C	-23.42924	148.15138		8485	6
		130302A	Dawson River at Taroom	S-C	-25.63756	149.79014		15,846	11
		130504B	Comet River at Comet Weir	S-C	-23.61247	148.55139		16,457	12
Burnett Mary	**Burnett**	**136014A**	**Burnett River at Ben Anderson Barrage Head Water**	**EoS**	**-24.88963**	**152.29215**	**33,207**	**32,891**	**99**
		136002D	Burnett River at Mt Lawless	S-C	-25.54471	151.65494		29,355	88
		136094A	Burnett River at Jones Weir Tail Water	S-C	-25.59483	151.29735		21,700	65
		136106A	Burnett River at Eidsvold	S-C	-25.40225	151.10327		7117	21

EoS = end-of-system site, S-C = sub-catchment site. $ = the North Johnstone and South Johnstone rivers combined act as an end-of-system site.

Table 2.2 Summary information on analytes measured and sample collection methods used as part of the Great Barrier Reef Catchment Loads Monitoring Program between 1 July 2012 and 30 June 2013. Text in bold are end-of-system sites and the corresponding data, all others are sub-catchment sites.

NRM region	Catchment	Gauging station	River and site name	Analytes measured	Sample collection method
Cape York	**Normanby**	**105107A**	**Normanby River at Kalpowar Crossing**	**TSS & N**	**Manual**
Wet Tropics	**Barron**	**110001D**	**Barron River at Myola**	**TSS & N**	**Manual and automatic**
	Johnstone	112004A	North Johnstone River at Tung Oil$	TSS, N & PSII	Manual
		112101B	South Johnstone River at Upstream Central Mill$	TSS & N	Manual
	Tully	**113006A**	**Tully River at Euramo**	**TSS, N & PSII**	**Manual and automatic**
		113015A	Tully River at Tully Gorge National Park	TSS & N	Manual and automatic
	Herbert	**116001F**	**Herbert River at Ingham**	**TSS, N & PSII**	**Manual**
Burdekin	**Haughton**	**119101A**	**Barratta Creek at Northcote**	**TSS, N & PSII**	**Manual and automatic**
	Burdekin	**120001A**	**Burdekin River at Home Hill**	**TSS, N & PSII**	**Manual**
		120002C	Burdekin River at Sellheim	TSS & N	Manual
		120301B	Belyando River at Gregory Development Road	TSS & N	Manual and automatic
		120302B	Cape River at Taemas	TSS & N	Manual and automatic
		120310A	Suttor River at Bowen Development Road	TSS & N	Manual and automatic
		120205A	Bowen River at Myuna	TSS & N	Manual and automatic
Mackay Whitsunday	**Pioneer**	**125013A**	**Pioneer River at Dumbleton Pump Station**	**TSS, N & PSII**	**Manual and automatic**
	Plane	**126001A**	**Sandy Creek at Homebush**	**TSS, N & PSII**	**Manual**
Fitzroy	**Fitzroy**	**1300000+**	**Fitzroy River at Rockhampton**	**TSS, N & PSII**	**Manual**
		130504B	Comet River at Comet Weir	TSS, N & PSII	Manual
		130401A	Isaac River at Yatton	TSS & N	Manual
		130302A	Dawson River at Taroom	TSS & N	Manual
		130206A	Theresa Creek at Gregory Highway	TSS & N	Manual
Burnett Mary	**Burnett**	**136014A**	**Burnett River at Ben Anderson Barrage HW**	**TSS, N &, PSII**	**Manual**
		136002D	Burnett River at Mt Lawless	TSS & N	Manual and automatic
		136094A	Burnett River at Jones Weir Tail Water	TSS & N	Manual and automatic
		136106A	Burnett River at Eidsvold	TSS & N	Manual and automatic

TSS = total suspended solids, N = nutrients, PSII = photosystem II inhibiting herbicides, HW = headwater. + This site is not at a gauging station. Refer to Table 2.4; $ = the North Johnstone and South Johnstone rivers combined to act as an end-of-system site.

Intensive sampling (daily or every few hours) occurred during high flow events and reduced sampling (monthly) was undertaken during ambient (low or base-flow) conditions. Where possible, total suspended solids, nutrients and pesticide samples were collected concurrently. Approximately 50 per cent of the total suspended solids and nutrient samples were collected by manual grab sampling and 50 per cent were collected using refrigerated automatic pump samplers. All pesticide samples were manually collected except in the Pioneer catchment where an automatic sampler fitted with glass bottles was installed.

Samples were stored and transported in accordance with the Environmental Protection (Water) Policy Monitoring and Sampling Manual (DERM 2010).

2.4 Quality control

During the 2012–2013 monitoring year the Great Barrier Reef Catchment Loads Monitoring Program continued to implement a quality management system. This system has been used to govern all aspects of the program delivery since 2010 to ensure consistency and transparency in all areas of the Program. Continual improvement in the program delivery has been achieved during the 2012–2013 monitoring year through adoption of the quality management system and demonstrated through:

- ongoing delivery of the Great Barrier Reef Catchment Loads Monitoring Quality Management training package to staff of the Department of National Parks, Racing, Sport and Recreation (Normanby and Taroom) and partner organisations including Burdekin Bowen Integrated Floodplain Management Committee
- installation of automated water quality monitoring equipment to improve sampling representivity during flood events in order to improve pollutant load estimates
- review of standard operating procedures to ensure all aspects of the program delivery are documented and undertaken in a manner consistent with state and national standards

2.5 Water quality sample analysis

Total suspended solids and nutrient analyses were undertaken by the Science Division Chemistry Centre (Dutton Park, Queensland) according to Standard Methods 2540 D, 4500-NO_3 I, 4500-NH_3 H, 4500-N_{org} D and 4500-P G (APHA-AWWA-WEF 2005). Total suspended solids samples were analysed by a gravimetric methodology and nutrient samples were analysed via Flow Injection Analysis (colourimetric techniques).

Queensland Health Forensic and Scientific Services (Coopers Plains, Queensland) undertook the analysis of water samples for pesticides. All pesticide samples were extracted via solid phase extraction and analysed using liquid chromatography-mass spectrometry (LC-MS) to quantify the five priority photosystem II inhibiting herbicides (ametryn, atrazine including its breakdown products desethyl atrazine and desisopropyl atrazine, diuron, hexazinone and tebuthiuron). For the purpose of this report, atrazine together with its breakdown products is reported as ‘total atrazine’. The total atrazine concentration for each sample was calculated according to Equation 1, which was then used to calculate a total atrazine load:

Equation 1

$$Total\ Atrazine = C_e \times \frac{M_a}{M_e} + C_i \times \frac{M_a}{M_i} + C_a$$

where, *C* = concentration, *M* = molecular weight, *a* = atrazine, *e* = desethylatrazine and *i* = desisopropyl.

During the 2012–2013 monitoring year, water samples were analysed for pesticides in addition to the photosystem II inhibiting herbicides and their loads are reported for the first time (see Appendix A).

Science Delivery Chemistry Centre (Dutton Park, Queensland) and Queensland Health Forensic and Scientific Services (Coopers Plains, Queensland) laboratories are both accredited by the National Association of Testing Authorities (NATA, Australia) for the analyses conducted. Table 2.3 provides a summary of all analysed parameters and their practical quantitation limits.

Table 2.3 Summary information for each analyte measured and the corresponding practical quantitation limit.

Monitored pollutants	Abbreviation	Analytes measured	Practical quantitation limit
Sediments			
Total suspended solids	TSS	Total suspended solids	1 mg L^{-1}
Nutrients			
Total nitrogen	TN	Total nitrogen as N	0.03 mg L^{-1}
Particulate nitrogen	PN	Total nitrogen (suspended) as N	0.03 mg L^{-1}
Dissolved organic nitrogen	DON	Organic nitrogen (dissolved) as N	0.03 mg L^{-1}
Ammonium nitrogen as N	NH_4-N	Ammonium nitrogen as N	0.002 mg L^{-1}
Oxidised nitrogen as N	NO_x-N	Oxidised nitrogen as N	0.001 mg L^{-1}
Dissolved inorganic nitrogen	DIN	Ammonium nitrogen as N + Oxidised nitrogen as N	0.002 mg L^{-1}
Total phosphorus	TP	Total Kjeldahl phosphorus as P	0.02 mg L^{-1}
Particulate phosphorus	PP	Total phosphorus (suspended) as P	0.02 mg L^{-1}
Dissolved organic phosphorus	DOP	Organic phosphorus (dissolved) as P	0.02 mg L^{-1}
Dissolved inorganic phosphorus	DIP	Phosphate phosphorus as P	0.001 mg L^{-1}
Pesticides			
Diuron	Pesticide (PSII)	Diuron	0.01 µg L^{-1}
Ametryn		Ametryn	0.01 µg L^{-1}
Total Atrazine		Atrazine, desethyl atrazine and desisopropyl atrazine	0.01 µg L^{-1}
Tebuthiuron		Tebuthiuron	0.01 µg L^{-1}
Hexazinone		Hexazinone	0.01 µg L^{-1}

2.6 River discharge

River discharge data (hourly-interpolated flow, $m^3 s^{-1}$) were extracted from the Department of Natural Resources and Mines, Surface Water Database using the Hydstra pre-programmed script (http://watermonitoring.derm.qld.gov.au/host.htm) (DNRM 2012). The method used to calculate discharge by the Surface Water Database is presented in Appendix B. The preference was to use data with a quality code of 10 to 30, based on the Department of Natural Resources and Mines hydrographic methodology for quality rating flow data (DNRM 2014) (see Appendix C for an explanation of DNRM quality coding). If such data were not available due to a gauging station error, flows with a quality code of 60 were used (see Appendix C for an explanation of DNRM quality coding).

If samples were collected at sites without an operating Department of Natural Resources and Mines gauging station (due to logistic or work health and safety reasons, or site decommissioning) a 'timing and flow factor' was calculated. Timing and flow factors were based on flow data from the nearest upstream gauging station(s). Timing and flow factors were applied to discharge data used in the calculation of loads during the 2012–2013 monitoring year at: North Johnstone River at Goondi Bridge, Burdekin River at Home Hill, Fitzroy River at Rockhampton and Burnett River at Ben Anderson Barrage Head Water (Table 2.4). In general, the factors adjust the timing of the flow to account for the delay in time it takes water to flow from the gauging station to the water quality sampling site.

The long-term mean annual discharge and historical maximum recorded flow for each monitoring site was calculated using data contained in the Surface Water Database. For three sites, Pioneer River at Dumbleton Pump Station, Burnett River at Ben Anderson Barrage Head Water and Burnett River at Mt Lawless, historical discharge was estimated using discharge data from upstream gauging stations as described in Table 2.4.

The exceedence probability (P_e) of the annual discharge was calculated for each monitored site by:

Equation 2

$$P_e = (1 - \frac{R_i}{N + 1}) \times 100$$

where *R* is the rank of the i^{th} total annual (1 July to 30 June) discharge, and *N* is the number of annual discharge observations at the monitoring site.

Table 2.4 Timing and flow factors applied to calculate discharge at non-gauged monitoring sites and recently installed gauging stations.

Gauging station	River and site name	Timing and flow factors
1120049	North Johnstone River at Goondi Bridge	Estimated from discharge data for Tung Oil GS 112004A where: Discharge $_{\text{North Johnstone River at Goondi Bridge}}$ = Discharge $_{\text{North Johnstone River at Tung Oil}}$
120001A	Burdekin River at Home Hill	Estimated from discharge data for Clare GS 120006B where: Discharge $_{\text{Burdekin River at Home Hill}}$ = Discharge $_{\text{Burdekin River at Clare}}$
125013A	Pioneer River at Dumbleton Pump Station	Historical discharge was estimated using data from Mirani Weir Tail Water GS 125007A where: Discharge $_{\text{Pioneer River Dumbleton Pump Station}}$ = Discharge $_{\text{Mirani Weir Tail Water}}$
1300000	Fitzroy River at Rockhampton	Estimated from discharge data from The Gap GS 130005A where: Time $_{\text{Rockhampton}}$ = Time $_{\text{The Gap}}$ + 14.5 hours
136014A	Burnett River at Ben Anderson Barrage Head Water	Estimated from discharge data for Fig Tree GS 136007A, Degilbo GS 136011A and Perry GS 136019A where: Discharge $_{\text{Burnett River at Ben Anderson Barrage Head Water}}$ = Discharge $_{\text{Fig Tree}}$ + Discharge $_{\text{Degilbo}}$ + Discharge $_{\text{Perry}}$ Historical discharge (pre-1988) was estimated from Walla GS 136001A and 136001B where: Discharge $_{\text{Burnett River at Ben Anderson Barrage Head Water}}$ = Discharge $_{\text{Walla}}$
136002D	Burnett River at Mt Lawless	Historical discharge was estimated using data from Burnett River at Yenda GS 136002A where: Discharge $_{\text{Burnett River at Mt Lawless}}$ = Discharge $_{\text{Yenda}}$

2.7 Data analysis

2.7.1 Rating of sampling representivity

The suitability of the total suspended solids and nutrients data at each site between 1 July 2012 and 30 June 2013 to calculate loads, was assessed by determining the representivity of the data for each analyte using the method of Turner et al. (2012) which was based on elements of the Kroon et al. (2010) and Joo et al. (2012) methods. This is the first time that sampling representivity was calculated for nutrients. The rating of sampling representivity for total suspended solids and all monitored nutrients are presented individually. The rating of sampling representivity was assessed against two criteria:

1. the number of samples collected in the top five per cent of flow; and
2. the ratio between the highest flow rate at which a water sample was collected in 2012–2013 and the maximum flow rate recorded (both measured in $m^3 s^{-1}$).

The representivity was determined by assigning a score using the system presented in Table 2.5.

Table 2.5 Scores assigned to total suspended solids and nutrients data to determine their representivity.

Number of samples in top 5 per cent of flow	Score	Ratio of highest flow sampled to maximum flow recorded	Score
0 - 9	1	0.0 - 0.19	1
10 - 19	2	0.2 - 0.39	2
20 - 29	3	0.4 - 0.59	3
30 - 39	4	0.6 - 0.79	4
>40	5	>0.8	5

The rating of sample representivity for each analyte was the sum of the scores for the two criteria. Sample representivity for each analyte was rated as "excellent" when the total score was greater than or equal to eight, "good" when the total score was six or seven, "moderate" for total scores of four or five or "indicative" when the score was less than four. Furthermore, hydrographs were used to verify the representivity rating.

The representivity of pesticide data was not assessed as the Turner et al. (2012) method is not appropriate due to maximum pesticide concentrations often not occurring at the same time as maximum flow.

2.7.2 Loads estimation

Load estimations were calculated using the Loads Tool component of the software Water Quality Analyser 2.1.1.4 (eWater 2011). Annual and daily loads were estimated for total suspended solids and nutrients, including total nitrogen, particulate nitrogen, dissolved organic nitrogen, oxidised nitrogen, ammonium nitrogen, total phosphorus, particulate phosphorus, dissolved inorganic phosphorus and dissolved organic phosphorus. Annual and daily pesticide loads were also estimated for ametryn, total atrazine, diuron, hexazinone and tebuthiuron. Whilst daily loads have been calculated for all analytes, only annual loads are presented in this report.

The total suspended solids and nutrient loads were calculated using concentrations reported in milligrams per litre (mg L^{-1}) and loads for pesticides were calculated using concentration data in micrograms per litre (µg L^{-1}).

One of two methods was used to calculate loads at each site: average load (linear interpolation of concentration)[3] or the Beale ratio. The average load (linear interpolation of concentration) and Beale ratio methods were applied using the following equations:

[3] This method was previously referred to as the 'Linear Interpolation' method in Water Quality Analyser (WQA) 2.1.1.0 and Turner et al. (2012). The revised name 'Average Load (linear interpolation of concentration)' is consistent with the load estimation method of Letcher et al. (1999) as referred to in Water Quality Analyser (WQA) 2.1.2.4.

Average load (linear interpolation of concentration):

Equation 3

$$Load = \sum_{j=1}^{n} \frac{c_j + c_{j+1}}{2} \times q_j$$

where c_j is the j^{th} sample concentration, and q_j is the inter-sample mean flow (eWater 2011).

Beale ratio:

Equation 4

$$Load = Q\left(\frac{\bar{l}}{\bar{q}}\right)\left\{\frac{1+\frac{1}{N}\frac{\rho\sigma L\sigma Q}{\bar{l}\bar{q}}}{1+\frac{1}{N}\frac{\sigma^2 Q}{\bar{q}^2}}\right\}$$

where Q is the total discharge for the period, $\bar{l}$ is the average load for a sample, L is the observed load, $\bar{q}$ is the average of *N* discharge measurements, σ is the standard error of L and ρ is the correlation coefficient for L and Q (eWater 2011; Joo et al. 2012).

2.7.2.1 Total suspended solids, nutrient and pesticides loads

The most appropriate method (average load (linear interpolation of concentration) or Beale ratio) to calculate annual loads of total suspended solids, total nutrients and dissolved nutrients was determined for each analyte at each site using the following criteria:

- if the majority of major events were sampled on both the rise and fall, then the average load (linear interpolation of concentration) method was applied (e.g. Barratta Creek at Northcote, Figure 7.10, Appendix D)
- if the majority of the events were not adequately sampled but the representivity rating was "moderate", "good" or better, the Beale ratio was applied (e.g. North Johnstone at Tung Oil, Figure 7.3, Appendix D and Tully River at Tully Gorge, Figure 7.8, Appendix D)
- if the majority of the events were not adequately sampled and the representivitiy rating was "indicative", then annual loads may be estimate using the Beale ratio method (e.g. Theresa Creek, Figure 7.24, Appendix D). No indicative loads are reported for the 2012–2013 monitoring year.

The most appropriate load calculation method varied between sites as the numbers of samples collected and the coverage of the hydrograph varied between sites (Appendix D). This year, as the sampling for total suspended solids and nutrients was similar, the same loads calculation method was used for both. Similarly, a single loads calculation method was used for all pesticides, which may have been different to that for total suspended solids and nutrients. In years where the sampling is not the same different methods may be used for each analyte.

The loads calculation method applied for total suspended solids, nutrients and pesticides at each monitoring site is provided in Table 3.2 to Table 3.6. Once the appropriate loads calculation method was determined, the loads were calculated using the following procedure:

- water quality concentration data with a date and time stamp were imported into Water Quality Analyser 2.1.1.4 (eWater 2011) for each parameter
- flow data ($m^3 s^{-1}$) were imported into Water Quality Analyser 2.1.1.4 (eWater 2011) on an hourly-interpolated time stamp
- for total suspended solids and nutrients, if the water quality concentration values were below the practical quantitation limit specified by the Science Division Chemistry Centre, the results were adjusted to a value of 50 per cent of the practical quantitation limit
- the flow data were then aligned to the water quality concentration data
- when pesticide concentrations were below the practical quantitation limit, but other samples in the same event detected the same pesticide, they were replaced by 50 per cent of the practical quantitation limit. In all other cases, where the sample concentration was reported as below the practical quantitation limit results were adjusted to 0 $\mu g\ L^{-1}$ in order to not potentially overestimate the loads
- the hydrograph and water quality concentration data were checked for relevance and suitability (i.e. trends in relation to hysteresis, visual relationship of water quality concentrations to flow and representativeness)
- the data were then processed by the Loads Tool component of Water Quality Analyser 2.1.1.4 (eWater 2011) using the appropriate loads estimation method (as outlined above) and annual loads for the 1 July 2012 to 30 June 2013 period were reported; and
- all calculated results were rounded to two significant figures.

At some sites, the average load (linear interpolation of concentration) method was determined to be the most appropriate calculation method, but inadequate ambient sampling points were available to calculate annual loads using Water Quality Analyser 2.1.1.4 (eWater 2011). In these cases, calculated data points that were 50 per cent of the lowest reported concentration were inserted into the dataset at 1 July 2012 and the lowest reported concentration was inserted into the dataset at 30 June 2013 to provide tie-down concentrations for calculations (eWater 2011).

The use of average load (linear interpolation of concentration) and Beale ratio loads calculation methods for total suspended solids, nutrients and pesticides is consistent with the previous monitoring years from 2006 to 2012 (Joo et al. 2012; Turner et al. 2012; Turner et al. 2013 and Wallace et al. 2014). This is only the second year, however, that we have reported different method outputs based on the number of concentration points of each analyte at each site, rather than using the number of concentration points of total suspended solids as a proxy for the number of concentration data points for all analytes.

2.7.3 Yields

Yields are the load of pollutants (e.g. kilograms, kg or tonnes, t) that originate from a monitored area of land (e.g. square kilometres, km^2) within a catchment (i.e. t km^{-2} for total suspended solids and kg km^{-2} for nutrients and pesticides). Yields provide a useful means of comparing the rate of pollutant delivery between monitored areas.

2.7.3.1 Total suspended solids and nutrient catchment yields

Catchment yields of total suspended solids and nutrients were calculated for all end-of-system and sub-catchment sites by dividing the monitored annual pollutant load of each analyte by the total monitored catchment area.

Equation 5

CY = monitored annual load/MCA

where CY is the catchment yield (t km^{-2} or kg km^{-2}) and MCA is the monitored catchment area (km^2) upstream of the monitoring site. The yields were calculated using MCA as all land within a catchment can contribute to total suspended solids and nutrient loads and yields.

Total suspended solids and nutrients may originate from all land use types within the monitored area including areas set aside for conservation purposes. The yields of total suspended solids and nutrients are therefore presented as an average rate of pollutant delivery across the total monitored catchment area. Research conducted in the priority reef catchments has demonstrated high variability in the rate of pollutant delivery over varying temporal and spatial scales.

2.7.3.2 Pesticide land use yields

In this report, only pesticide land use yields (the load divided by the total surface area of land uses where the pesticide is registered for use) are presented. In Turner et al (2012) only pesticide catchment yields (load divided by monitored catchment surface area) were reported while in Turner et al (2013) and Wallace et al (2014) pesticide catchment yields were presented in the body of the report and pesticide land use yields were presented in the Appendices.

It is important to note the method applied in the calculation of pesticide land use yields in the present report differs from previous years as outlined below. These changes were the result of extensive internal review and consultation with peak industry bodies.

Agricultural chemicals, including photosystem II inhibiting herbicides, are registered for specific applications within the agricultural sector by the Australian Pesticides and Veterinary Medicines Authority. The registration of chemicals allows restrictions to be applied to control potential environmental impacts of these chemical. These restrictions may include the crop type, timing and rate at which registered chemicals may be applied.

It is possible to use the registered chemical restriction information to determine for which agricultural production purposes the priority photosystem II inhibiting herbicides were registered during the 2012–2013 monitoring year. Together with land use data available through the Australian Collaborative Land Use Mapping Program, registered chemical information may be used to calculate the land use yield of photosystem II inhibiting herbicides.

In each monitored catchment, the land use data were obtained from the Queensland Land Use Monitoring Program, which is part of the Australian Collaborative Land Use Mapping Program sourced through the Queensland Government Information Service. These land use data were aggregated into eleven categories, with only the aggregated land use area for cropping, forestry, grazing, horticulture and sugarcane used to determine the land use yields (i.e., urban, mining, conservation and water were not used). Aggregated land use categories used in the calculation of land use yields for the photosystem II herbicides are presented in Table 2.6.

As these land use categories are an aggregation of land use data categories contained in the Queensland Land Use Monitoring Program dataset, it is acknowledged that these categories may include specific land uses to which the application of registered chemical is not permitted (e.g. ametryn may be applied to pineapples which are included in the horticulture land use category, but may not be applied to bananas which are also included in the horticulture land use category).

The binary codes (Table 2.6) indicate whether the pesticide is registered for application in an aggregated land use (indicated by a code of 1) or not (indicated by a code of 0) and whether validation criteria have been met. The validation criteria applied to the binary coding were:

- the pesticide is registered for a land use contained in the aggregated land use category (e.g. pineapples in horticulture)
- the specific land use (e.g. pineapples) to which the pesticide is registered occurs upstream of the monitoring site.

The pesticide land use yields (LUY) in each catchment were calculated using Equation 6:

Equation 6

LUY = annual monitored pesticide load/LUA

where LUA is the total land use area (km^2) in each catchment based on the aggregated land use categories to which a photosystem II inhibiting herbicide may be applied.

The LUA was determined by:

Equation 7

LUA = ∑ (binary code x surface area of each aggregated land use category) (Table 2.7)

The resulting land use yields ($kg\ km^{-2}$) are the yields of pesticides from the monitored area for each aggregated land use category in each catchment.

These estimates are still likely to underestimate the actual yields as not all land to which use of a pesticide is permitted will have had that pesticide applied. Complicating this, is that pesticides are predominantly transported to waterways when pesticide applied land receives sufficient rain to cause surface run-off – agricultural land not receiving rain but registered for a pesticide will not significantly contribute to the load or yield. At this point the spatial resolution for rainfall in the Great Barrier Reef catchments is not sufficient to permit this type of calculation of yields.

The binary coding applied in the calculation of the land use yields in this report is the product of a consultative review undertaken with peak industry bodies. Changes made to the binary code from previous reports (Turner et al 2012 and Wallace et al 2013) have removed the implied linkage between a photosystem II inhibiting herbicide and aggregated land use categories through the application of the validation criteria. As an example, the binary coding for ametryn and horticulture was adjusted from 1 to a 0. This occurred because while industry advice (G. Townsend, Growcom, pers. comm., 18 March 2015) confirmed ametryn is widely used in the control of broad leaf weeds in the production of pineapples. However, analysis of spatial data confirmed very limited or no pineapple production occurs upstream of the monitoring sites in the priority catchments (S. Newett, Queensland Department of Agriculture and Forestry, pers. comm., 16 April 2015). The binary code of atrazine to horticulture was revised from 1 to 0 following consultation with industry that confirmed atrazine is not typically used in the production of sweet corn upstream of current monitoring locations (M. Vitelli, AgForce, pers. comm. 4 March 2015; S. Wallace, Growcom, pers. comm., 18 March 2015). The binary code of atrazine to grazing was also revised from 1 to 0 as advice received from industry (M. Vitelli, AgForce, pers. comm. 4 March 2015) that was subsequently independently verified, indicated that atrazine is only registered for application to the Giant Sensitive Plant (Mimosa diplotricha) and this has a restricted distribution in the GBR catchments.

The land use yields of photosystem II inhibiting herbicides for the 2010–2011 and 2011–2012 monitoring years have also been recalculated using the revised binary coding and presented in Appendix E.

Table 2.6 Binary codes indicating which photosystem II inhibiting herbicides are registered for the aggregated land use categories in Great Barrier Reef catchments. A code of 1 indicates the pesticide is registered for application in that aggregated land use, while a code of 0 indicates that it is not registered for application in that land use[4].

Photosystem II inhibiting herbicides	Cropping	Forestry	Grazing	Horticulture	Sugarcane
Ametryn	0	0	0	0	1
Atrazine	1	1	0	0	1
Diuron	1	0	0	1	1
Hexazinone	0	1	1	0	1
Tebuthiuron	0	0	1	0	0

Table 2.7 Surface area of each aggregated land use category based on data were obtained from the Queensland Land Use Monitoring Program

Catchment	Gauging station	River and site name	Monitored area (km^2)	Monitored area of catchment (%)	Cropping (km^2)	Forestry (km^2)	Grazing (km^2)	Horticulture (km^2)	Sugarcane (km^2)
Johnstone	112004A[B]	North Johnstone River at Tung Oil	925	40	5.1	1.4	380	18	11
Tully	113006A[B]	Tully River at Euramo	1450	86	0.12	41	74	66	150
Herbert	116001F[L]	Herbert River at Ingham	8581	87	32	400	5300	3.4	240
Haughton	119101A[L]	Barratta Creek at Northcote	753	19	22	0.0	600	0.99	130
Burdekin	120001A[L]	Burdekin River at Home Hill	129,939	99	1300	830	120,000	2.7	120
Pioneer	125013A[L]	Pioneer River at Dumbleton Pump Station	1485	94	0.0	367	510	0.65	310
Plane	126001A[B]	Sandy Creek at Homebush	326	13	0.0	34	110	1.1	160
Fitzroy	1300000[L]	Fitzroy River at Rockhampton	139,159	98	9100	9000	111,000	42	3.3
Burnett	136014A[L]	Burnett River at Ben Anderson Barrage Head Water	32,891	99	1200	4100	25,000	73	63

[4] Binary coding of 0 was applied where reasonable information was available to support that the chemical is not used within the aggregated land uses in areas upstream of the Great Barrier Reef Catchment Loads Monitoring Program water quality monitoring sites.

3 Results and discussion

Automatic water sampling equipment at all Burnett River sub-catchment monitoring sites were destroyed during the major flood event in January 2013. Insufficient water quality data were subsequently available to calculate annual loads for three sites - Burnett River at Eidsvold, Burnett River at Jones Weir and Burnett River at Mt Lawless.

Due to logistical reasons, water quality monitoring at Isaac River at Yatton and Theresa Creek at Gregory Highway was also not sufficient to calculate annual loads for the 2012–2013 monitoring year (see Section 3.2 and Section 3.3). As a result, no calculated data for these sub-catchment sites are presented in this report.

Water samples received from the Normanby catchment were only analysed for total suspended solids due to extensive and prolonged flooding which prevented the nutrient samples being stored correctly. Monitored annual loads and yields of nutrients in the Normanby catchment are not presented in this report.

In the discussion of loads and yields, unless it is stated to the contrary, all comparisons are based solely on the end-of-system sites.

3.1 Rainfall and river discharge

Annual rainfall across the priority reef catchments during the 2012–2013 monitoring year (Figure 3.1) was generally average to slightly below average in the Cape York, Wet Tropics and Burdekin regions (Figure 3.2) with few flood events occurring in the monitored catchments of these regions (Appendix D). Rainfall in the Mackay Whitsunday region was average to above average over the same period. In the Fitzroy and Burnett regions the eastern section of the priority catchments received very high rainfall associated with Ex-Tropical Cyclone Oswald in late-January 2013 which contributed to these areas receiving above average to very much above average rainfall over the 2012–2013 monitoring year. The monitored western Fitzroy sub-catchments however did not receive the significant rainfall associated with this weather event and annual rainfall totals across this area were below average to very much below average.

3.1.1 El Niño Southern Oscillation and Southern Oscillation Index

Indicators of the El Niño Southern Oscillation were near El Niño thresholds during late winter before shifting to more neutral pattern during spring – this was an atypical weather pattern as El Niño or La Niña events typically consolidate during spring (BoM 2013b). The Southern Oscillation Index remained positive in the neutral range throughout spring before rapidly declining into the negative neutral range with a monthly Southern Oscillation Index average of -6.13 for December 2012 (BoM 2013b). The El Niño Southern Oscillation remained in the neutral range throughout summer with the Southern Oscillation Index persisting with a slightly negative monthly average in the range of -0.29 to -3.8 in January and February, 2013, respectively (BoM 2013b). Neutral El Niño Southern Oscillation conditions continued throughout autumn and early winter. The Southern Oscillation Index remained positive over this period with a high 30-day average of 13.9 recorded to June 30 2013 (BoM 2013b).

3.1.2 Monthly rainfall summary

Rainfall in the central and northern catchments during July 2012 was above average to very much above average (BoM 2012a) resulting in a small early event in Barratta Creek in the Haughton catchment, the Burdekin catchment including the Cape and Belyando sub-catchments, the Pioneer catchment, Sandy Creek in the Plane catchment and the Fitzroy catchment including the Theresa Creek sub-catchment.

Above average rainfall occurred across the central and northern catchments in August 2012. In the Fitzroy and Burnett regions, however, rainfall was very much below average over this same period (BoM 2012b).

The trend towards below average rainfall extended across most priority reef catchments in September and October 2012 (BoM 2012c and BoM 2012d) however, the Normanby catchment continued to receive above average rainfall over this same period. The dry conditions persisted in November and December 2012 with below average to very much below average rainfall across all priority reef catchments (BoM 2012e and BoM 2013c). Notable rainfall totals were recorded in the Burnett catchment during the first week in November 2012, however, no significant increase in river discharge resulted from these falls possibly owing to the very dry conditions over the preceding months.

During the middle of January 2013, a monsoon trough with an embedded low pressure system located over north Queensland resulted in widespread rain across the northern priority reef catchments. High rainfall totals were received during this period in the Wet Tropics region, including 470 mm at South Johnstone (BoM 2013c and BoM 2013e). On the 22nd January 2013, Tropical Cyclone Oswald crossed the Queensland coast from the Gulf of Carpentaria downgrading to a tropical low as it moved across the Peninsula District and then in a southerly direction toward Cairns. Together with a monsoon trough that extended across the southern Gulf of Carpentaria, Ex-Tropical Cyclone Oswald resulted in moderate to high rainfall totals across the Wet Tropics region and later inland of Mackay (BoM 2013e). Very heavy rainfall was received across the priority reef catchments in the Fitzroy and Burnett Mary regions on the 26th and 27th January 2013. Monthly rainfall totals in the Burnett catchment were 2–3 times greater than the January long-term average. In the lower Fitzroy catchment monthly rainfall totals were also very high with Rockhampton receiving 556 mm, more than 4 times greater than the long-term monthly average (BoM 2013c and BoM 2013e). Monthly rainfall totals across the remainder of the Fitzroy catchment were generally above average with rainfall totals at Comet and Taroom 1-2 times the long-term January average (BoM 2013e).

During February 2013, rainfall in the Cape York and Wet Tropics regions was below average to very much below average, average in the Burdekin and Mackay Whitsunday regions and above average in the Fitzroy and Burnett regions (BoM 2013f). Small increases in river discharge were observed at all monitoring sites in the Burnett catchment resulting from rain in the last week of February 2013. During the first week of March 2013 a strong easterly surface flow brought heavy rain to central Queensland (BoM 2013g). Rain received during this period resulted in a significant increase in discharge in the Pioneer River and Sandy Creek in the Mackay Whitsunday region and in the southern sub-catchments of the Burdekin region and in the Dawson and Comet sub-catchments of the Fitzroy region. Tropical Cyclone Sandra and Tropical Cyclone Tim formed during March 2013 but neither system crossed the coast (BoM 2013g).

All regions received average to above average rainfall during April 2013 (BoM 2013h). High daily rainfall totals were recorded during the second week of April in the Cape York and Mackay Whitsunday regions, with some priority reef catchments receiving monthly rainfall totals very much above average. Tropical Cyclone Zane formed on the 30th April 2013 but did not cross the coast.

Rainfall was average to above average across the priority reef catchments in May with isolated high rainfall totals occurring in the Johnstone catchment during the second week of May 2013 (BoM 2013i). These falls resulted in the second largest flow event in the North Johnstone and South Johnstone rivers during the 2012–2013 monitoring year. The remainder of the monitoring year was dry throughout Queensland with all regions receiving below average to very much below average rainfall in June (BoM 2013j).

3.1.3 River discharge

River discharge in all rivers of the Cape York, Wet Tropics and Burdekin Dry Tropics regions was very much below the long-term mean (Figure 3.3) with exceedence probabilities at end-of-system sites ranging from 50 per cent in Barratta Creek in the Haughton catchment to 78 per cent in the Barron catchment (Table 3.1). River discharge in all monitored catchments in the Mackay Whitsunday and Fitzroy regions was very much above average with exceedence probabilities similar between the Pioneer catchment (28 per cent), Sandy Creek in the Plane catchment (26 per cent) and the Fitzroy catchment (22 per cent). In the Burnett catchment, exceptionally high 24-hour rainfall totals in late January 2013 in the upper catchment, resulted in the highest maximum recorded flow and highest annual recorded discharge. Annual discharge in the Burnett River during the 2012–2013 monitoring year was five times higher than the long-term mean annual discharge with an exceedence probability of only three per cent.

River discharge in Burdekin sub-catchments was very much below the mean annual discharge in the Suttor, Cape, Belyando and upper-Burdekin rivers with exceedence probabilities ranging between 71 per cent and 95 per cent (Table 3.1). Annual river discharge in the Bowen River sub-catchment however was above average due to the large flow event following significant rainfall across much of the Bowen River sub-catchment resulting from Ex-Tropical Cyclone Oswald. The elevated river discharge in the Bowen River sub-catchment relative to the long-term mean is likely to have contributed to the magnitude of difference in the load of all monitored analytes between the Bowen River sub-catchments and other monitored sub-catchments in the Burdekin region.

River discharge in the monitored sub-catchments of the Fitzroy River were all very much below the long-term mean with exceedence probabilities ranging between 63 per cent at Theresa Creek and 80 per cent at Comet River (Table 3.1). Annual river discharge in these sub-catchments contrasts with the very high annual discharge for the Fitzroy end-of-system site, which during the 2012–2013 monitoring year was 175 per cent of the long-term mean annual discharge with an exceedence probability of 22 per cent.

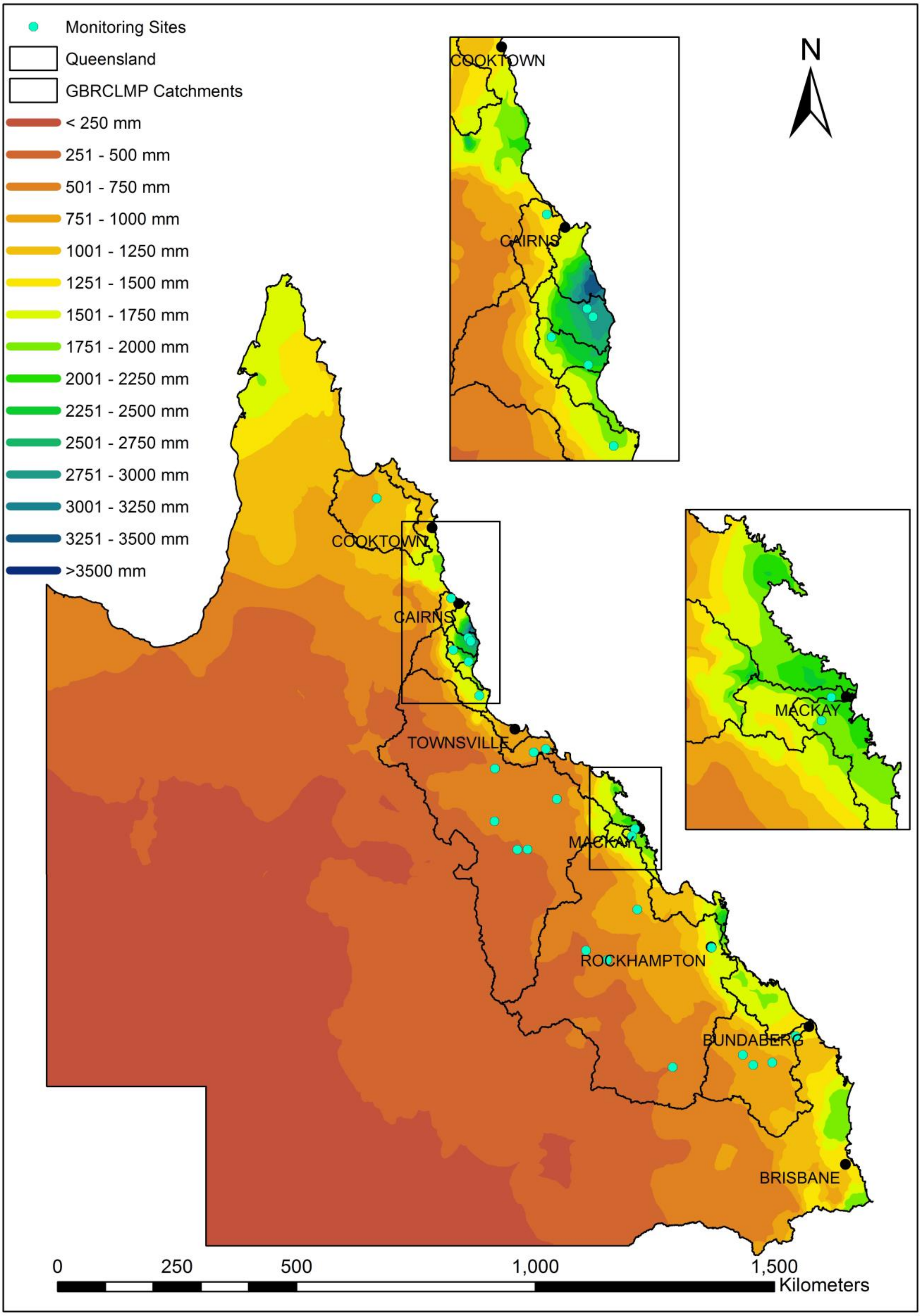


Figure 3.1 Queensland rainfall (millimetres) totals for 1 July 2012 to 30 June 2013 along with the monitored catchments and Great Barrier Reef Catchment Loads Monitoring Program sites.

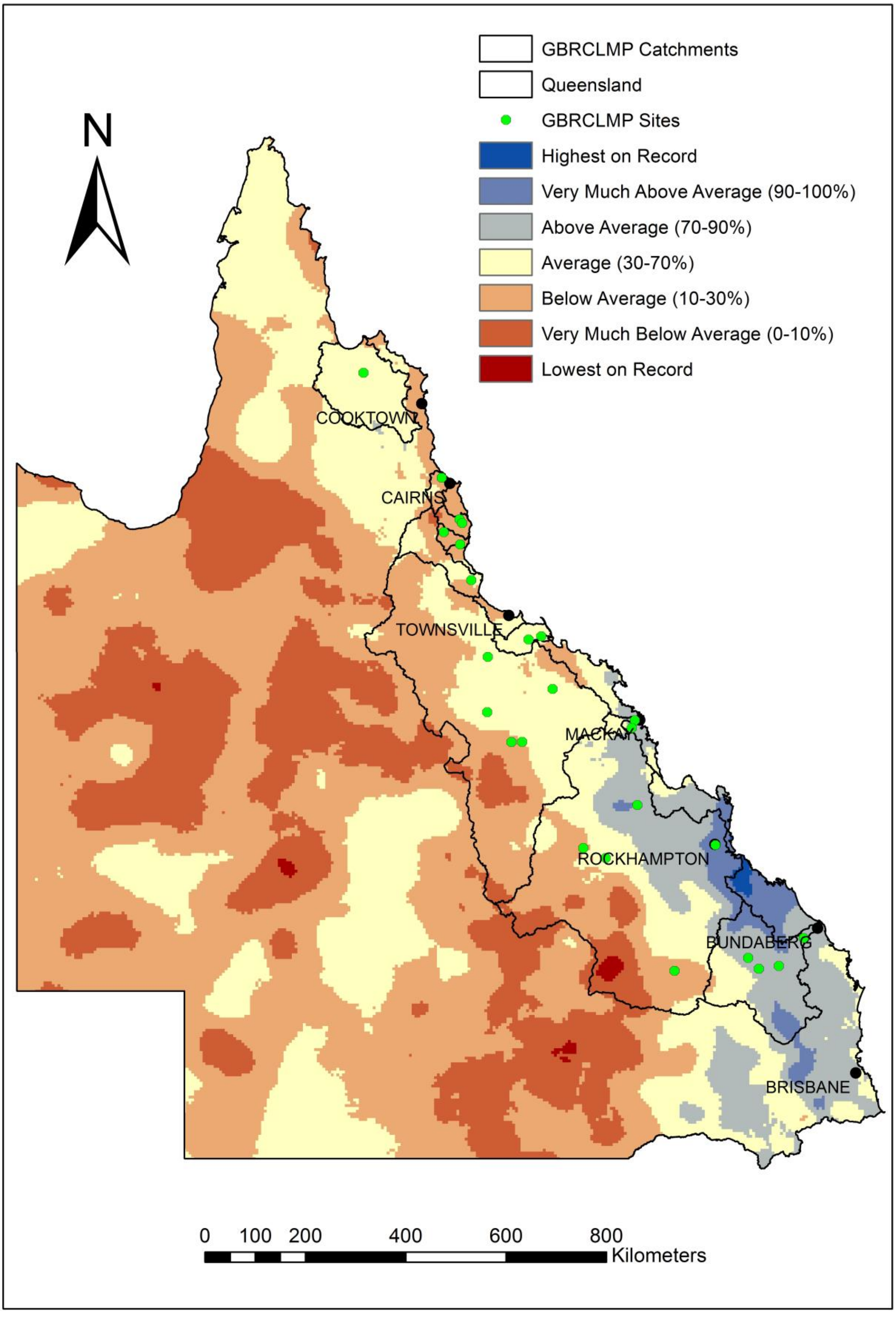


Figure 3.2 Queensland rainfall deciles for 1 July 2012 to 30 June 2013 along with the monitored catchments and Great Barrier Reef Catchment Loads Monitoring Program sites.

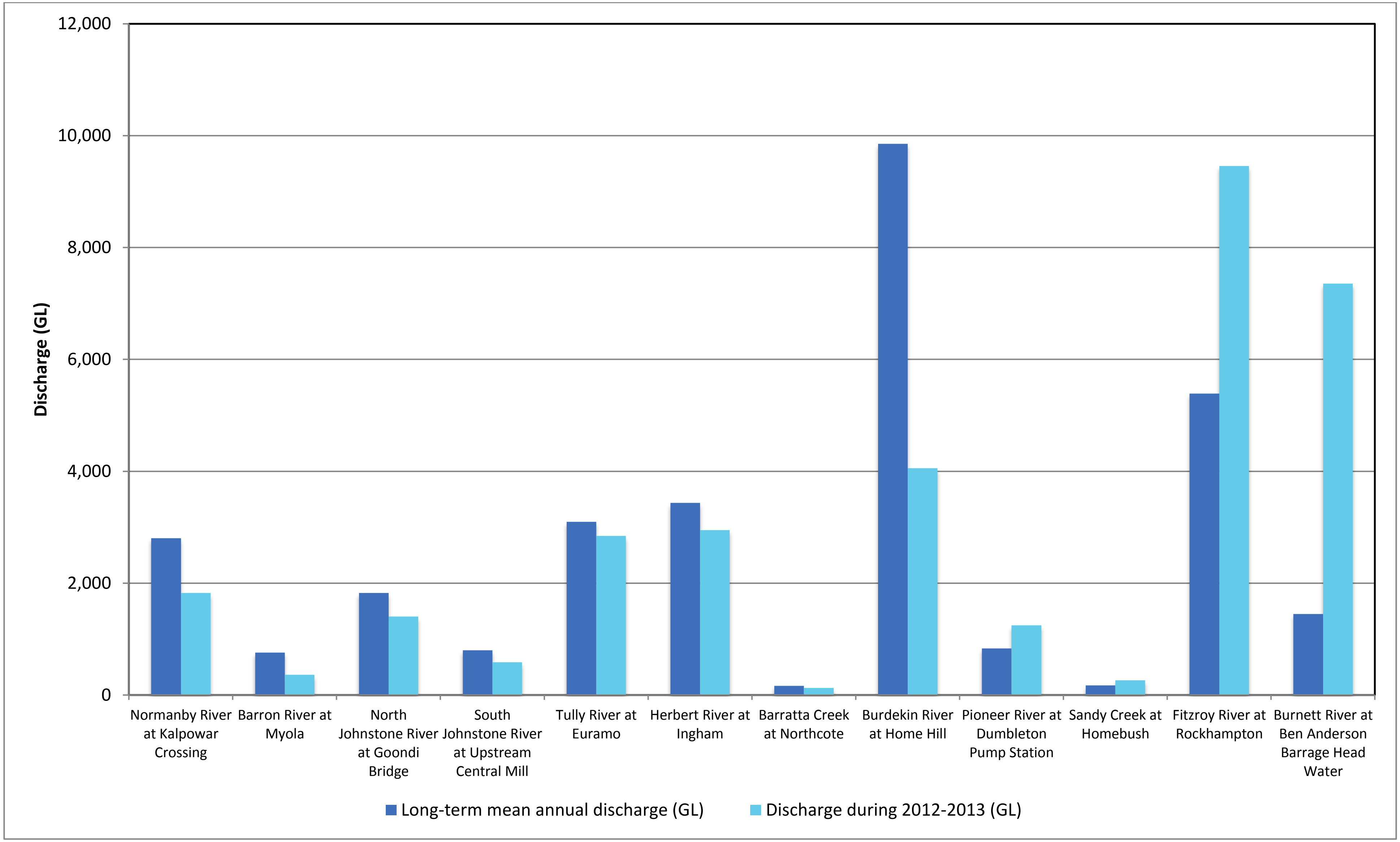


Figure 3.3 Annual discharge for the end-of-system sites (including the North Johnstone and South Johnstone sub-catchments) between 1 July 2012 and 30 June 2013, compared to the long-term mean annual discharge.

Table 3.1 The total and monitored area for each catchment and summary discharge and flow statistics for the 2012–2013 monitoring year. Text in bold are end-of-system sites and the corresponding data, all others are sub-catchment sites.

NRM region	Catchment	River and site name	Total catchment surface area (km^{-2})	Monitored surface area (km^{-2})	Monitored surface area of catchment (%)	Start year of flow records	Long-term mean annual discharge (GL)	Discharge during 2012–2013 (GL)	Exceedence probability (%)	Discharge as a per cent of the long-term mean annual discharge (%)	Historical maximum recorded flow (m^3 s^{-1})	Maximum recorded flow 2012–2013 (m^3 s^{-1})	Per cent of maximum recorded flow observed in 2012-2013 (%)
Cape York	**Normanby**	**Normanby River at Kalpowar Crossing**	**24,399**	**12,934**	**53**	**2005**	**2806**	**1827**	**63**	**65**	**2088**	**1860**	**89**
Wet Tropics	**Barron**	**Barron River at Myola**	**2188**	**1945**	**89**	**1957**	**759**	**365**	**78**	**48**	**3076**	**520**	**17**
	Johnstone[$]	North Johnstone River at Tung Oil	2325	925	40	1966	1827	1405	71	77	3051	1308	43
		South Johnstone River at Upstream Central Mill		400	17	1974	803	589	67	73	1680	673	40
	Tully	**Tully River at Euramo**	**1683**	**1450**	**86**	**1972**	**3098**	**2847**	**65**	**92**	**1052**	**1002**	**95**
		Tully River at Tully Gorge National Park		482	29	12/2009	990	757	75	76	1883	729	39
	Herbert	**Herbert River at Ingham**	**9844**	**8581**	**87**	**1915**	**3436**	**2951**	**56**	**86**	**11,267**	**7779**	**69**
Burdekin	**Haughton**	**Barratta Creek at Northcote**	**4051**	**753**	**19**	**1974**	**166**	**127**	**50**	**77**	**1107**	**434**	**39**
	Burdekin	**Burdekin River at Home Hill**	**130,120**	**129,939**	**99**	**1973**	**9855**	**4056**	**65**	**41**	**25,483**	**4688**	**18**
		Burdekin River at Sellheim		36,290	28	1968	4747	1932	71	41	24,200	5879	24
		Belyando River at Gregory Development Road		35,411	27	1976	680	56	95	8	4269	88	2
		Cape River at Taemas		16,074	12	1968	682	117	82	17	2995	245	8
		Suttor River at Bowen Development Road		10,758	8	2006	741	262	71	35	2379	448	19
		Bowen River at Myuna		7104	5	1960	976	1128	32	116	10,480	4458	43
Mackay Whitsunday	**Pioneer**	**Pioneer River at Dumbleton Pump Station**	**1572**	**1485**	**94**	**1977**	**834**	**1248**	**28**	**150**	**4337**	**1512**	**35**
	Plane	**Sandy Creek at Homebush**	**2539**	**326**	**13**	**1966**	**175**	**265**	**26**	**151**	**1314**	**791**	**60**
Fitzroy	**Fitzroy**	**Fitzroy River at Rockhampton**	**142,552**	**139,159**	**98**	**1964**	**5392**	**9458**	**22**	**175**	**14,493**	**8919**	**62**
		Theresa Creek at Gregory Highway		8485	6	1956	267	96	63	36	4234	216	5
		Dawson River at Taroom		15,846	11	1911	403	107	73	27	5858	239	4
		Comet River at Comet Weir		16,457	12	2002	1079	111	80	10	3975	106	3
Burnett Mary	**Burnett**	**Burnett River at Ben Anderson Barrage Head Water**	**33,207**	**32,891**	**99**	**1910**	**1452**	**7358**	**3**	**507**	**14,357**	**16,902**	**118**
		Burnett River at Mt Lawless		29,355	88	1909	1068	6180	5	579	14,983	16,646	111
		Burnett River at Jones Weir Tail Water		21,700	65	1981	567	3734	3	659	8932	14,536	163
		Burnett River at Eidsvold		7117	21	1960	218	2364	3	1084	3561	10,954	308
Summary end-of-system loads (including North Johnstone and South Johnstone rivers)			354,480	330,788	93								

[$] = the North and South Johnstone rivers combined act as an end-of-system site.

3.2 Sampling representivity

The sampling representivity rating identifies the sample coverage achieved during the period of maximum discharge at each monitoring site. The representivity metric was applied because the majority of the annual total suspended solids and nutrient loads are transported during the highest flow periods and in order to reliably calculate the annual pollutant load, it is important that the pollutant concentration data are available for the periods of highest discharge. Table 3.2 provides a summary of the sampling representivity ratings – indicating those parameters and sites where the representivity is good and excellent; moderate; and indicative. Table 7.7 and Table 7.8 in Appendix F provide the representivity rating and the number of samples used to calculate the loads and yields for all parameters (except pesticides) and sites.

3.2.1 Total suspended solids, total nutrients and dissolved nutrients

Good or excellent sampling representivities were achieved at all end-of-system monitoring sites for all monitored analytes during the 2012–2013 monitoring year (Table 3.2).

A high level of sampling representivity was achieved in many of the sub-catchment monitoring sites. In the Johnstone catchment, good sampling representivity was achieved at the North Johnstone River for all analytes and excellent sampling representivity was achieved at the South Johnstone River (Table 3.2). This is a notable improvement from the previous monitoring year when only moderate representivity was achieved at the South Johnstone River (Wallace et al. 2014).

In the Burdekin sub-catchments good sampling representivity was achieved at the Belyando, Cape and Suttor rivers and excellent sampling representivity was achieved in the Bowen River (Table 3.2). This is a significant achievement as no annual monitored loads have previously been reported for the Bowen River due to the very poor sample coverage at this remote site. The installation of an automated water quality monitoring trailer and the direct engagement of the Burdekin Bowen Integrated Floodplain Management Committee to collect water samples during ambient base flow and flood events, has demonstrated the significant data quality outcomes achieved through strategic investment in water quality monitoring infrastructure and investment in building strong relationships with regional natural resource management partners. In contrast to excellent sampling representivity achieved at the Bowen River, only moderate representivity was achieved at the upper-Burdekin River monitoring site at Sellheim which was manually sampled.

In the Fitzroy River sub-catchments, sampling representivity at the manually sampled Comet River and Dawson Rivers was good for all analytes (Table 3.2). Only indicative representivity was achieved however at the Theresa Creek sub-catchment monitoring site where only five samples were collected during the 2012–2013 monitoring year and no samples were collected during the largest flow event which unseasonably occurred during July 2012 (Figure 7.23).

In the upper Burnett River excellent monthly ambient sampling was conducted. All automated water quality sampling equipment was destroyed however during the record flood in the Burnett catchment following Ex-Tropical Cyclone Oswald which crossed the upper catchment during late-January 2013. Due to damage to road infrastructure caused by the flood it was not possible to manually collect water quality samples at these sites during the period of peak discharge. However, throughout this period water quality samples were manually collected at the Burnett River end-of-system monitoring site, achieving excellent sampling representivity for all monitored analytes.

3.3 Total suspended solids and nutrient loads and yields

The 2012–2013 annual monitored loads and yields of total suspended solids and nutrients for the 11 monitored catchments were determined using measured discharge and contaminant concentration data. The resulting loads are estimates of the mass of each analyte transported past the monitoring sites and do not necessarily represent the loads discharged to the Great Barrier Reef lagoon – as the end-of-system monitoring sites are not located at the mouth of the river or creek (refer to Section 2.1), this unmonitored portion of the catchment or sub-catchment may contribute, remove or degrade total suspended solids, nutrients and pesticides. The annual loads discharged to the Great Barrier Reef for all 35 catchments are estimated using catchment modelling and are reported elsewhere in the Paddock to Reef Program (DPC 2014).

The monitored annual loads and yields of total suspended solids and nutrients are presented in Table 3.2 to Table 3.4. The relative contribution of each monitored catchment to the total annual load for each parameter is presented in Figure 3.4 to Figure 3.14.

3.3.1 Total suspended solids

3.3.1.1 Total suspended solid loads

The combined monitored annual load of total suspended solids for the 11 priority catchments was 9.6 Mt (Table 3.2) of which, over 90 per cent was derived from the Burnett (3.7 Mt; 39 per cent), Burdekin (2.5 Mt; 26 per cent) and Fitzroy (2.5 Mt; 26 per cent) catchments (Table 3.2 and Figure 3.4). The monitored annual loads of total suspended solids in all other catchments were comparatively low, with each catchment contributing less than five per cent of the monitored total suspended solids load during 2012–2013. The lowest monitored total suspended solids load occurred in Barratta Creek in the Haughton catchment (5.5 kt; 0.06 per cent).

In the Burdekin catchment, the highest monitored annual sub-catchment load was in the Bowen River (2.3 Mt), with lower monitored annual loads of total suspended solids in the upper Burdekin river (monitored at Sellheim, 0.61 Mt) and in the Suttor (0.058 Mt), Belyando (0.019 Mt) and Cape (0.012 Mt) rivers (Table 3.2). The monitored annual load of total suspended solids in the Bowen River was approximately 90 per cent of the monitored annual Burdekin River end-of-system load. The magnitude of difference in the monitored annual load of total suspended solids between the Bowen River and other sub-catchments of the Burdekin is likely influenced by above average rainfall being received in the Bowen River sub-catchment and very much below average rainfall in all other sub-catchments during the 2012–2013 monitoring year.

The Fitzroy River sub-catchments produced low monitored annual loads of total suspended solids during the 2012–2013 monitoring year. The monitored annual total suspended solid loads in the Dawson River sub-catchment and Comet River sub-catchment were 0.028 Mt and 0.062 Mt, respectively. Insufficient data were available to calculate an annual load of total suspended solids for the Theresa Creek and Isaac River sub-catchments.

The end-of-system monitored annual load of total suspended solids in the Burnett River (3.7 Mt) during the 2012–2013 monitoring year was exceptionally high compared to the previous monitoring years 2006–2012 (Joo et all. 2012; Turner et al. 2012; Turner et al. 2013; Wallace et al. 2014) during which the end-of-system total suspended solids loads ranged between 15kt in the below average rainfall year of 2011–2012 (Wallace et al., 2014) to 2.6 Mt in 2010–2011 when rainfall was very much above average (Turner et al., 2013). It is estimated that greater than 90 per cent of the monitored annual total suspended solid load was exported past the monitoring point during the major flow event resulting from Ex-Tropical Cyclone Oswald.

Due to extensive damage to automated water quality monitoring equipment and road infrastructure, no water samples were collected from the Burnett River sub-catchment monitoring sites during the major flood. Although good ambient sampling was achieved by the regional hydrographic staff of the Department of Natural Resources and Mines throughout the year, insufficient data were available to calculate the monitored annual total suspended solids loads for these sites.

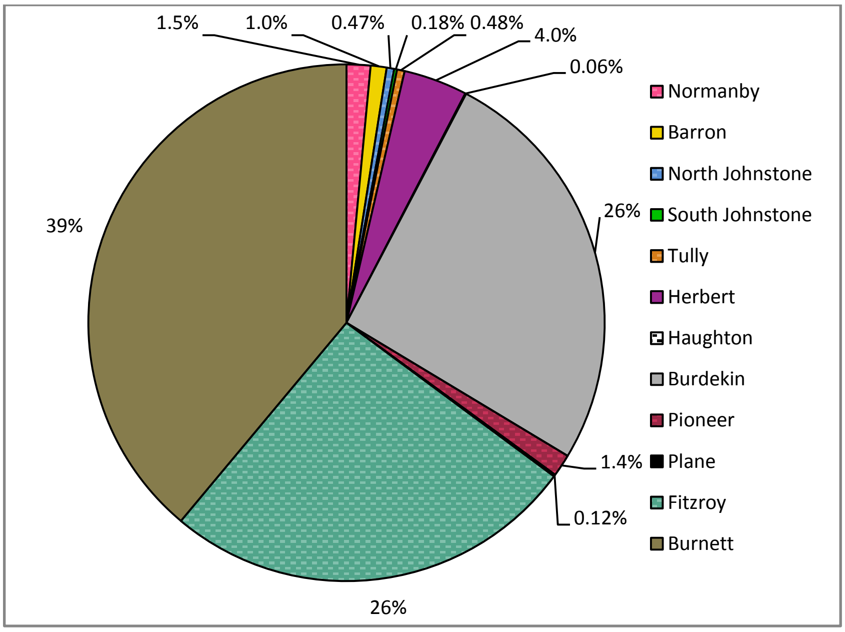


Figure 3.4 Per cent contribution from each catchment to the combined monitored annual total suspended solids load.

3.3.1.2 Total suspended solids yields

During the 2012–2013 monitoring year, the highest yield of total suspended solids was derived from the Burnett catchment (110 t km^{-2}) which resulted from the major flood in late January 2013 (Table 3.3). A high yield of total suspended solids was also monitored in the Pioneer River (89 t km^{-2}) and moderate yields in the Barron (51 t km^{-2}), North Johnstone (48 t km^{-2}), Herbert (44 t km^{-2}) and South Johnstone (43 t km^{-2}) catchments (Table 3.3). Excluding the Burnett River, all of these catchments are all located in the Wet Tropics and Mackay Whitsunday natural resource management regions and have consistently produced the highest yields of total suspended solids during previous monitoring years (Turner et al. 2012 and 2013; Wallace et al. 2014). It is notable, however, the yield of total suspended solids in the Tully catchment (32 t km^{-2}) during the 2012–2013 monitoring year was much less than other catchment within the Wet Tropics region.

The lowest monitored annual yields of total suspended solids occurred in Barratta Creek in the Haughton catchment (7.3 t km^{-2}) and the Normanby (11 t km^{-2}), Fitzroy (18 t km^{-2}) and Burdekin (20 t km^{-2}) catchments (Table 3.3). Land use in these latter catchments is predominately dry land grazing which have been reported previously as contributing low yields of total suspended solids (Turner et al. 2012; Turner et al. 2013; Wallace et al. 2014).

Amongst the sub-catchments of the Burdekin River, the yield of total suspended solids varied greatly (Table 3.3). The Bowen River sub-catchment had an exceptionally high yield of total suspended solids (330 t km^{-2}) compared to all other sub-catchments monitored as part of the Great Barrier Reef Catchment Loads Monitoring Program. As this is the first year of monitoring data for the Bowen River sub-catchment, it is not known whether this total suspended solids yield is typical for this catchment. The yield of total suspended solids at all other Burdekin sub-catchment monitoring sites was however, much less than reported for the previous monitoring years 2009–2012 (Turner et al. 2012; Turner et al. 2013; Wallace et al. 2014). The yield of total suspended solids in the upper Burdekin River sub-catchment monitored at Sellheim (17 t km^{-2}) was high compared to the monitored annual yield of total suspended solids in the Suttor (5.4 t km^{-2}), Cape (0.76 t km^{-2}) and Belyando (0.53 t km^{-2}) catchments (Table 3.3).

Within the Fitzroy sub-catchments the monitored annual yields of total suspended solids at the Comet River (3.7 t km^{-2}) was approximately twice the monitored annual yield at the Dawson River (1.8 t km^{-2}). No data were available for Theresa Creek or Isaac River sub-catchments during the 2012–2013 monitoring year.

3.3.2 Nitrogen

3.3.2.1 Nitrogen load

The combined monitored annual load of total nitrogen for the monitored reef catchments was 34 kt (Table 3.2). The Burnett (12 kt; 35 per cent), Fitzroy (9.3 kt; 27 per cent) and Burdekin (5.5 kt; 16 per cent) rivers produced the largest loads of total nitrogen with the Herbert River (3.3 kt; 9.7 per cent) also contributing a substantial load (Table 3.2 and Figure 3.5). All remaining catchments each contributed less than four per cent of the monitored annual total nitrogen load with Sandy Creek in the Plane catchment contributing the lowest total nitrogen load by an end-of-system site (0.20 kt; 0.59 per cent).

During the 2012–2013 monitoring year the combined monitored annual load of dissolved inorganic nitrogen was 6.6 kt (Table 3.2). The largest monitored annual loads of dissolved inorganic nitrogen were derived from the Burnett (2.0 kt; 30 per cent) and Herbert (1.5 kt; 23 per cent) catchments with substantial loads also from the Fitzroy (0.92 kt; 14 per cent), Burdekin (0.80 kt; 12 per cent) and Tully (0.71 kt; 11 per cent) catchments (Table 3.2 and Figure 3.6). The remaining catchments each contributed less than four per cent of the combined monitored load (Figure 3.6) with the lowest loads from end-of-system sites occurring in Sandy Creek in the Plane catchment (0.042 kt; 0.63 per cent) and Barron catchment (0.044 t; 0.66 per cent).

Oxidised nitrogen accounted for 87 per cent of the monitored dissolved inorganic nitrogen load during the 2012–2013 monitoring year. This ratio is less than previous monitoring years due largely to the high load of ammonium nitrogen (540 t) from the Burnett catchment relative to the total monitored end-of-system load of dissolved inorganic nitrogen from all catchments (6.6 kt). The Burnett (1.5 kt; 26 per cent), Herbert (1.5 kt; 26 per cent), Burdekin (0.76 kt; 13 per cent) and Fitzroy (0.71 kt; 12 per cent) and Tully (0.67 kt; 12 per cent) rivers together accounted for 89 per cent of the monitored oxidised nitrogen load. All remaining catchments each contributed less than four per cent of the monitored oxidised nitrogen load with the lowest monitored annual loads occurring in Sandy Creek in the Plane catchment (0.038 t; 0.66 per cent) and the Barron catchment (0.037 kt; 0.64 per cent).

During the 2012–2013 monitoring year, the monitored annual load of ammonium nitrogen from all monitored priority reef catchments was 970 t (Table 3.2). The largest monitored annual loads were derived from the Burnett (540 t; 56 per cent), Fitzroy (210 t; 22 per cent) and Herbert (63 t; 6.5 per cent) catchments. The remaining catchments each contributed less than five per cent of the total monitored annual ammonium nitrogen load. The lowest loads were derived from Barron catchment (6.9 t; 0.71 per cent), Barratta Creek in the Haughton catchment (5.4 t; 0.56 per cent), South Johnstone catchment (5.3 t; 0.55 per cent) and Sandy Creek in the Plane catchment (3.6 t; 0.37 per cent).

The relative proportion of the ammonium nitrogen load to the oxidised nitrogen load varied greatly amongst catchments. In the Burnett, Fitzroy, Pioneer and Barron catchments the relative proportion was high (1:2.8 to 1:5.4) whilst in the Tully (1:18) and Herbert (1:24) the relative proportions were much lower.

Approximately 42 per cent of the total monitored annual particulate nitrogen load of 17 kt was derived from the Burnett catchment (7.3 kt). The Fitzroy (4.3 kt; 25 per cent) Burdekin (3.1 kt; 18 per cent) and Herbert catchments also contributed moderate loads of particulate nitrogen with the remaining catchments each contributing less than four per cent of the monitored annual load. The lowest monitored annual loads of particulate nitrogen were derived from Sandy Creek in the Plane catchment (0.063 kt; 0.28 per cent) and Barratta Creek in the Haughton catchment (0.055 kt; 0.17 per cent).

The monitored annual load of dissolved organic nitrogen, 10kt, followed a similar trend to the particulate nitrogen load with the majority of the load coming from the large dry inland catchments of the Fitzroy (4.1 kt; 39 per cent), Burnett (2.9 kt; 28 per cent), Burdekin (1.5 kt; 14 per cent) and Herbert (0.75 kt; 7.2 per cent) catchments (Table 3.2 and Figure 3.10). All remaining sites each contributed less than four per cent of the dissolved organic nitrogen load with the lowest monitored annual loads derived from Sandy Creek in the Plane catchment (0.096 kt; 0.92 per cent), Barratta Creek in the Haughton catchment (0.078 kt; 0.75 per cent) and the South Johnstone catchment (0.057 kt; 0.55 per cent).

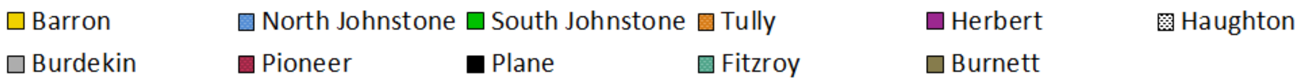
3.3.2.2 Nitrogen yields

The largest monitored annual yield of total nitrogen was derived from the Tully catchment (890 kg km^{-2}) with high yields of total nitrogen also occurring in the Pioneer catchment (700 kg km^{-2}), Sandy Creek in the Plane catchment (610 kg km^{-2}) and the North Johnstone and South Johnstone catchments (660 kg km^{-2} and 590 kg km^{-2}, respectively) (Table 3.3). The yield of total nitrogen from the Burnett catchment (370 kg km^{-2}) following the major flood event in January 2013 was substantially higher than previously reported by the Great Barrier Reef Catchment Loads Monitoring Program (Turner et al. 2012; Turner et al. 2013, Wallace et al. 2014). The lowest monitored annual yields of total nitrogen were derived from the Fitzroy (67 kg km^{-2}) and Burdekin (42 kg km^{-2}) catchments.

The highest yield of particulate nitrogen during the 2012–2013 monitoring year occurred in the Pioneer catchment (340 kg km^{-2}) with comparatively high yields also occurring in the North Johnstone (270 kg km^{-2}) and South Johnstone (230 kg km^{-2}) catchments, Sandy Creek in the Plane catchment (190 kg km^{-2}) and Tully catchment (170 kg km^{-2}). Each of these catchments contain high proportions of intensive agricultural land uses including irrigated cropping (DPC 2011) which is in contrast to the large inland catchments which are dominated by grazing and had comparatively low yields of particulate nitrogen. The lowest yields of particulate nitrogen occurred in the Fitzroy (31 kg km^{-2}) and Burdekin (24 kg km^{-2}) catchments.

The monitored annual yield of dissolved organic nitrogen was similar amongst the small coastal catchments in the Wet Tropics and Mackay Whitsunday regions (Table 3.3) with the highest yields derived from Sandy Creek in the Plane catchment (300 kg km^{-2}) and the Tully catchment (230 kg km^{-2}). The lowest yields of dissolved organic nitrogen were derived from the Fitzroy (29 kg km^{-2}) and Burdekin (12 kg km^{-2}) catchments.

The Tully catchment had the highest monitored annual yield of dissolved inorganic nitrogen (490 kg km^{-2}), which similar to previous years, was driven by a high yield of oxidised nitrogen (460 kg km^{-2}) (Table 3.3). High yields of oxidised nitrogen were monitored across all catchments of the Wet Tropics and Mackay Whitsunday regions excluding the Barron catchment which yielded only 19 kg km^{-2}. The high yield of ammonium nitrogen was similar for the Pioneer (29 kg km^{-2}) and Tully (26 kg km^{-2}) catchments. The lowest yields of dissolved inorganic nitrogen, ammonium nitrogen and oxidised nitrogen occurred in the Fitzroy and Burdekin catchments (Table 3.3).



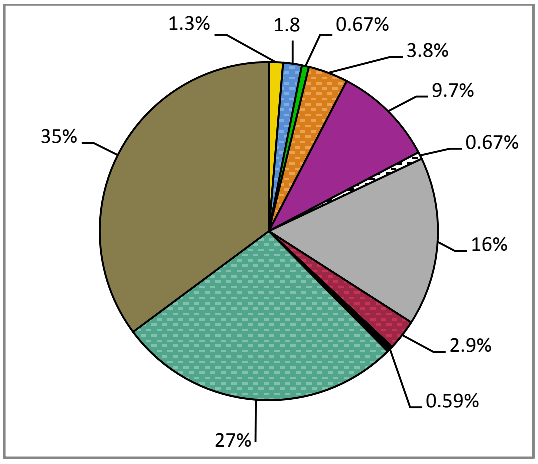


Figure 3.5 Per cent contribution from each catchment to the combined monitored total nitrogen annual load.

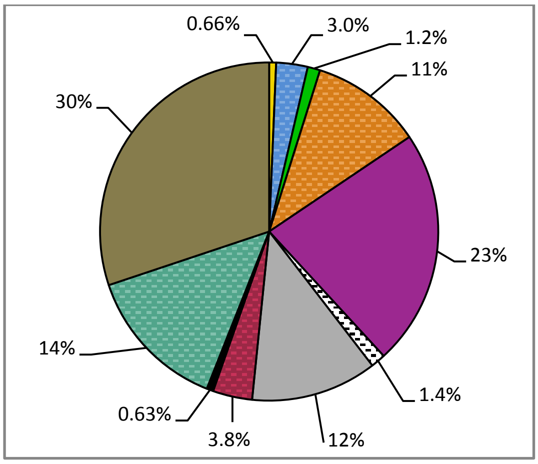


Figure 3.6 Per cent contribution from each catchment to the combined monitored dissolved inorganic nitrogen annual load.

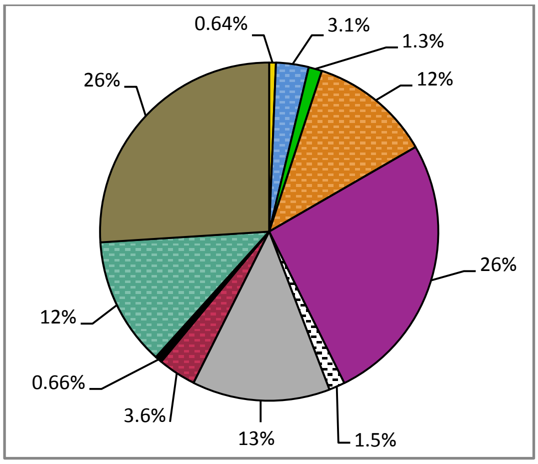


Figure 3.7 Per cent contribution from each catchment to the combined monitored oxidised nitrogen annual load.

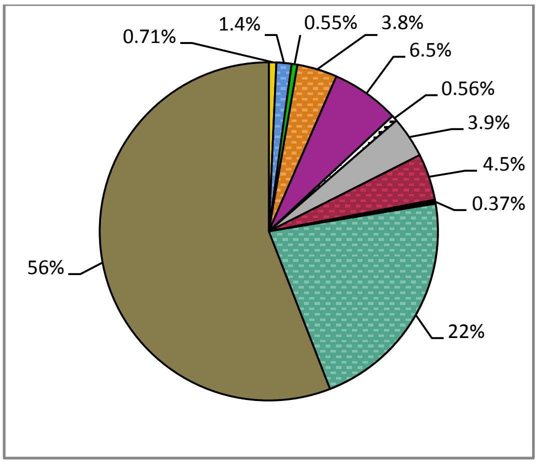


Figure 3.8 Per cent contribution from each catchment to the combined monitored ammonium nitrogen annual load.

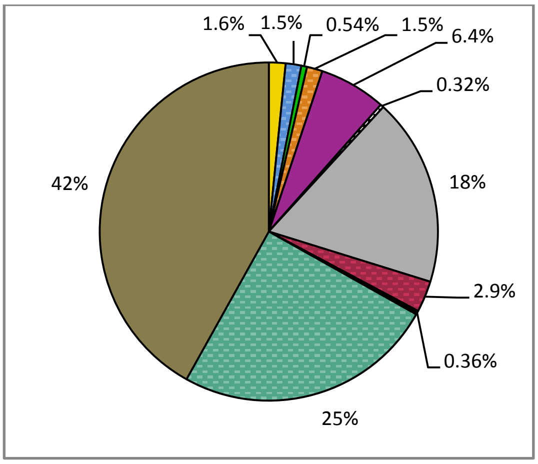


Figure 3.9 Per cent contribution from each catchment to the combined monitored particulate nitrogen annual load.

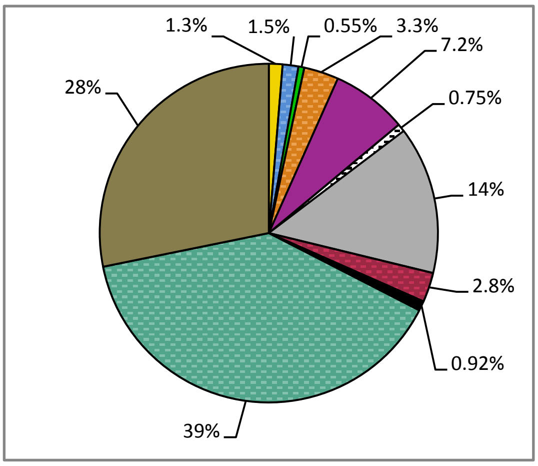


Figure 3.10 Per cent contribution from each catchment to the combined monitored dissolved organic nitrogen annual load.

3.3.3 Phosphorus

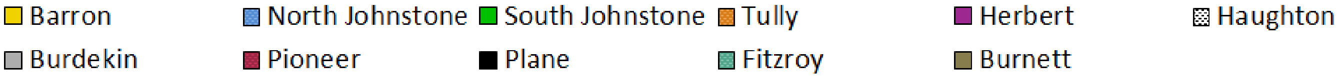
3.3.3.1 Phosphorus load

The combined annual monitored load of total phosphorus during the 2012–2013 monitoring year was approximately 9.4 kt (Table 3.2). The majority of the total phosphorus load was produced by the Fitzroy (3.7 kt; 39 per cent), Burnett (2.9 kt; 31 per cent) and Burdekin (1.9 kt; 20 per cent) catchments (Table 3.2 and Figure 3.11). The remaining catchments each contributed less than four per cent of the annual monitored total phosphorus load, with the lowest total phosphorus loads occurring in Sandy Creek in the Plane catchment (0.053 kt; 0.56 per cent), South Johnstone catchment 0.043 kt; 0.46 per cent) and Barratta Creek in the Haughton catchment (0.024 kt; 0.26 per cent).

The monitored annual load of dissolved organic phosphorus from all catchments was 370 t (Table 3.2). The Fitzroy (150 t; 40 per cent) and Burnett (78 t; 21 per cent) catchments contributed the largest monitored annual dissolved organic phosphorus loads (Table 3.2 and Figure 3.12). The Burdekin (40t; 11 per cent), Herbert (32 t; 8.6 per cent) and Tully (29 t; 7.8 per cent) catchments also contributed moderate loads. All other catchments each contributed less than four per cent of the combined monitored annual dissolved organic phosphorus load during the 2012–2013 monitoring year. The smallest load of dissolved organic phosphorus was monitored in Barratta Creek in the Haughton catchment (2.3 t; 0.62 per cent) (Figure 3.12).

Approximately two-thirds of the total monitored annual dissolved inorganic phosphorus load (2.3 kt) came from the Fitzroy catchment (1.5 kt) and a further 16 per cent from the Burdekin (0.36 kt) and 12 per cent from the Burnett catchment (0.28 kt) (Table 3.2 and Figure 3.13). Together these three catchments accounted for 93 per cent of the total monitored annual load of dissolved inorganic phosphorus. The proportionally high contribution from the Fitzroy catchment is consistent with the observed trend over 2009–2012 monitoring years (Turner et al. 2012; Turner et al. 2013; Wallace et al. 2014). All remaining catchments each contributed two per cent or less of the monitored annual load of dissolved inorganic phosphorus (Figure 3.13).

The monitored annual particulate phosphorus load (6.9 kt) accounted for approximately three quarters of the total phosphorus monitored annual load (9.4 kt) of the monitored catchments (Table 3.2) which is consistent with previous monitoring years (Turner et al. 2012; Turner et al. 2013; Wallace et al. 2014). The majority of the monitored annual particulate phosphorus load was derived from the Burnett (2.6 kt; 38 per cent), Fitzroy (2.1 kt; 30 per cent) and Burdekin (1.5 kt; 22 per cent) catchments (Figure 3.14 and Table 3.2). All other catchments each produced less than four per cent of the monitored annual particulate phosphorus load with the lowest loads occurring in Sandy Creek in the Plane catchment (0.019 kt; 0.28 per cent) and Barratta Creek in the Haughton catchment (0.012 kt; 0.17 per cent). Particulate phosphorus accounted for more than 75 per cent of the total phosphorus load at all end-of-system monitoring sites except at Sandy Creek in the Plane catchment (36 per cent), Barratta Creek in the Haughton catchment (50 per cent) and the Fitzroy catchment (57 per cent) where this proportion was considerably lower.



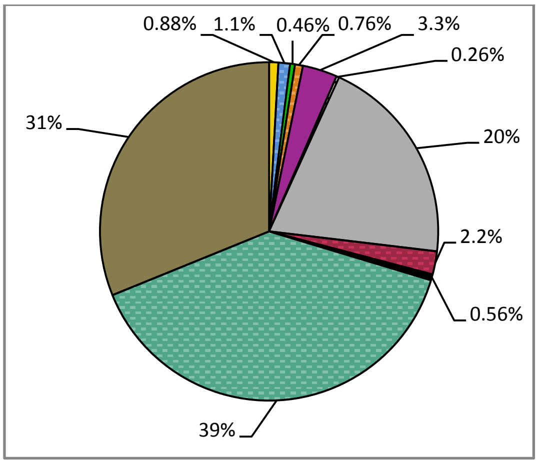


Figure 3.11 Per cent contribution from each catchment to the combined monitored total phosphorus annual load.

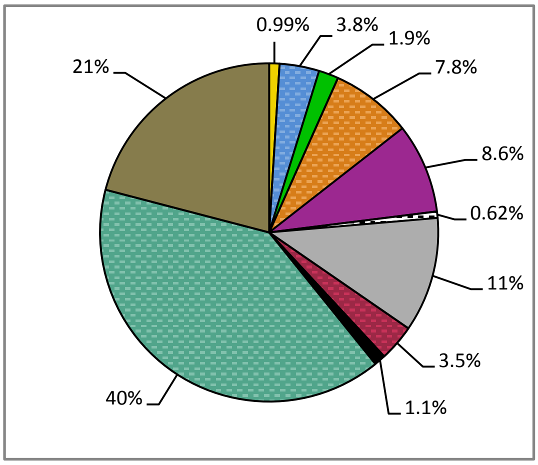


Figure 3.12 Per cent contribution from each catchment to the combined monitored dissolved organic phosphorus annual load.

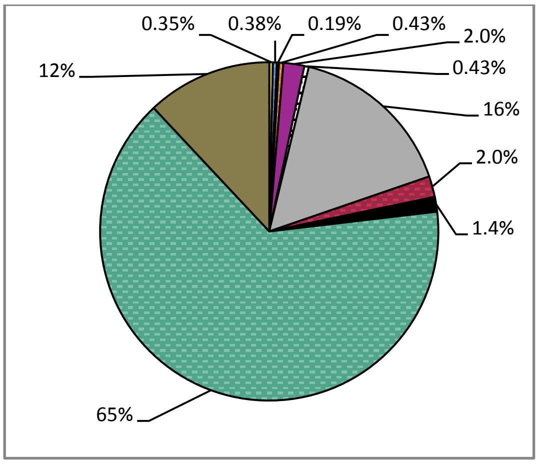


Figure 3.13 Per cent contribution from each catchment to the combined monitored dissolved inorganic phosphorus annual load.

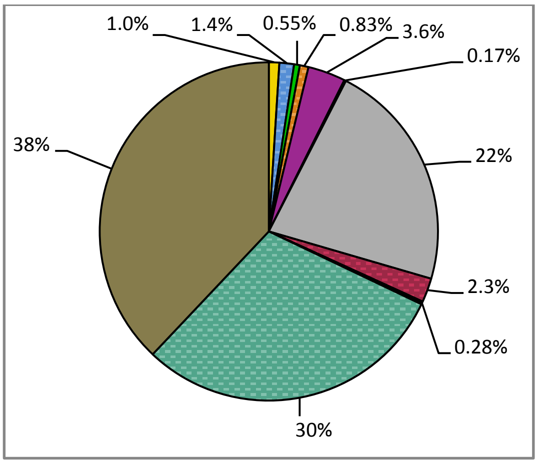


Figure 3.14 Per cent contribution from each catchment to the combined monitored particulate phosphorus annual load.

3.3.3.2 Phosphorus yields

Sandy Creek in the Plane catchment and the Pioneer catchment produced the highest monitored annual yields of total phosphorus (160 kg km^{-2} and 140 kg km^{-2}, respectively) (Table 3.4). High monitored annual yields of total phosphorus were also derived from the North Johnstone (110 kg km^{-2}) and South Johnstone (110 kg km^{-2}) catchments. The Burnett catchment also produced a high total phosphorus yield of 89 kg km^{-2}. The yield of total phosphorus from all other catchments was substantially less with the lowest yields occurring in the Fitzroy (27 kg km^{-2}) and Burdekin (14 kg km^{-2}) catchments. The yield of total phosphorus in the Bowen River sub-catchment, 270 kg km^{-2}, was exceptionally high compared to all end-of-system monitoring sites driven by a high yield of particulate phosphorus (260 kg km^{-2}) which accounted for approximately 96 per cent of the total phosphorus load at this site during the 2012–2013 monitoring year.

The highest yields of particulate phosphorus at the monitored end-of-system sites were in the Pioneer (110 kg km^{-2}), North Johnstone (100 kg km^{-2}) and South Johnstone (95 kg km^{-2}) catchments. The lowest yield of particulate phosphorus was in Barratta Creek in the Haughton catchment (15 kg km^{-2}) and the Fitzroy (15 kg km^{-2}) and Burdekin (11 kg km^{-2}) catchments.

The monitored annual yield of dissolved inorganic phosphorus at Sandy Creek in the Plane catchment (98 kg km^{-2}) was exceptionally high compared to all other monitored catchments including three times more than the monitored yield in the Pioneer catchment (30 kg km^{-2}) and ten to twenty times more than all catchments in the Wet Tropics region. The high yield of dissolved inorganic phosphorus in Sandy Creek in the Plane catchment is consistent with previous monitoring years (Wallace et al. 2014). The lowest yield of dissolved inorganic phosphorus was in the Burdekin catchment (2.7 kg km^{-2}).

The Tully and South Johnstone catchments produced the highest monitored annual yields of dissolved organic phosphorus (20 kg km^{-2}, 18 kg km^{-2}, respectively), with moderate yields also occurring in the North Johnstone catchment (15 kg km^{-2}) and Sandy Creek in the Plane catchment (13 kg km^{-2}). Consistent with all monitored forms phosphorus, the Fitzroy and Burdekin catchments produced the lowest yields of dissolved organic phosphorus, with 1.1 kg km^{-2} and 0.31 kg km^{-2} respectively.

Table 3.2 Monitored annual total suspended solids and nutrient loads for 2012–2013. Text in bold are end-of-system sites and the corresponding data, all others are sub-catchment sites. Green shading = excellent or good representivity rating; orange shading = moderate representivity; and red shading = indicative representivity.

NRM region	Catchment	Gauging station	River and site name	TSS (t)	TN (t)	PN (t)	NO_x-N (t)	NH_4-N (t)	DIN (t)	DON (t)	TP (t)	DIP (t)	PP (t)	DOP (t)
Cape York	**Normanby**	**105107A[B]**	**Normanby River at Kalpowar Crossing**	**142,000**										
Wet Tropics	**Barron**	**110001D[B]**	**Barron River at Myola**	**99,000**	**460**	**270**	**37**	**6.9**	**44**	**140**	**83**	**8.0**	**72**	**3.7**
	Johnstone	112004A[L]	North Johnstone River at Tung Oil[$]	45,000	610	250	180	14	200	160	100	8.7	94	14
		112101B[L]	South Johnstone River at Upstream Central Mill[$]	17,000	230	94	74	5.3	79	57	43	4.4	38	7.0
	Tully	**113006A[L]**	**Tully River at Euramo**	**46,000**	**1300**	**250**	**670**	**37**	**710**	**340**	**71**	**10**	**57**	**29**
		113015A[B]	Tully River at Tully Gorge National Park	9,900	300	55	140	8.0	150	100	17	3.4	13	7.9
	Herbert	**116001F[B]**	**Herbert River at Ingham**	**380,000**	**3300**	**1100**	**1500**	**63**	**1500**	**750**	**310**	**45**	**250**	**32**
Burdekin	**Haughton**	**119101A[L]**	**Barratta Creek at Northcote**	**5500**	**230**	**55**	**88**	**5.4**	**93**	**78**	**24**	**10**	**12**	**2.3**
	Burdekin	**120001A[B]**	**Burdekin River at Home Hill**	**2,500,000**	**5500**	**3100**	**760**	**38**	**800**	**1500**	**1900**	**360**	**1500**	**40**
		120002C[B]	Burdekin River at Sellheim	610,000	1500	830	250	15	260	450	320	66	260	19
		120205A[L]	Bowen River at Myuna	2,300,000	3100	2700	82	61	140	300	1900	59	1900	14
		120301B[B]	Belyando River at Gregory Development Road	19,000	63	34	1.9	1.6	3.5	26	15	2.8	11	0.6
		120302B[B]	Cape River at Taemas	12,000	99	55	4.4	0.84	5.2	38	13	0.50	11	1.2
		120310A[B]	Suttor River at Bowen Development Road	58,000	300	110	4.1	3.7	7.8	180	71	17	49	4.0
Mackay Whitsunday	**Pioneer**	**125013A[L]**	**Pioneer River at Dumbleton Pump Station**	**130,000**	**1000**	**510**	**210**	**43**	**250**	**290**	**210**	**45**	**160**	**13**
	Plane	**126001A[B]**	**Sandy Creek at Homebush**	**11,000**	**200**	**63**	**38**	**3.6**	**42**	**96**	**53**	**32**	**19**	**4.2**
Fitzroy	**Fitzroy**	**1300000[B]**	**Fitzroy River at Rockhampton**	**2,500,000**	**9300**	**4300**	**710**	**210**	**920**	**4100**	**3700**	**1500**	**2100**	**150**
		130206A	Theresa Creek at Gregory Highway											
		130302 AB	Dawson River at Taroom	28,000	180	82	14	2.1	16	72	61	31	27	2.0
		130504B[B]	Comet River at Comet Weir	62,000	130	72	16	2.0	18	41	53	10	41	1.2
Burnett Mary	**Burnett**	**136014A[L]**	**Burnett River at Ben Anderson Barrage Head Water**	**3,700,000**	**12,000**	**7300**	**1500**	**540**	**2000**	**2900**	**2900**	**280**	**2600**	**78**
		136002D	Burnett River at Mt Lawless											
		136094A	Burnett River at Jones Weir Tail Water											
		136106A	Burnett River at Eidsvold											
Total load (end-of-system sites plus North Johnstone and South Johnstone rivers)				9,600,000	34,000	17,000	5800	970	6600	10,000	9400	2300	6900	370

The number of concentration data points used in the calculation of loads for all analytes is presented in Appendix E. TSS = total suspended solids; TN = total nitrogen; PN = particulate nitrogen; NO_x-N = oxidised nitrogen as N; NH_4-N = ammonium nitrogen as N; DIN = dissolved inorganic nitrogen (DIN = (NO_x-N) + (NH_4-N)); DON = dissolved organic nitrogen; TP = total phosphorus; DIP = dissolved inorganic phosphorus; PP = particulate phosphorus; DOP = dissolved organic phosphorus; [B] = Beale ratio method used to calculate loads; [L] = average load (linear interpolation of concentration) method used to calculate loads; and [$] = the North and South Johnstone rivers combined act as an end-of-system site.

Table 3.3 Total suspended solids and nitrogen yields calculated for 2012–2013 along with the per cent of catchment monitored. Text in bold are end-of-system sites and the corresponding data, all others are sub-catchment sites. Green shading = excellent or good representivity rating; orange shading = moderate representivity; and red shading = indicative.

NRM region	Catchment	Gauging station	River and site name	Monitored area of catchment (%)	TSS (t km^{-2})	TN (kg km^{-2})	PN (kg km^{-2})	NO_x-N (kg km^{-2})	NH_4-N (kg km^{-2})	DIN (kg km^{-2})	DON (kg km^{-2})
Cape York	**Normanby**	**105107A[B]**	**Normanby River at Kalpowar Crossing**	**53**	**11**						
Wet Tropics	**Barron**	**110001D[B]**	**Barron River at Myola**	**89**	**51**	**230**	**140**	**19**	**3.6**	**22**	**72**
	Johnstone	112004A[L]	North Johnstone River at Tung Oil[$]	40	48	660	270	200	15	210	180
		112101B[L]	South Johnstone River at Upstream Central Mill[$]	17	43	590	230	190	13	200	140
	Tully	**113006A[L]**	**Tully River at Euramo**	**86**	**32**	**890**	**170**	**460**	**26**	**490**	**230**
		113015A[B]	Tully River at Tully Gorge National Park	29	21	630	110	290	17	300	220
	Herbert	**116001F[B]**	**Herbert River at Ingham**	**87**	**44**	**390**	**120**	**170**	**7.3**	**180**	**87**
Burdekin	**Haughton**	**119101A[L]**	**Barratta Creek at Northcote**	**19**	**7.3**	**300**	**73**	**120**	**7.1**	**120**	**100**
	Burdekin	**120001A[B]**	**Burdekin River at Home Hill**	**99**	**20**	**42**	**24**	**5.9**	**0.29**	**6.2**	**12**
		120002C[B]	Burdekin River at Sellheim	28	17	42	23	6.8	0.42	7.2	12
		120205A[L]	Bowen River at Myuna	5	330	440	370	12	8.5	20	43
		120301B[B]	Belyando River at Gregory Development Road	27	0.53	1.8	0.95	0.053	0.045	0.098	0.73
		120302B[B]	Cape River at Taemas	12	0.76	6.1	3.4	0.27	0.052	0.33	2.4
		120310A[B]	Suttor River at Bowen Development Road	8	5.4	28	10	0.38	0.34	0.72	17
Mackay Whitsunday	**Pioneer**	**125013A[L]**	**Pioneer River at Dumbleton Pump Station**	**94**	**89**	**700**	**340**	**140**	**29**	**170**	**190**
	Plane	**126001A[B]**	**Sandy Creek at Homebush**	**13**	**35**	**610**	**190**	**120**	**11**	**130**	**300**
Fitzroy	**Fitzroy**	**1300000[B]**	**Fitzroy River at Rockhampton**	**98**	**18**	**67**	**31**	**5.1**	**1.5**	**6.6**	**29**
		130206A[B]	Theresa Creek at Gregory Highway	6							
		130302A[B]	Dawson River at Taroom	11	1.8	11	5.2	0.87	0.13	1.0	4.5
		130504B[B]	Comet River at Comet Weir	12	3.7	7.9	4.4	0.99	0.12	1.1	2.5
Burnett Mary	**Burnett**	**136014A[L]**	**Burnett River at Ben Anderson Barrage Head Water**	**99**	**110**	**370**	**220**	**45**	**16**	**61**	**88**
		136002D	Burnett River at Mt Lawless	88							
		136094A	Burnett River at Jones Weir Tail Water	65							
		136106A	Burnett River at Eidsvold	21							

The number of concentration data points used in the calculation of loads for all analytes is presented in Appendix F. TSS = total suspended solids; TN = total nitrogen; PN = particulate nitrogen; NO_x-N = oxidised nitrogen as N; NH_4-N = ammonium nitrogen as N; DIN = dissolved inorganic nitrogen (DIN = (NO_x-N) + (NH_4-N)); DON = dissolved organic nitrogen; [B] = Beale ratio method used to calculate loads; [L] = average load (linear interpolation of concentration) method used to calculate loads; and [$] = the North and South Johnstone rivers combined act as an end-of-system site.

Table 3.4 Phosphorus yields calculated for 2012–2013 along with the per cent of catchment monitored. Text in bold are end-of-system sites and the corresponding data, all others are sub-catchment sites. Green shading = excellent or good representivity rating; orange shading = moderate representivity; and red shading = indicative.

NRM region	Catchment	Gauging station	River and site name	Monitored area of catchment (%)	TP (kg km^{-2})	DIP (kg km^{-2})	PP (kg km^{-2})	DOP (kg km^{-2})
Cape York	**Normanby**	**105107A[B]**	**Normanby River at Kalpowar Crossing**	**53**				
Wet Tropics	**Barron**	**110001D[B]**	**Barron River at Myola**	**89**	**42**	**4.1**	**37**	**1.9**
	Johnstone	112004A[L]	North Johnstone River at Tung Oil[$]	40	110	9.4	100	15
		112101B[L]	South Johnstone River at Upstream Central Mill[$]	17	110	11	95	18
	Tully	**113006A[L]**	**Tully River at Euramo**	**86**	**49**	**6.7**	**39**	**20**
		113015A[B]	Tully River at Tully Gorge National Park	29	35	7.0	28	16
	Herbert	**116001F[B]**	**Herbert River at Ingham**	**87**	**36**	**5.3**	**29**	**3.7**
Burdekin	**Haughton**	**119101A[L]**	**Barratta Creek at Northcote**	**19**	**32**	**14**	**15**	**3.0**
	Burdekin	**120001A[B]**	**Burdekin River at Home Hill**	**99**	**14**	**2.7**	**11**	**0.31**
		120002C[B]	Burdekin River at Sellheim	28	8.7	1.8	7.1	0.53
		120205A	Bowen River at Myuna	5	270	8.3	260	2.0
		120301B[B]	Belyando River at Gregory Development Road	27	0.42	0.079	0.32	0.018
		120302B[B]	Cape River at Taemas	12	0.80	0.031	0.70	0.073
		120310A[B]	Suttor River at Bowen Development Road	8	6.6	1.6	4.6	0.38
Mackay Whitsunday	**Pioneer**	**125013A[L]**	**Pioneer River at Dumbleton Pump Station**	**94**	**140**	**30**	**110**	**8.7**
	Plane	**126001A[B]**	**Sandy Creek at Homebush**	**13**	**160**	**98**	**60**	**13**
Fitzroy	**Fitzroy**	**1300000[B]**	**Fitzroy River at Rockhampton**	**98**	**27**	**11**	**15**	**1.1**
		130206A[B]	Theresa Creek at Gregory Highway	6				
		130302A[B]	Dawson River at Taroom	11	3.9	2	1.7	0.13
		130504B[B]	Comet River at Comet Weir	12	3.2	0.62	2.5	0.071
Burnett Mary	**Burnett**	**136014A[L]**	**Burnett River at Ben Anderson Barrage Head Water**	**99**	**89**	**8.6**	**79**	**2.4**
		136002D	Burnett River at Mt Lawless	88				
		136094A	Burnett River at Jones Weir Tail Water	65				
		136106A	Burnett River at Eidsvold	21				

The number of concentration data points used in the calculation of loads for all analytes is presented in Appendix F. TP = total phosphorus; DIP = dissolved inorganic phosphorus; PP = particulate phosphorus; DOP = dissolved organic phosphorus; [B] = Beale ratio method used to calculate loads; [L] = average load (linear interpolation of concentration) method used to calculate loads; and [$] = the North and South Johnstone rivers combined act as an end-of-system site.

3.4 Pesticide loads and yields

3.4.1.1 Annual load

The monitored annual loads of the five priority photosystem II inhibiting herbicides, ametryn, total atrazine, diuron, hexazinone and tebuthiuron, were calculated for each monitored site (Table 3.5). The loads of other herbicides detected are presented in Appendix A. It is important to note that no monitored annual loads of pesticides are presented for the North Johnstone sub-catchment due to insufficient data (only five pesticide samples were collected) being available for this manually sampled site. The annual monitored load of photosystem II inhibiting herbicides derived from the North Johnstone sub-catchment have previously been reported by the Great Barrier Reef Catchment Loads Monitoring Program since 2009 (see Turner et al. 2012; Turner et al. 2013 and Wallace et al. 2014).

When all monitored catchments are considered together, the total monitored annual load of the five priority photosystem II inhibiting herbicides exported past the end-of-system monitoring sites were (from largest to smallest): 5100 kg of tebuthiuron; 2600 kg of total atrazine; 1900 kg of diuron; 440 kg of hexazinone; and 100 kg of ametryn (Table 3.5). The per cent contributions of each catchment to the total monitored annual load for each of the five priority photosystem II inhibiting herbicides are presented in Figure 3.15 to Figure 3.19.

Of the five priority photosystem II inhibiting herbicides, only total atrazine and diuron were detected at all nine end-of-system monitoring sites where loads were calculated (Table 3.5). This is consistent with results from the previous monitoring year (Wallace et al. 2014). A monitored diuron load could not, however, be calculated for the Comet River sub-catchment as there were no detections of diuron above the limit of reporting. Ametryn was not detected above the limit of reporting in the Fitzroy catchment and hexazinone was not detected above the limit of reporting in the Burdekin catchment or Comet River sub-catchment. Tebuthiuron was detected (above the limit of reporting) at the least number of sites, with no monitored loads calculated for the Tully, Herbert, Pioneer or Plane catchments.

The largest monitored annual loads of ametryn were in the Pioneer (28 kg) and Burnett catchments (27 kg), together accounting for more than half (28 per cent and 27 per cent, respectively) of the total monitored ametryn load (100 kg) (Table 3.5 and Figure 3.15). The lowest calculable load of ametryn was from the Burdekin catchment (1.7 kg; 1.7 per cent). The largest monitored annual load of total atrazine was recorded at Barratta Creek in the Haughton catchment (520 kg) which was 20 per cent of the combined monitored total atrazine load of 2600 kg (Table 3.5). The monitored annual load of total atrazine in all other end-of-system sites ranged from 120 kg in the Herbert catchment (4.6 per cent) to 470 kg in the Fitzroy (18 per cent) and 460 kg in the Pioneer catchments (18 per cent) (Table 3.5 and Figure 3.16). The monitored annual load of total atrazine in the Comet River sub-catchment was 41 kg.

The greatest contributions to the total monitored annual diuron load (1900 kg) were from the Tully (570 kg; 30 per cent) and Pioneer (440 kg; 23 per cent) catchments, with Sandy Creek in the Plane catchment (310 kg; 16 per cent) and the Herbert catchment (270 kg; 14 per cent) also contributing a substantial proportion of the total monitored annual diuron load. The lowest calculable monitored annual load of diuron was in the Burdekin catchment (29 kg; 1.5 per cent) (Table 3.5 and Figure 3.17).

The largest monitored annual load of hexazinone was recorded in the Tully catchment (130 kg; 30 per cent). Comparatively moderate loads of hexazinone were recorded in the Pioneer (93 kg; 21 per cent), Herbert (81 kg; 19 per cent) and Burnett (71 kg; 16 per cent) catchments. The lowest calculable monitored load of hexazinone was in Barratta Creek in the Haughton catchment (1.1 kg; 0.25 per cent) (Table 3.5 and Figure 3.18).

The largest monitored annual load of tebuthiuron was recorded in the Fitzroy catchment (5000 kg; 98 per cent) with comparatively small loads in the Burnett (87 kg; 1.7 per cent) and Burdekin (30 kg; 0.59 per cent) catchments. Very small monitored annual loads of tebuthiuron occurred in Barratta Creek in the Haughton catchment (0.049 kg; 0.00096 per cent) (Table 3.5 and Figure 3.19) the Comet River sub-catchment (1.9 kg).

3.4.1.2 Pesticide land use yields

Pesticide land use yields[5] of the five priority photosystem II inhibiting herbicides are presented in Table 3.6 for all end-of-system sites monitored for pesticides. The highest land use yield of ametryn occurred in the Burnett catchment (0.43 kg km^{-2}) with moderate yields also occurring in Barratta Creek in the Haughton catchment (0.098 kg km^{-2}), the Pioneer catchment (0.091 kg km^{-2}) and Sandy Creek in the Plane catchment (0.077 kg km^{-2}). The lowest calculable yield of ametryn was in the Burdekin catchment (0.014 kg km^{-2}).

The highest land use yields of total atrazine was from Barratta Creek in the Haughton catchment (3.4 kg km^{-2}) followed by Sandy Creek in the Plane catchment (1.5 kg km^{-2}) and the Tully (1.0 kg km^{-2}) catchments (Table 3.6). The land use yields of total atrazine in all other catchments were much less, ranging from 0.18 kg km^{-2} in the Herbert catchment down to 0.026 kg km^{-2} in the Fitzroy catchment.

The diuron land use yields were highest in the Tully catchment (2.7 kg km^{-2}) followed by Sandy Creek in the Plane catchment (2.0 kg km^{-2}). Lower, but still substantial land use yields were recorded in the Pioneer (1.4 kg km^{-2}) and Herbert (0.98 kg km^{-2}) catchments and at Barratta Creek in the Haughton catchment (0.52 kg km^{-2}). The land use yields of diuron were comparatively low in all other monitored catchments with the lowest occurring in the Fitzroy catchment (0.011 kg km^{-2}).

The highest land use yield of hexazinone was also in the Tully catchment (0.49 kg km^{-2}) which was approximately 2.6 times larger than the next highest land use yield recorded at Sandy Creek in the Plane catchment (0.19 kg km^{-2}) (Table 3.6). The land use yield of hexazinone was moderate in the Pioneer catchment (0.079 kg km^{-2}) and low in all other catchments.

The land use yield of tebuthiuron was highest in the Fitzroy catchment (0.045 kg km^{-2}). The land use yields of tebuthiuron were markedly lower in the other three catchments where it was detected. The tebuthiuron land use yield was thirteen times smaller in the Burnett catchment (0.0034 kg km^{-2}), 180 times smaller in the

[5] Note pesticide land use yields for 2010–2011 and 2011–2012 are presented in the appendices of Turner et al (2013) and Wallace et al (2014), respectively.

Burdekin catchment (0.00025 kg km^{-2}), and approximately 550 times smaller at Barratta Creek in the Haughton Catchment (0.000082 kg km^{-2}).

Table 3.5 Monitored annual loads calculated for the five priority photosystem II inhibiting herbicides: ametryn, total atrazine, diuron, hexazinone and tebuthiuron. Text in bold are end-of-system sites and the corresponding data, all others are sub-catchment sites.

NRM region	Catchment	Gauging station	River and site name	Monitored area (km^{-2})	Monitored area of catchment (%)	n	Ametryn (kg)	Total Atrazine (kg)	Diuron (kg)	Hexazinone (kg)	Tebuthiuron (kg)
Wet tropics	**Johnstone**	112004A	North Johnstone River at Tung Oil	925	40	5	NC	NC	NC	NC	NC
	Tully	**113006A**	**Tully River at Euramo[B]**	**1450**	**86**	**65**	**10**	**190**	**570**	**130**	**NC**
	Herbert	**116001F**	**Herbert River at Ingham[L]**	**8581**	**87**	**44**	**7.8**	**120**	**270**	**81**	**NC**
Burdekin	**Haughton**	**119101A**	**Barratta Creek at Northcote[L]**	**753**	**19**	**31**	**13**	**520**	**80**	**1.1**	**0.049**
	Burdekin	**120001A**	**Burdekin River at Home Hill[L]**	**129,939**	**99**	**29**	**1.7**	**240**	**29**	**NC**	**30**
Mackay Whitsunday	**Pioneer**	**125013A**	**Pioneer River at Dumbleton Pump Station[L]**	**1485**	**94**	**104**	**28**	**460**	**440**	**93**	**NC**
	Plane	**126001A**	**Sandy Creek at Homebush[B]**	**326**	**13**	**26**	**12**	**280**	**310**	**55**	**NC**
Fitzroy	**Fitzroy**	**1300000**	**Fitzroy River at Rockhampton[B]**	**139,159**	**98**	**24**	**NC**	**470**	**98**	**4.5**	**5000**
		130504B	Comet River at Comet Weir[B]	16,457	12	8	NC	41	NC	NC	1.9
Burnett Mary	**Burnett**	**136014A**	**Burnett River at Ben Anderson Barrage Head Water[L]**	**32,891**	**27**	**70**	**27**	**310**	**130**	**71**	**87**
Total (monitored end-of-system sites)				314,584	97	393	100	2600	1900	440	5100

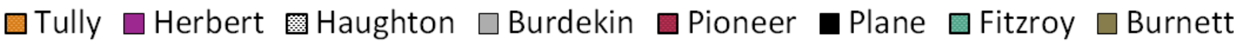
n = the number of grab samples used to estimate loads; NC = a load was not calculated as all the concentrations for all samples collected were below the practical quantitation limit or there were insufficient samples collected over the year to calculate a load; [L] = average load (linear interpolation of concentration) method used to calculate loads; [B] = Beale ratio method used to calculate loads.

Table 3.6 The monitored annual yields calculated for the five priority photosystem II inhibiting herbicides: ametryn, total atrazine, diuron, hexazinone and tebuthiuron. All sites are end-of-system sites with the corresponding data.

PSII herbicide	Registered land use types	River and site name	Land use yield (kg km^{-2})
Ametryn	Sugarcane	Tully River at Euramo[B]	0.067
		Herbert River at Ingham[L]	0.032
		Barratta Creek at Northcote[L]	0.098
		Burdekin River at Home Hill[L]	0.014
		Pioneer River at Dumbleton Pump Station[L]	0.091
		Sandy Creek at Homebush[B]	0.077
		Fitzroy River at Rockhampton[B]	NC
		Burnett River at Ben Anderson Barrage Head Water[L]	0.43
Total atrazine	Cropping, forestry, and sugarcane	Tully River at Euramo[B]	1.0
		Herbert River at Ingham[L]	0.18
		Barratta Creek at Northcote[L]	3.4
		Burdekin River at Home Hill[L]	0.11
		Pioneer River at Dumbleton Pump Station[L]	0.68
		Sandy Creek at Homebush[B]	1.5
		Fitzroy River at Rockhampton[B]	0.026
		Burnett River at Ben Anderson Barrage Head Water[L]	0.058
Diuron	Cropping, horticulture and sugarcane	Tully River at Euramo[B]	2.7
		Herbert River at Ingham[L]	0.98
		Barratta Creek at Northcote[L]	0.52
		Burdekin River at Home Hill[L]	0.020
		Pioneer River at Dumbleton Pump Station[L]	1.4
		Sandy Creek at Homebush[B]	2.0
		Fitzroy River at Rockhampton[B]	0.011
		Burnett River at Ben Anderson Barrage Head Water[L]	0.096
Hexazinone	Forestry, grazing and sugarcane	Tully River at Euramo[B]	0.49
		Herbert River at Ingham[L]	0.014
		Barratta Creek at Northcote[L]	0.0015
		Burdekin River at Home Hill[L]	NC
		Pioneer River at Dumbleton Pump Station[L]	0.079
		Sandy Creek at Homebush[B]	0.19
		Fitzroy River at Rockhampton[B]	0.000037
		Burnett River at Ben Anderson Barrage Head Water[L]	0.0024
Tebuthiuron	Grazing	Tully River at Euramo[B]	NC
		Herbert River at Ingham[L]	NC
		Barratta Creek at Northcote[L]	0.000082
		Burdekin River at Home Hill[L]	0.00025
		Pioneer River at Dumbleton Pump Station[L]	NC
		Sandy Creek at Homebush[B]	NC
		Fitzroy River at Rockhampton[B]	0.045
		Burnett River at Ben Anderson Barrage Head Water[L]	0.0034

NC = a load was not calculated as all the concentrations for all samples collected were below the practical quantitation limit

[L] = average load (linear interpolation of concentration) method used to calculate loads; [B] = Beale ratio method used to calculate loads



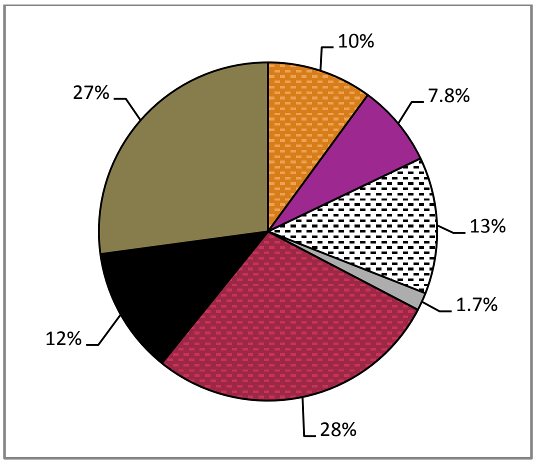


Figure 3.15 Per cent contribution from each end-of-system site (excluding North Johnstone) to the combined monitored annual ametryn load.

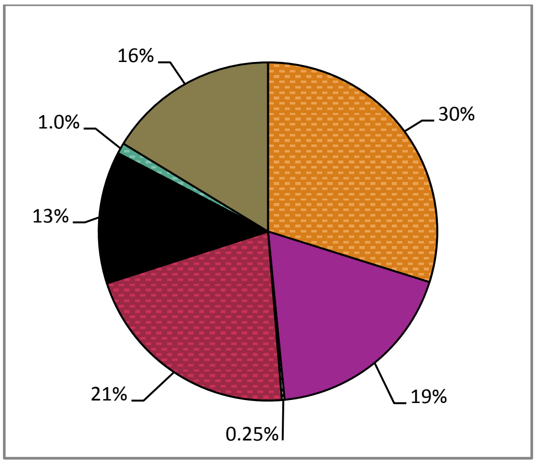


Figure 3.18 Per cent contribution from each end-of-system site (excluding North Johnstone) to the combined monitored annual hexazinone load.

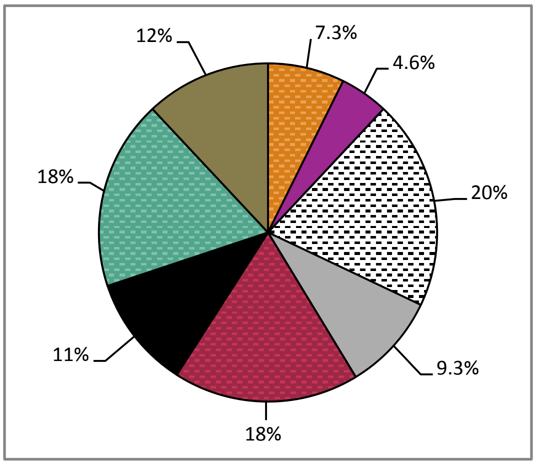


Figure 3.16 Per cent contribution from each end-of-system site (excluding North Johnstone) to the combined monitored annual total atrazine load.

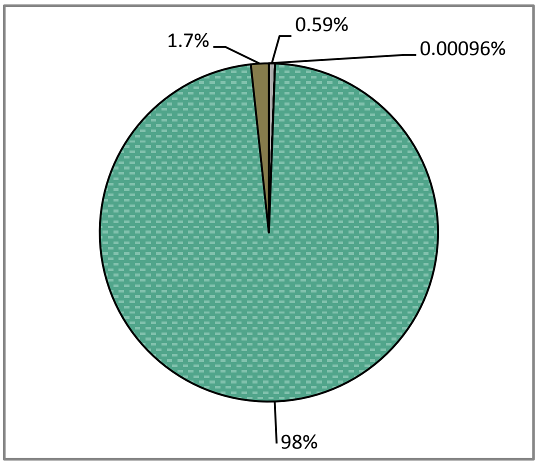


Figure 3.19 Per cent contribution from each end-of-system site (excluding North Johnstone) to the combined monitored annual tebuthiuron load.

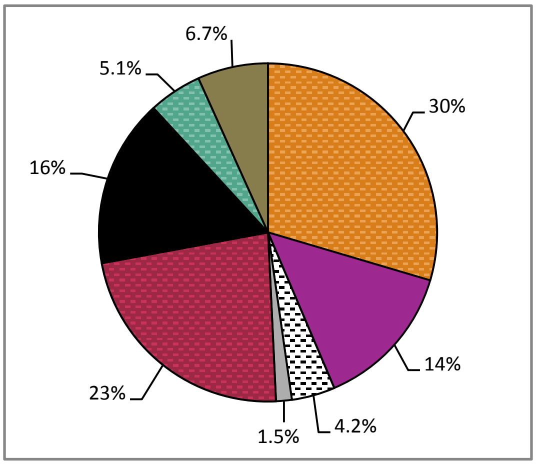


Figure 3.17 Per cent contribution from each end-of-system site (excluding North Johnstone) to the combined monitored annual diuron load.

4 Conclusions

The Great Barrier Reef Catchment Loads Monitoring Program determined the monitored annual loads and yields of total suspended solids and ten forms of phosphorus and nitrogen, for ten end-of-system sites and 15 sub-catchment sites, covering eleven catchments, during the 2012–2013 monitoring year. The monitored annual loads and yields of five priority photosystem II inhibiting herbicides were also determined for eight end-of-system sites and one sub-catchment monitoring site. During 2012–2013:

- Priority reef catchments in the Cape York, Wet Tropics and Burdekin regions received average to slightly below average rainfall over the monitoring year, average to above average rainfall in the Mackay Whitsunday region, and very much above average rainfall in the lower Fitzroy and Burnett catchments.
- The long-term mean annual discharge was exceeded in the Pioneer catchment, Sandy Creek in the Plane catchment and in the Fitzroy and Burnett catchments.
- Discharge in the Burnett River was five times greater than the long-term annual mean.
- Good to excellent sampling representivity was achieved for total suspended sediments and all measures of nutrients at all end-of-system monitoring sites providing robust loads data for the validation of catchment models. This was the first year that loads were reported for the Bowen River sub-catchment monitoring site – this was achieved through installation of automated water quality monitoring equipment and direct engagement with a regional natural resource management agency to collect water samples.
- The monitored catchments generated approximately 9.6 million tonnes of total suspended solids, 34,000 tonnes of nitrogen and 9400 tonnes of phosphorus.
- The Burnett and Fitzroy catchments generally generated the highest loads of all non-pesticide pollutants. The Herbert catchment also accounted for a large proportion of the dissolved inorganic nitrogen and oxidised nitrogen and the Burdekin catchment accounted for a large proportion of the dissolved inorganic phosphorus load.
- The Burnett, Fitzroy and Burdekin catchments combined accounted for at least 90 per cent of the monitored annual loads of total suspended solids and total phosphorus and more than 75 per cent of the monitored annual load of total nitrogen.
- Sandy Creek in the Plane catchment, Barratta Creek in the Haughton catchment and the South Johnstone sub-catchments generally produced the lowest loads of all non-pesticide pollutants and the Barron catchment also produced some of the lowest loads of some forms of nitrogen and phosphorus.
- The highest monitored annual yield of total suspended solids was in the Burnett catchment, total nitrogen in the Tully catchment and total phosphorus in Sandy Creek in the Plane catchment. The Tully, Johnstone and Pioneer catchments and Sandy Creek in the Plane catchment produced high yields of all monitored non-pesticide pollutants. The major flood in the Burnett catchment resulted

in yields of all monitored non-pesticide pollutants being much higher than previously reported by the Great Barrier Reef Catchment Loads Monitoring.

- Generally the lowest monitored annual yields of all non-herbicide pollutants were in the Burdekin and Fitzroy catchments. The Normanby catchment produced very low yields of total suspended solids but was not monitored for nutrients during the 2012–2013 monitoring year.
- The annual load of the five priority photosystem II inhibiting herbicides (ametryn, total atrazine, diuron, hexazinone and tebuthiuron) was approximately 10,000 kilograms.
- Photosystem II inhibiting herbicides were detected at all monitored sites.
- The total monitored annual pesticide loads at the end-of-system monitoring sites were, in descending order: 5100 kilograms of tebuthiuron; 2600 kilograms of total atrazine; 1900 kilograms of diuron; 440 kilograms of hexazinone; and 100 kilograms of ametryn.
- Total atrazine and diuron were detected at all monitored end-of-system sites; ametryn was detected at all catchments except in the Fitzroy and hexazinone was detected at all catchments except the Burdekin and the Comet River sub-catchment.
- The Pioneer and Burnett catchments contributed the largest monitored annual load of ametryn, Barratta creek contributed the largest load of total atrazine, the Tully catchment contributed the largest load of diuron and hexazinone and the Fitzroy catchment contributed the largest loads of tebuthiuron.
- The highest land use yield of ametryn was in the Burnett catchment, total atrazine at Barratta Creek in the Haughton catchment, diuron and hexazinone in the Tully catchment and tebuthiuron in the Fitzroy catchment.

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6 References

APHA-AWWA-WEF (American Public Health Association, American Water Works Association and Water Environment Federation) (2005). Standard methods for the examination of water and wastewater, 21st edition. Clesceri L.S., Greenberg A.E., Trussell R.R. (eds). American Public Health Association, American Water Works Association and Water Environment Federation, Washington, USA.

BoM (Bureau of Meteorology) (2012a) Monthly Weather Review – Queensland, July 2012. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2012b) Monthly Weather Review – Queensland, August 2012. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2012c) Monthly Weather Review – Queensland, September 2012. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2012d) Monthly Weather Review – Queensland, October 2012. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2012e) Monthly Weather Review – Queensland, November 2012. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2013a). Archive – Twelve month rainfall totals for Queensland. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2013b) ENSO Wrap-Up Archive, 03 Jul 2012 to 02 Jul 2013. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2013c) Special Climate Statement 44 – extreme rainfall and flooding in coastal Queensland and New South Wales, 5 February 2013. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2013d) Monthly Weather Review – Queensland, December 2013. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2013e) Monthly Weather Review – Queensland, January 2013. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2013f) Monthly Weather Review – Queensland, February 2013. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2013g) Monthly Weather Review – Queensland, March 2013. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2013h) Monthly Weather Review – Queensland, April 2013. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2013i) Monthly Weather Review – Queensland, May 2013. Accessed on 04/02/2014. <http://www.bom.gov.au>.

BoM (Bureau of Meteorology) (2013j) Monthly Weather Review – Queensland, June 2013. Accessed on 04/02/2014. <http://www.bom.gov.au>.

Brodie J.E., Binney J., Fabricius K., Gordon I., Hoegh-Gouldberg O., Hunter H., Peter O'Reagain P., Pearson R., Quick M., Thorburn P., Waterhouse J., Webster I., Wilkinson S. (2008). *Synthesis of evidence to support the Scientific Consensus Statement on Water Quality in the Great Barrier Reef.* The State of Queensland, Department of the Premier and Cabinet, Brisbane, Australia. Available from: <http://www.reefplan.qld.gov.au/resources/assets/reef-consensus.pdf>. Downloaded: 8 November 2014.

Brodie J.E., Waterhouse J., Lewis S., Bainbridge Z., Johnson J. (2009). Current Loads of Priority Pollutants Discharged from Great Barrier Reef Catchments to the Great Barrier Reef. ACTFR Technical Report 09/02. Australian Centre for Tropical Freshwater Research, Townsville, Australia.

Brodie J., Devlin M., Haynes D., Waterhouse J. (2010). Assessment of the eutrophication status of the Great Barrier Reef Lagoon (Australia). *Biogeochemistry*, 106(2):281.

Brodie J., Waterhouse J., Schaffelke B., Kroon F., Thorburn P., Rolfe J., Johnson J., Fabricus K., Lewis S., Devlin M., Warne M. St. J., McKenzie L. (2013a). *Scientific Consensus Statement – Land use impacts on Great Barrier Reef water quality and ecosystem condition*. Reef Water Quality Protection Plan Secretariat, Brisbane, Queensland. 9p. Available from: <http://www.reefplan.qld.gov.au/about/assets/scientific-consensus-statement-2013.pdf>. Downloaded: 8 November 2014.

Brodie J., Waterhouse J., Schaffelke B., Furnas M., Maynard J., Collier C., Lewis S., Warne M. St. J, Fabricus K., Devlin M., McKenzie L., Yorkston H., Randall L., Bennett J., Brando V. (2013b). *2013 Scientific Consensus Statement. Chapter 3 – Relative risks to the Great Barrier Reef from degraded water quality.* Reef Water Quality Protection Plan Secretariat, Brisbane, Queensland. 58p. Available from: <http://www.reefplan.qld.gov.au/about/scientific-consensus-statement/water-quality-risks.aspx>. Downloaded: 8 November 2014.

Carroll, C., Waters, D., Vardy, S., Silburn, D.M., Attard, S., Thorburn, P.J., Davis, A.M., Halpin, N., Schmidt, M., Wilson, B., Clark, A. 2012. A Paddock to reef monitoring and modelling framework for the Great Barrier Reef: Paddock and catchment component. *Marine Pollution Bulletin*, 65(4-9):136-149.

DERM (Department of Environment and Resource Management) (2010). Monitoring and Sampling Manual 2009, Version 3. Brisbane, Australia. Available from: <https://www.ehp.qld.gov.au/water/monitoring/monitoring_and_sampling_manual.html>. Downloaded: 8 November 2014.

DERM (Department of Environment and Resource Management) (2011a). Reef Plan I5 Event Monitoring Program Internal Review. Brisbane, Australia.

Devlin M., Brodie J. (2005). Terrestrial discharge into the Great Barrier Reef Lagoon: Nutrient behaviour in coastal waters. *Marine Pollution Bulletin*, 51(1–4):9–22.

DNRM (Department of Natural Resources and Mines) (2012). River discharge dataset (hourly-interpolated flow, $m^3 s^{-1}$), Surface Water Database, Queensland Government, Available from: http://watermonitoring.derm.qld.gov.au/host.htm. Downloaded: 8 November 2014.

DNRM (Department of Natural Resources and Mines) (2014), Quality coding water monitoring data (WM58), version 3.0, Brisbane Qld: State of Queensland, DNRM, Service Delivery.

DPC (Department of Premier and Cabinet) (2008). Scientific consensus statement on water quality in the Great Barrier Reef. Reef Water Quality Protection Plan Secretariat, Brisbane, Australia. Available from: <http://www.reefplan.qld.gov.au/about/assets/scientific-consensus-statement-on-water-quality-in-the-gbr.pdf>. Downloaded: 17 November 2014.

DPC (Department of Premier and Cabinet) (2009a). Paddock to Reef Program – Integrated monitoring, modelling and reporting. Reef Water Quality Protection Plan Secretariat, Brisbane, Australia. Available from: <http://www.reefplan.qld.gov.au/measuring-success/assets/paddock-to-reef.pdf>. Downloaded: 8 November 2014.

DPC (Department of Premier and Cabinet) (2009b). Reef Water Quality Protection Plan. Reef Water Quality Protection Plan Secretariat, Brisbane, Australia.

DPC (Department of Premier and Cabinet) (2011). Reef Water Quality Protection Plan – First Report Card (2009 Baseline). Reef Water Quality Protection Plan Secretariat, Brisbane, Australia. Available from: http://www.reefplan.qld.gov.au/about/assets/gbr.pdf. Downloaded: 8 November 2014.

DPC (Department of Premier and Cabinet) (2013a). Reef Water Quality Protection Plan – Second Report Card. Reef Water Quality Protection Plan Secretariat, Brisbane, Australia. Available from: <http://www.reefplan.qld.gov.au/about/assets/gbr-second-report.pdf>. Downloaded: 8 November 2014.

DPC (Department of Premier and Cabinet) (2013b). Reef Water Quality Protection Plan – Report Card 2011. Reef Water Quality Protection Plan Secretariat, Brisbane, Australia. Available from: <http://www.reefplan.qld.gov.au/measuring-success/report-cards/assets/report-card-2011.pdf>. Downloaded: 8 November 2014.

DPC (Department of the Premier and Cabinet) (2013c). Reef Water Quality Protection Plan 2013, Securing the health and resilience of the Great Barrier Reef World Heritage Area and adjacent catchments, Reef Water Quality Protection Plan Secretariat, Brisbane. Available from: www.reefplan.qld.gov.au. Downloaded: 8 November 2014.

DPC (Department of Premier and Cabinet) (2014). Reef Water Quality Protection Plan – Report Card 2012 and 2013. Reef Water Quality Protection Plan Secretariat, Brisbane, Australia. Available from: <http://www.reefplan.qld.gov.au/measuring-success/report-cards/assets/report-card-2012-2013.pdf>. Downloaded: 8 November 2014.

eWater Cooperative Research Centre (2011). Water Quality Analyser v2.0.0 User Guide. eWater Cooperative Research Centre, Canberra, Australia.

Eyre B. (1998). Transport, retention and transformation of material in Australian estuaries. *Estuaries*, 21(4A): 540–551.

Fabricius K. E., De'ath G., McCook L., Turak E., Williams D. McB. (2005). Changes in algal, coral and fish assemblages along water quality gradients on the inshore Great Barrier Reef. *Marine Pollution Bulletin*, 51(1–4):384–398.

Furnas M., Mitchell A., Skuza M. (1997). River inputs of nutrient and sediments to the Great Barrier Reef. In: Wachenfeld, D., Oliver, J., Davis, K., (eds). Proceedings of the State of the Great Barrier Reef World Heritage Area Workshop GBRMPA, Workshop Series No. 23, 27–29 November, 1995, Townsville, Australia.

Furnas M. (2003). Catchments and Corals: Terrestrial Runoff to the Great Barrier Reef. Australian Institute of Marine Science, Townsville, Australia. Available from: <http://epubs.aims.gov.au/handle/11068/6477>. Downloaded: 8 November 2014.

Hunter H., Walton R. (2008). Land-use effects on fluxes of suspended sediment, nitrogen and phosphorus from a river catchment of the Great Barrier Reef, Australia. *Journal of Hydrology*, 356(1–2):131–146.

Joo M., Raymond M., McNeil V., Huggins R., Turner R., Choy S. (2012). Estimates of sediment and nutrient loads in 10 major catchments draining to the Great Barrier Reef during 2006–2009. *Marine Pollution Bulletin*, 65(4–9):150–166.

Kroon F., Kuhnert P., Henderson B., Henderson A., Turner R., Huggins R., Wilkinson S., Abbot B., Brodie J., Joo M. (2010). Baseline pollutant loads to the Great Barrier Reef. CSIRO: Water for a Healthy Country Flagship Report Series, Australia. ISSN: 1835-095X. 41 pp.

Kroon F., Kuhnert P., Henderson B., Wilkinson S., Kinsey-Henderson A., Abbott B., Brodie J., Turner R. (2011). River loads of suspended solids, nitrogen, phosphorus and herbicides delivered to the Great Barrier Reef Lagoon. *Marine Pollution Bulletin*, 65(4–9):167–181.

Kroon F., Turner R., Smith R., Warne M.St.J., Hunter H., Bartley R., Wilkinson S., Lewis S., Waters D., Carroll C. (2013). *Scientific Consensus Statement. Chapter 3 – Sources of sediment, nutrients, pesticides and other pollutants in the Great Barrier Reef catchment.* Reef Water Quality Protection Plan Secretariat, Brisbane, Queensland. 42p. Available from:<http://www.reefplan.qld.gov.au/about/scientific-consensus-statement/sources-of-pollutants.aspx>. Downloaded: 8 November 2014.

Letcher R., Jakeman T., Merrit W., McKee L., Eyre B., Baginska B. (1999). Review of techniques to estimate catchment exports – Technical report. New South Wales Environment Protection Authority, Sydney, Australia.

Nicholls N. (1988). El Niño and rainfall variability. *Journal of Climate*, 1:418–442.

Packett R., Dougall C., Rohde K., Noble R. (2009). Agricultural lands are hot-spots for annual runoff polluting the southern Great Barrier Reef Lagoon. *Marine Pollution Bulletin*, 58:976–986.

Rayment G.E. (2003). Water quality in sugar catchments in Queensland. *Water Science and Technology*, 48(7):35–47.

Schaffelke B, Anthony K, Blake J, Brodie J, Collier C, Devlin M, Fabricus K, Martin K, McKenzie L, Negri A, Ronan, Thompson A, Warne M.St.J. (2013). *2013 Scientific Consensus Statement. Chapter 1 – Marine and coastal ecosystem impacts.* Reef Water Quality Protection Plan Secretariat, Brisbane, Queensland. 47p. Available from: <http://www.reefplan.qld.gov.au/about/scientific-consensus-statement/ecosystem-impacts.aspx>. Downloaded: 8 November 2014.

Smith R., Middlebrook R., Turner R., Huggins R., Vardy S., Warne M.St.J. (2012). Large-scale pesticide monitoring across Great Barrier Reef catchments – Paddock to Reef Integrated Monitoring, Modelling and Reporting Program. *Marine Pollution Bulletin*, 65(4–9):117–127.

Smith R., Turner R., Vardy S., Huggins R., Wallace R., Warne M.St.J. (2014) An evaluation of the prevalence of alternate pesticides of environmental concern in Great Barrier Reef catchments. Water Quality and Investigations, Environmental Monitoring and Assessment Science, Department of Science, Information Technology and the Arts, Brisbane. Available from: <http://www.qld.gov.au/environment/agriculture/sustainable-farming/reef/>. Downloaded: 8 November 2014.

State of Queensland and Commonwealth of Australia (2003). Reef Water Quality Protection Plan: For catchments adjacent to the Great Barrier Reef World Heritage Area. Queensland Department of Premier and Cabinet, Brisbane, Australia. Available from: <http://www.reefplan.qld.gov.au/about/assets/reefplan-2003.pdf>. Downloaded: 8 November 2014.

Turner, R., Huggins, R., Wallace, R., Smith, R., Vardy, S., Warne, M.St.J. (2012). Sediment, nutrient, and pesticide loads: Great Barrier Reef Catchment Loads Monitoring Program 2009–2010. Department of Science, Information Technology, Innovation and the Arts, Brisbane. Available from: <http://www.reefplan.qld.gov.au/measuring-success/paddock-to-reef/assets/2009-2010-gbr-catchment-loads-report.pdf>. Downloaded: 8 November 2014.

Turner, R., Huggins, R., Wallace, R., Smith, R., Vardy, S. and Warne, M.St.J. (2013). Total suspended solids, nutrient and pesticide loads (2010–2011) for rivers that discharge to the Great Barrier Reef: Great Barrier Reef Catchment Loads Monitoring Program 2010–2011. Department of Science, Information Technology, Innovation and the Arts, Brisbane. Available from: <http://www.reefplan.qld.gov.au/measuring-success/paddock-to-reef/assets/2010-2011-gbr-catchment-loads-report.pdf>. Downloaded: 8 November 2014. Downloaded: 8 November 2014.

Wachenfeld, D.R., Oliver, J.K., Morrissey, J.I. (1998). State of the Great Barrier Reef World Heritage Area. Great Barrier Reef Marine Park Authority, Townsville, Australia.

Wallace, R., Huggins, R., Smith, R., Turner, R., Vardy, S. and Warne, M.St.J. (2014). Total suspended solids, nutrient and pesticide loads (2011–2012) for rivers that discharge to the Great Barrier Reef – Great Barrier Reef Catchment Loads Monitoring Program 2011–2012. Department of Science, Information Technology, Innovation and the Arts. Brisbane. Available from: http://www.reefplan.qld.gov.au/measuring-success/paddock-to-reef/assets/2011-2012-gbr-catchment-loads-report.pdf. Downloaded: 8 November 2014.

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7 Appendices

Appendix A Loads of other pesticides detected by the Great Barrier Reef Catchment Loads Monitoring Program

All water samples collected for the analysis of pesticides were analysed via LCMS as described in Section 2.5. The LCMS analytical suite is capable of detecting pesticides and their breakdown products which are not modelled under the Reef Plan 2009 (i.e. other than the five priority photosystem II inhibiting herbicides). The monitored annual loads of these additional pesticides were calculated using the methods previously described in Section 2.7.2. The results presented in this section of the report are the monitored annual loads of these additional pesticides, namely 2,4-D, bromacil, fluometuron, fluroxypyr, haloxyfop, imidacloprid, isoxaflutole, MCPA, metolachlor, metribuzin, metsulfuron-methyl, prometryne, propazine-2-hydroxy (a metabolite of the herbicide propazine), simazine, terbuthylazine, triclopyr. The monitored annual loads of atrazine and its metabolites, desethyl atrazine and desisopropyl atrazine, are also presented although they will not be discussed further as the total atrazine load is already considered in Section 3.4.

The total monitored annual loads of the additional pesticides ranged from 0.30 kg of fluroxypyr to 1100 kg of metolachlor (Table 7.1 to Table 7.3). Overall, the additional pesticides reported here increase the total monitored annual load of pesticides by approximately 2800 kg (or approximately 28 per cent) to a total monitored annual load of approximately 12,800 kg.

Of the additional pesticides detected by the LCMS analysis, 2,4-D and metolachlor were detected at all monitored catchments. Barratta Creek in the Haughton catchment had the highest number of additional pesticides detected with calculable loads for all additional pesticides except terbuthylazine which was only detected in the Fitzroy catchment. Fluroxypyr and propazin-2-hydroxy were only detected in Barratta Creek in the Haughton catchment. The Herbert and Burnett catchments had the lowest number of additional pesticides detected with four in each catchment.

The largest monitored annual loads of 2,4-D were recorded in the Fitzroy (180 kg), Tully (110 kg) and Burnett (110 kg) catchments. The lowest monitored annual load of 2,4-D was in the Burdekin catchment (28 kg). Bromacil was only detected at Barratta Creek in the Haughton catchment (1.5 kg) and the Fitzroy catchment (41 kg). Fluometuron was only detected at Barratta Creek in the Haughton catchment (0.70 kg) and the Pioneer catchment (3.8 kg).

Haloxyfop was detected at three monitored end-of-system sites with the largest load occurring in the Burdekin catchment (32 kg). Haloxyfop was also detected in the Comet River sub-catchment where the monitored annual load was 0.4 kg. Imidacloprid and isoxaflutole were detected at all monitored catchments in the Wet Tropics, Burdekin and Mackay Whitsunday regions except isoxaflutole which was not detected in the Herbert catchment. The largest monitored annual load of imidacloprid was in the Tully catchment

(270 kg) and the largest monitored annual load of isoxaflutole was in Barratta Creek in the Haughton catchment (21 kg).

MCPA was detected at all monitored catchments in the Burdekin, Mackay Whitsunday and Fitzroy regions. The largest monitored annual load of MCPA was derived from Sandy Creek in the Plane catchment (120 kg) with comparatively small loads in the other monitored catchments of these regions. The majority of the total monitored annual load of metolachlor was derived from the Fitzroy (550 kg) and Burnett (470 kg) catchments which experienced major flooding in late-January 2013. The smallest monitored annual loads of metolachlor occurred in the Wet Tropics natural resource management region with the Herbert and Tully catchments contributing 7.0 kg and 1.8 kg, respectively. The monitored annual load of metolachlor in the Comet River sub-catchment was 28 kg.

Metribuzin was detected in four monitored catchments with the largest monitored annual load occurring in the Pioneer catchment (67 kg). Metsulfuron-methyl was also only detected at three monitored end-of-system sites with the largest load occurring in the Tully catchment (5.9 kg) and markedly lower loads in Barratta Creek in the Haughton catchment (0.027 kg) and Herbert catchment (0.0087 kg).

Prometryn was only detected at two monitored end-of-system sites with the vast majority of the monitored annual load derived from the Burnett catchment (31 kg) and a comparatively small load from Barratta Creek in the Haughton catchment (0.1 kg). Propazin-2-hydroxy, a metabolite of propazine, was only detected above the limit of reporting in Barratta Creek in the Haughton catchment with a calculated load of 0.80 kg. Simazine was detected in four monitored catchments with the largest monitored annual load occurring in the Fitzroy catchment (51 kg). Simazine was also detected in the Comet River sub-catchment with a monitored annual load calculated at 1.0 kg.

Terbuthylazine was detected only in the Fitzroy catchment with a load of 5.9 kg. Triclopyr was detected in all monitored end-of-system catchments except the Burdekin and Fitzroy. The largest monitored annual loads of triclopyr occurred in the Burnett catchment (60 kg) with smaller loads in the remaining catchments ranging from 2.3 kg in the Tully catchment to 0.50 kg in Barratta Creek in the Haughton catchment.

Table 7.1 The monitored annual loads calculated for the additional pesticides: 2,4-D, bromacil, fluometuron, fluroxypyr, haloxyfop, imidacloprid, isoxaflutole. Text in bold are end-of-system sites and the corresponding data, all others are sub-catchment sites.

NRM region	Catchment	Gauging station	River and site name	Monitored area of catchment (%)	n	2,4-D (kg)	Bromacil (kg)	Fluometuron (kg)	Fluroxypyr (kg)	Haloxyfop (kg)	Imidacloprid (kg)	Isoxaflutole (kg)
Wet Tropics	Johnstone	112004A	North Johnstone River at Tung Oil	40	5	NC	NC	NC	NC	NC	NC	NC
	Tully	**113006A[B]**	**Tully River at Euramo**	**86**	**65**	**110**	**NC**	**NC**	**NC**	**7.3**	**270**	**13**
	Herbert	**116001F[L]**	**Herbert River at Ingham**	**87**	**44**	**44**	**NC**	**NC**	**NC**	**NC**	**41**	**NC**
Burdekin	**Haughton**	**119101A[L]**	**Barratta Creek at Northcote**	**19**	**31**	**33**	**1.5**	**0.70**	**0.30**	**2.2**	**3.0**	**21**
	Burdekin	**120001A[L]**	**Burdekin River at Home Hill**	**99**	**29**	**28**	**NC**	**NC**	**NC**	**32**	**5.3**	**7.5**
Mackay Whitsunday	**Pioneer**	**125013A[L]**	**Pioneer River at Dumbleton Pump Station**	**94**	**104**	**62**	**NC**	**3.8**	**NC**	**NC**	**49**	**10**
	Plane	**126001A[B]**	**Sandy Creek at Homebush**	**13**	**26**	**49**	**NC**	**NC**	**NC**	**NC**	**18**	**15**
Fitzroy	**Fitzroy**	**1300000[B]**	**Fitzroy River at Rockhampton**	**98**	**24**	**180**	**41**	**NC**	**NC**	**NC**	**NC**	**NC**
		130504B[B]	Comet River at Comet Weir	12	8	3.3	NC	NC	NC	0.40	NC	NC
Burnett Mary	**Burnett**	**136014A[L]**	**Burnett River at Ben Anderson Barrage Head Water**	**99**	**70**	**110**	**NC**	**NC**	**NC**	**NC**	**NC**	**NC**
	Total (monitored end-of-system sites)			97	393	620	43	4.5	0.30	42	390	67

n = the number of grab samples used to estimate loads; NC = a load was not calculated as all the concentrations were below the practical quantitation limit or there were insufficient samples collected over the year to calculate a load; [L] = average load (linear interpolation of concentration) method used to calculate loads; [B] = Beale ratio method used to calculate loads.

Table 7.2 The monitored annual loads calculated for the additional pesticides: MCPA, metolachlor, metribuzin, metsulfuron-methyl, prometryn, propazin-2-hydroxy and simazine. Text in bold are end-of-system sites and the corresponding data, all others are sub-catchment sites.

NRM region	Catchment	Gauging station	River and site name	Monitored area of catchment (%)	n	MCPA (kg)	Metolachlor (kg)	Metribuzin (kg)	Metsulfuron -methyl (kg)	Prometryn (kg)	Propazin-2-hydroxy (kg)	Simazine (kg)
Wet Tropics	Johnstone	112004A	North Johnstone River at Tung Oil	40	5	NC	NC	NC	NC	NC	NC	NC
	Tully	**113006A[B]**	**Tully River at Euramo**	**86**	**65**	**NC**	**1.8**	**30**	**5.9**	**NC**	**NC**	**2.5**
	Herbert	**116001F[L]**	**Herbert River at Ingham**	**87**	**44**	**NC**	**7.0**	**NC**	**0.0087**	**NC**	**NC**	**NC**
Burdekin	**Haughton**	**119101A[L]**	**Barratta Creek at Northcote**	**19**	**31**	**6.9**	**16**	**21**	**0.027**	**0.1**	**0.8**	**1.4**
	Burdekin	**120001A[L]**	**Burdekin River at Home Hill**	**99**	**29**	**36**	**34**	**NC**	**NC**	**NC**	**NC**	**NC**
Mackay Whitsunday	**Pioneer**	**125013A[L]**	**Pioneer River at Dumbleton Pump Station**	**94**	**104**	**12**	**11**	**67**	**NC**	**NC**	**NC**	**0.8**
	Plane	**126001A[B]**	**Sandy Creek at Homebush**	**13**	**26**	**120**	**23**	**51**	**NC**	**NC**	**NC**	**NC**
Fitzroy	**Fitzroy**	**1300000[B]**	**Fitzroy River at Rockhampton**	**98**	**24**	**3.3**	**550**	**NC**	**NC**	**NC**	**NC**	**51**
		130504B[B]	Comet River at Comet Weir	12	8	NC	28	NC	NC	NC	NC	1.0
Burnett Mary	**Burnett**	**136014A[L]**	**Burnett River at Ben Anderson Barrage Head Water**	**99**	**70**	**NC**	**470**	**NC**	**NC**	**31**	**NC**	**NC**
	Total (monitored end-of-system sites)			97	393	180	1100	170	5.9	31	0.80	60

n = the number of grab samples used to estimate loads; NC = a load was not calculated as all the concentrations were below the practical quantitation limit or there were insufficient samples collected over the year to calculate a load; [L] = average load (linear interpolation of concentration) method used to calculate loads; [B] = Beale ratio method used to calculate loads.

Table 7.3 The monitored annual loads calculated for the additional pesticides: terbuthylazine, triclopyr, atrazine and its metabolites desethylatrazine, desisopropylatrazine. Text in bold are end-of-system sites and the corresponding data, all others are sub-catchment sites.

NRM region	Catchment	Gauging station	River and site name	Monitored area of catchment (%)	n	Terbuthylazine (kg)	Triclopyr (kg)	Total atrazine (kg)		
								Atrazine (kg)	Desethylatrazine (kg)	Desisopropylatrazine (kg)
Wet Tropics	Johnstone	112004A	North Johnstone River at Tung Oil	40	5	NC	NC	NC	NC	NC
	Tully	**113006A[B]**	**Tully River at Euramo**	**86**	**65**	**NC**	**2.3**	**143**	**18**	**1.1**
	Herbert	**116001F[L]**	**Herbert River at Ingham**	**87**	**44**	**NC**	**1.4**	**100**	**6.7**	**6.8**
Burdekin	**Haughton**	**119101A[L]**	**Barratta Creek at Northcote**	**19**	**31**	**NC**	**0.50**	**440**	**47**	**20**
	Burdekin	**120001A[L]**	**Burdekin River at Home Hill**	**99**	**29**	**NC**	**NC**	**180**	**32**	**18**
Mackay Whitsunday	**Pioneer**	**125013A[L]**	**Pioneer River at Dumbleton Pump Station**	**94**	**104**	**NC**	**1.2**	**390**	**47**	**17**
	Plane	**126001A[B]**	**Sandy Creek at Homebush**	**13**	**26**	**NC**	**0.60**	**240**	**22**	**10**
Fitzroy	**Fitzroy**	**1300000[B]**	**Fitzroy River at Rockhampton**	**98**	**24**	**5.9**	**NC**	**360**	**8.3**	**55**
		130504B[B]	Comet River at Comet Weir	12	8	NC	NC	33	4.4	3.0
Burnett Mary	**Burnett**	**136014A[L]**	**Burnett River at Ben Anderson Barrage Head Water**	**99**	**70**	**NC**	**60**	**270**	**26**	**NC**
	Total (monitored end-of-system sites)			97	393	5.9	66	2156	211.4	130.9

Data shaded blue (atrazine, desethyl atrazine and desisopropyl atrazine) have already been incorporated in the calculation of total atrazine as presented in the main body of this report.
n = the number of grab samples used to estimate loads; NC = a load was not calculated as all the concentrations were below the practical quantitation limit or there were insufficient samples collected over the year to calculate a load; [L] = average load (linear interpolation of concentration) method used to calculate loads; [B] = Beale ratio method used to calculate loads.

Appendix B Calculation of discharge

Discharge as contained in the Queensland Government surface water database is calculated following the equation:

Equation 8

$$q = va$$

where, q is the discharge ($m^3 s^{-1}$), a = the cross-sectional area of the river (m^2), and v = average velocity of the flow in the cross-sectional area (ms^{-1}).

Discharge is calculated for sub-sectional areas of the river channel and summed to determine the discharge across the whole cross-sectional area. Sub-sectional areas were calculated from a known width multiplied by the river gauge height at time *t*. Flow velocity was determined for each cross-sectional area at time *t* using a current meter.

During the 2012–2013 monitoring year, river gauge height was recorded by gauging stations using a float or a pressure sensor at intervals of approximately 15 minutes. Flow records were extracted for each site from the Queensland Government electronic data management system (Hydstra).

Appendix C Discharge data quality

The total period (hours) during the 2012–2013 monitoring year where discharge was calculated from interpolated height data is provided in Table 7.4. Discharge which was calculated from interpolated height data were assigned a quality code of 59 or 60.

Table 7.4 Per cent of annual discharge period calculated using interpolated discharge. Text in bold are end-of-system sites and the corresponding data, all others are sub-catchment sites.

Catchment	Gauging station	River and site name	Time period (hours)	Quality code[1]	Per cent of annual discharge calculated using interpolated discharge
Normanby	**105107A**	**Normanby River at Kalpowar Crossing**	**43**	**60**	**1**
Barron	**110001D**	**Barron River at Myola**	**112**	**59**	**1**
Johnstone	112004A	North Johnstone River at Tung Oil	0		0
	112101B	South Johnstone River at Upstream Central Mill	0		0
Tully	**113006A**	**Tully River at Euramo**	**0**		**0**
	113015A	Tully River at Tully Gorge National Park	25	60	7
Herbert	**116001F**	**Herbert River at Ingham**	**0**		**0**
Haughton	**119101A**	**Barratta Creek at Northcote**	**203**	**60**	**2**
Burdekin	**120001A**	**Burdekin River at Home Hill**	**0**		**0**
	120002C	Burdekin River at Sellheim	0		0
	120205A	Bowen River at Myuna	0		0
	120301B	Belyando River at Gregory Development Road	70	79	1
	120302B	Cape River at Taemas	0		0
	120310A	Suttor River at Bowen Development Road	0		0
Pioneer	**125013A**	**Pioneer River at Dumbleton Pump Station**	**391**	**60**	**4**
Plane	**126001A**	**Sandy Creek at Homebush**	**138**	**60**	**2**
Fitzroy	**1300000**	**Fitzroy River at Rockhampton**	**0**		**0**
	130206A	Theresa Creek at Gregory Highway	0		0
	130302A	Dawson River at Taroom	0		0
	130504B	Comet River at Comet Weir	0		0
Burnett	**136014A (136019A)**	**Burnett River at Ben Anderson Barrage Head Water (Perry River at Mt Rawdon)**	**239 732**	**60 160**	**3 8**
	136002D	Burnett River at Mt Lawless	4	60	<1
	136094A	Burnett River at Jones Weir Tail Water	114	60	1
	136106A	Burnett River at Eidsvold	123	60	1

[1] Quality codes are explained in Table 7.5.

Table 7.5 Description of discharge data quality codes (DNRM 2014).

Discharge data quality code	Description
10	Good
15	No flow
20	Fair
30	Poor
59	CITEC – Derived height
60	Estimate
160	Suspect

Appendix D Hydrograph plots of discharge and sample collection points

Figures in Appendix D are presented in the order of the location of the waterways from north to south.

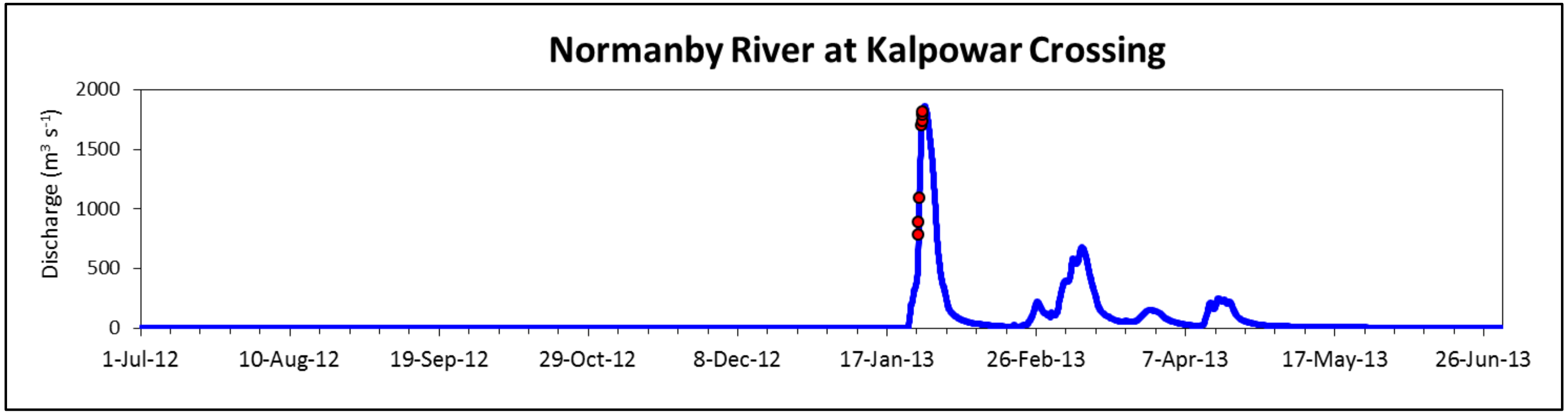

Figure 7.1 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Normanby River at Kalpowar Crossing between 1 July 2012 and 30 June 2013. Representivity rating was good for total suspended solids, no other analytes were calculated.

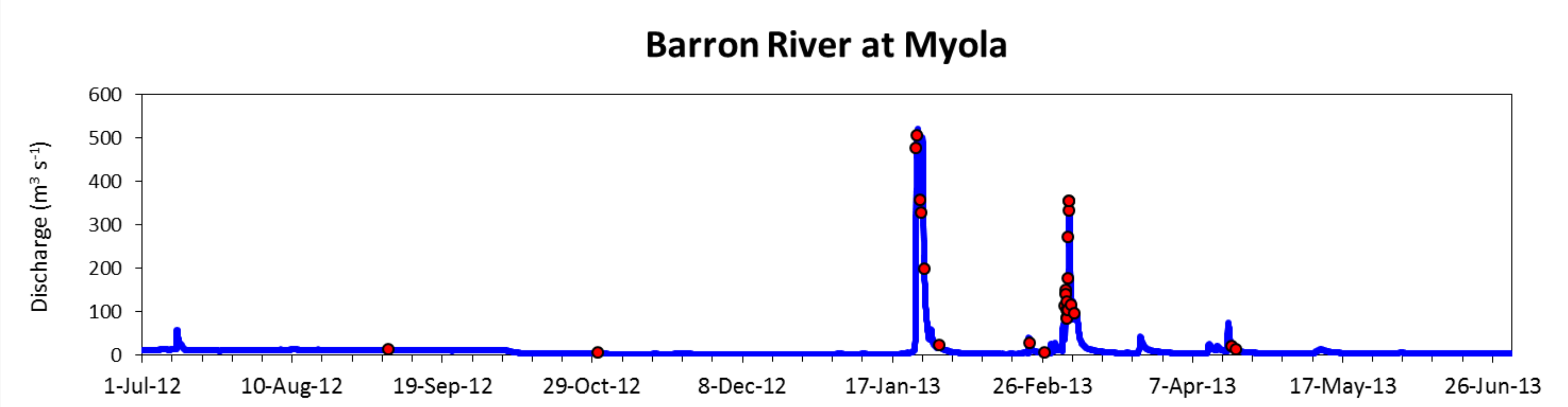

Figure 7.2 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Barron River at Myola between 1 July 2012 and 30 June 2013. Representivity rating was excellent for all analytes.

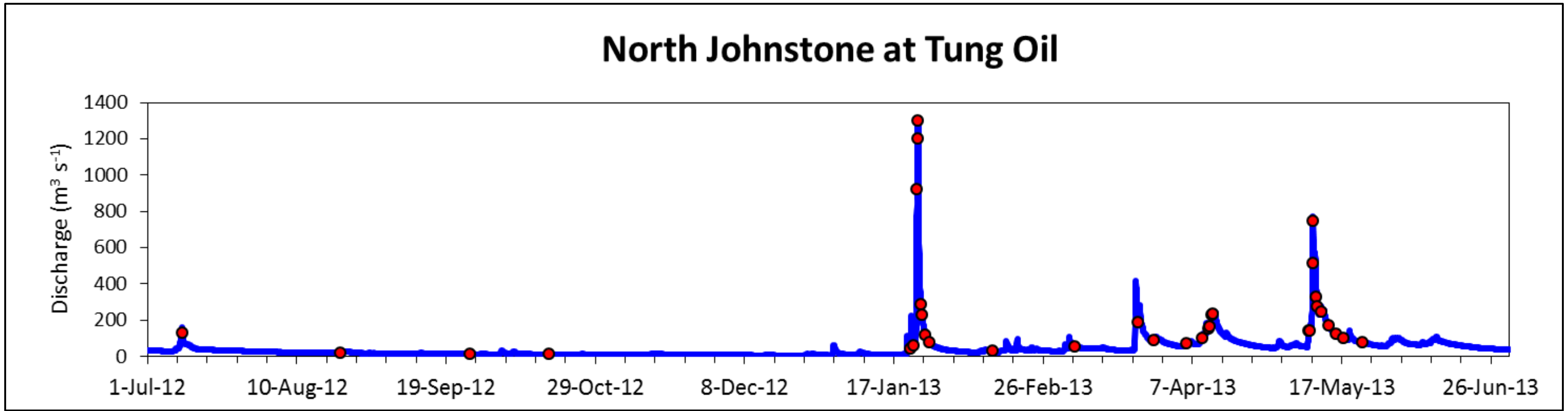

Figure 7.3 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the North Johnstone River at Tung Oil between 1 July 2012 and 30 June 2013. Representivity rating was good for all analytes.

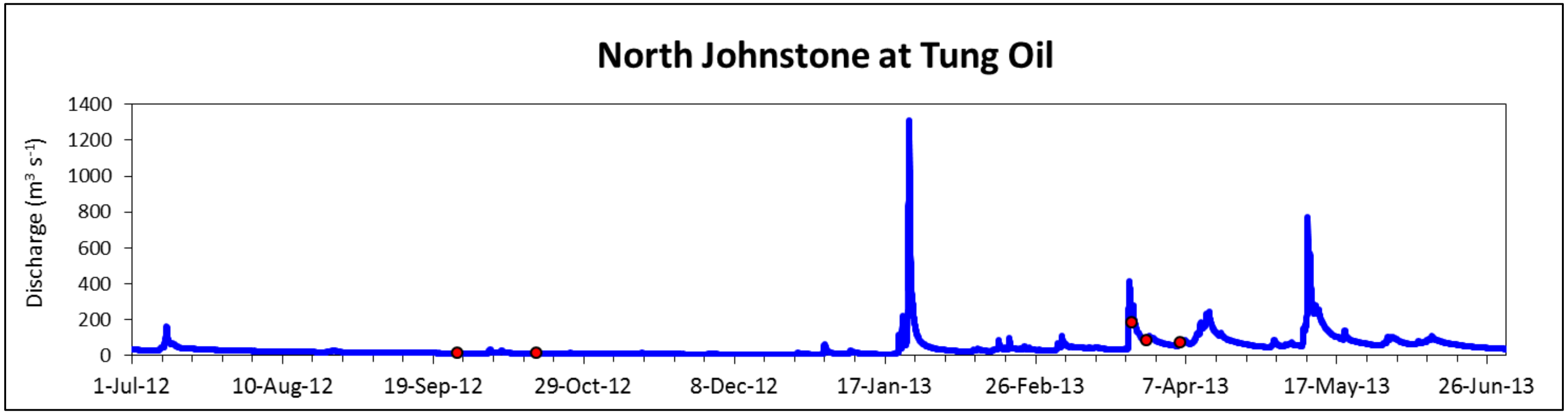

Figure 7.4 Hydrograph showing discharge (blue line) and photosystem II inhibiting pesticide sample coverage (red circles) for North Johnstone River at Tung Oil between 1 July 2012 and 30 June. 2013.

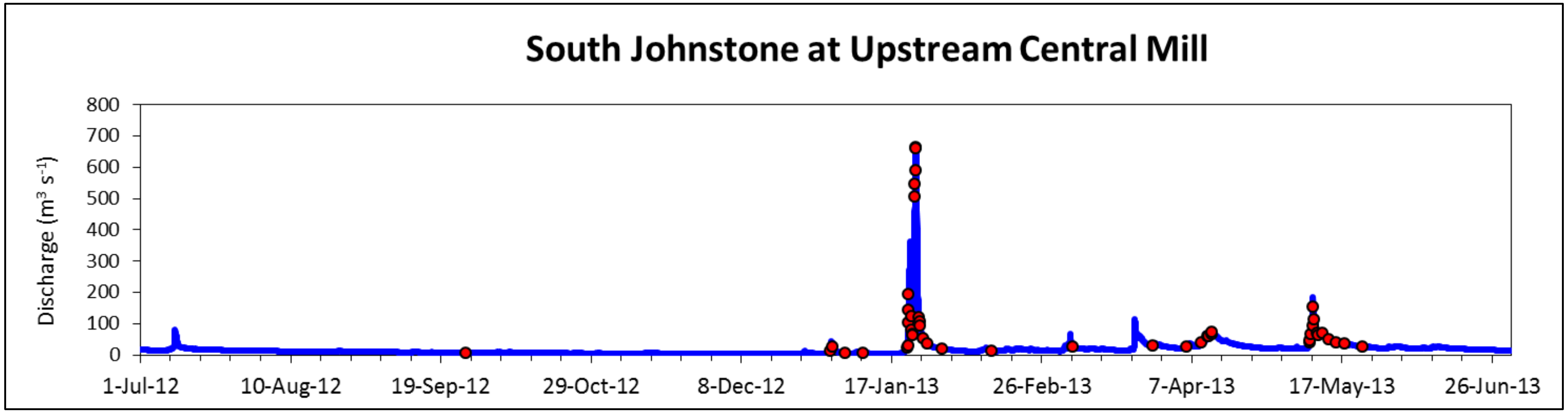

Figure 7.5 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the South Johnstone River at Upstream Central Mill between 1 July 2012 and 30 June 2013. Representivity rating was excellent for all analytes.

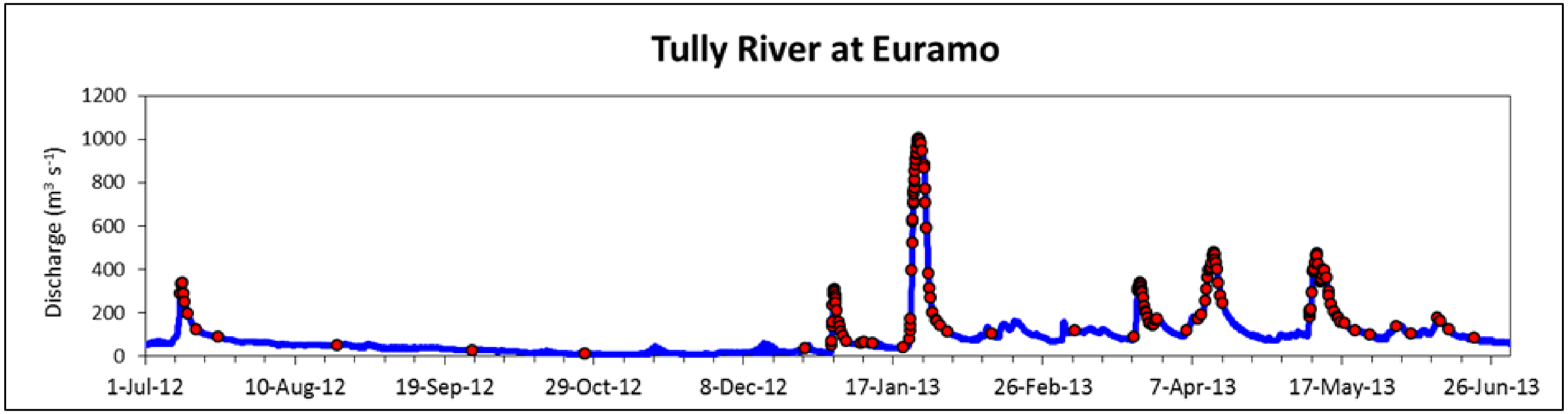

Figure 7.6 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Tully River at Euramo between 1 July 2012 and 30 June 2013. Representivity rating was excellent for all analytes.

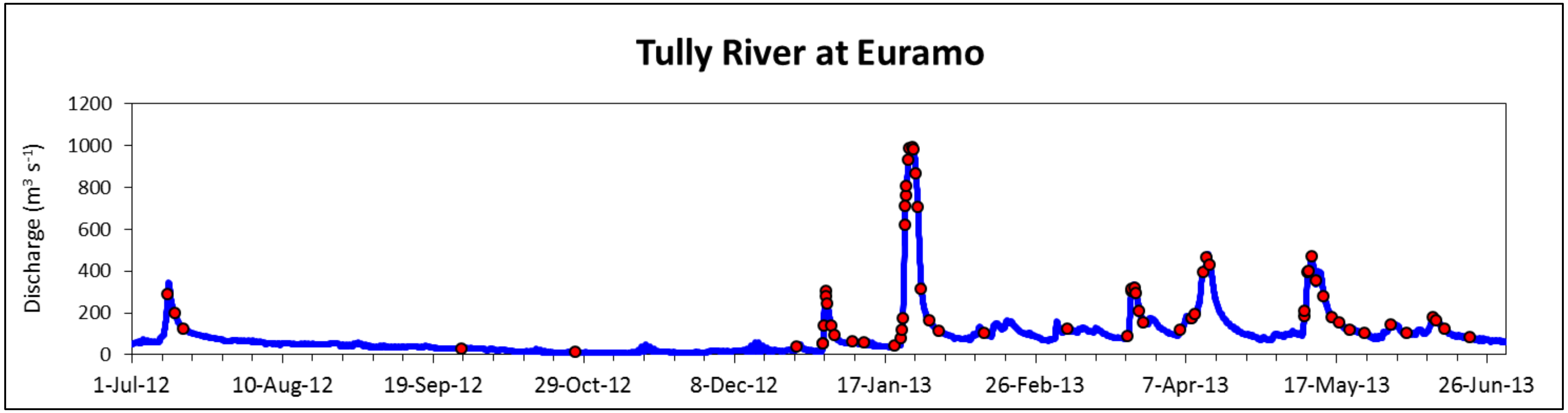

Figure 7.7 Hydrograph showing discharge (blue line) and photosystem II inhibiting pesticide sample coverage (red circles) for Tully River at Euramo between 1 July 2012 and 30 June 2013.

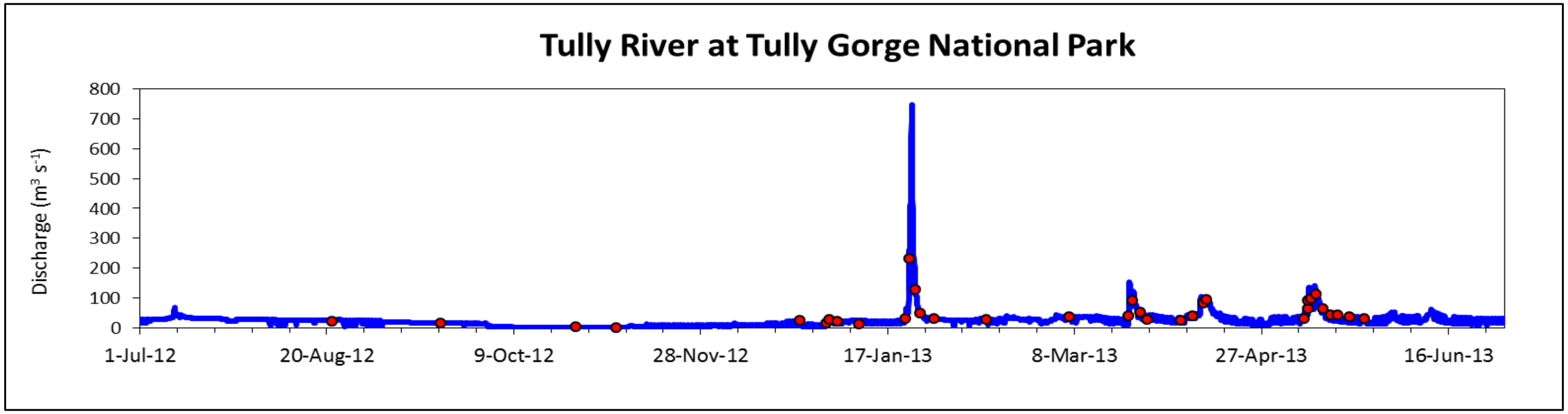

Figure 7.8 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Tully River at Tully Gorge National Park between 1 July 2012 and 30 June 2013. Representivity rating was moderate for all analytes.

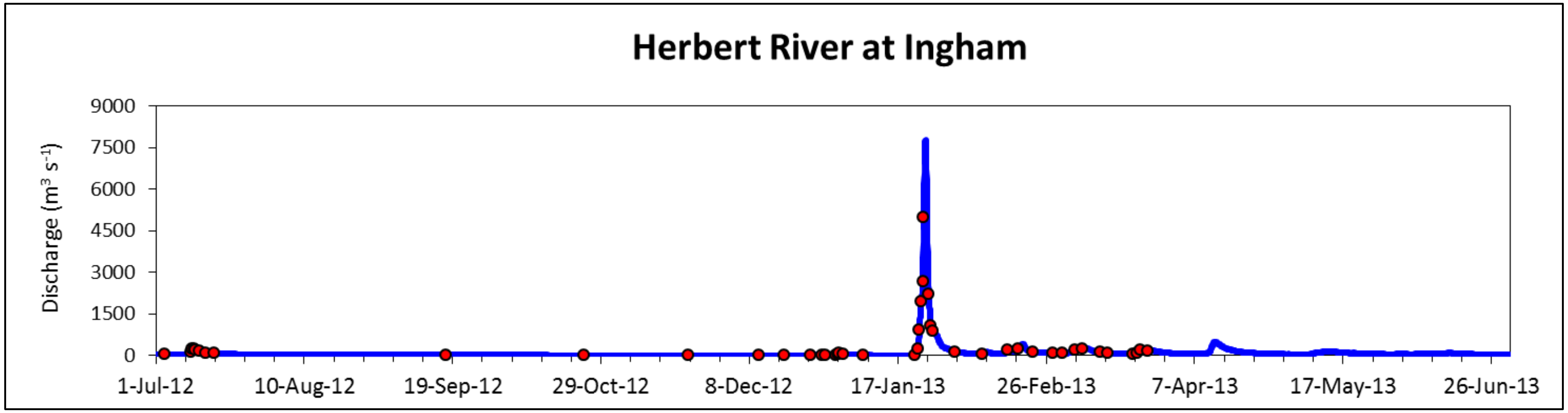

Figure 7.9 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients and photosystem II inhibiting herbicides (red circles) for the Herbert River at Ingham between 1 July 2011 and 30 June 2012. Representivity rating was good for all analytes (excluding photosystem II inhibiting herbicides.

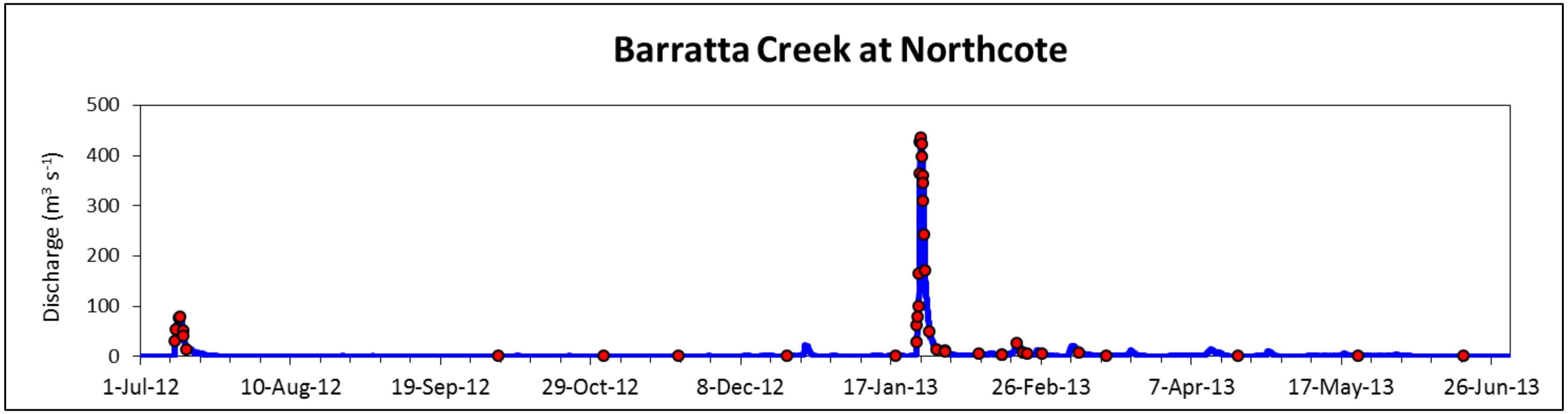

Figure 7.10 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients sample coverage (red circles) in the Barratta Creek at Northcote between 1 July 2012 and 30 June 2013. Representivity rating was excellent for all analytes.

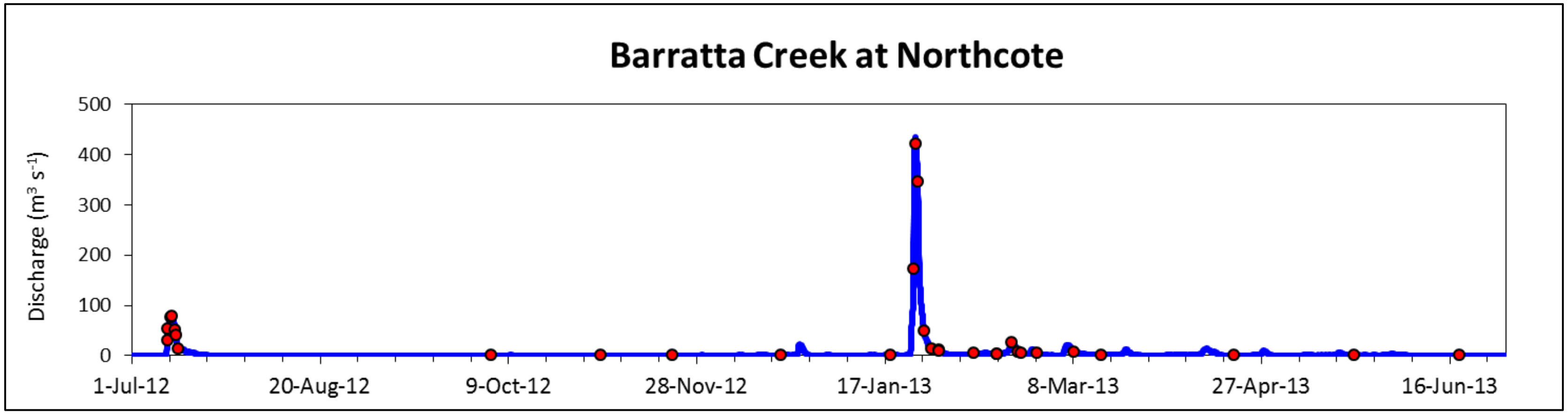

Figure 7.11 Hydrograph showing discharge (blue line) and photosystem II pesticide sample coverage (red circles) for Barratta Creek at Northcote between 1 July 2012 and 30 June 2013.

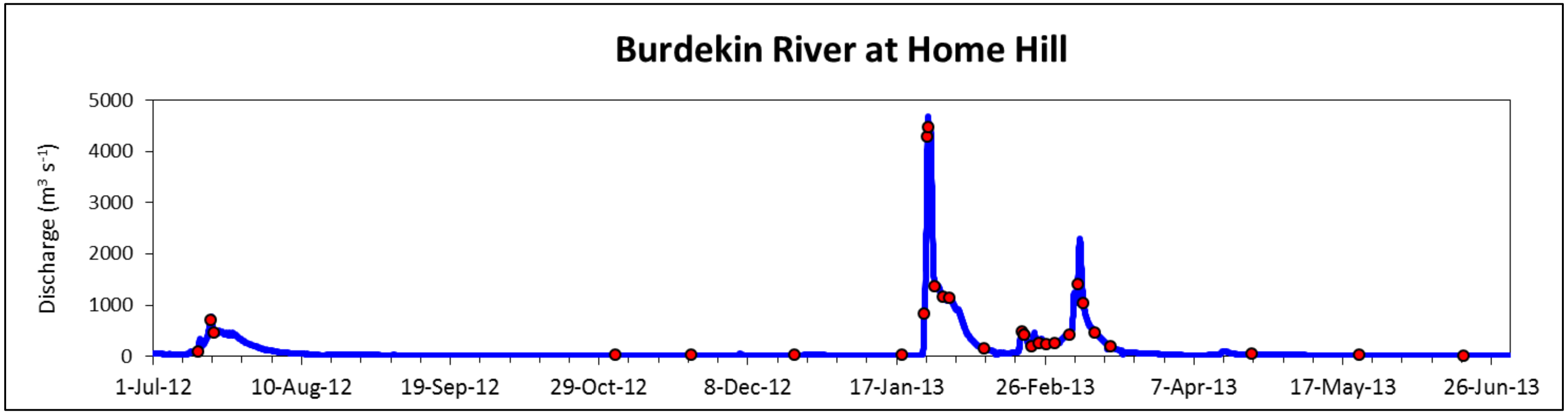

Figure 7.12 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Burdekin River at Home Hill between 1 July 2012 and 30 June 2013. Representivity rating was good for all analytes.

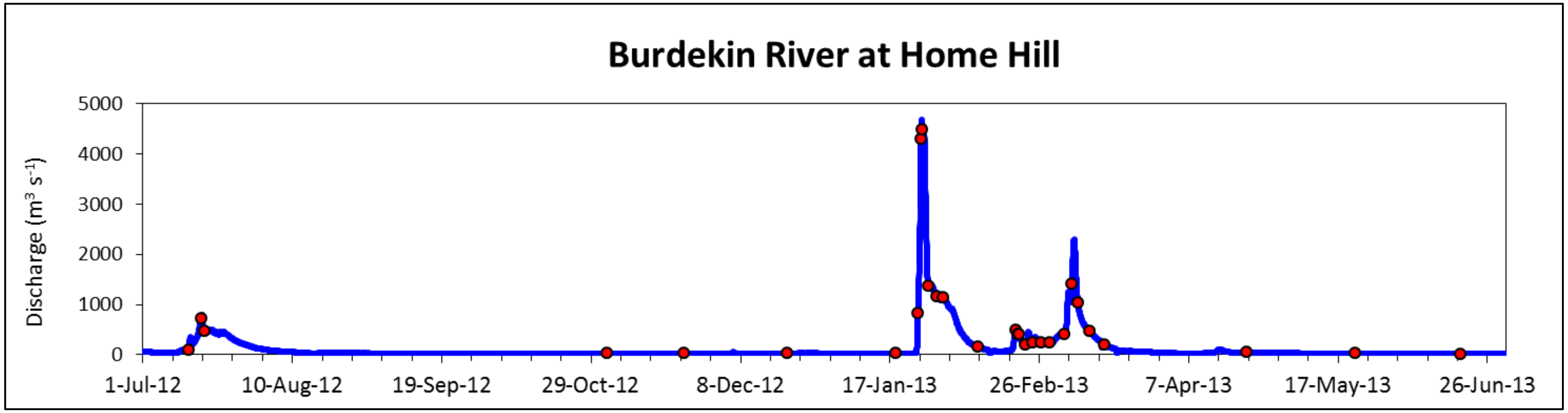

Figure 7.13 Hydrograph showing discharge (blue line) and photosystem II inhibiting herbicide sample coverage (red circles) for Burdekin River at Home Hill between 1 July 2012 and 30 June 2013.

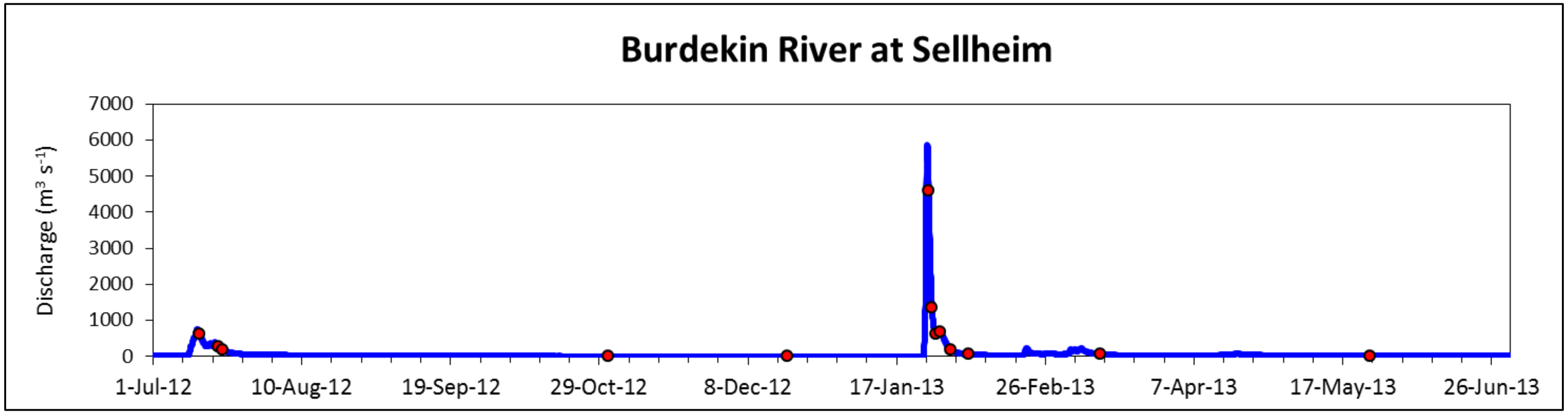

Figure 7.14 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Burdekin River at Sellheim between 1 July 2012 and 30 June 2013. Representivity rating was moderate for all analytes.

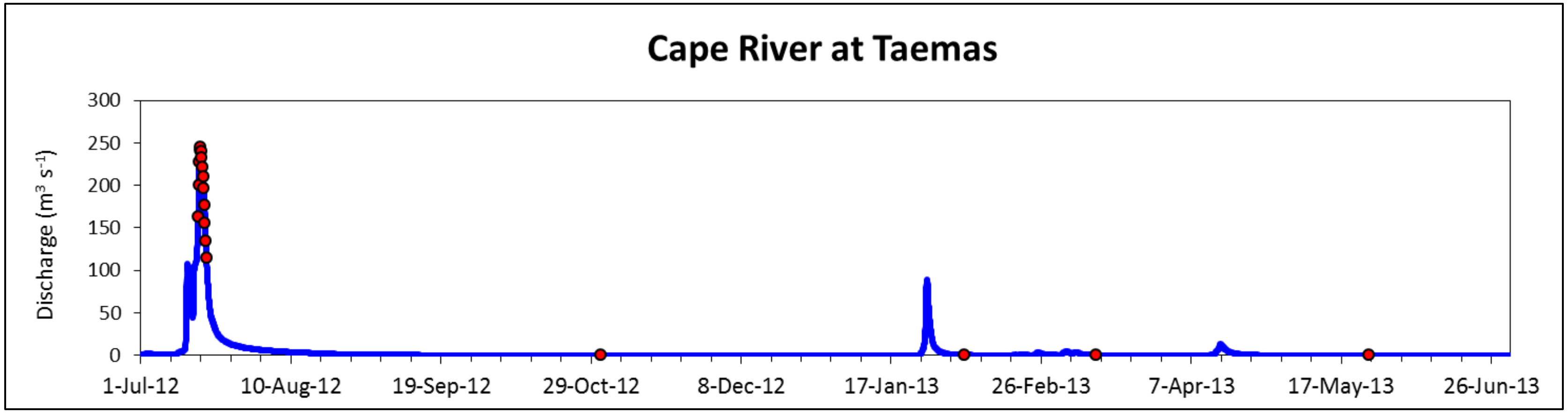

Figure 7.15 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) for Cape River at Taemas between 1 July 2012 and 30 June 2013. Representivity rating was good for all other analytes.

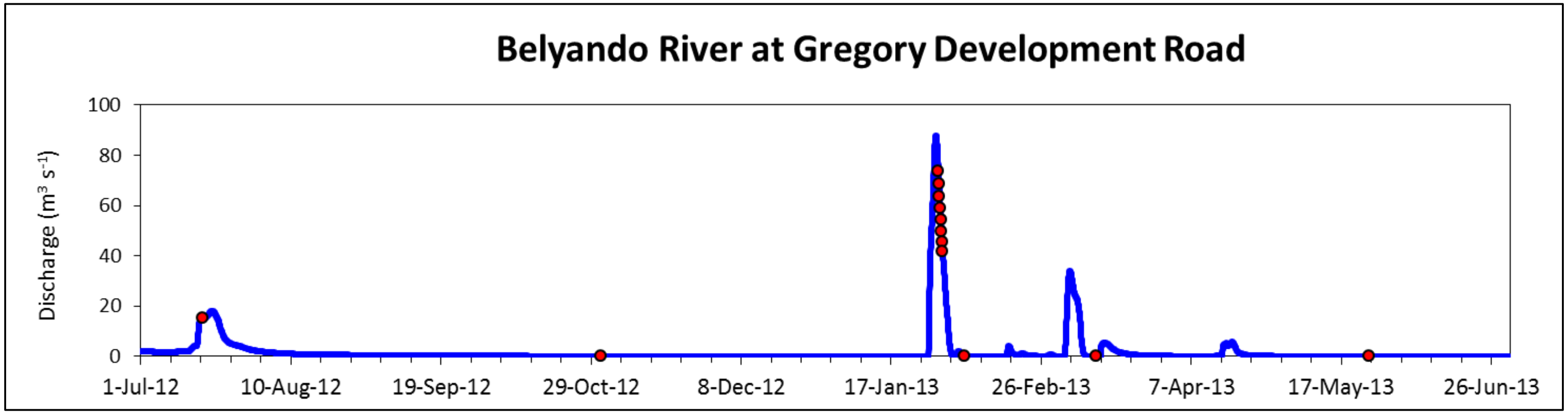

Figure 7.16 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids and total nutrients (red circles) for Belyando River at Gregory Development Road between 1 July 2012 and 30 June 2013. Representivity rating was good for all analytes.

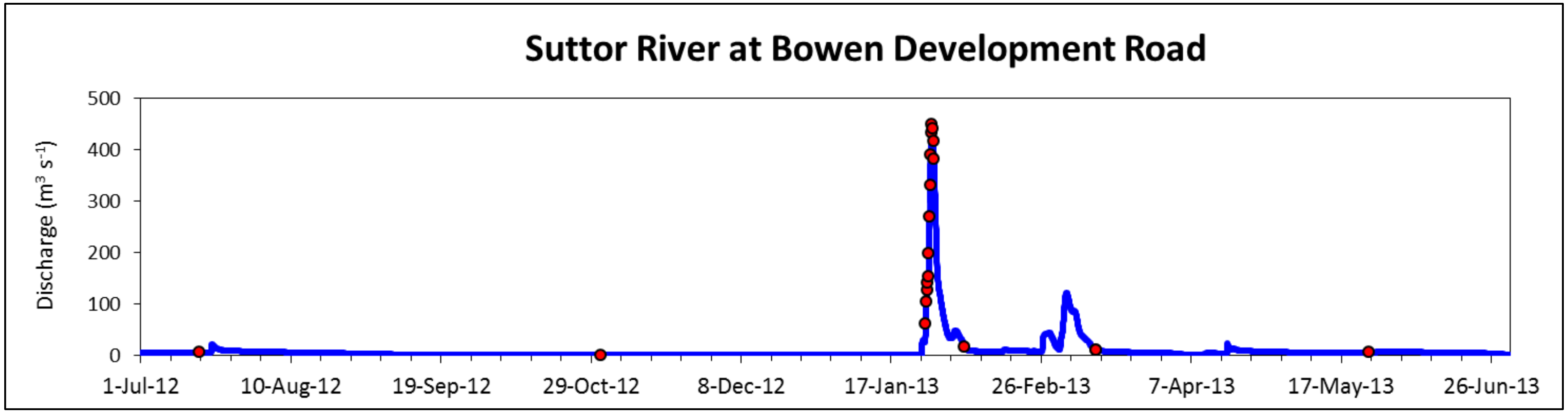

Figure 7.17 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Suttor River at Bowen Development Road between 1 July 2012 and 30 June 2013. Representivity rating was good for all analytes.

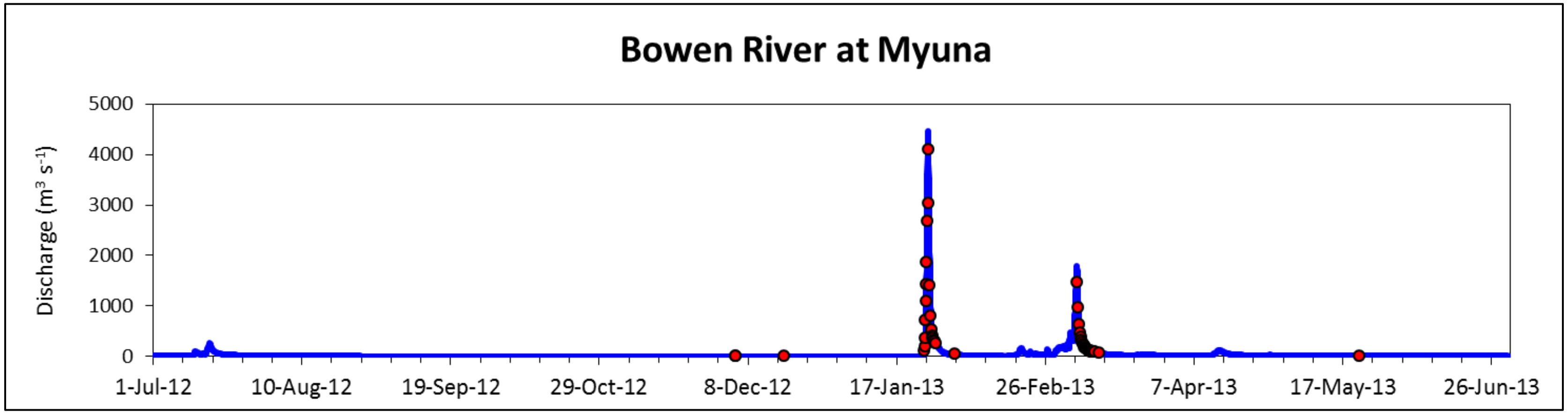

Figure 7.18 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Bowen River at Myuna between 1 July 2012 and 30 June 2013. Representivity rating was excellent for all analytes.

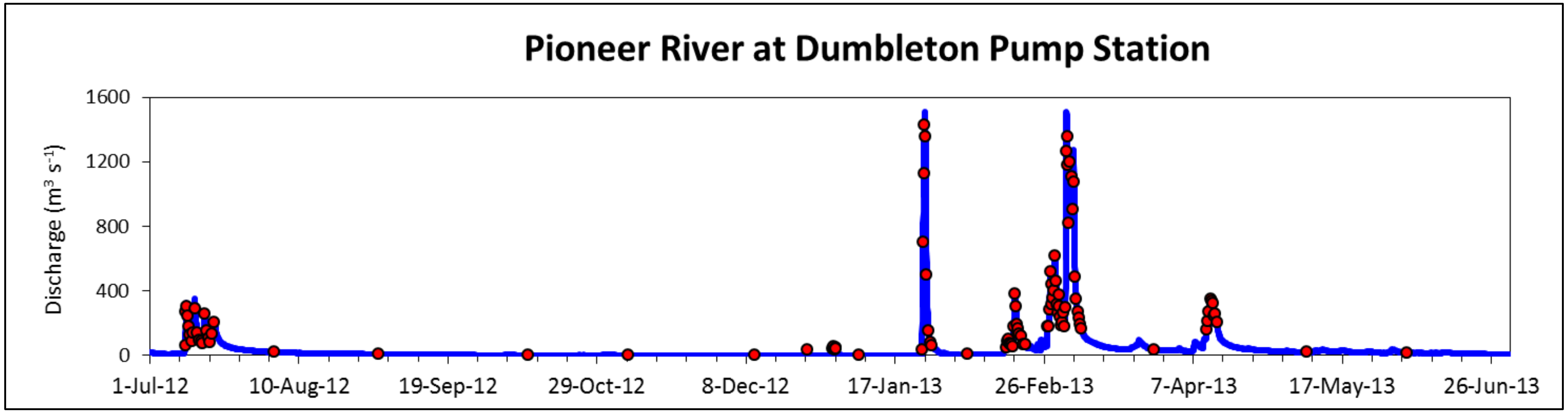

Figure 7.19 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients and photosystem II inhibiting herbicides (red circles) in the Pioneer River at Dumbleton Pump Station between 1 July 2012 and 30 June 2013. Representivity rating was excellent for all analytes (excluding photosystem II inhibiting herbicides).

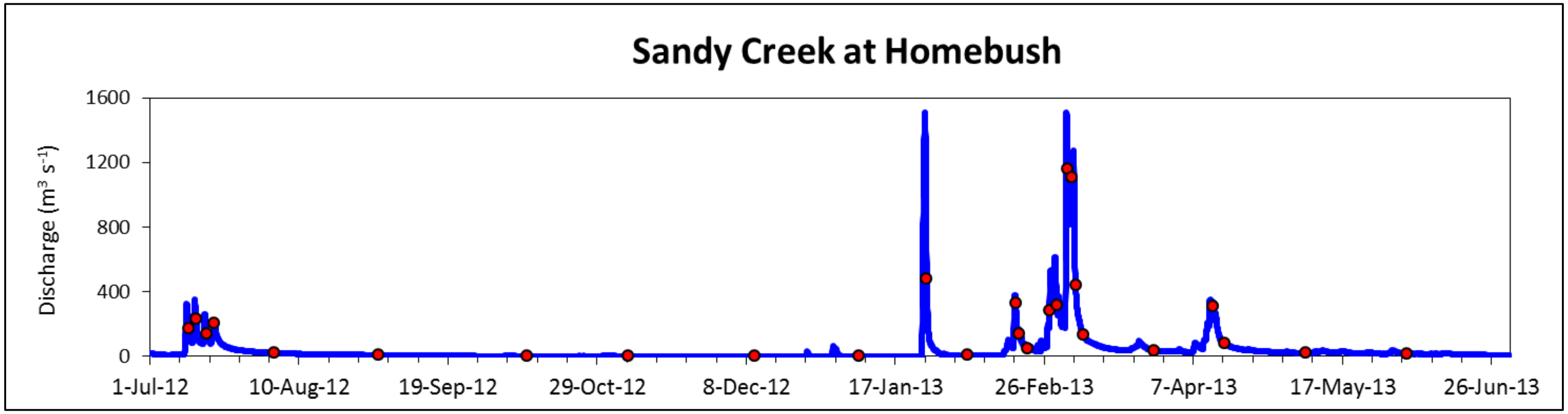

Figure 7.20 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients and photosystem II inhibiting herbicides (red circles) in Sandy Creek at Homebush between 1 July 2012 and 30 June 2013. Representivity rating was good for all analytes (excluding photosystem II inhibiting herbicides).

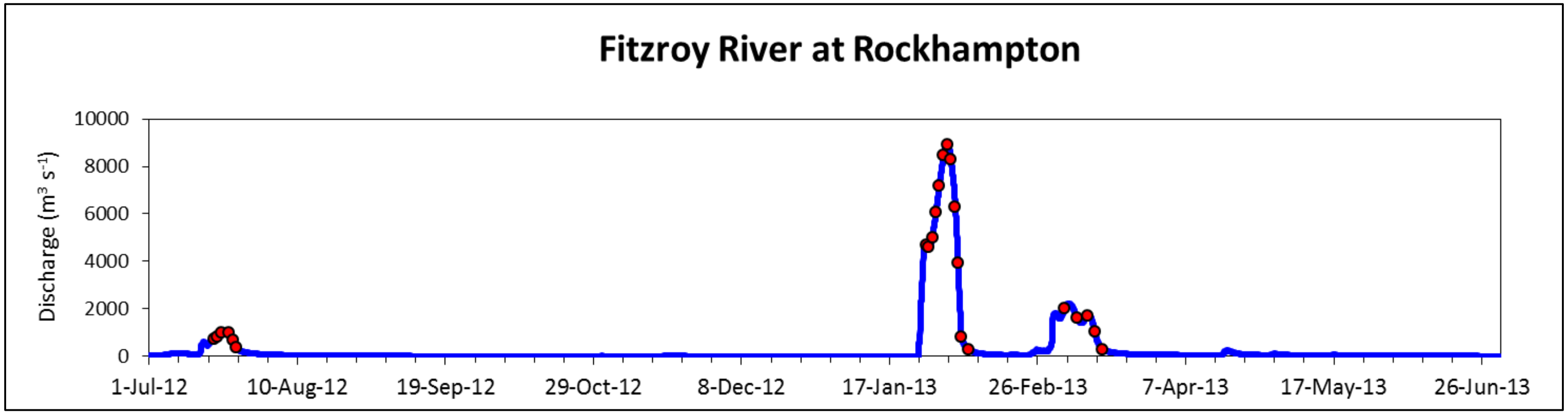

Figure 7.21 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients and photosystem II inhibiting herbicides (red circles) in the Fitzroy River at Rockhampton between 1 July 2012 and 30 June 2013. Representivity rating was good for all analytes (excluding photosystem II inhibiting herbicides).

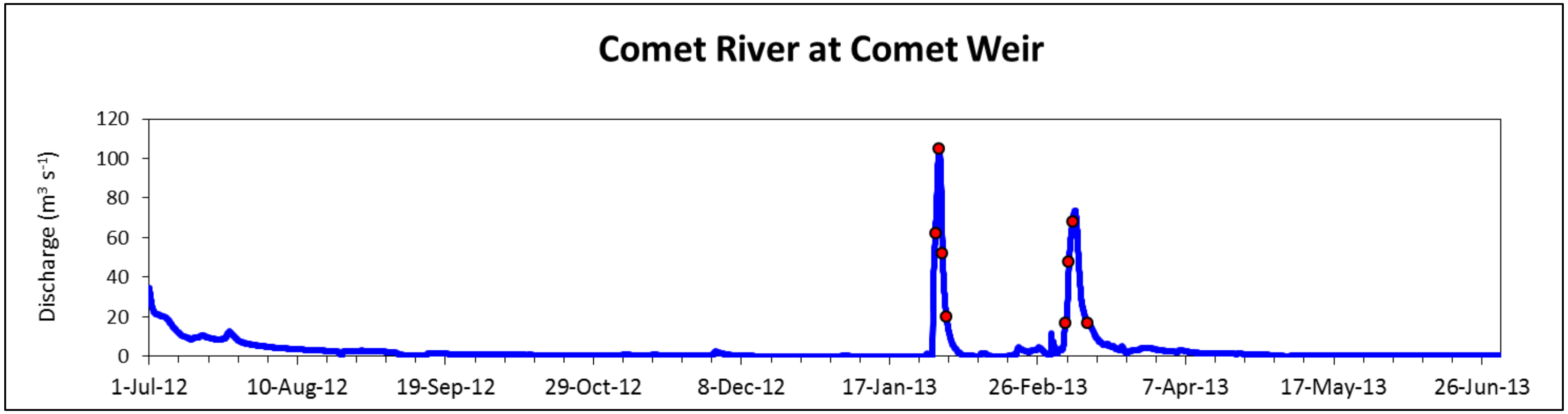

Figure 7.22 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients and photosystem II inhibiting herbicides (red circles) in the Comet River at Comet Weir between 1 July 2011 and 30 June 2012. Representivity rating was good for all analytes.

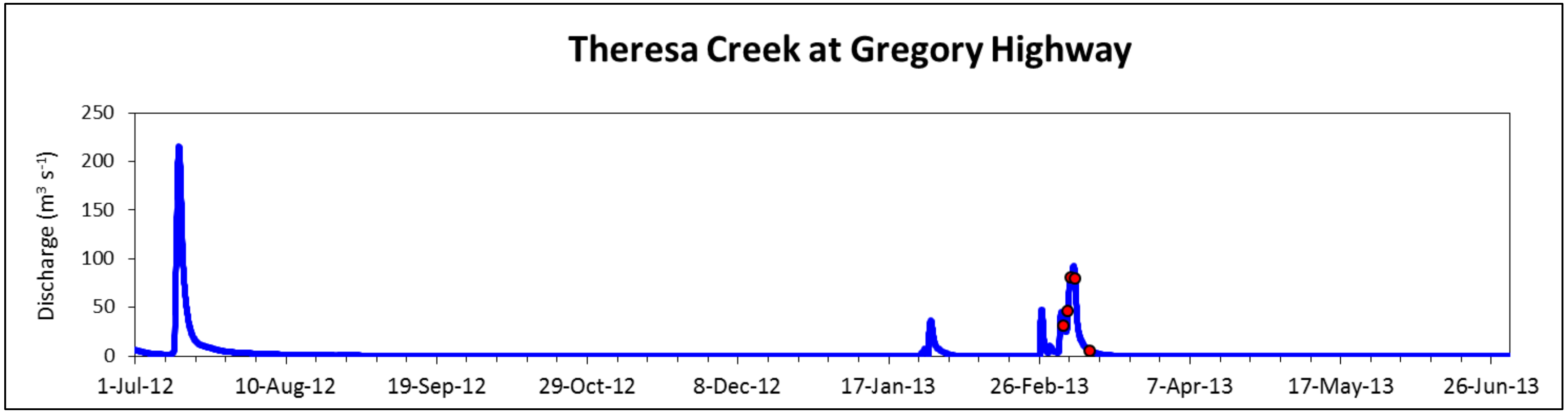

Figure 7.23 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients and photosystem II inhibiting herbicides (red circles) in Theresa Creek at Gregory Highway between 1 July 2011 and 30 June 2012. Representivity rating was indicative for all analytes.

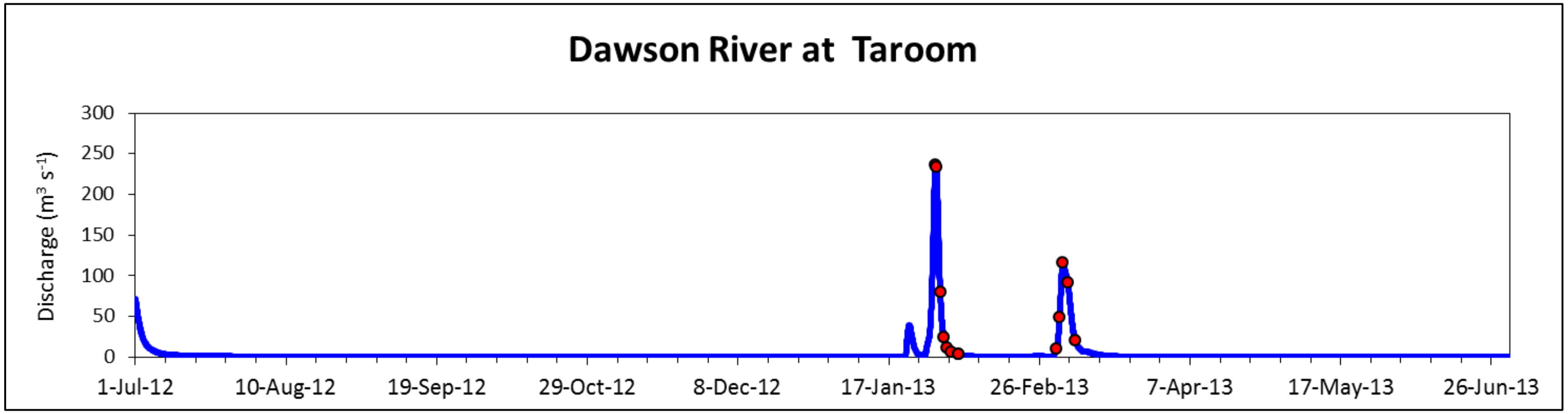

Figure 7.24 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Dawson River at Taroom between 1 July 2012 and 30 June 2013. Representivity rating was good for all analytes.

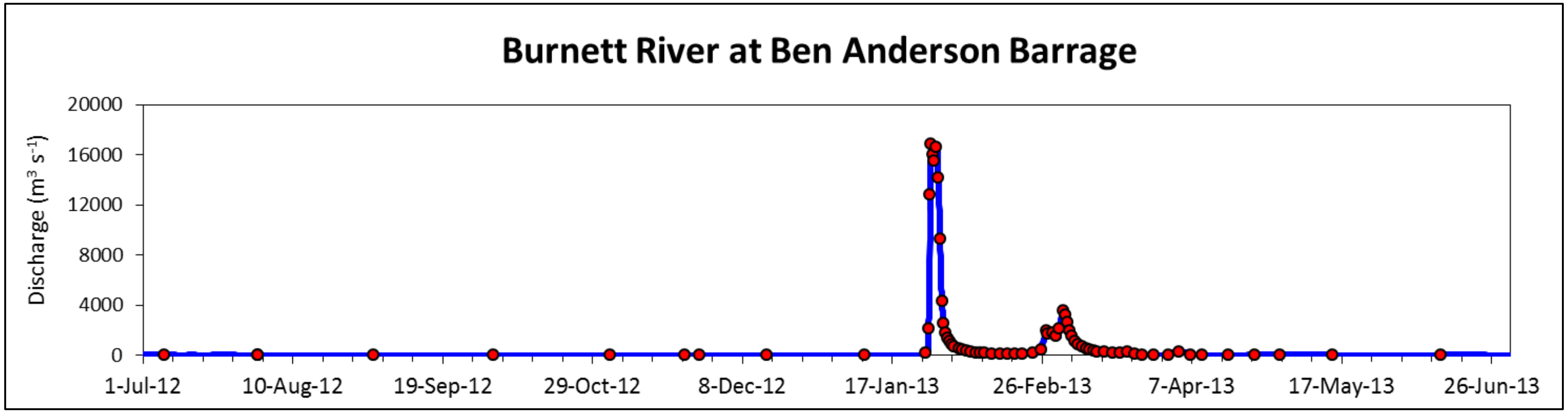

Figure 7.25 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients and photosystem II inhibiting herbicides (red circles) in the Burnett River at Ben Anderson Barrage between 1 July 2011 and 30 June 2012. Representivity rating was excellent for all analytes (excluding photosystem II inhibiting herbicides).

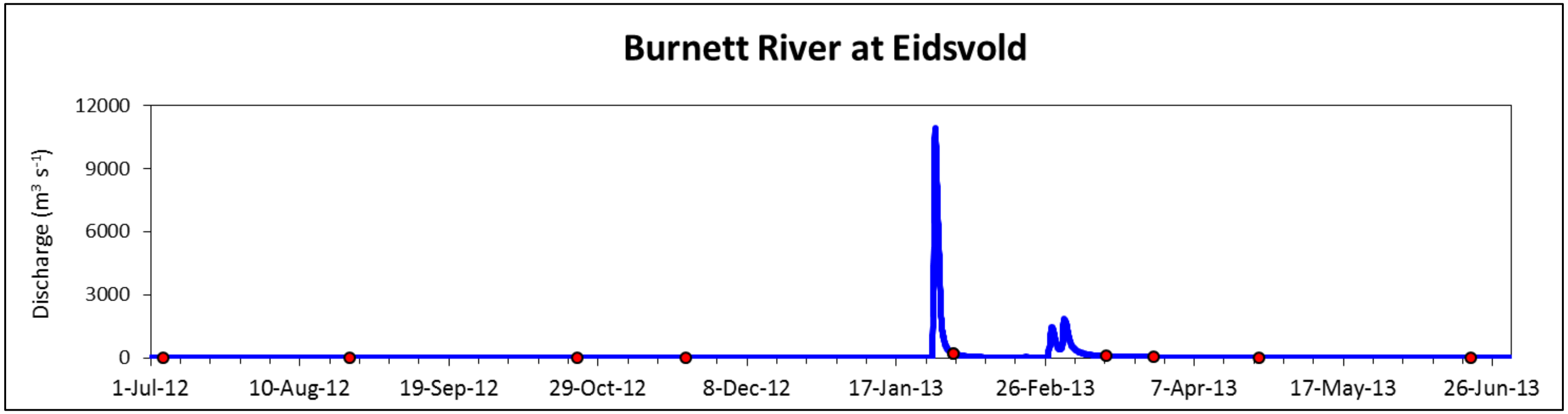

Figure 7.26 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Burnett River at Eidsvold between 1 July 2012 and 30 June 2013. Representivity rating was indicative for all analytes.

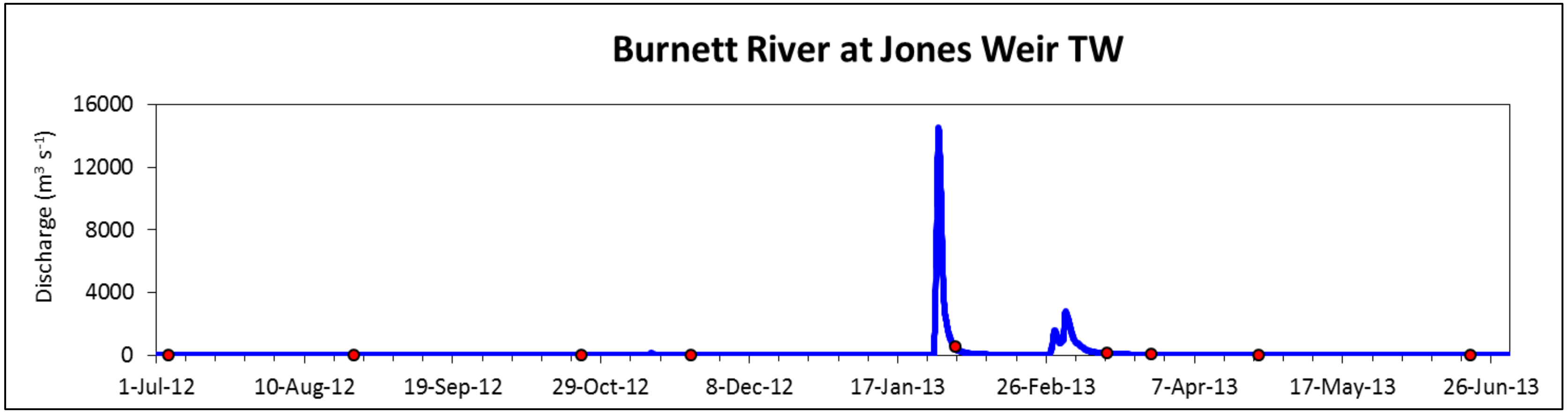

Figure 7.27 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Burnett River at Jones Weir Tail Water between 1 July 2012 and 30 June 2013. Representivity rating was indicative for all analytes.

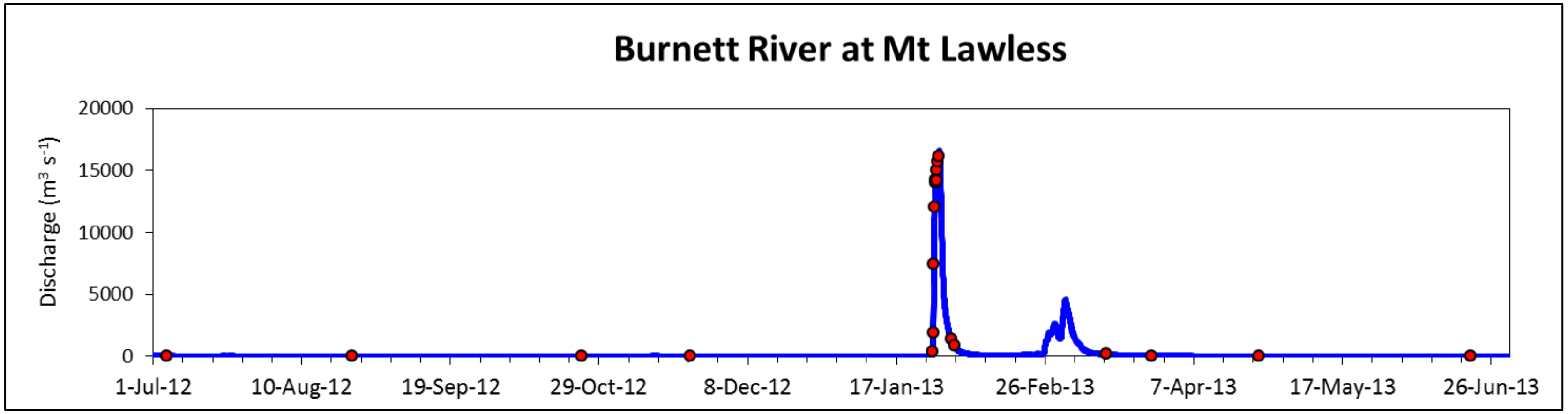

Figure 7.28 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Burnett River at Mt Lawless between 1 July 2011 and 30 June 2012. Representivity rating was good for total suspended solids and total nutrients and indicative for dissolve and particulate nutrients.

Appendix E Revised land use yields of priority photosystem II inhibiting herbicides for the 2010–2011 and 2011–2012 monitoring years

The calculation of land use yields of the priority photosystem II inhibiting herbicides applies a binary code to link priority photosystem II herbicides to the aggregated land use categories (see Section 2.7.3.2). The binary coding that has been applied in the calculation of land use yields in this report represents the outcome of an internal review and consultation with peak industry bodies. The revised binary coding applied to the calculation of land use yields is presented in Table 2.6.

To allow comparison with land use yields previously reported by the Great Barrier Reef Catchment Loads Monitoring Program, land use yields of the 2010–2011 and 2011–2012 monitoring years have been recalculated using the revised binary coding (see Table 2.6). The revised land use yield for the 2010–2011 and 2011–2012 monitoring years are presented in Table 7.6.

Table 7.6 The recalculated monitored annual land use yields for the five priority photosystem II inhibiting herbicides: ametryn, total atrazine, diuron, hexazinone and tebuthiuron for the 2010–2011 and 2011–2012 monitoring years. All sites and land use yields in bold are end-of-system sites and the corresponding data.

PSII herbicide	Registered land use types	River and site name	2010–2011 land use yield (kg km^{-2})	2011–2012 land use yield (kg km^{-2})
Ametryn	Sugarcane	North Johnstone River at Goondi Bridge[B,B]	NC	NC
		Tully River at Euramo[B,B]	**NC**	**0.042**
		Herbert River at Ingham[B,L]	**0.070**	**0.015**
		Barratta Creek at Northcote[B,L]	**0.0075**	**0.017**
		Burdekin River at Home Hill[L,L]	**NC**	**0.20**
		Pioneer River at Dumbleton Pump Station[L,L]	**0.24**	**0.028**
		Sandy Creek at Homebush[B,B]	**0.21**	**0.019**
		Fitzroy River at Rockhampton[L,L]	**NC**	**NC**
		Burnett River at Ben Anderson Barrage Head Water[L,L]	**NC**	**NC**
Total atrazine	Cropping, forestry and sugarcane	North Johnstone River at Goondi Bridge[B,B]	1.6	0.82
		Tully River at Euramo[B,B]	**0.58**	**0.79**
		Herbert River at Ingham[B,L]	**0.15**	**0.070**
		Barratta Creek at Northcote[B,L]	**1.9**	**1.4**
		Burdekin River at Home Hill[L,L]	**0.032**	**0.16**
		Pioneer River at Dumbleton Pump Station[L,L]	**0.78**	**0.33**
		Sandy Creek at Homebush[B,B]	**1.2**	**0.31**
		Fitzroy River at Rockhampton[L,L]	**0.13**	**0.055**
		Burnett River at Ben Anderson Barrage Head Water[L,L]	**0.037**	**0.0019**
Diuron	Cropping, horticulture and sugarcane	North Johnstone River at Goondi Bridge[B,B]	0.87	0.48
		Tully River at Euramo[B,B]	**1.0**	**1.1**
		Herbert River at Ingham[B,L]	**0.47**	**0.54**
		Barratta Creek at Northcote[B,L]	**0.30**	**0.39**
		Burdekin River at Home Hill[L,L]	**NC**	**0.020**
		Pioneer River at Dumbleton Pump Station[L,L]	**1.7**	**0.45**
		Sandy Creek at Homebush[B,B]	**2.2**	**0.35**
		Fitzroy River at Rockhampton[L,L]	**0.014**	**0.0072**
		Burnett River at Ben Anderson Barrage Head Water[L,L]	**0.046**	**0.0089**
Hexazinone	Forestry, grazing and sugarcane	North Johnstone River at Goondi Bridge[B,B]	0.0026	NC
		Tully River at Euramo[B,B]	**0.46**	**0.38**
		Herbert River at Ingham[B,L]	**0.0069**	**0.0082**
		Barratta Creek at Northcote[B,L]	**0.023**	**0.0040**
		Burdekin River at Home Hill[L,L]	**NC**	**NC**
		Pioneer River at Dumbleton Pump Station[L,L]	**0.11**	**0.023**
		Sandy Creek at Homebush[B,B]	**0.34**	**0.054**
		Fitzroy River at Rockhampton[L,L]	**0.00022**	**NC**
		Burnett River at Ben Anderson Barrage Head Water[L,L]	**0.0019**	**0.00019**
Tebuthiuron	Grazing	North Johnstone River at Goondi Bridge[B,B]	NC	0.00080
		Tully River at Euramo[B,B]	**NC**	**0.059**
		Herbert River at Ingham[B,L]	**NC**	**NC**
		Barratta Creek at Northcote[B,L]	**0.0017**	**0.0022**
		Burdekin River at Home Hill[L,L]	**0.0068**	**0.0019**
		Pioneer River at Dumbleton Pump Station[L,L]	**NC**	**0.0018**
		Sandy Creek at Homebush[B,B]	**NC**	**NC**
		Fitzroy River at Rockhampton[L,L]	**0.054**	**0.0080**
		Burnett River at Ben Anderson Barrage Head Water[L,L]	**0.0051**	**0.000067**

[L] = average load (linear interpolation of concentration) method used to calculate loads in the 2010–2011 and 2011–2012 years respectively; [B] = Beale ratio method used to calculate loads in the 2010–2011 and 2011–2012 years respectively.

Appendix F Representivity rating of all monitored annual total suspended solids and nutrient loads

Table 7.7 The number of samples collected and the representivity rating for monitored sites in 2012–2013. Text in bold are end-of-system sites and the corresponding data, all others are sub-catchment sites.

NRM region	Catchment	Gauging station	River and site name	TSS		TN		PN		NO_x-N		NH_4-N		DIN	
				n	Rating	n	Rating	n	Rating	n	Rating	n	Rating	n	Rating
Cape York	**Normanby**	**105107A**	**Normanby River at Kalpowar Crossing**	**7**	**good**	**0**		**0**		**0**		**0**		**0**	
Wet Tropics	**Barron**	**110001D**	**Barron River at Myola**	**28**	**excellent**	**28**	**excellent**	**28**	**excellent**	**28**	**excellent**	**28**	**excellent**	**28**	**excellent**
	Johnstone	112004A	North Johnstone River at Tung Oil[$]	34	good	34	good	34	good	34	good	34	good	34	good
		112101B	South Johnstone River at Upstream Central Mill[$]	47	excellent	47	excellent	47	excellent	47	excellent	47	excellent	47	excellent
	Tully	**113006A**	**Tully River at Euramo**	**161**	**excellent**	**161**	**excellent**	**161**	**excellent**	**161**	**excellent**	**161**	**excellent**	**161**	**excellent**
		113015A	Tully River at Tully Gorge National Park	34	moderate	34	moderate	34	moderate	34	moderate	34	moderate	34	moderate
	Herbert	**116001F**	**Herbert River at Ingham**	**45**	**good**	**45**	**good**	**45**	**good**	**45**	**good**	**45**	**good**	**45**	**good**
Burdekin	**Haughton**	**119101A**	**Barratta Creek at Northcote**	**43**	**excellent**	**43**	**excellent**	**43**	**excellent**	**43**	**excellent**	**43**	**excellent**	**43**	**excellent**
	Burdekin	**120001A**	**Burdekin River at Home Hill**	**29**	**good**	**29**	**good**	**29**	**good**	**29**	**good**	**29**	**good**	**29**	**good**
		120002C	Burdekin River at Sellheim	13	moderate	13	moderate	13	moderate	13	moderate	13	moderate	13	moderate
		120205A	Bowen River at Myuna	47	excellent	47	excellent	47	excellent	47	excellent	47	excellent	47	excellent
		120301B	Belyando River at Gregory Development Road	13	good	12	good	12	good	12	good	12	good	12	good
		120302B	Cape River at Taemas	18	good	18	good	18	good	18	good	18	good	18	good
		120310A	Suttor River at Bowen Development Road	20	good	20	good	20	good	20	good	20	good	20	good
Mackay Whitsunday	**Pioneer**	**125013A**	**Pioneer River at Dumbleton Pump Station**	**104**	**excellent**	**104**	**excellent**	**103**	**excellent**	**104**	**excellent**	**104**	**excellent**	**104**	**excellent**
	Plane	**126001A**	**Sandy Creek at Homebush**	**26**	**good**	**26**	**good**	**26**	**good**	**26**	**good**	**26**	**good**	**26**	**good**
Fitzroy	**Fitzroy**	**1300000**	**Fitzroy River at Rockhampton**	**23**	**good**	**23**	**good**	**23**	**good**	**23**	**good**	**23**	**good**	**23**	**good**
		130206A	Theresa Creek at Gregory Highway	5	indicative	5	indicative	5	indicative	5	indicative	5	indicative	5	indicative
		130302A	Dawson River at Taroom	13	good	13	good	12	good	13	good	13	good	13	good
		130504B	Comet River at Comet Weir	8	good	8	good	8	good	8	good	8	good	8	good
Burnett Mary	**Burnett**	**136014A**	**Burnett River at Ben Anderson Barrage Head Water**	**73**	**excellent**	**72**	**excellent**	**72**	**excellent**	**73**	**excellent**	**73**	**excellent**	**73**	**excellent**
		136002D	Burnett River at Mt Lawless	20	indicative	20	indicative	10	indicative	10	indicative	10	indicative	10	indicative
		136094A	Burnett River at Jones Weir Tail Water	9	indicative	9	indicative	9	indicative	9	indicative	9	indicative	9	indicative
		136106A	Burnett River at Eidsvold	10	indicative	10	indicative	10	indicative	10	indicative	10	indicative	10	indicative

n = number of concentration data points used in the calculation of loads; TSS = total suspended solids; TN = total nitrogen; PN = particulate nitrogen; NO_x-N = oxidised nitrogen as N; NH_4-N = ammonium nitrogen as N; DIN = dissolved inorganic nitrogen (DIN = (NO_x-N) + (NH_4-N)); DON = dissolved organic nitrogen; TP = total phosphorus; DIP = dissolved inorganic phosphorus; PP = particulate phosphorus; DOP = dissolved organic phosphorus; and [$] = the North and South Johnstone rivers combined act as an end-of-system site.

Table 7.8 The number of samples collected and the representivity rating for monitored sites in 2012–2013. Text in bold are end-of-system sites and the corresponding data, all others are sub-catchment sites.

NRM region	Catchment	Gauging station	River and site name	DON		TP		DIP		PP		DOP	
				n	Rating	n	Rating	n	Rating	n	Rating	n	Rating
Cape York	**Normanby**	**105107A**	**Normanby River at Kalpowar Crossing**	**0**		**0**		**0**		**0**		**0**	
Wet Tropics	**Barron**	**110001D**	**Barron River at Myola**	**28**	**excellent**	**28**	**excellent**	**28**	**excellent**	**28**	**excellent**	**28**	**excellent**
	Johnstone	112004A	North Johnstone River at Tung Oil[$]	34	good	34	good	34	good	34	good	34	good
		112101B	South Johnstone River at Upstream Central Mill[$]	47	excellent	47	excellent	47	excellent	47	excellent	47	excellent
	Tully	**113006A**	**Tully River at Euramo**	**161**	**excellent**	**161**	**excellent**	**161**	**excellent**	**161**	**excellent**	**161**	**excellent**
		113015A	Tully River at Tully Gorge National Park	34	moderate	34	moderate	34	moderate	34	moderate	34	moderate
	Herbert	**116001F**	**Herbert River at Ingham**	**45**	**good**	**45**	**good**	**45**	**good**	**45**	**good**	**45**	**good**
Burdekin	**Haughton**	**119101A**	**Barratta Creek at Northcote**	**43**	**excellent**	**43**	**excellent**	**43**	**excellent**	**43**	**excellent**	**43**	**excellent**
	Burdekin	**120001A**	**Burdekin River at Home Hill**	**29**	**good**	**29**	**good**	**29**	**good**	**29**	**good**	**29**	**good**
		120002C	Burdekin River at Sellheim	13	moderate	13	moderate	13	moderate	13	moderate	13	moderate
		120205A	Bowen River at Myuna	47	excellent	47	excellent	47	excellent	47	excellent	47	excellent
		120301B	Belyando River at Gregory Development Road	12	good	12	good	12	good	12	good	12	good
		120302B	Cape River at Taemas	18	good	18	good	18	good	18	good	18	good
		120310A	Suttor River at Bowen Development Road	20	good	20	good	20	good	20	good	20	good
Mackay Whitsunday	**Pioneer**	**125013A**	**Pioneer River at Dumbleton Pump Station**	**103**	**excellent**	**104**	**excellent**	**104**	**excellent**	**103**	**excellent**	**103**	**excellent**
	Plane	**126001A**	**Sandy Creek at Homebush**	**26**	**good**	**26**	**good**	**26**	**good**	**26**	**good**	**26**	**good**
Fitzroy	**Fitzroy**	**1300000**	**Fitzroy River at Rockhampton**	**23**	**good**	**23**	**good**	**23**	**good**	**23**	**good**	**23**	**good**
		130206A	Theresa Creek at Gregory Highway	5	indicative	5	indicative	5	indicative	5	indicative	5	indicative
		130302A	Dawson River at Taroom	12	good	13	good	13	good	12	good	12	good
		130504B	Comet River at Comet Weir	8	good	8	good	8	good	8	good	8	good
Burnett Mary	**Burnett**	**136014A**	**Burnett River at Ben Anderson Barrage Head Water**	**72**	**excellent**	**72**	**excellent**	**73**	**excellent**	**72**	**excellent**	**72**	**excellent**
		136002D	Burnett River at Mt Lawless	10	indicative	20	indicative	10	indicative	10	indicative	10	indicative
		136094A	Burnett River at Jones Weir Tail Water	9	indicative	9	indicative	9	indicative	9	indicative	9	indicative
		136106A	Burnett River at Eidsvold	10	indicative	10	indicative	10	indicative	10	indicative	10	indicative

n = the number of concentration data points used for the load calculation; TSS = total suspended solids; TN = total nitrogen; PN = particulate nitrogen; NO_x-N = oxidised nitrogen as N; NH_4-N = ammonium nitrogen as N; DIN = dissolved inorganic nitrogen (DIN = (NO_x-N) + (NH_4-N)); DON = dissolved organic nitrogen; TP = total phosphorus; DIP = dissolved inorganic phosphorus; PP = particulate phosphorus; DOP = dissolved organic phosphorus; and [$] = the North and South Johnstone rivers combined act as an end-of-system site.