Total suspended solids, nutrient and pesticide loads (2015–2016) for rivers that discharge to the Great Barrier Reef – Great Barrier Reef Catchment Loads Monitoring Program.

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Reef Water Quality Protection Plan

Total suspended solids, nutrient and pesticide loads (2015–2016) for rivers that discharge to the Great Barrier Reef

Great Barrier Reef Catchment Loads Monitoring Program

Australian Government

Queensland Government

Prepared by

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Executive summary

Poor water quality within the Great Barrier Reef lagoon, which occurs as a consequence of the export of diffuse pollutants from catchments, is a significant threat to the health and resilience of the Reef. Sediment, nutrients and pesticides leaving agricultural land have been identified as the most significant cause of poor water quality within the Reef lagoon (Brodie et al. 2013a). The Reef Water Quality Protection Plan 2013 (Reef Plan 2013), has the long-term goal of '*ensuring that by 2020 the quality of water entering the Reef from broad scale land use has no detrimental effect on the health and resilience of the Great Barrier Reef*' (DPC 2013a).

Reef Plan 2013 established new land and catchment management targets and water quality targets that are measured against baseline conditions outlined in the preceding Reef Water Quality Protection Plan 2009. These reduction targets, to be achieved in 2018, are: at least a 20 per cent reduction in anthropogenic end-of-catchment loads of sediment and particulate nutrients; at least a 50 per cent reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads; and at least a 60 per cent reduction in end-of-catchment pesticide loads.

Progress towards the Reef Plan 2013 water quality targets is measured based on modelled values (Waters et al. 2014) through the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (Paddock to Reef Program) and reported via annual Report Cards (SoQ 2016b). The Paddock to Reef Program also includes catchment scale water quality monitoring of pollutant loads entering the Great Barrier Reef lagoon. This monitoring program is implemented through the Great Barrier Reef Catchment Loads Monitoring Program.

Under Reef Plan 2013, pollutant loads are calculated annually by the Great Barrier Reef Catchment Loads Monitoring Program in the following natural resource management regions and priority basins:

- Cape York region – Normanby Basin
- Wet Tropics region – Barron, Mulgrave-Russell, Johnstone, Tully and Herbert basins
- Burdekin region – Burdekin and Haughton basins
- Mackay Whitsunday region – O'Connell, Pioneer and Plane basins
- Fitzroy region – Fitzroy Basin
- Burnett Mary region – Burnett and Mary basins.

This report presents annual loads calculated using monitoring data (monitored annual loads) collected during the 2015–2016 monitoring year (i.e. 1 July 2015 to 30 June 2016). The data made available through the Great Barrier Reef Catchment Loads Monitoring Program provides a foundation to validate the catchment models used to monitor progress against Reef Plan 2013 water quality targets, and thus assist in the effective management of Queensland and Australian natural resources. Reef Plan 2013 targets are based on reductions in anthropogenic loads, monitored annual loads do not define the anthropogenic or natural components of the loads.

During the 2015–2016 monitoring year, 17 end-of-catchment sites and nine sub-catchment sites across the 14 basins, were monitored for total suspended solids and nutrients. Pesticides were monitored at a sub-set of 15 end-of-catchment sites and two sub-catchment sites across 12 basins (pesticides were not monitored in the Normanby and Barron basins).

Total annual rainfall was average in the monitored catchments of the Cape York and Mackay Whitsunday natural resource management regions. The monitored catchments of the Wet Tropics received below average to very much below average rainfall. Total annual rainfall was below average in much of the Burdekin region, but average in southern areas of the Burdekin catchment. The Fitzroy and Burnett Mary regions generally received average to below average rainfall.

During the 2015–2016 monitoring year, all monitored reef catchments recorded annual discharges that were below the long-term mean. The annual discharges in the Barron, Mary, Barratta Creek and Tinana Creek catchments as well as sub-catchment sites in the Tully, Fitzroy (with the exception of the Dawson River) and Burnett catchments were the lowest recorded since water quality monitoring in these catchments commenced under the Great Barrier Reef Catchment Loads Program in 2009.

Across the six natural resource management regions, monitored catchments generated approximately 1.8 million tonnes of total suspended solids, 11,000 tonnes of total nitrogen and 2300 tonnes of total phosphorus. The Burdekin catchment generated the largest proportion of total suspended solids, with similarly high loads generated by the Fitzroy catchment (38 per cent and 37 per cent of the total monitored load respectively). The Fitzroy catchment also contributed the largest proportion to the combined loads of total nitrogen (29 per cent) and total phosphorus (40 per cent) followed by the Burdekin catchment (14 per cent and 20 per cent respectively). Substantial contributions of total nitrogen were also made by the Tully (10 per cent) and Normanby (8.3 per cent) catchments. The largest contributions to the combined total loads of particulate nitrogen and particulate phosphorus were made by the Fitzroy (36 percent and 42 per cent, respectively) and Burdekin (19 per cent and 23 per cent, respectively) catchments followed by the Johnstone (6.7 per cent and 7.2 per cent, respectively) catchment. Over half the combined load of dissolved inorganic nitrogen was derived from the Wet Tropics (51 per cent) region; substantial contributions were made by the Tully (18 per cent) and Russell (11 per cent) catchments. Generally, the Tinana Creek catchment in the Mary basin generated the smallest loads of all monitored analytes.

Catchment yields (the load divided by the monitored surface area of the catchment) provide a measure of the supply of pollutants from monitored catchments. This metric allows a comparison of the rate of pollutant delivery between catchments standardised by area. Of the monitored end-of-catchment sites, the highest monitored yield of total suspended solids occurred in the Russell catchment within the Mulgrave-Russell Basin. The Russell catchment also produced the highest monitored yields of all forms of nitrogen and phosphorus, with the exception of dissolved inorganic phosphorus in which the Sandy Creek catchment produced the highest yield. The Tully catchment also produced high yields of total nitrogen, dissolved inorganic nitrogen and dissolved organic nitrogen and the Johnstone catchment of total phosphorus and dissolved organic phosphorus.

The total monitored annual loads of photosystem II inhibiting herbicides[1] were (from largest to smallest): 1000 kg of tebuthiuron; 780 kg of total atrazine; 660 kg of total diuron; 260 kg of hexazinone; and 4.5 kg of ametryn. The combined toxicity-based load (toxic pesticide load[2]) of all monitored catchments was 750 kg TEq_{diuron}, with total diuron accounting for 87 per cent or 650 kg TEq_{diuron}. The Pioneer (180 kg TEq_{diuron}) and Tully (150 kg TEq_{diuron}) catchments produced the largest toxic pesticide load accounting for 44 per cent of the combined monitored toxic pesticide load.

The highest land use yields (the load divided by the total surface area of land uses where the pesticide is registered for use) of ametryn were in the Mulgrave and Tinana Creek catchments. Consistent with the previous monitoring year, the Barratta Creek catchment produced the highest yield of total atrazine, which was double the yield monitored in all other catchments. The highest land use yields of total diuron occurred in the Russell catchment which was also the case during the 2014–2015 monitoring year, although the yield was less than half of that recorded in 2014–2015. The highest monitored land use yields of hexazinone were in the Tully and Russell catchments. The highest land use yield of tebuthiuron was in the Fitzroy catchment, which also produced the largest monitored annual load of tebuthiuron.

This is the seventh technical report to be released by the Great Barrier Reef Catchment Loads Monitoring Program and the third under Reef Plan 2013. Access to water quality data associated with the Great Barrier Reef Catchment Loads Monitoring Program can be requested by completing the scientific data supply form available on the Queensland Government website (https://www.qld.gov.au/dsiti/science-innovation/science/services/sci-reefsds-form) (SoQ 2017).

In order to maintain consistency in the reported data, the underlying methods of the Great Barrier Reef Catchment Loads Monitoring Program have not changed substantially over the years. Improvements to the Program are ongoing and during the 2015–2016 monitoring year this included the commissioning of a new monitoring site in the lower Johnstone catchment. The capital cost of this site was co-funded by Terrain NRM and the Department of Environment and Science.

[1] Photosystem II herbicides inhibit electron transport in the photosystem II reaction centre (located in the thylakoid membranes), which is required for converting light into chemical energy in plant photosynthesis.

[2] A toxic pesticide load is the combined load of a group of pesticides that have been converted to the mass of one particular pesticide (diuron) based on the pesticides' relative toxicities.

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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). Its ecological, social and economic importance is widely acknowledged (DPC 2013a). In economic terms, Deloitte Access Economics has estimated the Great Barrier Reef is worth $56 billion and contributes approximately $6.4 billion annually to the Australian economy and supports 64,000 jobs (Deloitte Access Economics 2017). Poor water quality caused by pollutant runoff exported from catchments adjacent to the Great Barrier Reef is considered one of the most significant threats to the Great Barrier Reef World Heritage Area (Wachenfeld et al. 1998; State of Queensland and Commonwealth of Australia 2003; Wooldridge et al. 2006; Brodie et al. 2008, 2009, 2010, 2013a and 2013b; DPC 2008, 2009a and 2013a; Hunter and Walton 2008; Packett et al. 2009; Schaffelke et al. 2013). Agricultural land has been identified as the major source of these pollutants (e.g. Brodie et al. 2013a; Brodie et al. 2013b; Schaffelke et al. 2013).

In 2015, the Australian and Queensland government released the *Reef 2050 Long-Term Sustainability Plan*, which is an overarching framework to protect and manage the Great Barrier Reef from 2015–2050 (DPC 2013a). This plan is a response to the challenge of managing the health of the Great Barrier Reef in order to protect the Outstanding Universal Values identified in the World Heritage listing, whilst allowing continued sustainable development and use of this natural resource. The *Reef 2050 Long-Term Sustainability Plan* incorporates the water quality improvement goals and targets of the *Reef Water Quality Protection Plan 2013* (Reef Plan) (DPC 2013a).

In order to improve water quality entering the Great Barrier Reef lagoon from these catchments, the Queensland and Australian governments cooperatively initiated Reef Plan (DPC 2003), which was updated in 2009 (DPC 2009a) and 2013 (DPC 2013a) as part of a commitment towards refining its approach and targets as new information emerged. Reef Plan 2009 held the short-term goal of halting and reversing the decline in water quality entering the Great Barrier Reef lagoon. Reef Plan 2013 builds on the earlier plan and includes refined land and catchment management targets, and water quality targets to be achieved by 2018.

The Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (Paddock to Reef Program) measures and reports progress towards the Reef Plan goal and targets through annual publication of a report card. The Paddock to Reef program is a collaboration involving governments, industry, regional natural resource management bodies, landholders and research organisations (DPC 2009b, 2013b). 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.

The Great Barrier Reef Catchment Loads Monitoring Program was implemented in 2005 to monitor and report on loads of total suspended solids, nutrients and pesticides and assist in evaluating progress towards the water quality targets of Reef Plan. This is the seventh Great Barrier Reef Catchment Loads Monitoring Program report and the third under Reef Plan 2013 (DPC 2013a). Financial contributions by regional stakeholders has allowed the Great Barrier Reef Catcher Reef Catchment Loads Monitoring Program to increase the number of catchments monitored under Reef Plan 2013 to 26 sites in 14 priority basins for total

suspended solids and nutrients and 17 sites in 12 basins for pesticides for the 2015–2016 monitoring year. Under Reef Plan 2009, the Great Barrier Reef Catchment Loads Monitoring Program monitored total suspended solids and nutrients at 25 sites in 11 priority basins and pesticides at 11 sites in eight priority basins (Turner et al. 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Garzon-Garcia et al. 2015).

The Great Barrier Reef Water Science Taskforce was established in May 2015 to provide advice to the Queensland Government on how to achieve the ambitious water quality targets outlined in the 2050 *Long-Term Sustainability plan*. Members of the taskforce included experts drawn from the science, business, agriculture and community sectors. A recommendation in the Great Barrier Reef Water Science Taskforce final report was to increase monitoring and modelling coverage across Reef regions (SoQ 2016a). This included a recommendation to undertake nested monitoring to track improvements from paddock/plot to sub-catchment to end-of-catchment to the receiving marine system. It was stated, "Improved alignment of monitoring will aid in determining the effectiveness of practice management change and enhance the confidence in modelled outcomes" (SoQ 2016a). Increased government funding has been allocated to expand the Great Barrier Reef Catcher Reef Catchment Loads Monitoring Program to include up to 18 new monitoring sites to align with Taskforce objectives. Through consultation with representatives of the Paddock to Reef Program, additional high priority catchment monitoring sites were identified with installation of these sites commencing in September 2016 to be reported in the 2016–2017 monitoring year.

Elevated anthropogenic loads of total suspended solids, nutrients and pesticides exported to the Great Barrier Reef lagoon since European settlement (predevelopment) has been reported extensively (e.g. Eyre 1998; Wachenfeld et al. 1998; Fabricius et al. 2005; McKergow et al. 2005; Hunter and Walton 2008; Packett et al. 2009; Brodie et al. 2010; DPC 2011; Joo et al. 2011; Smith et al. 2012; Turner et al. 2012 and 2013; Kroon et al. 2010, 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Waters et al. 2014; Garzon-Garcia et al. 2015; McCloskey et al. 2017). The anthropogenic load of total suspended solids exported to the Great Barrier Reef is estimated to have increased by 4.0 times over the predevelopment load (McCloskey et al. 2017). McCloskey et al. (2017) also reports an increase above predevelopment load for total phosphorus (1.9 times) and similar anthropogenic and predevelopment loads for both total nitrogen (1.1 times larger than the predevelopment load) and equivalent loads for dissolved inorganic nitrogen. These estimates of the increase since pre-European times are considerably smaller than the earlier estimates of McKergow et al. (2005) and Kroon et al. (2010). Pesticides were not present before European settlement.

There are 35 basins that flow into the Great Barrier Reef lagoon and cover an area of approximately 424,000 square kilometres (DPC 2011). These basins extend from the tropics to the subtropics and cover over 1,500 kilometres of the eastern coastline of Queensland (DPC 2011). Across the study area, there are substantial climatic, hydrological and geological differences within and between basins and their catchments. These factors contribute to a high variation in river discharge and pollutant loads measured between catchments and years (Furnas et al. 1997; Devlin and Brodie 2005; Joo et al. 2012; Smith et al. 2012; Turner et al. 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Garzon-Garcia et al. 2015). The majority of pollutant loads are generated during the wet season, typically as runoff during high flow 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, 2015 and 2016; Garzon-Garcia et al. 2015).

Of the 35 basins, 14 priority basins, covering approximately 81 per cent of the total area, were monitored by the Great Barrier Reef Catchment Loads Monitoring Program in the 2015–2016 monitoring year. These priority basins were selected based on the Paddock to Reef Program Design 2013–2018 (DPC 2013b), which targets high priority areas. The 14 priority basins and the natural resource management regions in which they occur are the:

- Cape York region – Normanby Basin
- Wet Tropics region – Barron, Mulgrave-Russell, Johnstone, Tully and Herbert basins
- Burdekin region – Burdekin and Haughton basins
- Mackay Whitsunday region – O'Connell, Pioneer and Plane basins
- Fitzroy region – Fitzroy Basin
- Burnett Mary region – Burnett and Mary basins.

Grazing is the single largest land use within the Great Barrier Reef catchments (DPC 2011), accounting for around 80 per cent of the total area (DSITI 2016). Other significant land uses include conservation, forestry, sugarcane, horticulture and other cropping. In the Cape York region, the Normanby Basin is dominated by grazing and a large amount of land set aside for conservation in State protected areas. In the Wet Tropics region 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 basins. Within the Mackay Whitsunday region the O'Connell, Pioneer and Plane basins are dominated by grazing. This region also contains relatively large areas of sugarcane cultivation along the coastline and nature conservation. Grazing, dry land cropping, irrigated cotton and forestry 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 presents monitored annual loads and yields (the load divided by the monitored surface area of the catchment) of sediments (measured as total suspended solids) and nutrients for 17 end-of-catchment sites and nine sub-catchment sites across the 14 priority basins. The monitored annual pesticide loads and the annual toxic pesticide loads are also presented for the sub-set of 15 end-of-catchment sites and two sub-catchment sites across 12 priority basins (pesticides are not monitored in the Normanby and Barron basins). The loads of total suspended solids, nutrients and pesticides were calculated using the same methods in each of the technical reports issued under the Great Barrier Reef Catchment Loads Monitoring Program (Turner et al. 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Garzon-Garcia et al. 2015) and the toxic pesticide loads were calculated following Smith et al. (2017a).

All data presented in this report are the loads and yields exported from the area upstream of the monitoring site(s) in each catchment or sub-catchment. These pollutant loads do not represent the total load discharged to the Great Barrier Reef lagoon as not all catchments that drain to the Great Barrier Reef lagoon were monitored and not all the end-of-catchment monitoring sites are located at the mouth of the river or creek (refer to Section 2.1). In the unmonitored portion of the catchment or sub-catchment there may be addition, removal, transformation or degradation of total suspended solids, nutrients and pesticides. This report does not link land use, management practice 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 calculated from monitored water quality, which provides a point of truth to validate loads predicted by the catchment models which are used to report on progress towards water quality targets in the annual Reef Plan Report Card (DPC 2011, 2013c, 2013d, DPC 2014 and 2015; SoQ 2016b).

Previous publications 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), 2012–2013 (Wallace et al. 2015), 2013–2014 (Garzon-Garcia et al. 2015) and 2014–2015 (Wallace et al. 2016).

2. Methods

2.1 Monitoring sites

Fourteen priority basins were identified for monitoring under the Paddock to Reef Program (DPC 2013b). The majority of monitoring sites (Figure 2.1 and Table 2.1) are located at existing Queensland Government stream gauging stations installed and maintained by the Department of Natural Resources and Mines. Monitoring sites are classified as either end-of-catchment or sub-catchment sites. End-of-catchment sites are defined as sites located at the lowest point in a river or creek where the volume of water passing that point can be accurately measured and are not typically subject to tidal influence. In these cases, end-of-catchment sites are located some way upstream of the mouth of the river, and the influence of runoff from areas lower in the catchment on water quality cannot be easily assessed. Expansion of the Great Barrier Reef Catchment Loads Monitoring Program has led to the installation of automated monitoring sites further downstream in areas of tidal influence independent of the Department of Natural Resources and Mines gauging station network[3]. These end-of-catchment sites were situated to increase the area of monitored catchment, and are maintained by the Department of Science Information Technology and innovation for the Great Barrier Reef Catchment Loads Monitoring Program. All sub-catchment monitoring sites are located upstream of an end-of-catchment site monitored as part of the Great Barrier Reef Catchment Loads Monitoring Program and were selected to provide specific water quality data on various land uses or on a geographical region for enhanced validation of catchment models.

In the 2015–2016 monitoring year, a new tidally influenced end-of-catchment site in the Johnstone River was fully commissioned in partnership with Terrain Natural Resource Management (NRM). Terrain NRM requested installation of the site to enhance existing monitoring under Reef Plan 2013 and improve the current Water Quality Improvement Plan and Regional Report Card. Although both the North Johnstone and South Johnstone rivers are monitored in this priority basin, and will continue to be monitored, the addition of a monitoring site in the lower reaches of the Johnstone River captured pollutant contributions from a larger land use area than was previously possible. The structure and hydrology of the river did not allow for both flow monitoring and automated sampling equipment to be co-located. Consequently, a Horizontal

[3] Mulgrave River at Deeral, Russell River at East Russell and Johnstone River at Coquette Point.

Acoustic Doppler Current Profiler was installed in Innisfail to monitor river height, flow and discharge whereas the water quality monitoring equipment was installed four kilometres downstream at Coquette Point. The monitoring equipment located at Coquette Point was activated by the accumulation of discharge recorded at the Innisfail flow site and supported by the conductivity and turbidity readings monitored at Coquette Point. Detailed information relating to the calculation of discharge at all sites is presented in Section 2.6.

The new Johnstone River site was operational during all flow events allowing for the calculation of annual pollutant loads for the Johnstone River end-of-catchment site for the first time. Although previous reports have described both the existing North Johnstone and South Johnstone river sites as end-of-catchment sites, both will now be referred to as sub-catchment sites in this report. Summary information on each monitoring site is included in Table 2.1.

To assess progress towards Reef Plan 2013 targets, 26 sites located in 14 basins were selected to monitor total suspended solids and nutrients (Table 2.2), while 17 sites in 12 basins were selected to monitor pesticides (Table 2.2) (DPC 2013b). All sites monitored in the 2015–2016 monitoring year are the same sites monitored in the 2014–2015 monitoring year, with the inclusion of the Johnstone River end-of-catchment site.

2.2 Rainfall

Rainfall totals and rainfall decile data were obtained from the Commonwealth of Australia, Bureau of Meteorology National Climate Centre (BoM 2016a and 2016b). These data were synthesised using ArcGIS to create maps of Queensland to display total annual rainfall and annual rainfall deciles for the 2015–2016 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 (DEHP 2009). Water quality samples were collected between 1 July 2015 and 30 June 2016. Two different sampling methods were used to collect water samples – manual grab sampling and automatic grab sampling using refrigerated pump samplers. The specific sampling methods employed at each site are shown in Table 2.2. Intensive sampling (daily or every few hours) occurred during high flow events and monthly sampling was undertaken during low or base flow (ambient) conditions. Where possible, total suspended solids, nutrients and pesticide samples were collected concurrently. Manual grab samples collected during low flow conditions, where sites are tidally influenced, were taken on the outgoing, low tide. Automatic grab samplers installed in tidal sites were activated during rainfall runoff events based on discharge measured with Horizontal Acoustic Doppler Current Profilers and conductivity and turbidity readings recorded *in situ*.

In the Barratta Creek catchment, supplementary to routine sampling, weekly sampling throughout the wet season was implemented to provide comprehensive understanding of sediment, nutrient and pesticide behaviour as influenced by inputs from irrigation.

Approximately 40 per cent of the total suspended solids and nutrient samples were collected by manual grab sampling and 60 per cent were collected using refrigerated automatic pump samplers (Table 2.2). Pesticide samples were manually collected at eight sites and collected using refrigerated automatic samplers fitted with glass bottles at nine sites. All water samples were stored and transported in accordance with the Environmental Protection (Water) Policy Monitoring and Sampling Manual (DEHP 2009).

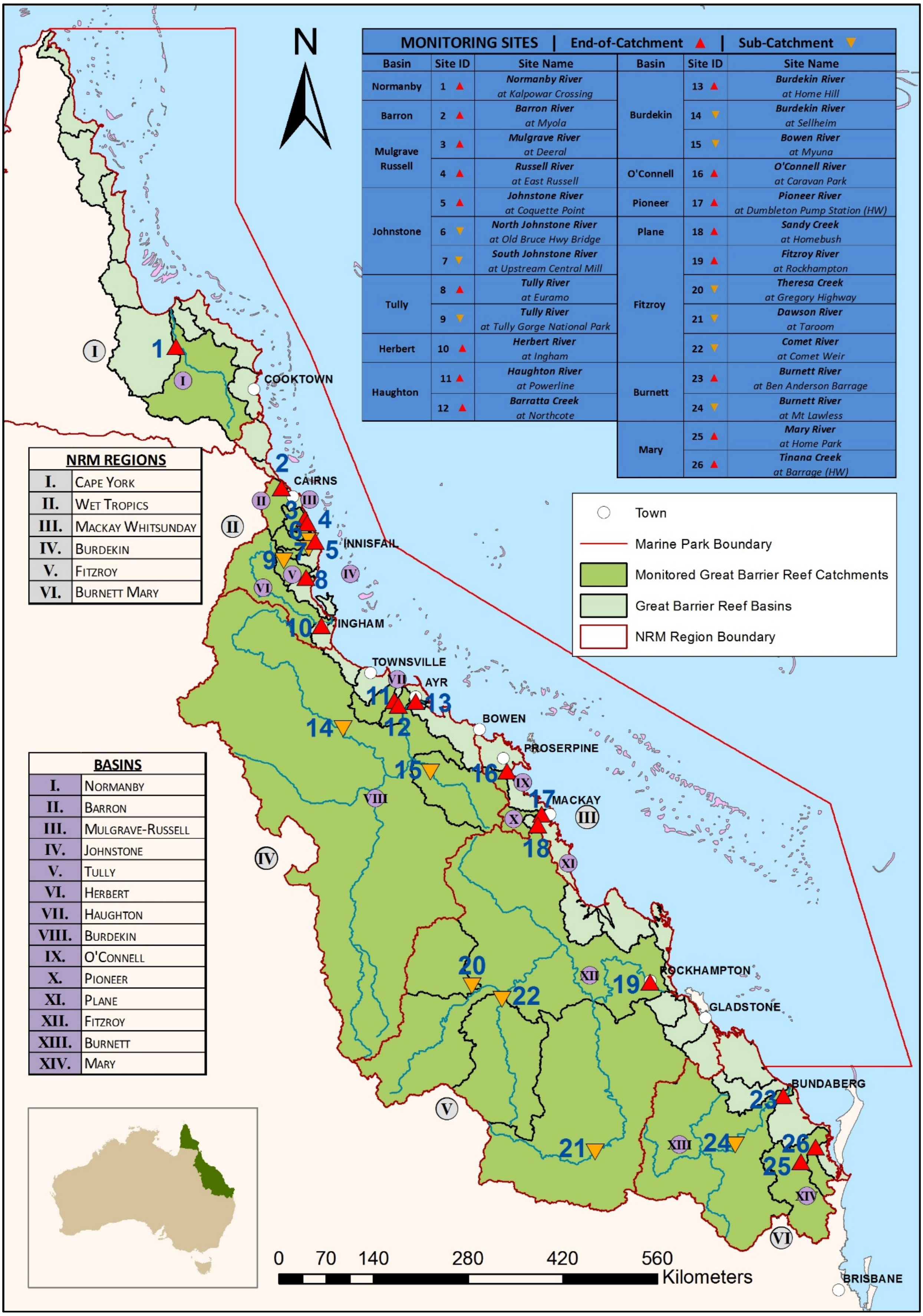


Figure 2.1 Map indicating the natural resource management regions, basins and sites where the Great Barrier Reef Catchment Loads Monitoring Program monitored during 2015–2016.

Table 2.1 Summary information on sites monitored during the 2015–2016 monitoring year by the Great Barrier Reef Catchment Loads Monitoring Program. Text in bold relate to end-of-catchment sites, all others relate to sub-catchment sites.

NRM region	Basin	Catchment	Gauging station	River and site name	Site location		Basin surface area (km^2)*	Catchment surface area (km^2)	Monitored surface area (km^2)	Catchment monitored (%)
					Latitude	Longitude				
Cape York	Normanby	**Normanby River**	**105107A**	**Normanby River at Kalpowar Crossing**	-14.9185	144.2100	24,408	15,030	12,920	86
Wet Tropics	Barron	**Barron River**	**110001D**	**Barron River at Myola**	-16.7998	145.6121	2182	2149	1933	90
	Mulgrave-Russell	**Mulgrave River**	**1110056**	**Mulgrave River at Deeral**	-17.2075	145.9264	1979	804	789	98
		Russell River	**1111019**	**Russell River at East Russell**	-17.2672	145.9544		560	522	93
	Johnstone	**Johnstone River**	**1120054**	**Johnstone River at Coquette Point**	-17.51119	146.06035	2321	1630	1630	100
		North Johnstone River	1120049	North Johnstone River at Old Bruce Highway Bridge (Goondi)	-17.5059	145.9920		1082	960	89
		South Johnstone River	112101B	South Johnstone River at Upstream Central Mill	-17.6089	145.9791		545	400	73
	Tully	**Tully River**	**113006A**	**Tully River at Euramo**	-17.9921	145.9425	1683	1563	1450	93
		Tully River	113015A	Tully River at Tully Gorge National Park	-17.7726	145.6503			482	31
	Herbert	**Herbert River**	**116001F**	**Herbert River at Ingham**	-18.6328	146.1427	9843	8817	8584	97
Burdekin	Haughton	**Haughton River**	**119003A**	**Haughton River at Powerline**	-19.6331	147.1103	4043	2037	1773	87
		Barratta Creek	**119101A**	**Barratta Creek at Northcote**	-19.6923	147.1688		1226	759	62
	Burdekin	**Burdekin River**	**120001A**	**Burdekin River at Home Hill**	-19.6436	147.3958	130,120	129,930	129,930	100
		Burdekin River	120002C	Burdekin River at Sellheim	-20.0078	146.4369		36,252	36,252	100
		Bowen River	120205A	Bowen River at Myuna	-20.5833	147.6000		9449	7107	75
Mackay Whitsunday	O'Connell	**O'Connell River**	**1240062**	**O'Connell River at Caravan Park**	-20.5664	148.6117	2387	860	819	95
	Pioneer	**Pioneer River**	**125013A**	**Pioneer River at Dumbleton Pump Station**	-21.1441	149.0753	1570	1570	1466	93
	Plane	**Sandy Creek**	**126001A**	**Sandy Creek at Homebush**	-21.2831	149.0228	2534	465	326	70
Fitzroy	Fitzroy	**Fitzroy River**	**1300000**	**Fitzroy River at Rockhampton**	-23.3175	150.4819	142,553	140,801	139,289	99
		Theresa Creek	130206A	Theresa Creek at Gregory Highway	-23.4292	148.1514		8632	8485	98
		Comet River	130504B	Comet River at Comet Weir	-23.6125	148.5514		17,297	16,422	95
		Dawson River	130302A	Dawson River at Taroom	-25.6376	149.7901		50,764	15,847	31
Burnett Mary	Burnett	**Burnett River**	**136014A**	**Burnett River at Ben Anderson Barrage Head Water**	-24.8896	152.2922	33,207	33,179	32,841	99
		Burnett River	136002D	Burnett River at Mt Lawless	-25.54471	151.6549			29,356	88
	Mary	**Mary River**	**138014A**	**Mary River at Home Park**	-25.76833	152.5274	9467	9161	6872	75
		Tinana Creek	**138008A**	**Tinana Creek at Barrage Head Water**	-25.57196	152.7173		1291	1284	99

NRM = natural resource management. *This includes the whole basin area, which contains catchments that might not drain directly to the monitored river but are considered part of the same basin.

Table 2.2 Summary information of analytes measured and sample collection methods used by the Great Barrier Reef Catchment Loads Monitoring Program during the 2015–2016 monitoring year. Text in bold relate to end-of-catchment sites; all others relate to sub-catchment sites.

NRM region	Basin	Catchment	Gauging station	River and site name	Analytes measured	Sample collection method
Cape York	Normanby	**Normanby River**	**105107A**	**Normanby River at Kalpowar Crossing**	TSS & Nut.	Manual
Wet Tropics	Barron	**Barron River**	**110001D**	**Barron River at Myola**	TSS & Nut.	Manual and automatic
	Mulgrave-Russell	**Mulgrave River**	**1110056**	**Mulgrave River at Deeral***	TSS, Nut. & Pesticides	Manual and automatic
		Russell River	**1111019**	**Russell River at East Russell***	TSS, Nut. & Pesticides	Manual and automatic
	Johnstone	**Johnstone River**	**1120054~**	**Johnstone River at Coquette Point***	TSS, Nut. & Pesticides	Manual and automatic
		North Johnstone River	1120049~	North Johnstone River at Old Bruce Highway Bridge (Goondi)	TSS, Nut. & Pesticides	Manual
		South Johnstone River	112101B	South Johnstone River at Upstream Central Mill	TSS & Nut.	Manual
	Tully	**Tully River**	**113006A**	**Tully River at Euramo**	TSS, Nut. & Pesticides	Manual and automatic
		Tully River	113015A	Tully River at Tully Gorge National Park	TSS & Nut.	Manual and automatic
	Herbert	**Herbert River**	**116001F**	**Herbert River at Ingham**	TSS, Nut. & Pesticides	Manual
Burdekin	Haughton	**Haughton River**	**119003A**	**Haughton River at Powerline**	TSS, Nut. & Pesticides	Manual
		Barratta Creek	**119101A**	**Barratta Creek at Northcote**	TSS, Nut. & Pesticides	Manual and automatic
	Burdekin	**Burdekin River**	**120001A~**	**Burdekin River at Home Hill**	TSS, Nut. & Pesticides	Manual
		Burdekin River	120002C	Burdekin River at Sellheim	TSS & Nut.	Manual
		Bowen River	120205A	Bowen River at Myuna	TSS & Nut.	Manual and automatic
Mackay Whitsunday	O'Connell	**O'Connell River**	**1240062~**	**O'Connell River at Caravan Park***	TSS, Nut. & Pesticides	Manual and automatic
	Pioneer	**Pioneer River**	**125013A~**	**Pioneer River at Dumbleton Pump Station**	TSS, Nut. & Pesticides	Manual and automatic
	Plane	**Sandy Creek**	**126001A**	**Sandy Creek at Homebush**	TSS, Nut. & Pesticides	Manual and automatic
Fitzroy	Fitzroy	**Fitzroy River**	**1300000~**	**Fitzroy River at Rockhampton**	TSS, Nut. & Pesticides	Manual
		Theresa Creek	130206A	Theresa Creek at Gregory Highway	TSS & Nut.	Manual
		Comet River	130302A	Dawson River at Taroom	TSS & Nut.	Manual
		Dawson River	130504B	Comet River at Comet Weir	TSS, Nut. & Pesticides	Manual
Burnett Mary	Burnett	**Burnett River**	**136014A~**	**Burnett River at Ben Anderson Barrage Head Water**	TSS, Nut. & Pesticides	Manual
		Burnett River	136002D	Burnett River at Mt Lawless	TSS & Nut.	Manual and automatic
	Mary	**Mary River**	**138014A**	**Mary River at Home Park**	TSS, Nut. & Pesticides	Manual and automatic
		Tinana Creek	**138008A**	**Tinana Creek at Barrage Head Water**	TSS, Nut. & Pesticides	Manual and automatic

TSS = total suspended solids, Nut. = nutrients, Pesticides = photosystem II inhibiting herbicides and alternate pesticides (See Appendix A), ~ = These are not gauging stations – flow is determined from upstream gauging stations as outlined in Table 2.5, * = Acoustic Doppler Current Profiler installed.

2.4 Quality Assurance and Quality control

During the 2015–2016 monitoring year the Great Barrier Reef Catchment Loads Monitoring Program continued to implement its 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 2015–2016 monitoring year through implementation of the quality management system as demonstrated by:

- ongoing delivery of the Great Barrier Reef Catchment Loads Monitoring Quality Management training package to staff in partner organisations including, Tully Sugar, Reef Catchments, Queensland Parks and Wildlife Service Taroom Base and Mary River Catchment Coordinating Committee,
- upgrade to software in order to enhance triggering of automatic samplers to improve collection of samples through all stages of the hydrograph, and
- update of existing methods within the Great Barrier Reef Catchment Loads Monitoring Programs' Quality Management System.

The continuous improvement of the Great Barrier Reef Catchment Loads Monitoring Program, including training, upgrade of sampling equipment and expansion of sites and analytes, made possible through partnerships and stakeholder collaborations, are all necessary to produce the data required to calculate high quality annual pollutant loads, which are in turn used to assess progress against Reef Plan 2013 water quality targets.

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 using a gravimetric method and nutrient samples were analysed via segmented flow analysis (colorimetric techniques).

Queensland Health Forensic and Scientific Services Organics Laboratory (Coopers Plains, Queensland) analysed the water samples for pesticides. All pesticide samples were extracted via solid phase extraction (SPE) and analysed using liquid chromatography-mass spectrometry to quantify 54 pesticides (Appendix A) which included the five photosystem II inhibiting herbicides listed under Reef Plan 2013 (ametryn, atrazine including its breakdown products desethyl atrazine and desisopropyl atrazine, diuron including its breakdown product 3,4-dichloroaniline, hexazinone and tebuthiuron). During the 2015–2016 monitoring year, the method of pesticide analysis was optimised to detect a broader range of analytes at lower concentrations affording a choice between the older method, referred to as LC-MS *High* or the newer method herein referred to as LC-MS *Low.* The increased sensitivity of the LC-MS *Low* method allows for a limit of reporting 10-fold lower than the LC-MS *High* method. The LC-MS *High* method was used at sites when the concentrations of analytes were predicted to be high based on previous monitoring data (catchments with low base flow or proportionally high agricultural development) or during periods of predicted elevated concentrations (event flows early in the season). The LC-MS *Low* method was used at sites when the concentrations of analytes were predicted to be low based on previous monitoring data. For example, LC-MS *Low* was used in catchments with high base flow or those with proportionally lower agricultural development or when analysing samples taken outside of event periods and late in the season when more sensitive analysis with a lower limit of reporting is required. The practical quantitation limit of each method is presented in Table 2.4. The solid-phase extraction coupled with the LC-MS analysis detects organic compounds with low octanol-water partition coefficient values (i.e. they tend to have high aqueous solubility). In general, this method will only detect non-bound pesticides, where samples contains large concentrations of sediment there is potential for the analysed pesticide concentration to be underestimated.

During the 2015–2016 monitoring year, the Great Barrier Reef Catchment Loads Monitoring Program, on behalf of the Department of Science Information Technology and Innovation, released a number of notifications reporting on exceedances of pesticide water quality guidelines based on the pesticide concentrations as reported by the Queensland Health Forensic and Scientific Services Organics Laboratory. All notifications relating to monitored reef catchments are provided in Appendix B.

For the purpose of this report, atrazine together with its breakdown products (desethyl atrazine and desisopropyl atrazine) is reported as ‘total atrazine’ and diuron and its breakdown product (3,4-dichloroaniline) are reported as ‘total diuron’. 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* = desethyl atrazine and *i* = desisopropyl atrazine.

The total diuron concentration for each sample was calculated according to Equation 2, which was then used to calculate a total diuron load:

Equation 2

$$Total\ diuron = C_{dc} \times \frac{M_d}{M_{dc}} + C_d$$

where, *C* = concentration, *M* = molecular weight, *d* = diuron and *dc* = 3,4-dichloroaniline.

The 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). Table 2.3 and Table 2.4 provide a summary of all analysed parameters, their practical quantitation limits and analytical uncertainty (measured as the 95 per cent confidence interval of the standard deviation).

Table 2.3 Summary information for total suspended solids and nutrients measured and the corresponding practical quantitation limit and uncertainties.

Monitored pollutants	Abbreviation	Analytes measured	Practical quantitation limit	Uncertainty ±% (as reported by laboratory)
Sediments				
Total suspended solids	TSS	Total suspended solids	1 mg L^{-1}	12
Nutrients				
Total nitrogen	TN	Total nitrogen as N	0.03 mg L^{-1}	15
Particulate nitrogen	PN	Total nitrogen (suspended) as N	0.03 mg L^{-1}	15
Dissolved organic nitrogen	DON	Organic nitrogen (dissolved) as N	0.03 mg L^{-1}	15
Ammonium nitrogen as N	NH_4-N	Ammonium nitrogen as N	0.002 mg L^{-1}	8
Oxidised nitrogen as N	NO_x-N	Oxidised nitrogen as N	0.001 mg L^{-1}	8
Dissolved inorganic nitrogen	DIN	Ammonium nitrogen as N + Oxidised nitrogen as N	0.002 mg L^{-1}	8
Total phosphorus	TP	Total Kjeldahl phosphorus as P	0.02 mg L^{-1}	12
Particulate phosphorus	PP	Total phosphorus (suspended) as P	0.02 mg L^{-1}	15
Dissolved organic phosphorus	DOP	Organic phosphorus (dissolved) as P	0.02 mg L^{-1}	15
Dissolved inorganic phosphorus	DIP	Phosphate phosphorus as P	0.001 mg L^{-1}	8

Table 2.4 Summary information for the five priority photosystem II inhibiting herbicides measured and the corresponding practical quantitation limit and uncertainties.

Monitored pollutants	Abbreviation	Analytes measured	LC-MS (*High*) Practical quantitation limit	Uncertainty ±% (as reported by laboratory)	LC-MS (*Low*) Practical quantitation limit	Uncertainty ±% (as reported by laboratory)
Ametryn	Pesticide (PSII inhibiting herbicide)	Ametryn	0.01 µg L^{-1}	52	0.001 µg L^{-1}	46
Total atrazine		Atrazine, desethyl atrazine and desisopropyl atrazine	0.01 µg L^{-1}	24	0.001 µg L^{-1}	35
Total diuron		Diuron and 3,4-dichloroaniline	0.01 µg L^{-1}	21	0.001 µg L^{-1}	35
Hexazinone		Hexazinone	0.01 µg L^{-1}	11	0.001 µg L^{-1}	19
Tebuthiuron		Tebuthiuron	0.01 µg L^{-1}	9	0.001 µg L^{-1}	17

2.6 River discharge

During the 2015–2016 monitoring year discharge was calculated using one of four methods:

- measured discharge from existing Department of Natural Resources and Mines gauging stations
- ‘time and flow factored’ measured discharge from existing Department of Natural Resources and Mines gauging station (Table 2.5),
- modelled flows generated in the Source Catchments modelling platform using the Sacramento rainfall runoff model, where the Parameter Estimation Tool (PEST) was coupled with Source for the calibration process, or
- a combination of modelled flow and flow measured by Horizontal Acoustic Doppler Current Profiler.

Where monitoring sites were located at existing Department of Natural Resources and Mines gauging stations, river discharge data (hourly-interpolated flow, $m^3 s^{-1}$) were extracted from the Department of Natural Resources and Mines, Surface Water Database using Hydstra pre-programmed scripts (DNRM 2012). The method used to calculate discharge by the Surface Water Database is presented Appendix C. The preference was to use archived discharge data with a quality code[4] of 10 to 30, based on the Department of Natural Resources and Mines hydrographic methodology for quality rating flow data (DNRM 2014) (see Appendix D for an explanation of quality coding). If such data were not available due to a gauging station error, discharge data with a quality code of 59 or 60 were used (see Appendix D).

When samples were collected at sites without an operational gauging station a 'timing and flow factor' was calculated to estimate downstream discharge based on flow data from the nearest upstream gauging station(s). Timing and flow factors were applied at: North Johnstone River at Old Bruce Highway Bridge (Goondi), Burdekin River at Home Hill, O'Connell River at Caravan Park, Fitzroy River at Rockhampton and also the Burnett River at Ben Anderson Barrage Head Water (Table 2.5). Timing and flow factors were only used for the Pioneer River at Dumbleton Pump Station and Burnett River at Mt Lawless for the purpose of calculating long-term mean discharge – both of these sites now have an operational gauging station (Table 3.1). In general, the factors adjust the flow to account for the delay in the time it takes water to flow from the gauging station to the water quality sampling site and for the change in flow volume due to large changes in catchment area (i.e. greater than four per cent).

Due to insufficient flow gaugings for Johnstone River at Coquette Point and Tinana Creek at Barrage Head Water sites, modelled discharge was used for the calculation of pollutant loads as there remains insufficient data to generate a rating table for these sites. Modelled flow for these sites was generated in the Source Catchments platform using the Sacramento rainfall runoff model for the period 1 July 1984 to 30 June 2016. The Parameter Estimation Tool (PEST) was coupled with Source for the calibration process following the approach detailed in Zhang et al. (2013). Details for the calibration statistics can be found in Zhang (2015). The Source Catchments platform was updated in September 2016 prior to calculation of the 2015–2016 monitoring year pollutant loads. As a result, modelled flow generated for Tinana Creek for the period 1 July 1984 to 30 June 2015 differed slightly from that used in the 2014–2015 reporting year. As such, the revised historical modelled flow increased by approximately 20 per cent and the long term mean annual discharge increased by approximately 10 per cent for this site. The Johnstone River was unaffected as this is the first year monitored loads are reported for this site.

During the 2015–2016 monitoring year, discharge in the Mulgrave and Russell rivers was calculated using a combination of measured and modelled flows. Flow in the Mulgrave and Russell rivers was measured using Horizontal Acoustic Doppler Current Profilers. The mounting position of this equipment is above the low tide water level during low flow conditions. As such, modelled flows are used for daily flow calculations during the low flow period. During high flow periods, the Horizontal Acoustic Doppler Current Profilers are able to

[4] Quality codes are used to differentiate between reliability of discharge values available for the calculation of loads. Quality codes of 59 and 60 are interpolated discharge values.

measure continuously providing a more precise measure of discharge during flood events. Further information relating to the calculation of discharge at these sites is provided in Appendix E.

Table 2.5 Timing and flow factors applied to calculate discharge at non-gauged monitoring sites and recently installed gauging stations# during the 2015–2016 monitoring year.

Gauging station	River and site name	Timing and flow factors
1110056	Mulgrave River at Deeral	Estimated from modelled discharge and measured flow – see Appendix E
1111019	Russell River at East Russell	Estimated from modelled discharge and measured flow – see Appendix E
1120054	Johnstone River at Coquette Point	Estimated from modelled discharge – see Section 2.6
1120049	North Johnstone River at Old Bruce Highway Bridge (Goondi)#	Estimated from discharge data for Tung Oil GS 112004A where: $\text{Discharge}_{\text{North Johnstone River at Old Bruce Highway Bridge (Goondi)}} = \text{Discharge}_{\text{North Johnstone River at Tung Oil}}$
120001A	Burdekin River at Home Hill#	Estimated from discharge data for Clare GS 120006B where: $\text{Discharge}_{\text{Burdekin River at Home Hill}} = \text{Discharge}_{\text{Burdekin River at Clare}}$
1240062	O'Connell River at Caravan Park	Estimated using the HYCRSUM function in Hydstra using discharge data for Andromache River GS 124003A and O'Connell River GS 124001B
125013A	Pioneer River at Dumbleton Pump Station	Estimated from Pioneer River at Dumbleton Pump Station Tail Water GS 125016A Historical discharge was estimated using data from Mirani Weir Tail Water GS 125007A where: $\text{Discharge}_{\text{Pioneer River Dumbleton Pump Station}} = 1.226 \times \text{Discharge}_{\text{Mirani Weir Tail Water}}$
1300000	Fitzroy River at Rockhampton#	Estimated from discharge data from The Gap GS 130005A where: $\text{Time}_{\text{Rockhampton}} = \text{Time}_{\text{The Gap}} + 14.5$ 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: $\text{Discharge}_{\text{Burnett River at Ben Anderson Barrage Head Water}} = \text{Discharge}_{\text{Fig Tree}} + \text{Discharge}_{\text{Degilbo}} + \text{Discharge}_{\text{Perry}}$ Historical discharge (pre-1988) was estimated from Walla GS 136001A and 136001B where: $\text{Discharge}_{\text{Burnett River at Ben Anderson Barrage Head Water}} = \text{Discharge}_{\text{Walla}}$
136002D	Burnett River at Mt Lawless#	Historical discharge was estimated using data from Burnett River at Yenda GS 136002A where: $\text{Discharge}_{\text{Burnett River at Mt Lawless}} = \text{Discharge}_{\text{Yenda}}$
138008A	Tinana Creek at Tinana Barrage Head Water	Estimated from modelled discharge – see Section 2.6

Sites where discharge was directly applied from another site or calculated by the addition of multiple sites differed in catchment areas by less than four per cent. In all other cases a flow factor was included to account for the effect of catchment area difference on flow.

Where possible, 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 four sites, O'Connell River at Caravan Park, 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 2.5. For Mulgrave River at Deeral, Russell River at East Russell, Johnstone River at Coquette Point and Tinana Creek at Tinana Barrage Head Water modelled historic daily flows were used.

The exceedance probability of monitored annual discharge for all sites was calculated using Equation 3. The exceedance probability is the probability that the observed annual discharge will be exceeded in any given year based on the historical flow records available for the monitoring site.

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

Equation 3

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

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.

2.7 Data analysis

2.7.1. Rating of sampling representivity

The suitability of the total suspended solids and nutrients data at each site to calculate loads was assessed by determining the representivity rating using the method of Turner et al. (2012), based on elements of the Kroon et al. (2010) and Joo et al. (2012) methods. This method of determining the representivity rating has been used in all Great Barrier Reef Catchment Loads Monitoring Program reports since 2009. The sampling representivity rating identifies the sample coverage achieved during the period of maximum discharge at each monitoring site and assesses the quality of sample coverage. This method assumes that the majority of the annual total suspended solids and nutrient loads are transported during the highest flow periods, which is generally the case (Joo et al. 2012). In order to reliably calculate the annual pollutant load, the pollutant concentration data should be available for the periods of highest discharge. The rating of sampling representivity was assessed against two criteria:

1. the number of samples collected in the top five per cent of annual monitored flow
2. the ratio between the highest flow rate at which a water sample was collected in the 2015–2016 monitoring year and the maximum flow rate recorded.

The representivity was determined by assigning a score using the system presented in Table 2.6.

Table 2.6 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	0.00 – 0.19	1
10 – 19	2	0.20 – 0.39	2
20 – 29	3	0.40 – 0.59	3
30 – 39	4	0.60 – 0.79	4
>40	5	>0.80	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 visually assessed to verify the representivity rating. The sample coverage for each monitoring site is presented in the hydrographs provided in Appendix F. The representivity rating and the number of samples used to calculate the loads and yields of total suspended solids and nutrients are presented in Appendix G. The representivity of pesticide data was not assessed as the Turner et al. (2012) method is not appropriate because maximum pesticide concentrations often don’t occur at the same time as maximum flow.

2.7.2. Loads calculation

Loads were calculated using the Loads Tool component of the software Water Quality Analyser 2.1.2.6 (eWater 2012). 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 concentrations reported in micrograms per litre (µg L^{-1}).

Annual and daily loads were calculated for total suspended solids and nutrients, including total nitrogen, particulate nitrogen, dissolved organic nitrogen, dissolved inorganic nitrogen (calculated by adding oxidised nitrogen load and ammonium nitrogen load), oxidised nitrogen, ammonium nitrogen, total phosphorus, particulate phosphorus, dissolved inorganic phosphorus and dissolved organic phosphorus. Annual and daily pesticide loads were also calculated for all pesticides detected above the practical quantitation limit a minimum of three times throughout the monitoring year (Table 2.3 and Table 2.4).

One of two methods was used to calculate loads: the average load (linear interpolation of concentration)[5] or the Beale ratio. Average load (linear interpolation of concentration) is the most accurate and reliable method, provided events are adequately sampled, or at least with reasonably representative sampling including the peak concentration (Joo et al. 2012). For poorly sampled and/or complex events the Beale ratio is one of the recommended methods (Joo et al. 2012). The average load (linear interpolation of concentration) and Beale ratio methods were applied using the following equations:

Average load (linear interpolation of concentration):

Equation 4

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

where c_j is the j^{th} sample concentration, and q_j is the inter-sample mean flow (eWater 2012).

[5] This method was previously referred to as the ‘Linear Interpolation’ method in Water Quality Analyser 2.1.1.0 and Turner et al. (2012). The revised name ‘average load (linear interpolation of concentration)’ is consistent with the load calculation method of Letcher et al. (1999) as referred to in Water Quality Analyser 2.1.2.6.

Beale ratio:

Equation 5

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

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 2012).

The most appropriate method (average load (linear interpolation of concentration) or Beale ratio) to calculate annual pollutant loads was determined for each analyte at each site using the following criteria:

- if the majority of major events were well sampled on both the rise and fall, then the average load (linear interpolation of concentration) method was applied,
- if the majority of the events were not adequately sampled but the representivity rating was “moderate”, “good” or better, the Beale ratio was applied, and
- if the majority of the events were not adequately sampled and the representivity rating was “indicative”, the Beale ratio method was applied.

Both Johnstone River at Coquette Point and Tinana Creek at Barrage were given an indicative rating as modelled daily flows were used exclusively to calculate annual loads and yields. This indicative rating was given as no measurements of flow (the dominant factor determining the magnitude of loads) for either site was used in the calculation process. This approach is consistent with the calculation of loads for the 2013–2014 and 2014–2015 monitoring years (Garzon-Garcia et al. 2015; Wallace et al. 2016).

The most appropriate load calculation method varied between sites as the numbers of samples collected and the coverage over the hydrograph varied between events (Appendix F). The availability of concentration data for total suspended solids and each measure of nitrogen and phosphorus were similar within sites as indicated by similar representivity ratings across analytes. The same load calculation method was used for all total suspended solids, nutrient and pesticide analytes in each site.

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 (eWater 2012 and 2015) for each parameter,
- discharge data were imported into Water Quality Analyser (eWater 2012 and 2015) on an hourly interpolated time stamp,

- for total suspended solids and nutrients, if the concentrations were below the practical quantitation limit specified by the Science Division Chemistry Centre (Table 2.3) the results were adjusted to a value of 50 per cent of the practical quantitation limit,
- where pesticide concentrations were below the practical quantitation limit, but other samples in the same event contained 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 µg L^{-1} in order to not potentially overestimate the loads,
- the water quality concentration data were then aligned to the hourly flow data (nearest time match)
- 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 (eWater 2012 and 2015) using the appropriate loads calculation method (as outlined above) and annual loads for the period 1 July 2015 to 30 June 2016 period were reported, and
- all calculated loads 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 (eWater 2012 and 2015). For all sites, a calculated data point that was 50 per cent of the lowest reported concentration was inserted into the dataset at 1 July 2015 and the lowest reported concentration was inserted into the dataset at 30 June 2016 to provide tie-down concentrations for calculations (eWater 2012 and 2015).

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 2015 (Joo et al. 2011; Turner et al. 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Garzon-Garcia et al. 2015).

2.7.2.1 Toxicity-based loads (Toxic pesticide loads)

As part of our ongoing commitment to improving the Great Barrier Reef Catchment Loads Monitoring Program, the concept of a toxicity-based load (toxic pesticide load) was introduced in the 2013–2014 monitoring year as a more toxicologically relevant measure for pesticides. Photosystem II inhibiting herbicides all have the same toxic mode of action, and therefore, the total toxic pesticide load of ametryn, atrazine, diuron, hexazinone and tebuthiuron were calculated. A toxic pesticide load is the calculated load of a pesticide weighted by the pesticide's relative toxicity to the toxicity of diuron (Smith et al. 2017a). The toxic pesticide load is therefore expressed as an equivalent mass of diuron, i.e. diuron equivalent kilograms. Following Smith et al. (2017b), the loads of each of the five herbicides were multiplied by the appropriate toxicity equivalency factor (Table 2.7) and then summed. Although the other detected pesticides would contribute to the total toxic pesticide load, the diuron toxicity equivalence factors have not been determined for any other pesticides.

Table 2.7 Toxic equivalency factors for the five priority photosystem II inhibiting herbicides relative to the toxicity of diuron used for the calculation of toxic pesticide loads (adopted from Smith et al. 2017b).

	Ametryn	Atrazine	Diuron	Hexazinone	Tebuthiuron
Diuron equivalency factor	0.65	0.036	1.0	0.21	0.019

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 different monitored areas (e.g. between catchments).

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-catchment and sub-catchment sites by dividing the monitored annual pollutant load of each analyte by the total monitored catchment area using Equation 6.

Equation 6

$$Catchment\ Yield = \frac{Monitored\ annual\ load}{Monitored\ catchment\ area}$$

where catchment yield is expressed as t km^{-2} or kg km^{-2}, annual load is expressed as t or kg, and monitored catchment area is expressed as km^2 upstream of the monitoring site.

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

The methods used to calculate pesticide land use yields in this report (the load divided by the total surface area of land uses where the pesticide is registered for use) are consistent with Wallace et al. (2015).

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 chemicals. These restrictions may include the crop type, timing and rate at which registered chemicals may be applied. Although records of agricultural chemical use must be maintained by the user, no centralised reporting of these data is required under current regulations. It is not possible, therefore, to obtain chemical use records for the purpose of calculating land use yields at the scale of the Great Barrier Reef Catchment Loads Monitoring Program. It is possible to use the registered chemical restriction information (e.g. Infopest Database, Growcom 2013) to determine whether the five photosystem II inhibiting herbicides were registered for agricultural production purposes being conducted in specific regions during the 2015–2016 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, or ultimately for all detected pesticides.

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 and Management Program (http://www.agriculture.gov.au/abares/aclump/about-aculmp) sourced through the Queensland Government Queensland Spatial Catalogue (DSITI 2016). 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. monitored loads of pesticides were not attributed to the additional six land use categories of urban, mining, conservation, intensive animal production, water and other land uses, although it is acknowledged that photosystem II inhibiting herbicides may be applied in these land use classes). As these land use categories are an aggregation of land use data categories contained in the Queensland Land Use and Management Program dataset, it is acknowledged that these categories may include specific land uses for which the application of registered chemical is not permitted (e.g. ametryn may be applied to pineapples that are included in the horticulture land use category, but may not be applied to bananas that are also included in the horticulture land use category). Aggregated land use categories used in the calculation of land use yields for the photosystem II inhibiting herbicides are presented in Table 2.8 and Table 2.9.

The binary codes (Table 2.8) indicate whether a 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 relating the allocation of pesticides to particular land uses 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.

A binary code of 1 was applied to the aggregated land use category of horticulture for ametryn only for the Tinana Creek catchment. This is the only catchment to contain land use registered for the use of ametryn (pineapples) upstream of the monitoring site.

The pesticide land use yields (LUY) in each catchment were calculated using Equation 7:

Equation 7

$$LUY = \frac{Annual\ monitored\ pesticide\ load}{LUA}$$

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

The LUA was determined by:

Equation 8

$$LUA = \sum binary\ code \times aggregated\ land\ use\ category$$

where the binary codes used are as presented in Table 2.8 and the surface area of each aggregated land use category is presented in Table 2.9.

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 are likely underestimates of the actual yields as: (1) not all land for which use of a pesticide is permitted will have had that pesticide applied; (2) pesticides are predominantly transported to waterways when the land to which pesticide is applied receives sufficient rain to cause surface runoff – in this case, agricultural land not receiving rain but registered for a pesticide will not significantly contribute to the load or yield, but this land has been included in the calculation.

The binary coding applied in the calculation of the land use yields in this report, was subject to a consultative review undertaken with peak industry bodies in April 2015 (Wallace et al. 2015).

Table 2.8 Binary codes indicating which photosystem II inhibiting herbicides are registered for the aggregated land use categories. A binary code of 1 indicates the pesticide is registered for application in that aggregated land use and the validation criteria are met.

Photosystem II inhibiting herbicides	Cropping	Forestry	Grazing	Horticulture	Sugarcane
Ametryn	0	0	0	1#	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

 # applied only to the Tinana Creek catchment.

Table 2.9 Surface area of each aggregated land use category upstream of the monitoring sites (obtained from the Queensland Land Use Monitoring Program) for the 2015–2016 monitoring year. Text in bold relate to end-of-catchment sites and the corresponding data.

Basin	Catchment	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)
Mulgrave-Russell	Mulgrave River	**Mulgrave River at Deeral**	789	98	1.6	5.0	34	1.1	77
	Russell River	**Russell River at East Russell**	522	93	0.15	1.7	45	12	85
Johnstone	Johnstone River	**Johnstone River at Coquette Point**	1630	100	7.2	3.8	480	47	96
	North Johnstone River	North Johnstone River at Old Bruce Highway Bridge (Goondi)*	960	89	6.5	1.0	380	21	11
Tully	Tully River	**Tully River at Euramo**	1450	93	0.10	<0.1	88	51	160
Herbert	Herbert River	**Herbert River at Ingham**	8584	97	25	390	5200	4.2	240
Haughton	Haughton River	**Haughton River at Powerline**	1773	87	4.6	33	1500	6.8	20
	Barratta Creek	**Barratta Creek at Northcote**	759	62	22	<0.1	600	0.99	130
Burdekin	Burdekin River	**Burdekin River at Home Hill**	129,930	100	1300	830	120,000	2.7	120
O'Connell	O'Connell River	**O'Connell River at Caravan Park**	819	95	<0.1	150	520	0.47	50
Pioneer	Pioneer River	**Pioneer River at Dumbleton Pump Station**	1466	93	<0.1	370	510	0.65	310
Plane	Sandy Creek	**Sandy Creek at Homebush**	326	70	<0.1	34	100	1.1	160
Fitzroy	Fitzroy River	**Fitzroy River at Rockhampton**	139,289	99	9100	9000	110,000	42	3.3
		Comet River at Comet Weir	16,422	95	1900	930	12,000	<0.1	<0.1
Burnett	Burnett River	**Burnett River at Ben Anderson Barrage Head Water**	32,841	99	1200	4100	25,000	84	93
Mary	Mary River	**Mary River at Home Park**	6872	75	35	900	4000	42	15
		Tinana Creek at Barrage Head Water	1284	99	3.5	780	210	29	61

*Prior to Garzon-Garcia et al. (2015) land use surface areas for this site were calculated based on the location of the North Johnstone River site at Tung Oil (monitored area of 925 km^2) where discharge was measured.

3. Results and discussion

3.1 Rainfall and river discharge

3.1.1. El Niño-Southern Oscillation and Southern Oscillation Index

During the commencement of the 2015–2016 monitoring year (i.e. July, August), the El Niño-Southern Oscillation (ENSO) was well established and continued to strengthen with a strong negative Southern Oscillation index (BoM 2015a). September and October of 2015 saw the development of the strongest ENSO since 1997–1998 (comparable to 1982–1983) (BoM 2015b) with Tropical Pacific sea surface temperatures reaching more than 2.0°C above average. Tropical Pacific Ocean temperatures during the 2015–2016 monitoring year suggests the ENSO event was one of the top three strongest events in the past 50 years (BoM 2015c). The 2015–2016 ENSO event began to weaken during January and February 2016, reaching moderate levels in March 2016. The event continued to weaken, returning to neutral during May and remained neutral for the remainder of the 2015–2016 monitoring year.

3.1.2. Rainfall

Annual rainfall and rainfall deciles (with respect to long-term mean rainfall) across the priority reef catchments and natural resource management regions during the 2015–2016 monitoring year are presented in Figure 3.1 and Figure 3.2.

During the 2015–2016 monitoring year the Normanby catchment in the Cape York region received between 1000 mm and 2000 mm of rain, which is average across the majority of the catchment. Total annual rainfall across the monitored catchments of the Wet Tropics region was very much below average to below average (2000 mm to 3000 mm). The upper Barron and upper Herbert catchments received between 500 mm and 1500 mm (below average), whereas the lower Mulgrave and Russell catchments received 3500 mm. Rainfall in the Johnstone, Tully and Herbert catchments were in the range of 1000 mm to 3000 mm with the lower rainfall totals occurring in the upper areas of each catchment.

In the Burdekin region, rainfall was below average to average across the Burdekin catchments with annual rainfall totals between 500 mm to 1000 mm. The monitored catchments of the Mackay Whitsunday region generally received average rainfall (i.e. 1000 mm to 2000 mm), while much of the Fitzroy region received below average to average rainfall (500 mm to 1500 mm). The remainder of the monitored catchments in the Burnett Mary region received from 500 mm to 1500 mm of rainfall, which was below average to average. A detailed monthly rainfall summary is presented in Appendix H.Appendix **G**

3.1.3. River discharge

During the 2015–2016 monitoring year, all monitored catchments produced an annual discharge less than the long-term mean annual discharge, consistent with the rainfall totals.

The exceedance probability of annual discharge for the Normanby River, Barron River, Mulgrave River, Russell River, Johnstone River, Tully River, Herbert River, Haughton River, Barratta Creek, Burdekin River, Bowen River, O'Connell River, Theresa Creek, Comet River, Burnett River, Mary River and Tinana Creek ranged between 63 per cent and 95 per cent (Table 3.1), all sites producing less than half the long-term mean annual discharge (Figure 3.3). The Barron River, upper Tully River, Barratta Creek, Theresa Creek, Comet River, upper Burnett River, Mary River and Tinana Creek all produced the lowest annual discharge since water quality monitoring for the Great Barrier Reef Catchment Loads Monitoring Program commenced in each location.

Exceedance probability of annual discharge within Sandy Creek and the Pioneer River was somewhat less, 60 per cent and 54 per cent respectively, each producing 55 per cent of their long-term mean annual discharges.

Of the monitored end-of-catchment sites, the Burnett (47 per cent), Pioneer (54 per cent) and Fitzroy (58 per cent) rivers had the lowest exceedance probabilities during the 2015–2016 monitoring year.

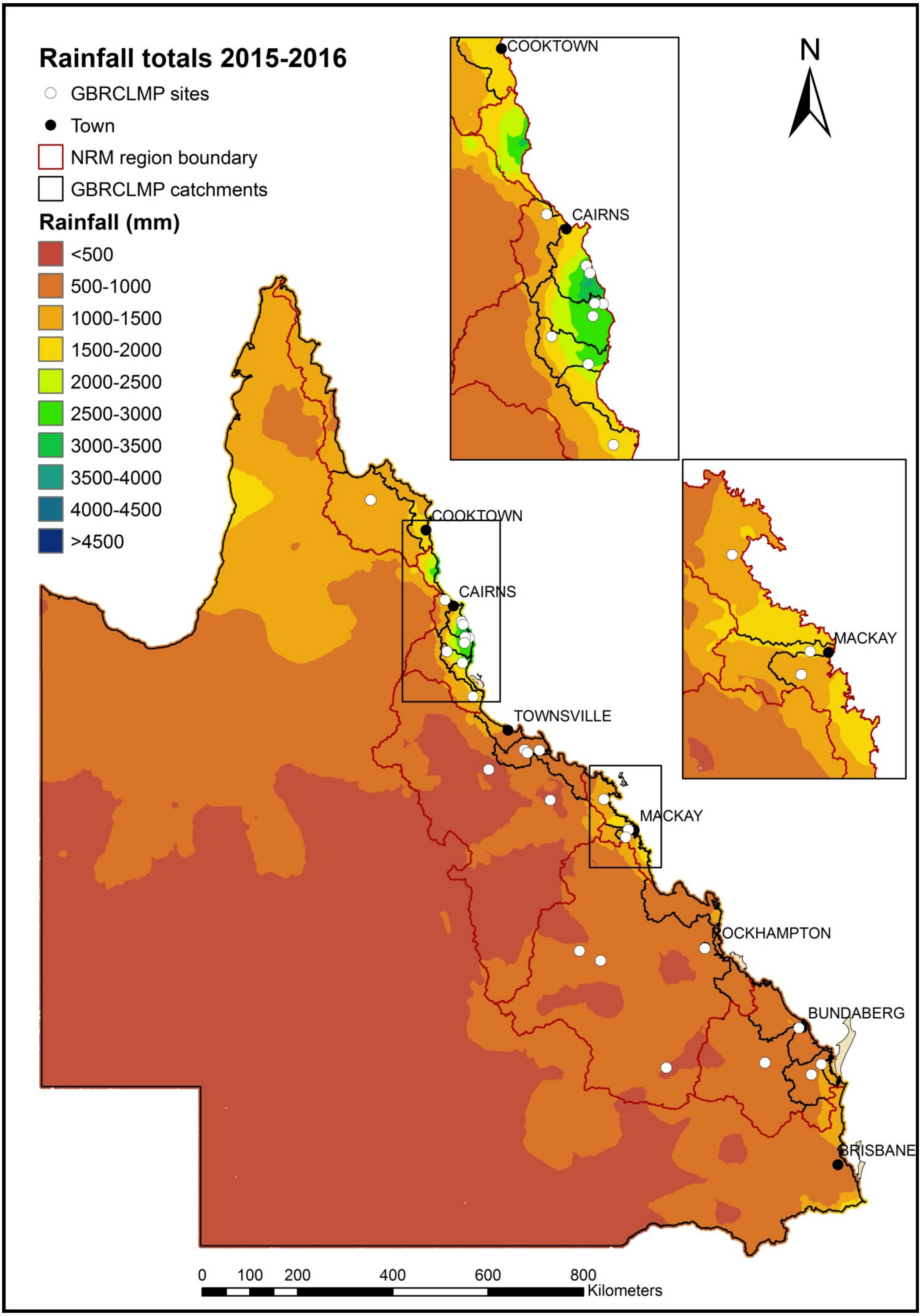


Figure 3.1 Queensland rainfall totals (millimetres) for 1 July 2015 to 30 June 2016, with the natural resource management region, catchments and sites sampled by the Great Barrier Reef Catchment Loads Monitoring Program.

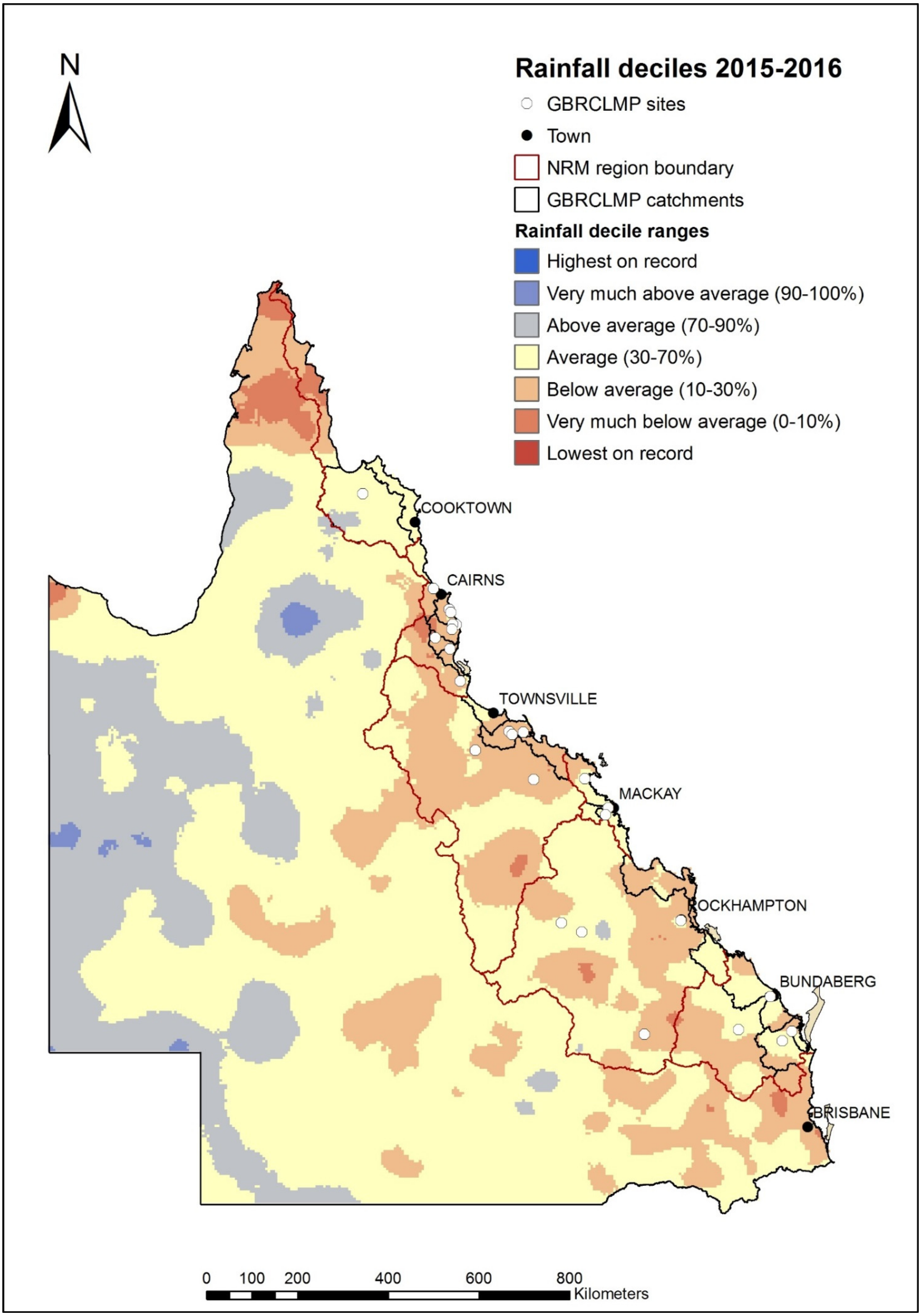


Figure 3.2 Queensland rainfall deciles for 1 July 2015 to 30 June 2016 with respect to long-term mean rainfall, with the natural resource management region, catchments and sites sampled by the Great Barrier Reef Catchment Loads Monitoring Program

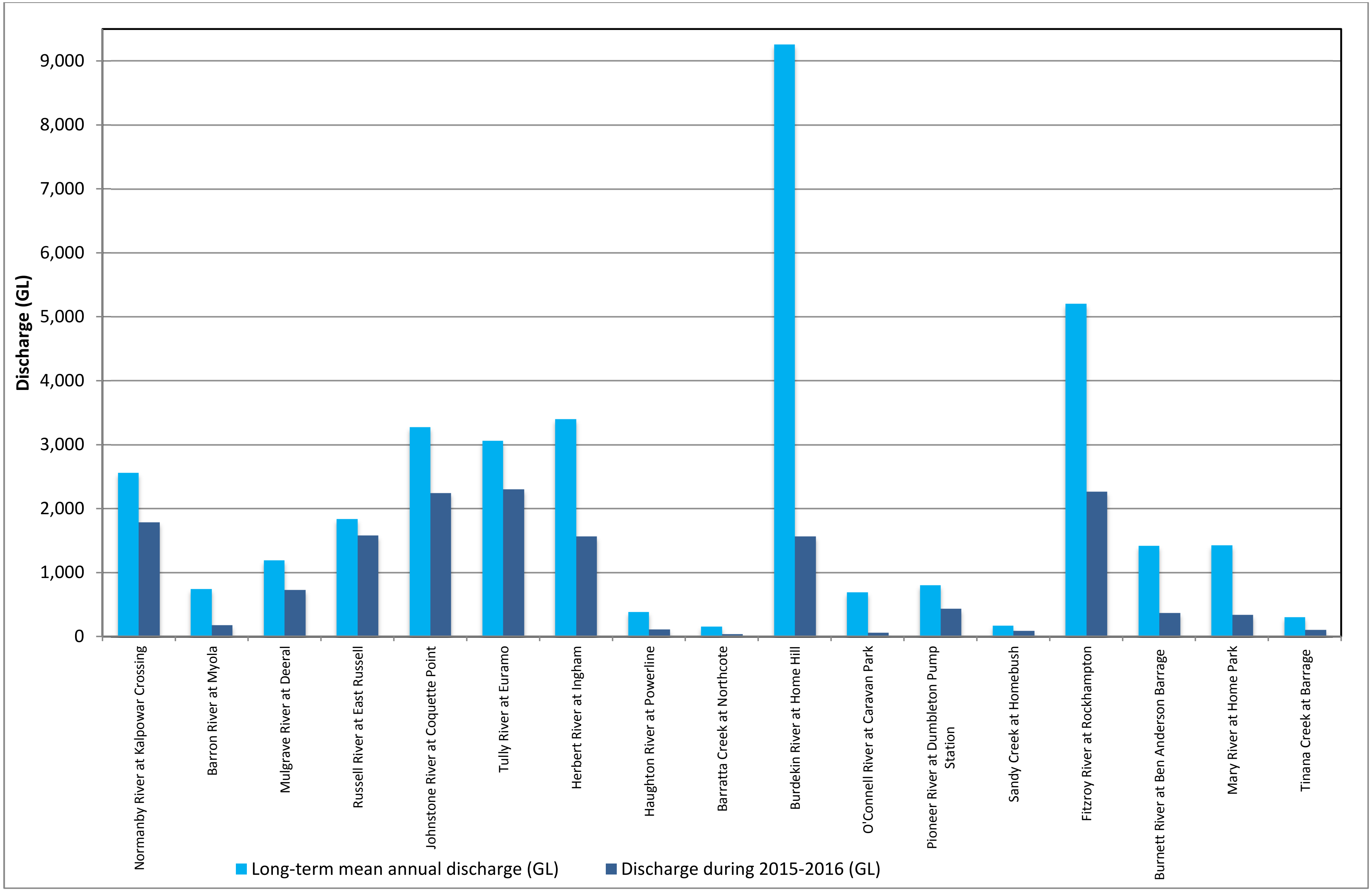


Figure 3.3 Annual discharge for the end-of-catchment sites for the 2015–2016 monitoring year, compared to the long-term mean annual discharge.

Table 3.1 The natural resource management region, basin, catchment and site names, total and monitored area for each catchment and summary discharge and flow statistics for each site sampled in the 2015–2016 monitoring year. Text in bold relate to end-of-catchment sites and the corresponding data; all others relate to sub-catchment sites.

NRM region	Basin	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 2015–2016 (GL)	Exceedance probability (%)	Discharge as a per cent of the long-term mean annual discharge (%)	Historical maximum recorded flow ($m^3 s^{-1}$)	Maximum recorded flow 2015–2016 ($m^3 s^{-1}$)	Per cent of maximum recorded flow observed in 2015–2016 (%)
Cape York	Normanby	**Normanby River at Kalpowar Crossing**	15,030	12,920	86	2005	2600	1800	64	69	2075	822	40
Wet Tropics	Barron	**Barron River at Myola**	2149	1933	90	1957	740	180	95	24	3076	420	14
	Mulgrave-Russell	**Mulgrave River at Deeral**	804	789	98	1984	1200	730	81	61	2161	394	18
		Russell River at East Russell	560	522	93	1984	1800	1600	72	89	1131	493	44
	Johnstone	**Johnstone River at Coquette Point**	1630	1630	100	1984	3300	2200	85	67	3505	491	14
		North Johnstone River at Old Bruce Highway Bridge (Goondi)	1082	960	89	1966	1800	1300	75	72	2935	924	31
		South Johnstone River at Upstream Central Mill	545	400	73	1974	790	560	72	71	1005	367	37
	Tully	**Tully River at Euramo**	1563	1450	93	1972	3100	2300	76	74	1045	683	65
		Tully River at Tully Gorge National Park	1563	482	31	2009	910	560	86	62	637	291	46
	Herbert	**Herbert River at Ingham**	8817	8584	97	1915	3400	1600	74	47	11,267	1508	13
Burdekin	Haughton	**Haughton River at Powerline**	2037	1773	87	1970	380	120	77	32	2636	139	5
		Barratta Creek at Northcote	1226	759	62	1974	160	40	86	25	1107	48	4
	Burdekin	**Burdekin River at Home Hill**	129,930	129,930	100	1973	9300	1600	79	17	25,483	2242	9
		Burdekin River at Sellheim	36,252	36,252	100	1968	4600	1100	83	24	21,377	1106	5
		Bowen River at Myuna	9449	7107	75	1960	940	370	63	39	10,480	1572	15
Mackay Whitsunday	O'Connell	**O'Connell River at Caravan Park**	860	819	95	1976	690	58	80	8	6541	318	5
	Pioneer	**Pioneer River at Dumbleton Pump Station**	1570	1466	93	1977	800	440	54	55	2263	1429	63
	Plane	**Sandy Creek at Homebush**	465	326	70	1966	170	93	60	55	1314	294	22
Fitzroy	Fitzroy	**Fitzroy River at Rockhampton**	140,801	139,289	99	1964	5200	2300	58	44	14,493	2356	16
		Theresa Creek at Gregory Highway	8632	8485	98	1956	260	73	78	28	4075	350	9
		Comet River at Comet Weir	17,297	16,422	95	2002	840	22	77	3	3434	43	1
		Dawson River at Taroom	50,764	15,847	31	1911	400	240	45	60	5555	253	5
Burnett Mary	Burnett	**Burnett River at Ben Anderson Barrage Head Water**	33,179	32,841	99	1910	1420	370	47	26	16,902	474	3
		Burnett River at Mt Lawless	33,179	29,356	88	1909	1100	330	50	30	15,713	761	5
	Mary	**Mary River at Home Park**	9161	6872	75	1982	1400	340	71	24	11,633	349	3
		Tinana Creek at Barrage Head Water	1291	1284	99	1970	300	110	67	37	1117	50	4
Summary end-of-catchment catchment areas (excluding sub-catchments)			351,764	343,187	98								

NRM = natural resource management.

3.2 Sampling representivity

The sampling representivity rating classified the sample coverage achieved during the period of maximum flow at each monitoring site. Table 3.2 to Table 3.4 provide a summary of the sampling representivity ratings – indicating those parameters and sites where the representivity is excellent or good, moderate or indicative.

As outlined in Section 2.7.1, the method of assessing representivity is not applicable to pesticide data.

Excellent or good sampling representivity was achieved at all monitoring sites for all monitored analytes, except in the Haughton, Johnstone, Comet and Tinana Creek catchments as well as total suspended solids in the Normanby catchment (Table 3.2).

During the 2015–2016 monitoring year, annual discharge for the Haughton River was very much below average and consisted of few high flow events. Because there was poor data coverage for the highest flow event, the Beale ratio method was selected to calculate annual pollutant loads based on an indicative representivity rating.

In the Comet River sub-catchment, sample representivity was moderate for all analytes. During the 2015–2016 monitoring year the Comet River had very low annual discharge (77 per cent exceedance probability) (Table 3.1) with few samples collected during periods of elevated flow. Sample coverage requirements for low flow monitoring is considered less stringent than high flow (concentrations during low flow do not have such a high variability as those during high flow events), as such, the average load (linear interpolation of concentration) method was selected to calculate annual pollutant loads.

The sample coverage during all measures of flow in both the Johnstone River and Tinana Creek catchments was outstanding with 85 and 66 samples collected across the monitoring year respectively, including all major flow events. However, as modelled flow was used to calculate annual loads for the Johnstone River and Tinana Creek, loads were assigned an indicative rating. The same approach was used in the 2013–2015 monitoring years (Garzon-Garcia et al. 2015, Wallace et al. 2016).

In the Normanby catchment sampling representivity for total suspended solids was moderate and good for all other analytes. This occurred as fewer water quality samples were collected for analysis of total suspended solids during periods of high flow compared to the coverage of samples collected for nutrient analysis during the same periods of peak discharge.

The continuous improvement of the Great Barrier Reef Catchment Loads Monitoring Program, including targeted sampling of both manual and automatic sampling sites, achieved through ongoing staff training and advancement of automated sampling software programs, has resulted in improved sample representivity ratings. Since this method was first implemented in 2009, the number of monitored sites that achieved an excellent sampling representivity ranged between 20 per cent during the 2011–2012 monitoring year to

47 per cent in 2013–2014. Fifty-four per cent of monitored sites reported in this current monitoring year achieved an excellent sampling representivity, the largest to date.

3.3 Total suspended solids and nutrient loads and yields

The monitored annual loads and yields of total suspended solids and nutrients were calculated using measured concentration data. The resultant loads are the mass of each analyte transported past the monitoring sites and do not necessarily represent the loads discharged to the Great Barrier Reef lagoon. This occurs because most of the end-of-catchment monitoring sites are not located at the mouth of the river or creek (refer to Section 2.1) and in the unmonitored portion of the catchment or sub-catchment there may be contribution, removal, transformation or degradation of total suspended solids and nutrients. The annual loads discharged to the Great Barrier Reef for all 35 basins are calculated using catchment models and are reported elsewhere in the Paddock to Reef Program (DPC 2015).

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 of 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 priority catchments during the 2015–2016 monitoring year was 1.8 Mt (Table 3.2) of which, 75 per cent was derived from large inland catchments dominated by dry land grazing comprising the Burdekin (700 kt; 38 per cent) and Fitzroy (670 kt; 36 per cent) catchments (Table 3.2 and Figure 3.4). All remaining catchments contributed less than five per cent of the total monitored annual load each. Of these catchments, the Johnstone (78 kt; 4.2 per cent), Tully (64 kt; 3.5 per cent), Normanby (62 kt; 3.3 per cent), Herbert (58 kt; 3.2 per cent) and Mary (52 kt; 2.8 per cent) made the largest contributions. The lowest monitored annual load of total suspended solids during the 2015–2016 monitoring year was in the Tinana Creek catchment (1.7 kt; 0.092 per cent).

The Burdekin and Fitzroy catchments typically contribute the majority of the monitored total suspended solids annual loads (between 52 per cent in 2012–2013 and 92 per cent in 2007–2008, although the majority of the monitored load in 2008–2009 was derived from the Burdekin catchment alone (87 per cent)). However, in the 2013–2014 monitoring year these catchments produced only 20 per cent of the combined monitored annual load which is consistent with the annual discharge being much below average in these catchments compared to others (Garzon-Garcia et al. 2015). The high proportion of the monitored loads from these two catchments during the 2015–2016 monitoring year, relative to the mass load of other catchments, is explained by the below average discharge across *all* monitored catchments during the 2015–2016 monitoring year relative to historic discharge.

Within the Cape York region, the monitored load of total suspended solids derived from the Normanby catchment (62 kt; 3.4 per cent) was approximately double the load during the previous monitoring year

(Wallace et al. 2016). This is likely due to the increased total rainfall across the majority of the catchment during the 2015–2016 monitoring year compared to 2014–2015.

In the Wet Tropics region, the Johnstone (78 kt; 4.2 per cent), Tully (64 kt; 3.5 per cent) and Herbert (58 kt; 3.2 per cent) catchments produced monitored annual loads of total suspended solids that, although largest of the monitored catchments in the Wet Tropics region, were low compared to the Burdekin and Fitzroy catchments (Table 3.2 and Figure 3.4). The majority of the total suspended solids load monitored at the Johnstone end-of-catchment site was derived from the North Johnstone (36 kt) catchment which generated a load three times larger than the South Johnstone (12 kt) catchment. The Barron catchment contributed the lowest monitored annual load since monitoring in this catchment commenced in 2006 (14 kt; 0.76 per cent) corresponding with an annual exceedance probability of discharge of 95 per cent.

In the Burdekin region, the Haughton (14 kt; 0.76 per cent) catchment generated a monitored annual load of total suspended solids three times larger than the Barratta Creek (4.3 kt; 0.23 per cent) catchment which contributed the smallest monitored annual load since monitoring at this site commenced in 2009. The largest monitored annual sub-catchment load of total suspended solids was derived from the Upper Burdekin River (monitored at Sellheim, 1500 kt) followed by the Bowen River (790 kt) (Table 3.2). The monitored annual load of total suspended solids in the Upper Burdekin River (Sellheim) was approximately double the monitored annual load at the Burdekin River end-of-catchment site. Marked differences in the monitored annual total suspended solids loads at these sites have been noted previously (Turner et al. 2012 and 2013; Wallace et al. 2014 and 2015). The Burdekin Falls Dam which overtopped within the monitored year, is located in between these two sites and is known to reduce the sediment load exported downstream due to the settling of coarse sediment, although the majority of the fine fraction is not retained by the dam (Bainbridge et al. 2014).

The monitored annual load of total suspended solids in the Pioneer (44 kt; 2.4 per cent) catchment was the largest of all monitored catchments in the Mackay Whitsunday region, approximately five times greater than the O'Connell catchment (9.9 kt; 0.54 per cent) and Sandy Creek catchment (8.4 kt; 0.46 per cent) (Table 3.2 and Figure 3.4). Monitored loads of total suspended solids derived from the Mackay Whitsunday region was largely driven by a moderate flood event early in March 2016, during which time this region received above average to very much above average rainfall.

In the Fitzroy region, the Theresa Creek and Dawson River sub-catchments produced similar monitored annual loads of total suspended solids during the 2015–2016 monitoring year (120 kt and 100 kt, respectively). The monitored annual load of total suspended solids derived from the Comet River (35 kt) sub-catchment was the lowest reported for this sub-catchment since monitoring commenced in 2006. This is consistent with the very low discharge during the 2015–2016 monitoring year, attaining a 77 per cent annual exceedance probability of discharge.

In the Burnett Mary region, the monitored load of total suspended solids derived from the Mary River (52 kt; 2.8 per cent) was 30 times larger than the monitored load contributed from the Tinana Creek catchment (1.7 kt; 0.092 per cent) despite the monitored area of the Mary River catchment being only 5.4 times larger than the monitored area of the Tinana Creek catchment. These are the lowest monitored loads reported in the Mary basin since monitoring commenced in these catchments in 2013. The monitored annual sub-catchment load of total suspended solids derived from the Upper Burnett River (monitored at Mt Lawless, 69 kt) was approximately 11 times larger than the monitored load at the Burnett River end-of-catchment site (Burnett River at Ben Anderson Barrage Headwater) (6.5kt, 0.35 per cent) (Table 3.2 and Figure 3.4). This site is downstream of Paradise Dam and the reduced load of total suspended solids may be due to solids settling out as water velocity reduces as it enters Paradise Dam (Turner et al. 2012 and Turner et al. 2013). This pattern has been seen in previous monitoring years.

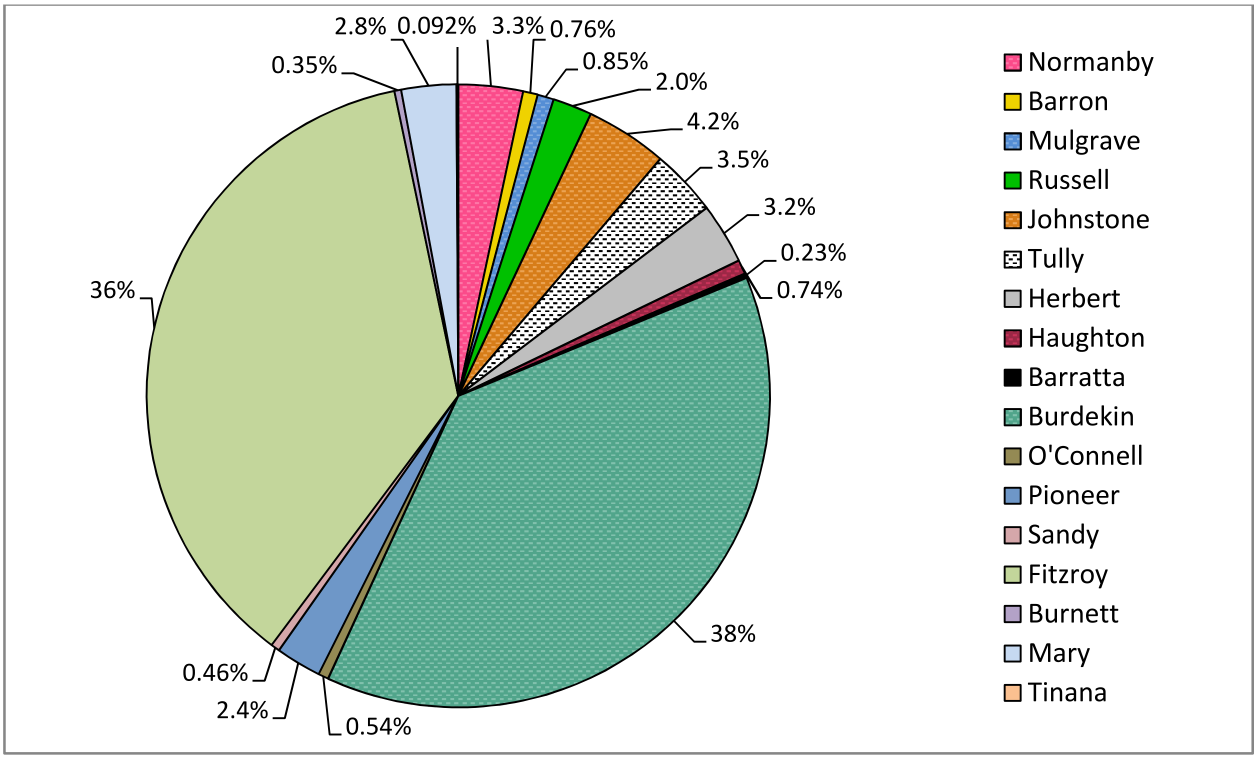


Figure 3.4 Per cent contribution of each catchment to the combined monitored annual total suspended solids load during the 2015–2016 monitoring year.

3.3.1.2 Total suspended solids yields

During the 2015–2016 monitoring year, the highest end-of-catchment yield of total suspended solids was contributed by the Russell catchment (72 t km^{-2}) (Table 3.3). Moderate yields of total suspended solids were contributed by the Johnstone (48 t km^{-2}), Tully (44 t km^{-2}), Pioneer (30 t km^{-2}), Sandy Creek (26 t km^{-2}) and Mulgrave (20 t km^{-2}) catchments (Table 3.3). The lowest monitored annual yield of total suspended solids occurred in the Burnett catchment (0.20 t km^{-2}).

During the 2015–2016 monitoring year, high yields were produced in the smaller coastal catchments (i.e. surface areas less than 2000 km^2) of the Mackay Whitsunday (range, 12 t km^{-2}–30 t km^{-2}) and Wet Tropics regions (range, 20 t km^{-2}–72 t km^{-2}), excluding the Barron and Herbert catchments (Table 3.3). The yield of total suspended solids in the Barron catchment (7.2 t km^{-2}) was the lowest monitored since 2006; yields from previous years of monitoring ranged between 24 t km^{-2} in 2014–2015 and 190 t km^{-2} in 2010–2011 (Wallace et al. 2015 and 2016; Garzon-Garcia et al. 2015). In comparison, the large catchments (i.e. surface areas greater than 8000 km^2), including the Mary (7.6 t km^{-2}), Herbert (6.8 t km^{-2}), Burdekin (5.4 t km^{-2}), Normanby (4.8 t km^{-2}) and Fitzroy (4.8 t km^{-2}), produced lower yields of total suspended solids (Table 3.3).

Within the Cape York region, the yield of total suspended solids for the Normanby catchment was approximately double the yield of the previous monitoring year (Wallace et al. 2016) despite only a 13 per cent increase in annual discharge between the 2014–2015 and 2015–2016 monitoring years.

Historically, catchments in the Wet Tropics region have consistently produced high yields of total suspended solids relative to other monitored catchments (Garzon-Garcia et al. 2015). Although the yield for total suspended solids from the North Johnstone and South Johnstone sub-catchments in 2015–2016 were the lowest since monitoring commenced in 2006, the North and South Johnstone sub-catchments have consistently been in the top five highest yielding monitored catchments since 2006 and have remained so in this monitoring year. This result is likely influenced by the long-term mean annual discharge for the Johnstone sub-catchments being surpassed 60 per cent of the time between 2006 and 2016.

In the Burdekin region, the Barratta Creek catchment also produced the lowest yield of total suspended solids since monitoring at this site commenced in 2009. Similar end-of-catchment yields for total suspended solids were produced by the Haughton (7.7 t km^{-2}), Barratta Creek (5.7 t km^{-2}) and Burdekin (5.4 t km^{-2}) catchments. The highest sub-catchment yield of total suspended solids in the Burdekin catchment was contributed by the Bowen River sub-catchment (monitored at Myuna, 110 t km^{-2}), which was approximately twice the yield of total suspended solids during the previous monitoring year (Wallace et al. 2016). The yield of total suspended solids from the Bowen River sub-catchment was approximately three times larger than the monitored yield in the Upper Burdekin River (monitored at Sellheim (42 t km^{-2})) and 21 times the yield observed at the Burdekin River end-of-catchment site (monitored at Home Hill). Annual discharge in monitored catchments of the Burdekin basin, other than the Bowen River in 2012–2013 (Wallace et al. 2015), has been consistently below 45 per cent of the long-term mean annual discharge over the last four monitoring years, which has contributed to lower observed yields of total suspended solids during that period.

Within the Mackay Whitsunday region, the monitored yield of total suspended solids derived from the Sandy Creek (26 t km^{-2}) catchment, was similar to that derived from the Pioneer (30 t km^{-2}) catchment, despite the monitored area of the Pioneer catchment being four times the monitored area of the Sandy Creek catchment. During the previous two monitoring years, the yield of total suspended solids from the Sandy Creek catchment was approximately double the yield of the Pioneer catchment in 2013–2014 and five times larger in 2014–2015.

In the monitored sub-catchments of the Fitzroy region, the yield of total suspended solids in the Theresa Creek sub-catchment was 14 t km^{-2}, approximately twice the yield observed in the Dawson River (6.2 t km^{-2}) and six times the Comet River (2.2 t km^{-2}) sub-catchment. The low yield of total suspended solids from the Comet River sub-catchment is likely due to the exceptionally low discharge from this sub-catchment during the monitoring year, which was only three per cent of the long-term annual average (Table 3.1).

During the 2015–2016 monitoring year, low discharge from catchments of the Burnett Mary region contributed to lower loads of total suspended solids over the monitoring period. The yield of total suspended solids in the Mary (7.6 t km^{-2}) and Tinana Creek (1.3 t km^{-2}) catchments was low compared to previous monitoring years (33 t km^{-2} and 3.2 t km^{-2} respectively in 2014–2015; 13 t km^{-2} and 3.0 t km^{-2}, respectively in 2013–2014) (see Garzon-Garcia et al. 2015, Wallace et al. 2015).

3.3.2. Nitrogen

3.3.2.1 Nitrogen load

During the 2015–2016 monitoring year, the combined monitored annual load of total nitrogen was 11,000 t (Table 3.2); similar to the monitored load of total nitrogen in the 2013–2014 and 2014–15 monitoring years (Garzon-Garcia et al. 2015, Wallace et al. 2016). The Fitzroy (3300 t; 29 per cent) catchment produced the largest monitored annual load of total nitrogen with moderate loads also contributed by the Burdekin (1500 t; 14 per cent), Tully (1100 t; 9.7 per cent), Normanby (910 t; 8.1 per cent) and Herbert (840 t; 7.5 per cent) catchments (Table 3.2 and Figure 3.5). All other monitored catchments each contributed less than seven per cent of the combined monitored load of total nitrogen during the 2015–2016 monitoring year. The lowest loads of total nitrogen were derived from the Haughton (98 t; 0.88 per cent), Tinana Creek (97 t; 0.87 per cent), Barratta Creek (88 t; 0.79 per cent) and O'Connell (78 t; 0.70 per cent) catchments (Table 3.2 and Figure 3.5). The Fitzroy and Burdekin catchments typically contribute the majority of the combined monitored annual load of total nitrogen, each producing the two largest loads between 2007–2012 (together contributing between 56 per cent and 84 per cent of the combined monitored annual load) (Turner et al. 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Garzon-Garcia et al. 2015). The Burdekin (10,000 t; 54 per cent) catchment also produced the largest load during 2006–2007 and the Fitzroy (3200 t; 27 per cent) catchment in 2014–2015 (Wallace et al. 2016). During the 2012–2013 monitoring year, the Burnett catchment produced the largest load (12,000 t; 35 per cent) which is consistent with an annual discharge five times greater than the long-term mean annual discharge (Wallace et al. 2015). The Herbert catchment produced the largest monitored load of total nitrogen in 2013–2014 (2600 t; 22 per cent), in which the Herbert catchment produced the largest annual discharge of all monitored catchments (Garzon-Garcia et al. 2015).

The combined monitored annual load of dissolved inorganic nitrogen was 2900 t (Table 3.2). The largest monitored annual loads of dissolved inorganic nitrogen was derived from the Fitzroy catchment (680 t; 24 per cent) with moderate loads from the Tully (510 t; 18 per cent), Russell (310 t; 11 per cent), Burdekin (280 t; 9.8 per cent), Herbert (270 t; 9.3 per cent) and Johnstone (260 t; 9.0 per cent) catchments (Table 3.2 and Figure 3.6). The remaining catchments each contributed less than eight per cent of the combined monitored dissolved inorganic nitrogen load, with the lowest monitored loads occurring in the O'Connell (13 t; 0.46 per cent) and Tinana Creek (12 t; 0.41 per cent) catchments (Table 3.2 and Figure 3.6). The Fitzroy catchment produced the largest monitored annual load of dissolved inorganic nitrogen during the 2009–2011 monitoring years (2100 t; 37 per cent and 3900 t; 32 per cent) (Turner et al. 2012 and 2013) and also the 2014–2015 monitoring year (470 t; 18 per cent) (Wallace et al. 2016). Reef Plan 2013 water quality targets are based on reductions in anthropogenic baseline loads resulting from the adoption of improved land management practices as evidenced by catchment loads modelling. Waters et al. (2014) and McCloskey et al. (2017) report the anthropogenic portion of the modelled dissolved inorganic nitrogen loads for the Fitzroy catchment comprised 6.1 per cent (2014) and 20 per cent (2015). To achieve the 50 per cent reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads by 2018 (DPC 2013a), reductions in the Fitzroy catchment would be of less priority.

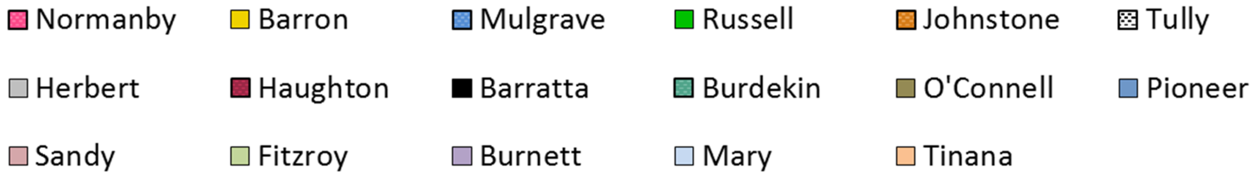
Oxidised nitrogen accounted for 85 per cent of the combined monitored dissolved inorganic nitrogen load during the 2015–2016 monitoring year. The largest monitored annual loads of oxidised nitrogen were contributed by the Fitzroy (560 t; 23 per cent), Tully (480 t; 19 per cent), Russell (270 t; 11 per cent), Herbert (250 t; 9.9 per cent) and Burdekin (250 t; 10 per cent) catchments that, together, accounted for 73 per cent of the combined monitored end-of-catchment load. The remaining catchments each contributed eight per cent or less of the total monitored oxidised nitrogen load, with the lowest annual load of oxidised nitrogen load monitored in the Tinana Creek catchment (7.3 t; 0.30 per cent) (Table 3.2 and Figure 3.7).

During the 2015–2016 monitoring year, the total monitored annual load of ammonium nitrogen was 420 t (Table 3.2). The Fitzroy (120 t; 29 per cent), Johnstone (57 t; 13 per cent), Russell (38 t; 9.0 per cent) and Normanby (37 t; 8.6 per cent) catchments contribute 60 per cent of the total ammonium nitrogen load with moderate loads also measured in the Burdekin (34 t; 7.9 per cent), Pioneer (30 t; 7.1 per cent), Tully (29 t; 6.7 per cent) and Herbert (23 t; 5.4 per cent) catchments. All remaining catchments each contributed less than five per cent of the monitored ammonium nitrogen load, with the lowest monitored annual loads occurring in the Haughton catchment (2.0 t; 0.46 per cent) (Figure 3.8).

The ratio of the monitored annual oxidised nitrogen load to the ammonium nitrogen load varied greatly amongst catchments. In the Tully, Sandy Creek, Barratta Creek, Herbert and Mulgrave catchments the ratio was high (range of 17:1 to 10:1). In all other catchments the ratio was in the range 4:1 to 8:1, except in the O'Connell, Burnett and Tinana Creek catchments where the ratio was 2:1. The Normanby catchment was the only monitored catchment where the load of ammonium nitrogen was similar to the oxidised nitrogen load (1:1). In previous years the ratio of ammonium nitrogen to oxidised nitrogen has been less than 1:1 (Wallace et al. 2015; Garzon-Garcia et al. 2015).

During the 2015–2016 monitoring year, the combined monitored annual load of particulate nitrogen was 4500 t (Table 3.2). Consistent with the observed trend of total suspended solids loads, the largest monitored annual loads of particulate nitrogen during the 2015–2016 monitoring year were contributed by the Fitzroy (1600 t; 36 per cent), Burdekin (870 t: 20 per cent) and Johnstone (300 t; 6.8 per cent) catchments (Table 3.2 and Figure 3.9). The remaining catchments each contributed six per cent or less of the combined monitored load, with the lowest end-of-catchment load monitored in the Tinana Creek catchment (21 t; 0.47 per cent) (Table 3.2 and Figure 3.9). Across the ten years of monitoring by the Great Barrier Reef Catchment Loads Monitoring Program, the Fitzroy and Burdekin catchments produced the largest monitored annual loads of particulate nitrogen over eight out of ten monitoring years (collectively contributing between 41 per cent and 87 per cent of the combined monitored annual load during those years). The Burnett and Herbert catchments each produced the largest loads in the remaining two years (2012–2013 (7300 t; 42 per cent) and 2013–2014 (1100 t; 24 per cent), respectively) (Wallace et al. 2015; Garzon-Garcia et al. 2015).

The combined monitored annual load of dissolved organic nitrogen during the 2015–2016 monitoring year was 3800 t (Table 3.2) – more than one third of the combined total nitrogen load. The largest monitored annual loads of dissolved organic nitrogen were contributed by the Fitzroy (920 t; 24 per cent), Normanby (580 t; 15 per cent) and Burdekin (390 t; 10 per cent) catchments that, together, accounted for over half the combined monitored annual end-of-catchment load during the 2015–2016 monitoring year. Moderate loads, relative to other monitored catchments, were also monitored in the Herbert (350 t; 9.2 per cent) and Tully (330 t; 8.7 per cent) catchments (Table 3.2 and Figure 3.10). The remaining catchments each contributed less than five per cent of the combined monitored load of dissolved organic nitrogen (Figure 3.10), with the lowest loads monitored in the Sandy Creek (59 t; 1.6 per cent), Haughton (38 t; 1.0 per cent), Barratta Creek (28 t; 0.74 per cent) and O'Connell (26 t; 0.69 per cent) catchments. Typically the majority of the combined monitored annual load of dissolved organic nitrogen is generated by the Fitzroy and Burdekin catchments, the Fitzroy catchment has produced the largest load in five out of the ten monitoring years and the Burdekin catchment four times out of the ten years of monitoring (Joo et al. 2011; Turner et al. 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Garzon-Garcia et al. 2015). The Normanby catchment has consistently produced monitored annual loads within the five largest each monitoring year.



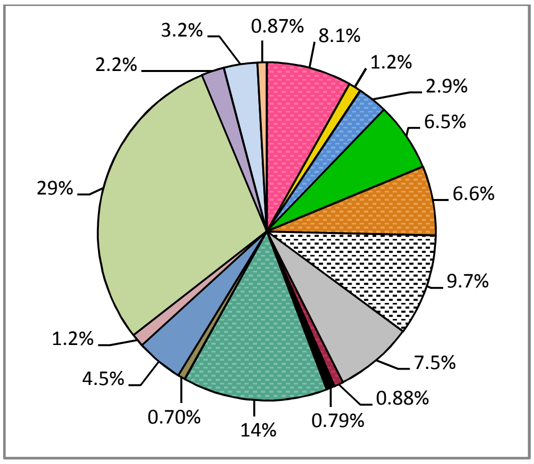


Figure 3.5 Per cent contribution of each catchment to the combined monitored annual total nitrogen load during the 2015–2016 monitoring year.

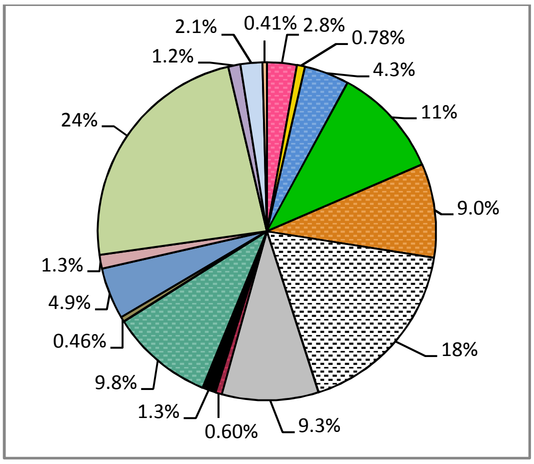


Figure 3.6 Per cent contribution of each catchment to the combined monitored annual dissolved inorganic nitrogen load during the 2015–2016 monitoring year.

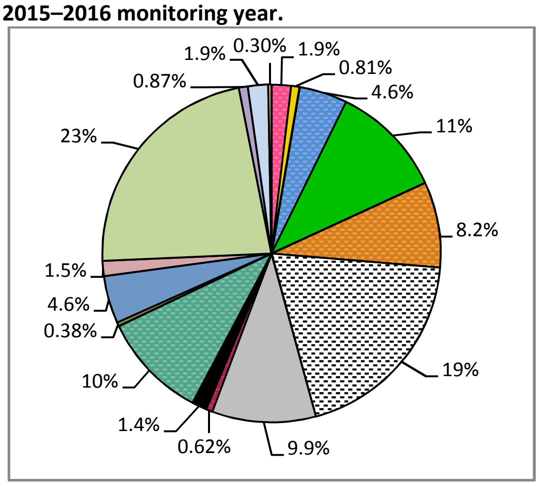


Figure 3.7 Per cent contribution of each catchment to the combined monitored annual oxidised nitrogen load during the 2015–2016 monitoring year.

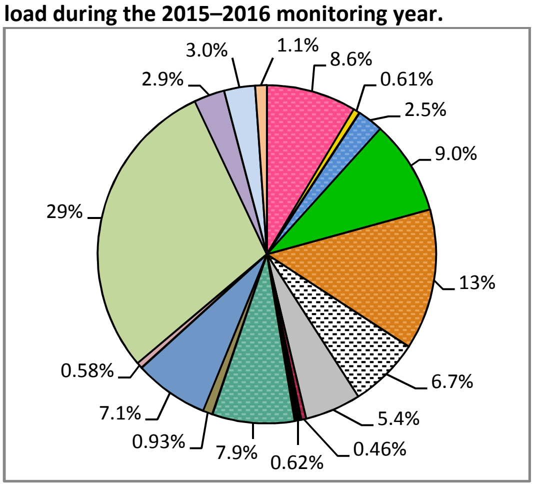


Figure 3.8 Per cent contribution of each catchment to the combined monitored annual ammonium nitrogen load during the 2015–2016 monitoring year.

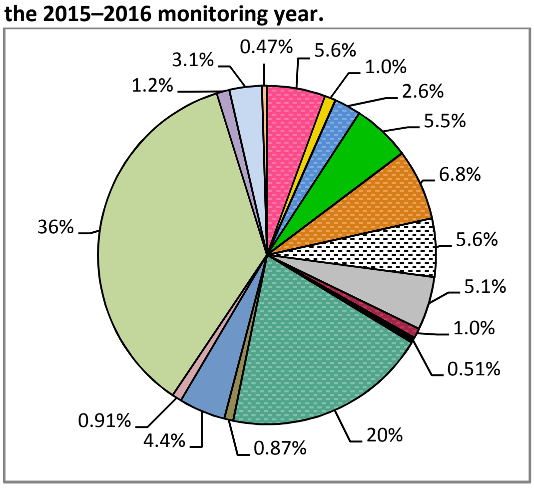


Figure 3.9 Per cent contribution of each catchment to the combined monitored annual particulate nitrogen load during the 2015–2016 monitoring year.

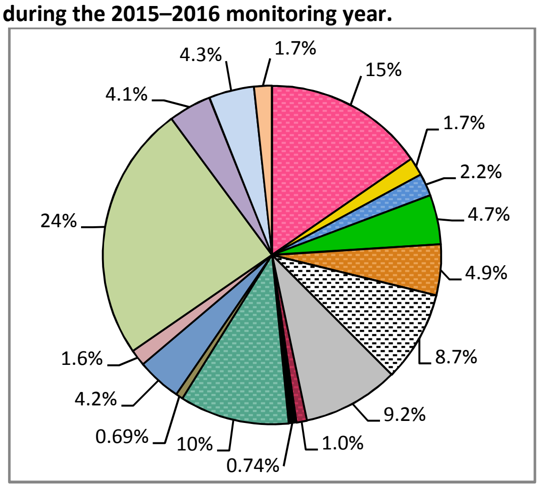


Figure 3.10 Per cent contribution of each catchment to the combined monitored annual dissolved organic nitrogen load during the 2015–2016 monitoring year.

3.3.2.2 Nitrogen yields

During the 2015–2016 monitoring year the highest yield of total nitrogen was derived from the Russell catchment (1400 kg km^{-2}). High yields were also derived from other coastal catchments in the Wet Tropics region including the Tully (750 kg km^{-2}), Johnstone (450 kg km^{-2}) and Mulgrave (410 kg km^{-2}) catchments (Table 3.3). High yields were also contributed by the Sandy Creek (420 kg km^{-2}) and Pioneer (340 kg km^{-2}) catchments. Moderate yields of total nitrogen were also contributed by Barratta Creek (120 kg km^{-2}) catchment. The lowest monitored annual yields of total nitrogen were contributed by the larger inland catchments in which the dominant land use is dry land grazing, including the Burdekin (12 kg km^{-2}), Burnett (7.4 kg km^{-2}) and Fitzroy (23 kg km^{-2}) catchments, which is consistent with previous monitoring years between 2006–2015 (Garzon-Garcia et al. 2015, Wallace et al. 2016). The highest yields of total nitrogen were derived from the North Johnstone catchment five out of the ten years of monitoring and the South Johnstone catchment for two years (in previous monitoring years both the North Johnstone and South Johnstone catchments were reported as end-of-catchment sites for the Johnstone Basin) (Joo et al. 2011; Turner et al. 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Garzon-Garcia et al. 2015). The Tully catchment has consistently produced total nitrogen yields within the four highest each monitoring year.

The Russell (470 kg km^{-2}), Johnstone (180 kg km^{-2}) and Tully (170 kg km^{-2}) catchments generated the highest yield of particulate nitrogen during the 2015–2016 monitoring year (Table 3.3). Moderate yields of particulate nitrogen were contributed by the Mulgrave (140 kg km^{-2}), Pioneer (130 kg km^{-2}) and Sandy Creek (120 kg km^{-2}) catchments. The lowest yields of particulate nitrogen during the 2015–2016 monitoring year were contributed by Tinana Creek (16 kg km^{-2}), Fitzroy (11 kg km^{-2}), Burdekin (6.7 kg km^{-2}) and Burnett (1.6 kg km^{-2}) catchments. The highest yields of particulate nitrogen over the ten years of monitoring were also derived from the North Johnstone and South Johnstone catchments (four and three years, respectively), both catchments produced above average annual discharge during these years, with the exception of the North Johnstone catchment during the 2014–2015 monitoring year (Joo et al. 2011; Turner et al. 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Garzon-Garcia et al. 2015).

The yield of dissolved inorganic nitrogen in the Russell (590 kg km^{-2}) catchment was again exceptionally high relative to all other catchments monitored during the 2015–2016 monitoring year similar to that of the 2014–2015 monitoring year (Wallace et al. 2016). The yield of dissolved inorganic nitrogen was high in the Tully (350 kg km^{-2}), Johnstone (160 kg km^{-2}), Mulgrave (160 kg km^{-2}) and Sandy Creek (120 kg km^{-2}) catchments relative to other monitored catchments. Pioneer (98 kg km^{-2}) catchment produced a comparatively moderate yield of dissolved inorganic nitrogen. The Fitzroy (4.9 kg km^{-2}), Burdekin (2.2 kg km^{-2}) and Burnett (1.0 kg km^{-2}) catchments produced the lowest monitored yields of dissolved inorganic nitrogen over the 2015–2016 monitoring year (Table 3.3). The yields of dissolved inorganic nitrogen generated by Tully catchment were among the two highest for each of the ten years of monitoring and the highest for seven of those (Joo et al. 2011; Turner et al. 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Garzon-Garcia et al. 2015).

The yield of oxidised nitrogen was high across the smaller monitored coastal catchments in the Wet Tropics region (e.g. Russell 510 kg km^{-2}, Tully 330 kg km^{-2}, Mulgrave 140 kg km^{-2} and Johnstone 120 kg km^{-2}) with comparatively lower yields in the larger Herbert and Barron catchments (29 kg km^{-2} and 10 kg km^{-2} respectively).Outside of the Wet Tropics region, the Sandy Creek (110 kg km^{-2}), Pioneer (77 kg km^{-2}) and Barratta Creek (47 kg km^{-2}) catchments also produced moderate yields of oxidised nitrogen relative to other monitored catchments (Table 3.3). The lowest yields of oxidised nitrogen during the 2015–2016 monitoring year were in the Fitzroy (4.0 kg km^{-2}), Normanby (3.5 kg km^{-2}), Burdekin (1.9 kg km^{-2}) and Burnett (0.65 kg km^{-2}) catchments.

The largest yields of ammonium nitrogen were also in the smaller coastal catchments of the Wet Tropics region, with the Russell (74 kg km^{-2}), Johnstone (35 kg km^{-2}), Tully (20 kg km^{-2}) and Mulgrave (13 kg km^{-2}) catchments generating yields higher than all other monitored catchments (Table 3.3). The Pioneer (21 kg km^{-2}) catchment also produced high yields in relation to other catchments. The lowest yields were derived from the Fitzroy (0.89 kg km^{-2}), Burnett (0.38 kg km^{-2}) and Burdekin (0.26 kg km^{-2}) catchments. The highest yields of ammonium nitrogen were derived from the Pioneer catchment six out of the ten years of monitoring producing yields between 21 kg km^{-2} (2011–2012 monitoring year) and 65 kg km^{-2} (2010–2011) (Joo et al. 2011; Turner et al. 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Garzon-Garcia et al. 2015). The Tully catchment has consistently produced monitored annual loads within the four largest each monitoring year.

The monitored annual yield of dissolved organic nitrogen during the 2015–2016 monitoring year was high in the smaller coastal catchments of the Wet Tropics and the Mackay Whitsunday region, with the highest yields occurring in the Russell (340 kg km^{-2}), Tully (220 kg km^{-2}), Sandy Creek (180 kg km^{-2}), Johnstone (110 kg km^{-2}), and Pioneer (110 kg km^{-2}) catchments (Table 3.3). Moderate yields were contributed by the Tinana Creek (50 kg km^{-2}) catchment with all other catchments contributing lower yields of less than 50 kg km^{-2}. The lowest yields of dissolved organic nitrogen during the 2015–2016 monitoring year were contributed by the Fitzroy (6.6 kg km^{-2}), Burnett (4.7 kg km^{-2}) and Burdekin (3.0 kg km^{-2}) catchments.

3.3.3. Phosphorus

3.3.3.1 Phosphorus load

The combined end-of-catchment monitored annual load of total phosphorus during the 2015–2016 monitoring year was 2300 t (Table 3.2).The largest monitored annual load was contributed by the Fitzroy (910 t; 40 per cent) catchment. This figure is consistent with the 2014–2015 monitoring year in which 44 per cent (1300 t) of the combined monitored annual load of total phosphorus resulted from the Fitzroy catchment (Wallace et al. 2016). Moderate loads of total phosphorus were monitored in the Burdekin (460 t; 21 per cent), Johnstone (210 t; 9.2 per cent) and Normanby (120 t; 5.4 per cent) catchments (Figure 3.11). The monitored annual load of total phosphorus in the Upper Burdekin River sub-catchment site (monitored at Sellheim) was 1100 t, approximately double the monitored total phosphorus load at the end-of-catchment Burdekin River site (Home Hill, 460 t). As previously described for monitored annual loads of total suspended solids in the Burdekin catchment, the Burdekin Falls Dam may account for the reduction in total phosphorus

loads observed between these sites as phosphorus binds with sediment and sediment is known to drop out of suspension in the dam (Bainbridge et al. 2014). All remaining catchments each contributed less than five per cent of the combined monitored annual load of total phosphorus, with the lowest load derived from Tinana Creek (7.7 t; 0.34 per cent).

The combined monitored annual load of dissolved inorganic phosphorus was 280 t during the 2015–2016 monitoring year (Table 3.2). The largest monitored annual load of dissolved inorganic phosphorus was contributed by the Fitzroy (130 t; 47 per cent) catchment. The high proportion of dissolved inorganic phosphorus contributed by the Fitzroy is consistent with previous years (2009–2015) of reporting with the exception of 2013–2014 (65 t; 26 per cent) when there was a low annual discharge (Garzon-Garcia et al. 2015). Relative to other monitored catchments, the Burdekin (34 t; 12 per cent), Pioneer (23 t; 8.4 per cent) and Sandy Creek (16 t; 5.7 per cent) catchments contributed moderate monitored annual loads of dissolved inorganic phosphorus for 2015–2016 (Figure 3.12). All other catchments each contributed less than four per cent of the total combined monitored load of dissolved inorganic phosphorus, the lowest occurred in Tinana Creek (0.42 t; 0.15 per cent).

The combined monitored annual load of particulate phosphorus was 1800 t (Table 3.2) which accounted for 78 per cent of the monitored total phosphorus load in 2015–2016. Similar to total phosphorus and dissolved inorganic phosphorus, the largest contribution of particulate phosphorus (750 t; 42 per cent) was monitored in the Fitzroy catchment. Smaller contributions of particulate phosphorus load were monitored in the Burdekin (420 t; 24 per cent), Johnstone (130 t; 7.1 per cent) and Normanby (95 t; 5.3 per cent) catchments (Figure 3.13). The remaining catchments each produced less than five per cent of the combined monitored annual load, with the lowest load contributed by Tinana Creek (5.2 t; 0.29 per cent). Consistent with the trend of particulate nitrogen, the Fitzroy and Burdekin catchments produced the largest monitored annual loads of particulate phosphorus in eight out of the ten years of monitoring (collectively contributing between 55 per cent and 90 per cent of the combined monitored annual load during those years). The Burnett and Herbert catchments each produced the largest loads in the remaining two years (2012–2013 (2600 t; 38 per cent) and 2013–2014 (330 t; 24 per cent), respectively) (Wallace et al. 2015; Garzon-Garcia et al. 2015).

During the 2015–2016 monitoring year the combined monitored annual load of dissolved organic phosphorus was 240 t (Table 3.2). Approximately one third (75 t; 31 per cent) of the monitored annual load of dissolved organic phosphorus was derived from the Johnstone catchment. Moderate loads of dissolved organic phosphorus were monitored in the Tully (29 t; 12 per cent), Fitzroy (27 t; 11 per cent) and Normanby (23 t; 9.3 per cent) catchments (Figure 3.14). The remaining catchments each contributed less than four per cent of the combined monitored annual load, with the lowest end-of-catchment load derived from the Barratta Creek (0.76 t; 0.31 per cent) catchment.

Normanby Barron Mulgrave Russell Johnstone Tully
Herbert Haughton Barratta Burdekin O'Connell Pioneer
Sandy Fitzroy Burnett Mary Tinana

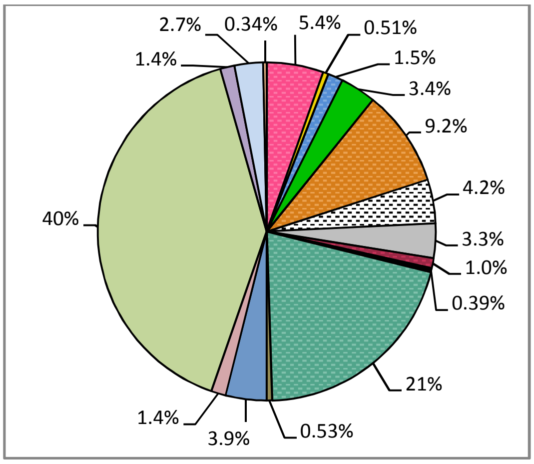


Figure 3.11 Per cent contribution of each catchment to the combined monitored annual total phosphorus load during the 2015–2016 monitoring year.

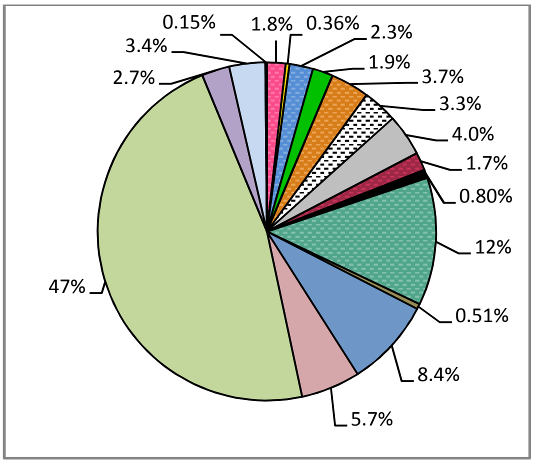


Figure 3.12 Per cent contribution of each catchment to the combined monitored annual dissolved inorganic phosphorus load during the 2015–2016 monitoring year.

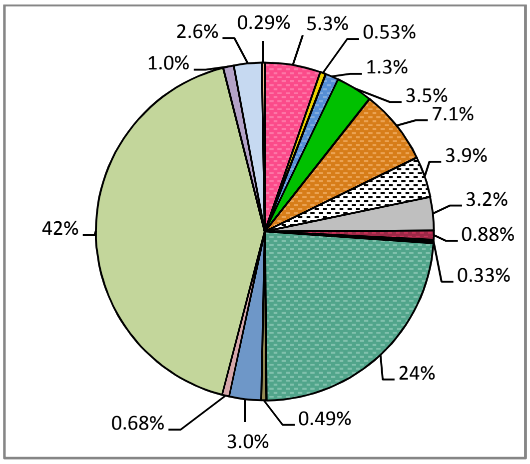


Figure 3.13 Per cent contribution of each catchment to the combined monitored annual particulate phosphorus load during the 2015–2016 monitoring year.

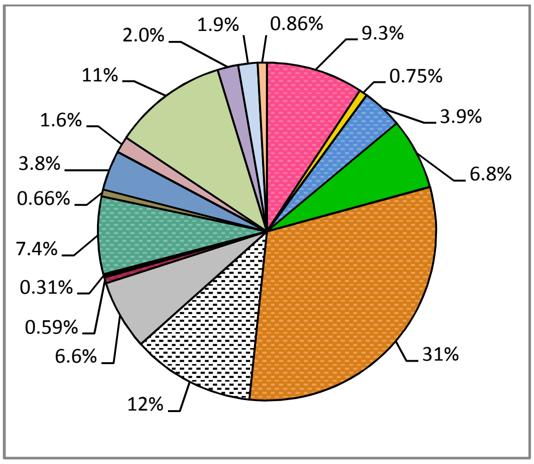


Figure 3.14 Per cent contribution of each catchment to the combined monitored annual dissolved organic phosphorus load during the 2015–2016 monitoring year.

3.3.3.2 Phosphorus yields

During the 2015–2016 monitoring year the largest yields of total phosphorus were contributed by the Russell catchment (150 kg km^{-2}) (Table 3.4). Other catchments with moderate total phosphorus yields include the Johnstone (130 kg km^{-2}), Sandy Creek (97 kg km^{-2}), Tully (65 kg km^{-2}) and Pioneer (60 kg km^{-2}) catchments (Table 3.4). The Burdekin catchment contributed a relatively low yield (3.6 kg km^{-2}) despite the moderate yield (84 kg km^{-2}) derived from the Bowen River sub-catchment. The lowest monitored annual yield of total phosphorus was monitored in the Burnett catchment (0.94 kg km^{-2}).

The Sandy Creek catchment generated the highest yield of dissolved inorganic phosphorus during the 2015–2016 monitoring year (48 kg km^{-2}). The yields of dissolved inorganic phosphorus were also high in the Pioneer (16 kg km^{-2}) and Russell (10 kg km^{-2}) catchments. The Johnstone River end-of-catchment site had a yield of 6.4 kg km^{-2} dissolved inorganic phosphorus, low in comparison to the North Johnstone and South Johnstone sub-catchments (7.2 kg km^{-2} and 12 kg km^{-2} respectively) (Table 3.4). The Fitzroy (0.94 kg km^{-2}), Barron (0.52 kg km^{-2}), Normanby (0.39 kg km^{-2}), Burdekin (0.26 kg km^{-2}) and Burnett (0.23 kg km^{-2}) catchments all contributed less than one kilogram per square kilometre of monitored annual yields for dissolved inorganic phosphorus. The Sandy Creek catchment has consistently produced the highest yields of dissolved inorganic phosphorus since 2009 (between 18 kg km^{-2} in 2014–2015 and 202 kg km^{-2} in 2010–2011. Yields of dissolved inorganic phosphorus generated by the Pioneer catchment were among the two highest in six out of the ten years of monitoring (Joo et al. 2011; Turner et al. 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Garzon-Garcia et al. 2015).

The highest yield of particulate phosphorus during the 2015–2016 monitoring year was in the Russell catchment (120 kg km^{-2}). Similar to monitored annual yield of dissolved inorganic phosphorus, the yields of particulate phosphorus yields contributed by the North Johnstone (110 kg km^{-2}) and South Johnstone (83 kg km^{-2}) sub-catchments were both larger than the Johnstone River end-of-catchment site (78 kg km^{-2}) (Table 3.4). Other moderate yields were monitored in the Tully (48 kg km^{-2}), Pioneer (37 kg km^{-2}), Sandy Creek (37 kg km^{-2}) and Mulgrave (29 kg km^{-2}) catchments. The smallest yields of monitored annual particulate phosphorus occurred in the Burdekin (3.3 kg km^{-2}) and Burnett (0.55 kg km^{-2}) catchments (Table 3.4).

The largest monitored yields of dissolved organic phosphorus were in the Johnstone (46 kg km^{-2}), Russell (32 kg km^{-2}) and Tully (20 kg km^{-2}) catchments (Table 3.4). Dissolved organic phosphorus yields in the 2015–2016 monitoring year were below one kilogram per square kilometre in the Barron (0.95 kg km^{-2}), Haughton (0.80 kg km^{-2}), Mary (0.66 kg km^{-2}), Fitzroy (0.19 kg km^{-2}) and Burnett (0.15 kg km^{-2}) catchments (Table 3.4). Since 2006, the majority of the largest monitored yields of dissolved organic phosphorus have been produced by the Johnstone catchments (including the North Johnstone and South Johnstone catchments) and the Tully catchment (Joo et al. 2011; Turner et al. 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Garzon-Garcia et al. 2015).

Table 3.2 Monitored annual total suspended solids and nutrient loads for the 2015–2016 monitoring year. Text in bold relate to end-of-catchment sites and the corresponding data, all others relate to sub-catchment sites. Green shading = excellent or good representivity; orange shading = moderate representivity; red shading = indicative representivity.

NRM region	Basin	Catchment	River and site name	Method	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	**Normanby River**	**Normanby River at Kalpowar Crossing**	B	62,000	910	250	46	37	82	580	120	5.0	95	23
Wet Tropics	Barron	**Barron River**	**Barron River at Myola**	B	14,000	130	46	20	2.6	23	65	12	1.0	9.4	1.8
	Mulgrave-Russell	**Mulgrave River**	**Mulgrave River at Deeral**	L	16,000	320	110	110	11	120	81	33	6.3	23	9.5
		Russell River	**Russell River at East Russell**	L	38,000	730	240	270	38	310	180	77	5.4	62	17
	Johnstone	**Johnstone River**	**Johnstone River at Coquette Point**	L	78,000	740	300	200	57	260	180	210	10	130	75
		North Johnstone River	North Johnstone River at Old Bruce Highway Bridge (Goondi)	L	36,000	610	330	150	14	160	130	120	6.9	100	13
		South Johnstone River	South Johnstone River at Upstream Central Mill	L	12,000	230	110	60	4.6	64	54	39	4.7	33	5.8
	Tully	**Tully River**	**Tully River at Euramo**	L	64,000	1100	250	480	29	510	330	95	9.3	70	29
		Tully River	Tully River at Tully Gorge National Park	L	12,000	220	130	31	4.5	35	53	22	0.96	19	5.6
	Herbert	**Herbert River**	**Herbert River at Ingham**	L	58,000	840	230	250	23	270	350	74	11	57	16
Burdekin	Haughton	**Haughton River**	**Haughton River at Powerline**	B	14,000	98	43	15	2.0	17	38	22	4.8	16	1.4
		Barratta Creek	**Barratta Creek at Northcote**	L	4300	88	23	36	2.7	38	28	8.8	2.2	5.9	0.76
	Burdekin	**Burdekin River**	**Burdekin River at Home Hill**	L	700,000	1500	870	250	34	280	390	460	34	420	18
		Burdekin River	Burdekin River at Sellheim	B	1,500,000	2900	2300	280	22	300	300	1100	15	1000	11
		Bowen River	Bowen River at Myuna	L	790,000	1200	1100	58	11	69	120	600	21	580	3.8
Mackay Whitsunday	O'Connell	**O'Connell River**	**O'Connell River at Caravan Park**	L	9900	78	39	9.4	4.0	13	26	12	1.4	8.8	1.6
	Pioneer	**Pioneer River**	**Pioneer River at Dumbleton Pump Station**	L	44,000	500	200	110	30	140	160	88	23	54	9.3
	Plane	**Sandy Creek**	**Sandy Creek at Homebush**	L	8400	140	40	36	2.5	39	59	31	16	12	3.8
Fitzroy	Fitzroy	**Fitzroy River**	**Fitzroy River at Rockhampton**	B	670,000	3300	1600	560	120	680	920	910	130	750	27
		Theresa Creek	Theresa Creek At Gregory Highway	L	120,000	150	110	8.1	0.72	8.8	26	74	7.6	65	1.7
		Dawson River	Dawson River at Taroom	L	100,000	400	220	29	6.0	35	140	140	44	94	6.1
		Comet River	Comet River at Comet Weir	L	35,000	60	46	4.6	2.1	6.6	7.6	34	4.4	30	0.37
Burnett Mary	Burnett	**Burnett River**	**Burnett River at Ben Anderson Barrage Head Water**	L	6500	240	54	21	13	34	150	31	7.4	18	4.9
			Burnett River at Mt Lawless	L	69,000	450	270	23	9.3	32	150	110	16	86	4.0
	Mary	**Mary River**	**Mary River at Home Park**	L	52,000	360	140	48	13	61	160	61	9.5	47	4.5
		Tinana Creek	**Tinana Creek at Barrage Head Water**	L	1700	97	21	7.3	4.7	12	64	7.7	0.42	5.2	2.1
Total combined monitored load (excluding sub-catchment sites)					1,800,000	11,000	4,500	2,500	420	2,900	3,800	2,300	280	1,800	240

The number of concentration data points used in the calculation of loads for all analytes is presented in Appendix H TSS = total suspended solids; TN = total nitrogen; PN = particulate nitrogen; NOx-N = oxidised nitrogen as N; NH_4-N = ammonium nitrogen as N; DIN = dissolved inorganic nitrogen (DIN = (NOx-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.

Table 3.3 Total suspended solids and nitrogen yields calculated for the 2015–2016 monitoring year. Text in bold relate to end-of-catchment sites and the corresponding data, all others relate to sub-catchment sites. Green shading = excellent or good representivity; orange shading = moderate representivity; red shading = indicative representivity.

NRM region	Basin	Catchment	River and site name	Method	TSS (t km^{-2})	TN (kg km^{-2})	PN (kg km^{-2})	NOx-N (kg km^{-2})	NH_4-N (kg km^{-2})	DIN (kg km^{-2})	DON (kg km^{-2})
Cape York	Normanby	**Normanby River**	**Normanby River at Kalpowar Crossing**	B	4.8	70	19	3.5	2.8	6.4	45
Wet Tropics	Barron	**Barron River**	**Barron River at Myola**	B	7.2	69	24	10	1.3	12	34
	Mulgrave-Russell	**Mulgrave River**	**Mulgrave River at Deeral**	L	20	410	140	140	13	160	100
		Russell River	**Russell River at East Russell**	L	72	1,400	470	510	74	590	340
	Johnstone	**Johnstone River**	**Johnstone River at Coquette Point**	L	48	450	180	120	35	160	110
		North Johnstone River	North Johnstone River at Old Bruce Highway Bridge (Goondi)	L	37	640	340	150	14	170	130
		South Johnstone River	South Johnstone River at Upstream Central Mill	L	30	570	280	150	12	160	130
	Tully	**Tully River**	**Tully River at Euramo**	L	44	750	170	330	20	350	220
		Tully River	Tully River at Tully Gorge National Park	L	25	450	270	64	9.3	73	110
	Herbert	**Herbert River**	**Herbert River at Ingham**	L	6.8	97	26	29	2.7	31	40
Burdekin	Haughton	**Haughton River**	**Haughton River at Powerline**	B	7.7	55	24	8.7	1.1	9.8	21
		Barratta Creek	**Barratta Creek at Northcote**	L	5.7	120	30	47	3.5	50	37
	Burdekin	**Burdekin River**	**Burdekin River at Home Hill**	L	5.4	12	6.7	1.9	0.26	2.2	3.0
		Burdekin River	Burdekin River at Sellheim	B	42	81	64	7.7	0.61	8.3	8.3
		Bowen River	Bowen River at Myuna	L	110	170	150	8.1	1.5	9.7	17
Mackay Whitsunday	O'Connell	**O'Connell River**	**O'Connell River at Caravan Park**	L	12	95	47	11	4.8	16	32
	Pioneer	**Pioneer River**	**Pioneer River at Dumbleton Pump Station**	L	30	340	130	77	21	98	110
	Plane	**Sandy Creek**	**Sandy Creek at Homebush**	L	26	420	120	110	7.6	120	180
Fitzroy	Fitzroy	**Fitzroy River**	**Fitzroy River at Rockhampton**	B	4.8	23	11	4.0	0.89	4.9	6.6
		Theresa Creek	Theresa Creek At Gregory Highway	L	14	18	13	1.0	0.085	1.0	3.0
		Dawson River	Dawson River at Taroom	L	6.2	24	13	1.8	0.37	2.1	8.8
		Comet River	Comet River at Comet Weir	L	2.2	3.8	2.9	0.29	0.13	0.42	0.48
Burnett Mary	Burnett	**Burnett River**	**Burnett River at Ben Anderson Barrage Head**	L	0.20	7.4	1.6	0.65	0.38	1.0	4.7
			Burnett River at Mt Lawless	L	2.3	15	9.3	0.77	0.32	1.1	5.0
	Mary	**Mary River**	**Mary River at Home Park**	L	7.6	52	20	7.0	1.8	8.8	24
		Tinana Creek	**Tinana Creek at Barrage Head Water**	L	1.3	76	16	5.7	3.7	9.4	50

The number of concentration data points used in the calculation of loads for all analytes is presented in Appendix G. TSS = total suspended solids; TN = total nitrogen; PN = particulate nitrogen; NOx-N = oxidised nitrogen as N; NH_4-N = ammonium nitrogen as N; DIN = dissolved inorganic nitrogen (DIN = (NOx-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; *Yields for Johnstone River and Tinana Creek at Barrage Head Water are indicative considering modelled daily flow was used for load calculations.

Table 3.4 Phosphorus yields calculated for the 2015–2016 monitoring year. Text in bold relate to end-of-catchment sites and the corresponding data, all others relate to sub-catchment sites. Green shading = excellent or good representivity; orange shading = moderate representivity; red shading = indicative representivity.

NRM region	Basin	Catchment	River and site name	Method	TP (kg km^{-2})	DIP (kg km^{-2})	PP (kg km^{-2})	DOP (kg km^{-2})
Cape York	Normanby	**Normanby River**	**Normanby River at Kalpowar Crossing**	B	9.5	0.39	7.4	1.8
Wet Tropics	Barron	**Barron River**	**Barron River at Myola**	B	6.0	0.52	4.8	0.95
	Mulgrave-Russell	**Mulgrave River**	**Mulgrave River at Deeral**	L	41	8.0	29	12
		Russell River	**Russell River at East Russell**	L	150	10	120	32
	Johnstone	**Johnstone River**	**Johnstone River at Coquette Point**	L*	130	6.4	78	46
		North Johnstone River	North Johnstone River at Old Bruce Highway Bridge (Goondi)	L	120	7.2	110	14
		South Johnstone River	South Johnstone River at Upstream Central Mill	L	98	12	83	15
	Tully	**Tully River**	**Tully River at Euramo**	L	65	6.4	48	20
		Tully River	Tully River at Tully Gorge National Park	L	45	2.0	39	12
	Herbert	**Herbert River**	**Herbert River at Ingham**	L	8.6	1.3	6.6	1.9
Burdekin	Haughton	**Haughton River**	**Haughton River at Powerline**	B	12	2.7	8.8	0.80
		Barratta Creek	**Barratta Creek at Northcote**	L	12	3.0	7.8	1.0
	Burdekin	**Burdekin River**	**Burdekin River at Home Hill**	L	3.6	0.26	3.3	0.14
		Burdekin River	Burdekin River at Sellheim	B	29	0.40	29	0.31
		Bowen River	Bowen River at Myuna	L	84	2.9	82	0.53
Mackay Whitsunday	O'Connell	**O'Connell River**	**O'Connell River at Caravan Park**	L	14	1.8	11	1.9
	Pioneer	**Pioneer River**	**Pioneer River at Dumbleton Pump Station**	L	60	16	37	6.3
	Plane	**Sandy Creek**	**Sandy Creek at Homebush**	L	97	48	37	12
Fitzroy	Fitzroy	**Fitzroy River**	**Fitzroy River at Rockhampton**	B	6.5	0.94	5.4	0.19
		Theresa Creek	Dawson River at Taroom	L	8.8	0.89	7.7	0.20
		Comet River	Comet River at Comet Weir	L	8.8	2.7	5.7	0.37
		Dawson River	Theresa Creek At Gregory Highway	L	2.2	0.28	1.9	0.023
Burnett Mary	Burnett	**Burnett River**	**Burnett River at Ben Anderson Barrage Head Water**	L	0.94	0.23	0.55	0.15
			Burnett River at Mt Lawless	L	3.6	0.54	2.9	0.14
	Mary	**Mary River**	**Mary River at Home Park**	L	8.9	1.4	6.9	0.66
		Tinana Creek	**Tinana Creek at Barrage Head Water**	L*	6.0	0.33	4.0	1.6

The number of concentration data points used in the calculation of loads for all analytes is presented in Appendix G. 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; *Yields for Johnstone River at Coquette Point and Tinana Creek at Barrage Head Water are indicative considering modelled daily flow was used for load calculations.

3.4 Pesticide loads, toxicity-based loads (toxic pesticide loads) and yields

In this section, the monitored annual loads, the toxic pesticide load and yields of the five photosystem II inhibiting herbicides of importance under Reef Plan 2013 are presented for 17 monitoring sites (Table 3.5).

As a consequence of the inclusion of the new LC-MS method (with a lower limit of reporting) into the routine analysis of pesticide samples in 2015–2016, some pesticides have been detected (albeit at very low concentrations) in more samples and in catchments where they may not have been detected in the past. This is not necessarily a reflection of changes in use patterns of these pesticides, but more likely a consequence of the increased sensitivity of the LC-MS *Low* method detecting pesticides present at concentrations below the limit of reporting of the LC-MS *High* method.

3.4.1. Pesticide loads

The monitored annual loads of photosystem II inhibiting herbicides ametryn, total atrazine, total diuron, hexazinone and tebuthiuron were calculated for 15 end-of-catchment sites and two sub-catchment sites across 12 basins. The loads of the other pesticides detected by the expanded analytical suite funded by the Queensland Department of Environment and Heritage Protection (Reef Water Quality Unit) under project RP57C, are presented in Appendix A.

The total monitored annual load of the five photosystem II inhibiting herbicides exported past the monitoring sites were (from largest to smallest): 1000 kg of tebuthiuron; 780 kg of total atrazine; 660 kg of total diuron; 260 kg of hexazinone; and 4.5 kg of ametryn (Table 3.5). The contribution of each monitored catchment to the total monitored annual loads of these five photosystem II inhibiting herbicides is presented in Figure 3.15 to Figure 3.19.

Total atrazine and total diuron were the only photosystem II inhibiting herbicides detected at all monitored catchments (Table 3.5). Hexazinone was detected in all catchments except the Haughton and Burdekin catchments (Table 3.5). Ametryn was detected in the Mulgrave, Barratta Creek, Pioneer and Sandy Creek catchments, the Comet River sub-catchment and, for the first time since monitoring commenced at this site in 2013, the Tinana Creek catchment. Tebuthiuron was detected in the Haughton, Barratta Creek, Burdekin, O'Connell, Fitzroy, Burnett and Mary catchments, and the Comet River sub-catchment (Table 3.5).

Almost half the monitored annual ametryn load was generated from the Mackay Whitsunday region, of which the Sandy Creek (1.4 kg; 31 per cent) catchment produced double the load monitored in the Pioneer (0.72 kg; 16 per cent) catchment (Figure 3.15). A large contribution of monitored annual load of ametryn was also derived from the Tinana Creek (0.92 kg; 21 per cent) catchment. Moderate annual loads were monitored in the Mulgrave (0.77 kg; 17 per cent) and Barratta Creek (0.67 kg; 15 per cent) catchments and a smaller contribution from the Comet River (0.00048 kg; 0.011 per cent) sub-catchment. The total monitored load of ametryn (4.5 kg) was low compared to the 2014–2015 monitoring year (7.7 kg) (Wallace et al. 2015) and significantly smaller than the monitored annual loads reported for the period 2009–2014 (range 48 kg–120 kg) despite the increase in the number of monitored catchments and total monitored area. The low proportion of monitored annual ametryn load generated during the 2015–2016 monitoring year is explained by the below average discharge across *all* monitored catchments during the 2015–2016 monitoring year relative to historic discharge.

The Mackay Whitsunday region produced one-third of the combined monitored annual total atrazine load. The largest annual load of total atrazine across all monitored catchments was contributed by the Pioneer (180 kg; 23 per cent) catchment, with comparatively smaller loads monitored in the Sandy Creek (59 kg; 7.6 per cent) and O'Connell (17 kg; 2.2 per cent) catchments (Table 3.5, Figure 3.16). Within the Burdekin region, the Barratta Creek and Haughton catchments contributed 20 per cent of the monitored annual total atrazine load (130 kg; 17 per cent and 26 kg; 3.3 per cent respectively). The Fitzroy catchment contributed 18 per cent (140 kg) of the monitored annual load which is approximately one quarter of the annual total atrazine load monitored in the Fitzroy catchment during the 2014–15 monitoring year. The monitored annual load of total atrazine in the Comet River sub-catchment was 16 kg, which is 11 per cent of the Fitzroy River end-of-catchment total atrazine load. The five smaller coastal catchments of the Wet Tropics region together contributed 19 per cent of the monitored annual total atrazine load. Individually, small contributions were derived from the Tully (51 kg; 6.6 per cent), Herbert (32 kg; 4.1 per cent), Russell (29 kg; 3.7 per cent) and Johnstone (20 kg; 2.6 per cent) catchments (0.73 kg; 3.7 per cent was monitored upstream at the North Johnstone River sub-catchment site). All other monitored catchments contributed less than five per cent of the combined monitored annual total atrazine load, with the lowest load contributed by the Burdekin (36 kg; 4.7 per cent), Burnett (20 kg; 2.6 per cent), Tinana Creek (16 kg; 2.1 per cent), Mulgrave (15 kg; 1.9 per cent) and Mary (9.5 kg; 1.2 per cent) catchments. Typically the Fitzroy catchment contributes the majority of the monitored annual total atrazine load (between 520 kg; 32 per cent in 2014–2015 and 2400 kg; 50 per cent in 2010–2011) (Wallace et al. 2016).

During the 2015–2016 monitoring year, the largest monitored annual total diuron load came from the Pioneer (170 kg; 26 per cent) catchment, with 35 per cent of the combined monitored annual total diuron load from the Mackay Whitsunday region (the Sandy Creek catchment contributing 56 kg and the O'Connell catchment 4.1 kg). Catchments within the Wet Tropics region accounted for over half the total monitored annual load of total diuron (Table 3.5, Figure 3.17). The Tully catchment contributed 140 kg (21 per cent), followed by the Russell (81 kg; 12 per cent), Herbert (58 kg; 8.9 per cent), Johnstone (45 kg; 6.8 per cent) and Mulgrave (14 kg; 2.1 per cent) catchments to the combined monitored annual total diuron load. A monitored annual load of total diuron of 4.6 kg was discharged by the North Johnstone River sub-catchment site. The Fitzroy catchment contributed 58 kg (8.8 per cent) of the total monitored annual load of total diuron, with 0.60 kg monitored in the Comet River sub-catchment site. The remaining catchments each contributed less than two per cent of the combined monitored annual load of total diuron; this included (from highest to lowest) the Barratta Creek (10 kg), Tinana Creek (7.1 kg), Haughton (4.4 kg), Burnett (4.2 kg) Mary (3.7 kg) and Burdekin (4.8 kg) catchments. Across the six years of pesticide monitoring for the Great Barrier Reef Catchment Loads Monitoring Program, the Pioneer and Tully catchments have produced the largest monitored annual loads of total diuron in five out of six years (collectively contributing between 36 per cent and 56 per cent of the combined monitored annual load during those years).

The majority of the combined monitored annual hexazinone load for the end-of-catchment sites was contributed by the Wet Tropics (65 per cent). The portion of the combined monitored annual load of hexazinone contributed by the Tully catchment was highest (77 kg; 29 per cent), followed by the Russell (36 kg; 14 per cent), Herbert (32 kg; 12 per cent), Johnstone (15 kg; 5.8 per cent – of which 2.7 kg (17 per cent) was recorded upstream at the North Johnstone sub-catchment site) and Mulgrave (9.2 kg; 3.5 per cent) catchments (Table 3.5, Figure 3.18). The monitored annual hexazinone load in catchments of the Mackay Whitsunday region contributed 24 per cent of the total monitored load, including 16 per cent from the Pioneer (42 kg), 7.1 per cent from Sandy Creek (19 kg) and 1.0 per cent from the O'Connell (2.7 kg) catchment. All other catchments contributed eleven per cent of the combined monitored annual hexazinone load. This included the Fitzroy (17 kg; 6.6 per cent), Burnett (5.1 kg; 1.9 per cent), Tinana Creek (4.2 kg; 1.6 per cent) and Barratta Creek (1.5 kg; 0.57 per cent) catchments. The monitored annual load of hexazinone in the Comet River sub-catchment was less than one percent (0.024 kg) of the hexazinone load monitored at the Fitzroy end-of-catchment monitoring site. Similar to the current year of reporting, since 2011, the majority of the combined monitored annual hexazinone load was produced by the Tully catchment (between 73 kg; 27 per cent in 2014–2015 and 99 kg; 48 per cent in 2011–2012 (Turner et al. 2012 and 2013; Wallace et al. 2014, 2015 and 2016; Garzon-Garcia et al. 2015).

The Fitzroy catchment has contributed the largest annual loads of tebuthiuron of all monitored catchments since pesticide monitoring began in 2009. The 2015–2016 monitoring year was no different with 96 per cent of the total monitored annual load of tebuthiuron derived from the Fitzroy catchment (1000 kg) (Table 3.5, Figure 3.19). The monitored annual load of tebuthiuron in the Comet River (4.3 kg) sub-catchment equated to less than one per cent of the tebuthiuron load monitored at Fitzroy River end-of-catchment site. The remaining four per cent of the combined monitored annual load of tebuthiuron was distributed between six catchments, and included (from highest to lowest); 3.2 per cent from the Burdekin catchment (34 kg) and less than one percent from the Haughton (3.8 kg), Burnett (2.9 kg), O'Connell (1.2 kg), Barratta Creek (0.53 kg) and Mary (0.12 kg) catchments.

3.4.2. Toxic pesticide load

During the 2015–2016 monitoring year, the combined toxic pesticide load of all monitored catchments (excluding the sub-catchment monitoring sites at North Johnstone River and Comet River), was 750 kg TEq_{diuron} (Table 3.5). The load of diuron accounted for 87 per cent of the toxic load, while the remaining 13 per cent was comprised principally of hexazinone (7.4 per cent) and atrazine (3.0 per cent) and smaller proportions of tebuthiuron (2.6 per cent) and ametryn (0.39 per cent). Consistent with previous monitoring years, catchments with high diuron loads were the main contributors to the annual toxic pesticide loads due to the higher relative toxicity of diuron.

As was the case in the 2014–2015 monitoring year, the Pioneer, Tully and Russell catchments had the largest annual toxic pesticide loads in the 2015–2016 monitoring year, although not in the same order (from highest to lowest) (Figure 3.20) (Wallace et al. 2016). The largest toxic pesticide load in 2015–2016 was derived from the Pioneer catchment (180 kg TEq_{diuron}; 24 per cent) followed by the Tully (150 kg TEq_{diuron}; 21 per cent), Russell (89 kg TEq_{diuron}; 12 per cent) and Fitzroy (84 kg TEq_{diuron}; 11 per cent) catchments. Contributing a smaller proportion to the monitored toxic pesticide loads (from highest to lowest) was the Herbert (65 kg TEq_{diuron}; 8.8 per cent), Sandy Creek (60 kg TEq_{diuron}; 8.1 per), Johnstone (48 kg TEq_{diuron}; 6.5 per cent) and Mulgrave (17 kg TEq_{diuron}; 2.2 per cent), Barratta Creek (14 kg TEq_{diuron}; 1.9 per cent from) and Tinana Creek (8.9 kg TEq_{diuron}; 1.2 per cent) catchments. The toxic load in all other catchments was less than one per cent of the combined annual toxic load (Table 3.5; Figure 3.20).

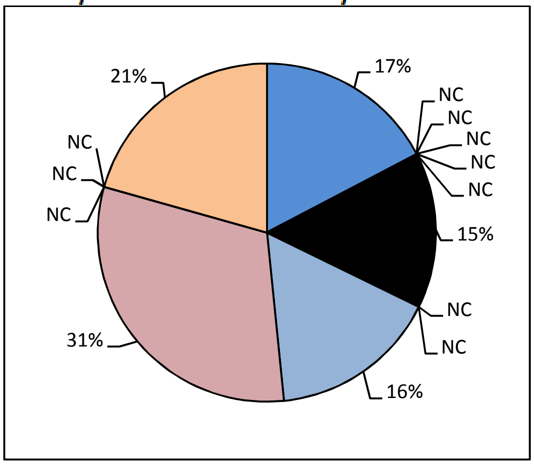


Figure 3.15 Per cent contribution of all sites monitored for pesticides to the combined monitored annual ametryn load during the 2015–2016 monitoring year (NC = load not calculable).

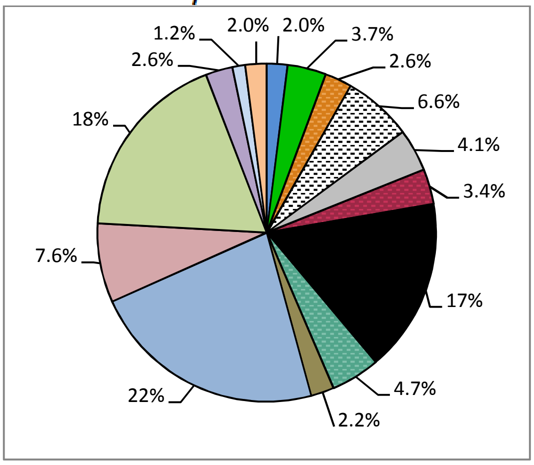


Figure 3.16 Per cent contribution of all sites monitored for pesticides to the combined monitored annual total atrazine load during the 2015–2016 monitoring year.

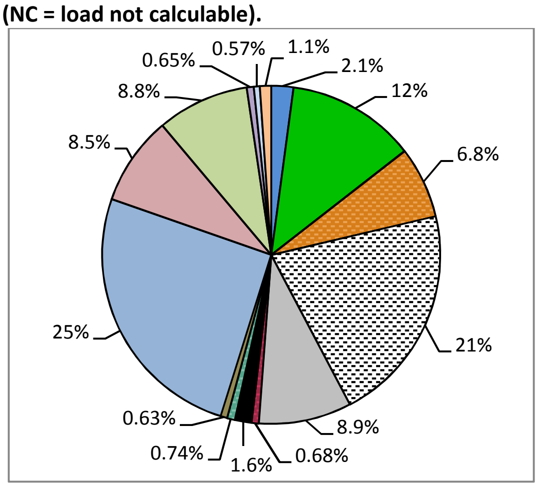


Figure 3.17 Per cent contribution of all sites monitored for pesticides to the combined monitored annual total diuron load during the 2015–2016 monitoring year.

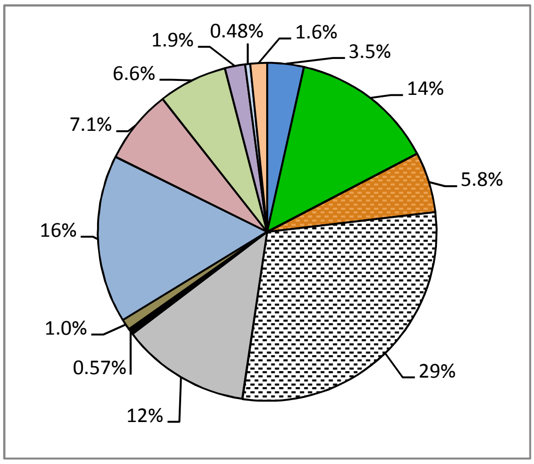


Figure 3.18 Per cent contribution of all sites monitored for pesticides to the combined monitored annual hexazinone load during the 2015–2016 monitoring year.

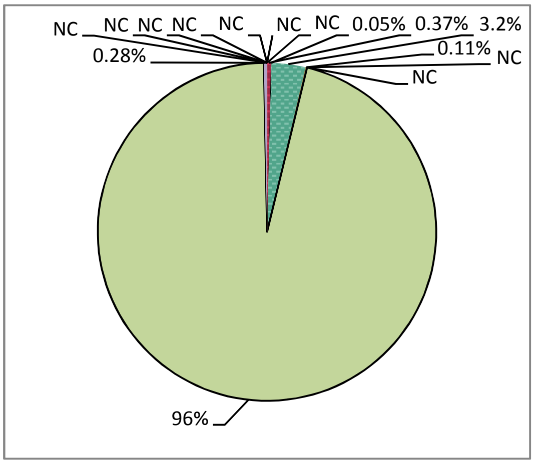


Figure 3.19 Per cent contribution of all sites monitored for pesticides to the combined monitored annual tebuthiuron load during the 2015–2016 monitoring year (NC = load not calculable).

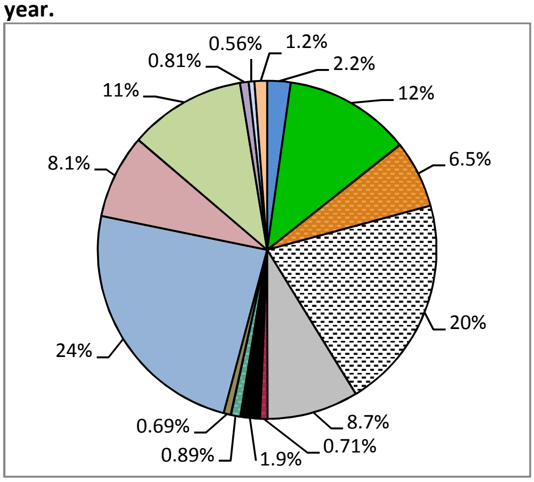


Figure 3.20 Per cent contribution of all sites monitored for pesticides to the combined monitored annual toxic pesticide load during the 2015–2016 monitoring year.

3.4.3. Pesticide land use yields

Pesticide land use yields of five photosystem II inhibiting herbicides (ametryn, total atrazine, total diuron, hexazinone and tebuthiuron) were calculated for the 15 end-of-catchment sites monitored during 2015–2016. The land use yields for each monitored catchment are presented in Table 3.6. No land use yields are reportable for sites where the concentration of the pesticide was below the analytical limit of reporting and the mass load of the chemical was not calculated.

Ametryn was detected above the analytical limit of reporting in five catchments with the highest calculated land use yields contributed by the Mulgrave and Tinana Creek (each 0.010 kg km^{-2}) catchments (Table 3.6). A similar yield was calculated for the Sandy Creek (0.0089 kg km $^{-2}$) catchment, from which the largest monitored annual load of ametryn was calculated. Smaller land use yields for ametryn were estimated for the remaining catchments, Barratta Creek (0.0050 kg km^{-2}) and Pioneer (0.0023 kg km^{-2}).

The highest land use yields for total atrazine were in the Barratta Creek catchment (0.84 kg km^{-2}), followed by the Haughton catchment (0.44 kg km^{-2}) (Table 3.6). Similar land use yields of total atrazine were estimated for the Russell, Tully and Sandy Creek catchments (0.31 kg km^{-2} to 0.33 kg km^{-2}), and likewise for the Pioneer, Johnstone and Mulgrave catchments (0.18 kg km^{-2} to 0.26 kg km^{-2}). The land use yields in all other catchments were low, with the lowest monitored land use yield of total atrazine occurring in the Burnett catchment (0.0037 kg km^{-2}) (Table 3.6).

The highest land use yields of total diuron occurred in the Russell catchment (0.83 kg km^{-2}) (Table 3.6). This was also the case during the 2014–2015 monitoring year, although the yield was less than half of that recorded in 2014–2015 (2.1 kg km^{-2}) (Wallace et al. 2016). The land use yields of total diuron in the Tully and Pioneer catchments were comparable to the Russell catchment; 0.65 kg km^{-2} and 0.54 kg km $^{-2}$, respectively. Smaller land use yields of total diuron were estimated for the Sandy Creek (0.35 kg km^{-2}), Johnstone (0.30 kg km^{-2}), Herbert (0.22 kg km^{-2}), Mulgrave (0.17 kg km^{-2}) and Haughton (0.14 kg km^{-2}) catchments. The calculated total diuron land use yields of the remaining catchments (O'Connell, Tinana Creek, Barratta Creek, Mary, Fitzroy, Burdekin and Burnett) ranged from 0.081 kg km^{-2} to 0.003 kg km^{-2}.

The land use yields of hexazinone in the Russell and Tully catchments were almost equal (0.27 kg km^{-2} and 0.31 kg km^{-2}, respectively) and higher than all other catchments (Table 3.6). The land use yield of hexazinone in the Mulgrave, Sandy Creek, Pioneer and Johnstone catchments were an order of magnitude below the land use yields in the Tully and Russell catchment, ranging from 0.026 kg km^{-2}–0.079 kg km^{-2} The land use yield of hexazinone in the remaining catchments were two to three orders of magnitude below the highest calculated land use yields of hexazinone, and included (from highest to lowest); the Herbert, Tinana Creek, O'Connell and Barratta Creek catchments (ranging from 0.0056 kg km^{-2} to 0.002 kg km^{-2}) and the Mary, Burnett and Fitzroy catchments (ranging from 0.00025 kg km^{-2} to 0.00014 kg km^{-2}).

The catchment with the highest land use yield of tebuthiuron during the 2015–2016 monitoring year was the Fitzroy River (0.009 kg km^{-2}) (Table 3.6), which also produced the largest monitored annual load of tebuthiuron (Table 3.6). The Haughton and O'Connell catchments had comparable tebuthiuron land use yields, which ranged from 0.0026 kg km^{-2} to 0.0022 kg km^{-2}. During the 2015–2016 monitoring year, tebuthiuron was only detected in four other catchments, the Barratta Creek, Burdekin, Burnett and Mary catchments where the land use yields ranged from 0.00089 kg km^{-2} to 0.000029 kg km^{-2}.

Table 3.5 Monitored annual loads and total toxic pesticide loads for the 2015-2016 monitoring year calculated for the five priority photosystem II inhibiting herbicides: ametryn, total atrazine, total diuron, hexazinone and tebuthiuron. Text in bold relate to end-of-catchment sites and the corresponding data, all other relate to sub-catchment sites.

NRM region	Basin	Catchment	River and site name	n	Method	Ametryn load (kg)	Total Atrazine load (kg)	Total Diuron load (kg)	Hexazinone load (kg)	Tebuthiuron load (kg)	Total Toxic pesticide load (diuron-equivalent kg)
Wet Tropics	Mulgrave-Russell	**Mulgrave River**	**Mulgrave River at Deeral**	82	L	0.77	15	14	9.2	NC	17
		Russell River	**Russell River at East Russell**	115	L	NC	29	81	36	NC	89
	Johnstone	**Johnstone River**	**Johnstone River at Coquette Point**	74	L*	NC	20	45	15	NC	48
		North Johnstone River	North Johnstone River at Old Bruce Highway Bridge (Goondi)	55	L	NC	0.73	4.6	2.7	NC	5.2
	Tully	**Tully River**	**Tully River at Euramo**	141	L	NC	51	140	77	NC	150
	Herbert	**Herbert River**	**Herbert River at Ingham**	58	L	NC	32	58	32	NC	65
Burdekin	Haughton	**Haughton River**	**Haughton River at Powerline**	18	B	NC	26	4.4	NC	3.8	5.3
		Barratta Creek	**Barratta Creek at Northcote**	104	L	0.67	130	10	1.5	0.53	14
	Burdekin	**Burdekin River**	**Burdekin River at Home Hill**	32	L	NC	36	4.8	NC	34	6.7
Mackay Whitsunday	O'Connell	**O'Connell River**	**O'Connell River at Caravan Park**	37	L	NC	17	4.1	2.7	1.2	5.1
	Pioneer	**Pioneer River**	**Pioneer River at Dumbleton Pump Station**	82	L	0.72	180	170	42	NC	180
	Plane	**Sandy Creek**	**Sandy Creek at Homebush**	140	L	1.4	59	56	19	NC	60
Fitzroy	Fitzroy	**Fitzroy River**	**Fitzroy River at Rockhampton**	24	B	NC	140	58	17	1000	84
		Comet River	Comet River at Comet Weir	21	L	0.00048	16	0.6	0.024	4.3	1.1
Burnett Mary	Burnett	**Burnett River**	**Burnett River at Ben Anderson Barrage Head Water**	21	L	NC	20	4.2	5.1	2.9	6.0
	Mary	**Mary River**	**Mary River at Home Park**	58	L	NC	9.5	3.7	1.3	0.12	4.2
		Tinana Creek	**Tinana Creek at Barrage Head Water**	65	L*	0.92	16	7.1	4.2	NC	8.9
Total monitored annual load (excluding North Johnstone River and Comet River)						4.5	780	660	260	1000	750

n = the number of grab samples used to calculate loads; NC = a load was not calculated as there were insufficient samples (<3) where the concentration detections were above practical quantitation limit or there were insufficient samples collected over the year to calculate a load; B = Beale ratio method used to calculate loads; L = average load (linear interpolation of concentration) method used to calculate loads; *Loads for Johnstone River and Tinana Creek at Barrage are indicative considering modelled daily flow was used for load calculations.

Table 3.6 The monitored annual yields calculated for the photosystem II inhibiting herbicides: ametryn, total atrazine and total diuron for the 2015–2016 monitoring year.

PSII herbicide	Registered land use types	River and site name	Method	Land use yield (kg km^{-2})
Ametryn	Sugarcane	Mulgrave River at Deeral	L	0.010
		Russell River at East Russell	L	NC
		Johnstone River at Coquette Point	L	NC
		Tully River at Euramo	L	NC
		Herbert River at Ingham	L	NC
		Haughton River at Powerline	B	NC
		Barratta Creek at Northcote	L	0.0050
		Burdekin River at Home Hill	L	NC
		O'Connell River at Caravan Park	L	NC
		Pioneer River at Dumbleton Pump Station	L	0.0023
		Sandy Creek at Homebush	L	0.0089
		Fitzroy River at Rockhampton	B	NC
		Burnett River at Ben Anderson Barrage Head Water	L	NC
		Mary River at Home Park	L	NC
		Tinana Creek at Tinana Barrage Head Water	L	0.010
Total atrazine	Cropping, forestry, and sugarcane	Mulgrave River at Deeral	L	0.18
		Russell River at East Russell	L	0.33
		Johnstone River at Coquette Point	L	0.19
		Tully River at Euramo	L	0.32
		Herbert River at Ingham	L	0.048
		Haughton River at Powerline	B	0.44
		Barratta Creek at Northcote	L	0.84
		Burdekin River at Home Hill	L	0.016
		O'Connell River at Caravan Park	L	0.086
		Pioneer River at Dumbleton Pump Station	L	0.26
		Sandy Creek at Homebush	L	0.31
		Fitzroy River at Rockhampton	B	0.0079
		Burnett River at Ben Anderson Barrage Head Water	L	0.0037
		Mary River at Home Park	L	0.010
		Tinana Creek at Tinana Barrage Head Water	L	0.019
Total diuron	Cropping, horticulture and sugarcane	Mulgrave River at Deeral	L	0.17
		Russell River at East Russell	L	0.830
		Johnstone River at Coquette Point	L	0.300
		Tully River at Euramo	L	0.65
		Herbert River at Ingham	L	0.22
		Haughton River at Powerline	B	0.14
		Barratta Creek at Northcote	L	0.067
		Burdekin River at Home Hill	L	0.003
		O'Connell River at Caravan Park	L	0.081
		Pioneer River at Dumbleton Pump Station	L	0.54
		Sandy Creek at Homebush	L	0.35
		Fitzroy River at Rockhampton	B	0.0063
		Burnett River at Ben Anderson Barrage Head Water	L	0.003
		Mary River at Home Park	L	0.041
		Tinana Creek at Tinana Barrage Head Water	L	0.076

NC = not calculable; B = Beale ratio method used to calculate loads; L = average load (linear interpolation of concentration) method used to calculate loads; Loads for Johnstone River at Coquette Point and Tinana Creek at Barrage are indicative considering modelled daily flow was used for load calculations.

Table 3.7 The monitored annual yields calculated for the photosystem II inhibiting herbicides hexazinone and tebuthiuron for the 2015–2016 monitoring year.

PSII herbicide	Registered land use types	River and site name	Method	Land use yield (kg km^{-2})
Hexazinone	Forestry, grazing and sugarcane	Mulgrave River at Deeral	L	0.079
		Russell River at East Russell	L	0.27
		Johnstone River at Coquette Point	L	0.026
		Tully River at Euramo	L	0.31
		Herbert River at Ingham	L	0.0056
		Haughton River at Powerline	B	NC
		Barratta Creek at Northcote	L	0.0020
		Burdekin River at Home Hill	L	NC
		O'Connell River at Caravan Park	L	0.0038
		Pioneer River at Dumbleton Pump Station	L	0.036
		Sandy Creek at Homebush	L	0.063
		Fitzroy River at Rockhampton	B	0.00014
		Burnett River at Ben Anderson Barrage Head Water	L	0.00017
		Mary River at Home Park	L	0.00025
		Tinana Creek at Tinana Barrage Head Water	L	0.0040
Tebuthiuron	Grazing	Mulgrave River at Deeral	L	NC
		Russell River at East Russell	L	NC
		Johnstone River at Coquette Point	L	NC
		Tully River at Euramo	L	NC
		Herbert River at Ingham	L	NC
		Haughton River at Powerline	B	0.0026
		Barratta Creek at Northcote	L	0.00089
		Burdekin River at Home Hill	L	0.00028
		O'Connell River at Caravan Park	L	0.0022
		Pioneer River at Dumbleton Pump Station	L	NC
		Sandy Creek at Homebush	L	NC
		Fitzroy River at Rockhampton	B	0.0090
		Burnett River at Ben Anderson Barrage Head Water	L	0.00011
		Mary River at Home Park	L	0.000029
		Tinana Creek at Tinana Barrage Head Water	L	NC

NC = not calculable; B = Beale ratio method used to calculate loads; L = average load (linear interpolation of concentration) method used to calculate loads; Loads for Johnstone River at Coquette Point and Tinana Creek at Barrage are indicative considering modelled daily flow was used for load calculations.

4. Conclusions

During 2015–2016, the Great Barrier Reef Catchment Loads Monitoring Program calculated the monitored annual loads and yields of total suspended solids and ten forms of nitrogen and phosphorus for 17 end-of-catchment sites and nine sub-catchment sites across 14 priority basins. The monitored annual loads, toxic pesticides loads and yields of five photosystem II inhibiting herbicides were also calculated for 15 end-of-catchment sites and two sub-catchment sites across 12 priority basins. During the 2015–2016 monitoring year:

- Monitored catchments within the Wet Tropics region generally received below average rainfall, the lower Russell and Mulgrave catchments received the highest rainfall totals in the region. Average rainfall occurred within catchments of the Cape York and Mackay Whitsunday regions, and generally below average to average rainfall in the Burdekin, Fitzroy and Burnett Mary regions.
- Annual river discharge was less than half the long-term mean in all monitored catchments of the Burdekin, Fitzroy and Burnett Mary regions and the Herbert and Barron catchments of the Wet Tropics region. The Barron River, upper Tully River, Barratta Creek, Theresa Creek, Comet River, upper Burnett River, Mary River and Tinana Creek all recorded the lowest annual discharge since water quality monitoring for the Great Barrier Reef Catchment Loads Monitoring Program commenced. Of the monitored end-of-catchment sites, the Burnett (47 per cent), Pioneer (54 per cent), Fitzroy (58 per cent) rivers and Sandy Creek (60 per cent) had the lowest exceedance probabilities during the 2015–2016 monitoring year.
- Excellent to good sampling representivity was achieved at all monitoring sites for total suspended solids, total nutrients and dissolved nutrients, except in the Comet and Haughton River where representivity for all analytes was moderate and indicative, respectively. Representivity for the Normanby River was moderate for total suspended solids and good for all other analytes. Loads for the Johnstone and Tinana Creek catchments are indicative only because modelled flow was used for load calculations.
- During the 2015–2016 monitoring year, 54 per cent of the monitored sites achieved a sample representivity rating of excellent, the highest achieved since the inclusion of the method in 2009. Eighty-five per cent of monitored sites achieved a rating of good or better. The representivity of sampling for the calculation of pesticide loads was not assessed in the current report.
- This is the first year in which annual loads were reported for the Johnstone River end-of-catchment site monitored at Coquette Point. Although this priority basin is already monitored in both the North Johnstone and South Johnstone rivers, establishing a monitoring site in the lower reaches of the Johnstone River captures pollutant contributions from greater land use area than was previously possible.
- The monitored catchments generated approximately 1.8 million tonnes of total suspended solids, 11,000 tonnes of nitrogen and 2300 tonnes of phosphorus.

- The Burdekin and Fitzroy catchments generated the largest loads of total suspended solids by far; 38 per cent and 37 per cent of the combined total suspended solids load respectively, despite an exceedance probability of 79 per cent (17 per cent of the long-term mean annual discharge) for the Burdekin catchment. The Fitzroy catchment also contributed the largest measures of all nutrients, including 29 per cent of the combined total nitrogen load; and 40 per cent of the combined total phosphorus load with the exception of dissolved organic phosphorus in which 31 per cent of the combined load was derived from the Johnstone catchment. Following the Fitzroy, the largest contributions of both particulate nitrogen and phosphorus was generated by the monitored catchments of the Burdekin and Johnstone basins. The Tully, Russell and Burdekin catchments made substantial contributions of most nitrogen fractions, as did the Johnstone catchment to the combined load of ammonium nitrogen. Overall, 52 per cent of the combined dissolved inorganic nitrogen load was contributed by the Wet Tropics region.
- The smallest contributions of total suspended solids and most other nutrient analytes were contributed by the Tinana Creek and Barratta Creek catchments. Both catchments generated low discharge relative to the long-term mean during the 2015–2016 monitoring year.
- The highest end-of-catchment monitored yield of total suspended solids occurred in the Russell catchment and highest sub-catchment yield in the Bowen catchment, within the Burdekin basin. In general, the monitored catchments of the Wet Tropics region produced the highest yields of all nutrient analytes with the exception of dissolved inorganic phosphorus, which was highest in the Sandy Creek catchment. In particular, the highest monitored yields of total nitrogen, particulate nitrogen, total phosphorus and particulate phosphorus occurred in the Russell catchment. High yields of both dissolved organic and inorganic nitrogen occurred in the Tully and North and South Johnstone catchments.
- The lowest yields of most analytes generally occurred in the larger catchments of the Burnett and Fitzroy owing in part to the low discharge during the 2015–2016 monitoring year.
- The total monitored annual photosystem II inhibiting herbicide loads were, in descending order: 1000 kg of tebuthiuron; 780 kg of total atrazine; 660 kg of total diuron; 260 kg of hexazinone; and 4.5 kg of ametryn.
- The photosystem II inhibiting herbicides total atrazine and total diuron were detected at all monitored sites.
- The Fitzroy catchment produced the largest monitored annual load of tebuthiuron, which is consistent with all monitoring years since 2009 when monitoring of pesticides was first implemented. The Pioneer catchment produced the largest load of total atrazine; substantial loads were also contributed by the Fitzroy and Barratta Creek catchments and collectively the three catchments contributed 58 per cent of the combined load of total atrazine. The Pioneer and Tully catchments contributed very high loads of total diuron; together they contributed almost half the combined load of total diuron. The Tully catchment produced the largest monitored annual load of hexazinone which is consistent with all years of reporting with the exception of the 2010–2011

monitoring year. The largest monitored annual loads of ametryn were in the Sandy Creek and Tinana Creek catchments.

- The combined toxic pesticide load of all monitored sites was 750 kg TEq_{diuron}, with total diuron accounting for 87 per cent or 650 kg TEq_{diuron}. The Pioneer and Tully catchments produced the largest toxic pesticide load (180 kg and 150 kg TEq_{diuron} respectively), with both catchments accounting for 45 per cent of the combined monitored toxic pesticide load.
- The highest land use yield of tebuthiuron was in the Fitzroy catchment, which also produced the largest monitored annual load of tebuthiuron. The highest land use yield of total atrazine was in the Barratta Creek catchment, with the yield more than double the yield of all other monitored catchments. The highest monitored land use yields of total diuron and hexazinone were derived from the Russell and Tully catchments. The highest land use yield of ametryn was in the Mulgrave and Tinana Creek catchments.

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7. Appendices

Appendix A Loads of pesticides, other than the five priority Reef Plan pesticides, measured by the Great Barrier Reef Catchment Loads Monitoring Program

Funding provided by the Queensland Department of Environment and Heritage Protection, Reef Quality Protection Unit, has allowed the continued analysis of water samples for a broader suite of pesticides during the 2015–2016 monitoring year. The analysis of water samples for the extended suite of chemicals was initiated in 2012 under Project RP57C.The mass loads of these additional chemicals were reported for the 2013–2014 and 2014–2015 monitoring years in Garzon-Garcia et al. (2015) and Wallace et al. (2016), respectively.

Through the EHP funded extension to RP57C, all pesticide water samples collected from all sites during the 2015–2016 monitoring year were analysed using LC-MS as described in Section 2.5 for the extended suite of chemicals. The extended analytical suite is capable of detecting more than 49 pesticides and their breakdown products (i.e. in addition to the five photosystem II inhibiting herbicides presented in the body of the report) (See Table 7.1). The monitored annual loads of the additional pesticides were calculated using the methods described in Section 2.7.2.

The results presented in this section of the report are the monitored annual loads of the additional pesticides detected above the analytical limit of reporting, including 2,4-D, acetamiprid, acifluorfen, bromacil, clomazone, clothiandin, fluroxypyr, haloxyfop, imazapic, imazapyr, imazethapyr, imidacloprid, imidacloprid metabolites, isoxaflutole, MCPA, MCPB, methoxyfenozide, metolachlor, metribuzin, metsulfuron methyl, prometryn, propazine-2-hydroxy (a metabolite of the herbicide propazine), simazine and triclopyr (Table 7.2 to Table 7.6).

The largest total monitored load (the sum of all end-of-catchment sites) of the additional pesticides was 510 kg of imidacloprid (Table 7.3). Other pesticides with total monitored loads greater than 100 kg included 2,4-D (490 kg), metolachlor (350 kg) and fluroxypyr (190 kg) (Table 7.3 and Table 7.2). An additional eight pesticides[6] had total annual monitored loads above 10 kg and another five[7] had total loads greater than 1.0 kg (Table 7.2 to Table 7.6). These loads are comparable to the total monitored annual loads of the five photosystem II inhibiting herbicides reported in Section 3.4 (7.0 kg to 1000 kg). At the other end of the scale, the pesticides with an estimated total monitored load of less than 0.10 kg included imazapyr (0.062 kg), acetamiprid (0.017 kg) and prometryn (0.013 kg) (Table 7.2 to Table 7.6).

Excluding the five photosystem II inhibiting herbicides presented in Section 3.4, an additional 24 pesticides (including metabolites) were measured across monitored catchments, 19 of those were detected in the Sandy Creek catchment and 18 in the Barratta Creek catchment (Table 7.2 to Table 7.6). This is a marked

[6] Haloxyfop (31 kg), Imazapic (48 kg), Isoxaflutole (17 kg), MCPA (45 kg), Metribuzin (24 kg), Metsulfuron methyl (11 kg), Simazine (13 kg) and Triclopyr (66 kg).

[7] Acifluorfen (2.0 kg), Bromacil (7.9 kg), Clothiandin (5.5 kg), Imazethapyr (6.4 kg) and MCPB 1.3 kg)

increase in the number of chemicals detected in the 2014–2015 monitoring year (Wallace et al. 2016), due, in part, to the increased number of pesticides available in the analytical suite and increased sensitivity of the analytical method for the 2015–2016 monitoring year. The Pioneer and Mulgrave catchments also ranked highly with 15 and 14 additional chemicals (respectively) measured in each catchment. The lowest number of additional pesticides detected in any catchment was two in the Burdekin catchment and four in the Fitzroy catchment (Table 7.2 to Table 7.6).

The herbicides 2,4-D and fluroxypyr were measured in all monitored catchments (Table 7.2 to Table 7.6). Other pesticides commonly measured across catchments included metolachlor (14 out of 15 catchments), triclopyr (13 catchments), imidacloprid and MCPA (each detected in ten catchments) and imazapic, metsulfuron methyl and haloxyfop (each detected in nine catchments). By contrast, the herbicides prometryn, imazapyr, clomazone, MCPB and acifluorfen and the insecticides acetamiprid, methoxyfenozide and clothianidin were the least commonly measured pesticides across catchments (Table 7.2 to Table 7.6).

The following section describes the monitored loads of each of the additional pesticides in more detail, presented in order of the most to least commonly detected pesticides across catchments.

The largest monitored annual loads of 2,4-D occurred in the Tully catchment (170 kg; 35 per cent of the total monitored annual load of 2,4-D) (Table 7.2), which was a large increase in the monitored load from this catchment in the previous monitoring year (2014–2015) of 40 kg (Wallace et al. 2016) and more than twice the annual load monitored at any other catchment in the 2015–2016 monitoring year. The monitored annual load of 2,4-D in the remaining catchments ranged from 59 kg (12 per cent) in the Herbert catchment to 4.3 kg (0.89 per cent) monitored in the Burnett catchment (Table 7.2).

The largest monitored annual loads of fluroxypyr were in the Herbert (56 kg; 29 per cent), Fitzroy (36 kg; 19 per cent) and Pioneer (28 kg; 15 per cent) catchments (Table 7.3). The monitored annual load of fluroxypyr in the Comet River sub-catchment was 3.2kg (Table 7.3, which is 8.9 per cent of the Fitzroy end-of-catchment load. The monitored annual fluroxypyr loads in the remaining monitored catchments ranged from 17 kg (8.9 per cent of the total monitored annual load) in the Sandy Creek catchment to 0.81 kg (0.42 per cent of total monitored annual load) in the Mary catchment (Table 7.3).

Similar to the 2014–2015 monitoring year, the largest monitored annual load of metolachlor was in the Fitzroy catchment (270 kg; 77 per cent) (Table 7.4), although this load was comparatively smaller than the load monitored in 2014–2015 (440 kg).The monitored annual load from the Comet sub-catchment (31 kg), was 11 per cent of the end-of-catchment load monitored in the Fitzroy River. The monitored annual metolachlor load was considerably smaller in all other end-of-catchment sites than the Fitzroy, by a factor of 19 or more. The smallest monitored annual loads of metolachlor were monitored in the Wet Tropics catchments; the Russell (1.3 kg; 0.38 per cent of total monitored annual load), Johnstone and Mulgrave (1.2 kg; 0.33 per cent) and Tully (0.42 kg; 0.12 per cent) catchments (Table 7.3).

The total monitored annual load of triclopyr was relatively small (66 kg) compared to the other pesticides detected across all end-of-catchment sites (Table 7.5). The largest monitored annual loads of triclopyr were measured in the Johnstone (19 kg; 29 per cent of total monitored annual load), Tully (17 kg; 26 per cent) and Mary (11 kg; 16 per cent) catchments (Table 7.5). The smallest calculable loads of triclopyr were monitored in the Sandy Creek (0.56 kg; 0.85 per cent), Barratta Creek (0.48 kg; 0.72 per cent) and O'Connell (0.40 kg; 0.60 per cent) catchments (Table 7.5).

The insecticide, imidacloprid, which was detected in all catchments apart from the Burdekin, Haughton (the end-of-catchment site monitored at Powerline is situated upstream of the main sugarcane producing area of the Haughton catchment), Fitzroy and Burnett catchments (Table 7.3). As previously mentioned, imidacloprid had the largest total annual load of all monitored pesticides (not including the five photosystem II herbicides). The largest monitored load of imidacloprid was measured in the Tully catchment (150 kg; 29 per cent of total monitored annual load), which was markedly higher than all other monitored catchments. Another six catchments had monitored loads greater than 10 kg, these included the Johnstone (92 kg; 18 per cent), Herbert (88 kg; 17 per cent), Pioneer (76 kg; 15 per cent), Russell (62 kg; 12 per cent) and Sandy Creek (23 kg; 4.6 per cent) catchments (Table 7.3). By contrast, the smallest loads of imidacloprid were monitored in the Barratta Creek (2.3 kg; 0.45 per cent) and Tinana Creek (2.1 kg; 0.42 per cent) catchments. Metabolites of imidacloprid were also detected (Table 7.4) but in much smaller quantities – the total monitored annual load was 0.94 kg derived from five end-of-catchment sites ranging from to 0.48 kg (48 per cent of total monitored annual load) in the Pioneer catchment to 0.015 kg (1.5 per cent) in the Tinana Creek catchment.

The total monitored annual load of MCPA during the 2015–2016 monitoring year was 45 kg. MCPA was detected in all catchments with the exception of the Tully, Herbert, Fitzroy and Burnett catchments (Table 7.4). When compared with other pesticides, the monitored annual load of MCPA varied little between catchments, loads ranging from 0.51 kg to 9.9 kg. The three largest monitored loads of MCPA were in the Johnstone (9.9 kg; 22 per cent of total monitored annual load), Pioneer (9.7 kg; 22 per cent) and Sandy Creek (9.6 kg; 21 per cent) catchments (Table 7.4). The catchments with the smallest loads were the Haughton (0.89 kg; 2.0 per cent of total monitored annual load), Tinana Creek (0.83 kg; 1.8 per cent) and O'Connell (0.51 kg; 1.1 per cent) (Table 7.4).

Imazapic (referred to in previous years as total imazapic – Wallace et al. 2016), was detected in all end-of-catchment sites apart from the Johnstone, Herbert, Haughton, Burdekin, Fitzroy and Burnett catchments (Table 7.3). Similar to triclopyr, the combined monitored annual load of imazapic was relatively small (48 kg) compared to other pesticides commonly detected across catchments. Only two catchments exported monitored annual loads above 10 kg; the Sandy Creek catchment had the largest load of 14 kg (29 per cent of total monitored annual load), followed by the Pioneer (11 kg; 23 per cent) catchment (Table 7.3). The monitored annual loads of imazapic in the remaining catchments ranged from 6.9 kg (14 per cent) in the Tully and Russell catchments to 1.1 kg (2.2 per cent of total monitored annual load) in the Barratta Creek catchment (Table 7.3).

Metsulfuron methyl was detected in all end-of-catchment sites with the exception of the Herbert, Haughton, Burdekin, Fitzroy, Burnett and Tinana Creek catchments (Table 7.5). The total monitored annual load of metsulfuron methyl across all end-of-catchment sites was relatively low (11 kg) compared to other pesticides. The largest loads were derived from four of the Wet Tropics catchments which contributed to 88 per cent of the total load; the Tully (6.0 kg; 57 per cent of total monitored annual load), Johnstone (1.8 kg; 17 per cent), Russell (0.85 kg; 8.1 per cent) and Mulgrave (0.62 kg; 5.9 per cent) catchments (Table 7.5). The Mary and Sandy Creek catchments had similar loads (0.62 kg and 0.52 kg, of total monitored annual load respectively) to the Mulgrave catchment. Metsulfuron methyl monitored loads ranged from 0.11 kg to 0.012 kg in the remaining catchments (Table 7.5).

The total monitored annual load of haloxyfop was 31 kg (Table 7.3). The largest loads of haloxyfop were monitored in four of the Wet Tropics catchments (Tully, Johnstone, Herbert and Russell catchments) which amounted to 95 per cent of the combined monitored annual load. In addition, the monitored annual load of haloxyfop at the North Johnstone nested sub-catchment monitoring site equated to 23 per cent of the Johnstone River end-of-catchment haloxyfop load. All other catchment annual loads of haloxyfop were less than 1.0 kg, ranging from 0.91 kg (3.0 per cent of total monitored annual load) at Tinana Creek to 0.016 kg (0.051 per cent of total monitored annual load) in the O’Connell River (Table 7.3).

Metribuzin was detected above the analytical limit of reporting in eight out of the 15 end-of-catchment sites, with a total monitored annual load of 24 kg (Table 7.5). The largest end-of-catchment load was monitored in the Sandy Creek catchment (7.8 kg; 33 per cent of total monitored annual load), which was comparable with the loads monitored in the Tully (5.0 kg; 21 per cent) and Barratta Creek (4.4 kg; 19 per cent) catchments (Table 7.5). The smallest monitored loads of metribuzin were monitored in the O’Connell (0.36 kg; 1.5 per cent of total monitored annual load) and Tinana Creek (0.049 kg; 0.21 per cent) catchments (Table 7.5).

Isoxaflutole was also detected above the analytical limit of reporting in five catchments with a combined monitored annual load of 17 kg (Table 7.4). The two largest catchment loads were almost equal; 5.7 kg (33 per cent of total monitored annual load) in the Barratta Creek catchment and 5.5 kg (32 per cent) in the Pioneer catchment, together amounting to 65 per cent of the total monitored isoxaflutole load (Table 7.4). Similarly, the isoxaflutole loads were also comparable between the remaining Sandy Creek (2.7 kg; 16 per cent of total monitored annual load), Russell (2.3 kg; 13 per cent) and Mulgrave (1.0 kg; 6.0 per cent) catchments (Table 7.4).

The total monitored annual load of simazine was 13 kg in the 2015–2016 monitoring year, derived from six end-of-system catchments (Table 7.5). The majority of the load (78 per cent of total monitored annual load) was contributed by two catchments in the Wet Tropics region; the Johnstone (5.4 kg; 43 per cent) and the Tully (4.4 kg; 35 per cent) catchments (Table 7.5). The monitored annual loads in all other catchments were less than 1.0 kg, with the exception of the Mary catchment (1.8 kg; 15 per cent of total monitored annual load) and ranged from 0.50 kg in the Pioneer catchment to 0.016 kg in the Sandy Creek catchment (Table 7.5).

The monitored annual bromacil load was 7.9 kg which originated from six catchments (Table 7.2). The majority of the mass load (84 per cent) was derived from the Barratta and Tinana Creek catchments (3.3 kg; 42 per cent of total monitored annual load each). The remaining 18 per cent was contributed by the Mary (0.63 kg), Mulgrave (0.31 kg), Fitzroy (0.27 kg), and Pioneer (0.077 kg) catchments (Table 7.2).

Imazethapyr and propazine-2-hydroxy, the metabolite of propazine (which is not part of the analysis suite), were both detected in four catchments and one nested sub-catchment (Comet River). The total monitored annual load of imazethapyr was 6.4 kg (Table 7.3), and a much smaller total load of propazine-2-hydroxy, 0.14 kg (Table 7.5). The largest monitored annual loads for imazethapyr and propazine-2-hydroxy were in the Barrratta Creek catchment (2.7 kg; 42 per cent and 0.098 kg; 68 per cent of total monitored annual load respectively). Both chemicals were also detected above the analytical limit of reporting in the Sandy Creek (2.4 kg; 38 per cent and 0.014 kg; 9.6 per cent, respectively) and Tinana Creek (0.72 kg; 11 per cent and 0.015 kg; 11 per cent, respectively) catchments. Imazethapyr and propazine-2-hydroxy were also detected above the analytical limit of reporting in the Comet River nested sub-catchment, generating loads of 0.31 kg and 0.0014 kg, respectively, although neither pesticides was detected at the Fitzroy end-of-catchment site. Imazethapyr was also detected in the Pioneer (0.54 kg; 8.4 per cent) catchment and propazine-2-hydroxy in the O'Connell (0.016 kg; 11 per cent) catchment (Table 7.3 and Table 7.5).

The remaining eight pesticides and metabolites were detected in less than five catchments and generally at smaller total monitored annual load contributions than those previously mentioned. One exception was the insecticide, clothianidin, which was only detected at the Johnstone end-of-catchment site contributing a monitored annual load of 5.5 kg (Table 7.2) and the North Johnstone River sub-catchment site monitored at the Old Bruce Highway Bridge (Goondi) (7.6 kg). During the 2015–2016 monitoring year, the total monitored annual load of MCPB (1.3 kg) was detected in two catchments; the Mulgrave and Herbert catchments (Table 7.4). Clomazone was detected in two catchments, the Mulgrave and Barratta Creek catchments, contributing a total annual monitored load of 0.83 kg (Table 7.2).

Acifluorfen was only detected in the Barratta Creek and Sandy Creek catchments and the Comet River sub-catchment site (Table 7.2). Their total monitored annual loads were estimated to be 2.0 kg. Methoxyfenozide and prometryn were detected in the Sandy Creek catchment with a total annual monitored load of 0.32 kg and 0.013 kg respectively (Table 7.4 and Table 7.5). Acetamiprid, with a total monitored annual load of 0.017 kg, was detected in the Barratta Creek catchment (Table 7.2).

Table 7.1 Pesticides analysed for by the Great Barrier Catchment Loads Monitoring Program using the liquid chromatography-mass spectrometry high and low method.

Pesticide	LC-MS (*High*) limit of reporting (µg L^{-1})	LC-MS (*Low*) limit of reporting (µg L^{-1})	Pesticide	LC-MS (*High*) limit of reporting (µg L^{-1})	LC-MS (*Low*) limit of reporting (µg L^{-1})
2,4-D	0.01	0.001	Mecoprop	0.01	0.001
2,4-DB	0.01	0.001	Mesosulfuron methyl	0.01	0.001
3,4-dichloroaniline	0.05	0.005	Methoxyfenozide	0.01	0.001
Acetamiprid	0.01	0.001	Metolachlor	0.01	0.001
Acifluorfen	0.01	0.001	Metribuzin	0.01	0.001
Ametryn	0.01	0.001	Metsulfuron methyl	0.01	0.001
Atrazine	0.01	0.001	Napropamide	0.01	0.001
Bromacil	0.01	0.001	N-demethyl acetamiprid	0.02	0.001
Clomazone	0.01	0.001	Prometryn	0.01	0.001
Clothianidin	0.01	0.001	Propachlor	0.01	0.001
Cyanazine	0.01	0.001	Propazin-2-hydroxy	0.02	0.001
Desethyl atrazine	0.01	0.001	Sethoxydim (including Clethodim)	0.02	0.001
Desisopropyl atrazine	0.01	0.001	Simazine	0.01	0.001
Diuron	0.01	0.001	Sulfosulfuron	0.01	0.002
Ethametsulfuron methyl	0.01	0.001	Tebuthiuron	0.01	0.001
Fluometuron	0.01	0.001	Terbuthylazine	0.01	0.001
Fluroxypyr	0.01	0.001	Terbuthylazine desethyl	0.01	0.001
Flusilazole	0.02	0.001	Terbutryn	0.02	0.001
Haloxyfop	0.01	0.001	Thiacloprid	0.01	0.001
Hexazinone	0.01	0.001	Thiamethoxam	0.01	0.001
Imazapic	0.01	0.001	Total Acetamiprid	0.03	0.003
Imazapic metabolites	0.02	0.001	Total Diuron	0.1	0.01
Imazapyr	0.01	0.001	Total Imazapic	0.05	0.002
Imazethapyr	0.01	0.001	Isoxaflutole	0.01	0.003
Imidacloprid	0.01	0.001	Triclopyr	0.01	0.001
Imidacloprid metabolites	0.01	0.001	Trifloxysulfuron	0.01	0.002
MCPA	0.01	0.001			
MCPB	0.01	0.001			

Table 7.2 The monitored annual loads calculated for the additional pesticides: 2,4-D, acetamiprid, acifluorfen, bromacil, clomazone and clothiandin. Text in bold refer to end-of-catchment sites and the corresponding data, all others refer to sub-catchment sites.

NRM region	Basin	Catchment	River and site name	n	Method	2,4-D (kg)	Acetamiprid (kg)	Acifluorfen (kg)	Bromacil (kg)	Clomazone (kg)	Clothiandin (kg)
Wet Tropics	Mulgrave-Russell	**Mulgrave River**	**Mulgrave River at Deeral**	82	L	13	NC	NC	0.31	0.53	NC
		Russell River	**Russell River at East Russell**	115	L	23	NC	NC	NC	NC	NC
	Johnstone	**Johnstone River**	**Johnstone River at Coquette Point**	74	L	37	NC	NC	NC	NC	5.5
		North Johnstone River	North Johnstone River at Old Bruce Highway Bridge (Goondi)	55	L	5.6	NC	NC	NC	NC	7.6
	Tully	**Tully River**	**Tully River at Euramo**	141	L	170	NC	NC	NC	NC	NC
	Herbert	**Herbert River**	**Herbert River at Ingham**	58	L	59	NC	NC	NC	NC	NC
Burdekin	Haughton	**Haughton River**	**Haughton River at Powerline**	18	B	13	NC	NC	NC	NC	NC
		Barratta Creek	**Barratta Creek at Northcote**	104	L	41	0.017	1.9	3.3	0.3	NC
	Burdekin	**Burdekin River**	**Burdekin River at Home Hill**	32	L	15	NC	NC	NC	NC	NC
Mackay Whitsunday	O'Connell	**O'Connell River**	**O'Connell River at Caravan Park**	37	L	10	NC	NC	NC	NC	NC
	Pioneer	**Pioneer River**	**Pioneer River at Dumbleton Pump Station**	82	L	44	NC	NC	0.077	NC	NC
	Plane	**Sandy Creek**	**Sandy Creek at Homebush**	140	L	31	NC	0.13	NC	NC	NC
Fitzroy	Fitzroy	**Fitzroy River**	**Fitzroy River at Rockhampton**	24	B	11	NC	NC	0.27	NC	NC
		Comet River	Comet River at Comet Weir	21	L	6.8	NC	0.00048	NC	NC	NC
Burnett Mary	Burnett	**Burnett River**	**Burnett River at Ben Anderson Barrage Head Water**	21	L	4.3	NC	NC	NC	NC	NC
	Mary	**Mary River**	**Mary River at Home Park**	58	L	12	NC	NC	0.63	NC	NC
		Tinana Creek	**Tinana Creek at Barrage Head Water**	65	L	6.1	NC	NC	3.3	NC	NC
Total monitored load (excluding North Johnstone River at Old Bruce Highway Bridge (Goondi)# and Comet River at Comet Weir#)				1127		490	0.017	2.0	7.9	0.83	5.5

n = the number of grab samples used to calculate loads; NC = a load was not calculated as there were insufficient samples (<3) where concentration detections were above 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.

North Johnstone River at Old Bruce Highway Bridge (Goondi) is a sub-catchment monitoring site located upstream of the Johnstone River at Coquette Point monitoring site and the Comet River at Comet Weir is located upstream of the Fitzroy River at Rockhampton monitoring site and has therefore these sub-catchment sites have not been included in the calculation of total monitored load.

Table 7.3 The monitored annual loads calculated for the additional pesticides: fluroxypyr, haloxyfop, imazapic, imazapyr, imazethapyr and imidacloprid. Text in bold refer to end-of-catchment sites and the corresponding data, all others refer to sub-catchment sites.

NRM region	Basin	Catchment	River and site name	n	Method	Fluroxypyr (kg)	Haloxyfop (kg)	Imazapic (kg)	Imazapyr (kg)	Imazethapyr (kg)	Imidacloprid (kg)
Wet Tropics	Mulgrave-Russell	**Mulgrave River**	**Mulgrave River at Deeral**	82	L	13	0.82	1.3	NC	NC	6.2
		Russell River	**Russell River at East Russell**	115	L	6.1	1.7	6.9	NC	NC	62
	Johnstone	**Johnstone River**	**Johnstone River at Coquette Point**	74	L	3.3	6.2	NC	NC	NC	92
		North Johnstone River	North Johnstone River at Old Bruce Highway Bridge (Goondi) #	55	L	1.5	1.4	NC	NC	NC	76
	Tully	**Tully River**	**Tully River at Euramo**	141	L	6.5	15	6.9	NC	NC	150
	Herbert	**Herbert River**	**Herbert River at Ingham**	58	L	56	5.4	NC	NC	NC	88
Burdekin	Haughton	**Haughton River**	**Haughton River at Powerline**	18	B	3.5	NC	NC	NC	NC	NC
		Barratta Creek	**Barratta Creek at Northcote**	104	L	4.4	0.65	1.1	NC	2.7	2.3
	Burdekin	**Burdekin River**	**Burdekin River at Home Hill**	32	L	6.9	NC	NC	NC	NC	NC
Mackay Whitsunday	O'Connell	**O'Connell River**	**O'Connell River at Caravan Park**	37	L	1.7	0.016	1.2	NC	NC	8.3
	Pioneer	**Pioneer River**	**Pioneer River at Dumbleton Pump Station**	82	L	28	NC	11	0.047	0.54	76
	Plane	**Sandy Creek**	**Sandy Creek at Homebush**	140	L	17	0.023	14	0.015	2.4	23
Fitzroy	Fitzroy	**Fitzroy River**	**Fitzroy River at Rockhampton**	24	B	36	NC	NC	NC	NC	NC
		Comet River	Comet River at Comet Weir#	21	L	3.2	0.13	0.21	0.00048	0.31	0.00048
Burnett Mary	Burnett	**Burnett River**	**Burnett River at Ben Anderson Barrage Head Water**	21	L	4.0	NC	NC	NC	NC	NC
	Mary	**Mary River**	**Mary River at Home Park**	58	L	0.81	NC	1.5	NC	NC	NC
		Tinana Creek	**Tinana Creek at Barrage Head Water**	65	L	3.0	0.91	4.1	NC	0.72	2.1
Total monitored load (excluding North Johnstone River at Old Bruce Highway Bridge (Goondi)# and Comet River at Comet Weir#)				1127		190	31	48	0.062	6.4	510

n = the number of grab samples used to calculate loads; NC = a load was not calculated as there were insufficient samples (<3) where concentration detections were above 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.

North Johnstone River at Old Bruce Highway Bridge (Goondi) is a sub-catchment monitoring site located upstream of the Johnstone River at Coquette Point monitoring site and the Comet River at Comet Weir is located upstream of the Fitzroy River at Rockhampton monitoring site and has therefore these sub-catchment sites have not been included in the calculation of total monitored load.

Table 7.4 The monitored annual loads calculated for the additional pesticides: imidacloprid metabolites, isoxaflutole, MCPA, MCPB, methoxyfenozide and metolachlor. Text in bold refer to end-of-catchment sites and the corresponding data, all others refer to sub-catchment sites.

NRM region	Basin	Catchment	River and site name	n	Method	Imidacloprid metabolites (kg)	Isoxaflutole (kg)	MCPA (kg)	MCPB (kg)	Methoxy-fenozide (kg)	Metolachlor (kg)
Wet Tropics	Mulgrave-Russell	**Mulgrave River**	**Mulgrave River at Deeral**	82	L	NC	1.0	5.2	0.079	NC	1.2
		Russell River	**Russell River at East Russell**	115	L	NC	2.3	3.0	NC	NC	1.3
	Johnstone	**Johnstone River**	**Johnstone River at Coquette Point**	74	L	0.38	NC	9.9	NC	NC	1.2
		North Johnstone River	North Johnstone River at Old Bruce Highway Bridge (Goondi) #	55	L	NC	NC	0.49	NC	NC	NC
	Tully	**Tully River**	**Tully River at Euramo**	141	L	NC	NC	NC	NC	NC	0.42
	Herbert	**Herbert River**	**Herbert River at Ingham**	58	L	NC	NC	NC	1.2	NC	8.0
Burdekin	Haughton	**Haughton River**	**Haughton River at Powerline**	18	B	NC	NC	0.89	NC	NC	3.9
		Barratta Creek	**Barratta Creek at Northcote**	104	L	NC	5.7	4.2	NC	NC	7.3
	Burdekin	**Burdekin River**	**Burdekin River at Home Hill**	32	L	NC	NC	NC	NC	NC	NC
Mackay Whitsunday	O'Connell	**O'Connell River**	**O'Connell River at Caravan Park**	37	L	0.017	NC	0.51	NC	NC	2.8
	Pioneer	**Pioneer River**	**Pioneer River at Dumbleton Pump Station**	82	L	0.48	5.5	9.7	NC	NC	14
	Plane	**Sandy Creek**	**Sandy Creek at Homebush**	140	L	0.043	2.7	9.6	NC	0.32	10
Fitzroy	Fitzroy	**Fitzroy River**	**Fitzroy River at Rockhampton**	24	B	NC	NC	NC	NC	NC	270
		Comet River	Comet River at Comet Weir#	21	L	NC	NC	NC	NC	NC	31
Burnett Mary	Burnett	**Burnett River**	**Burnett River at Ben Anderson Barrage Head Water**	21	L	NC	NC	NC	NC	NC	9.8
	Mary	**Mary River**	**Mary River at Home Park**	58	L	NC	NC	1.5	NC	NC	8.5
		Tinana Creek	**Tinana Creek at Barrage Head Water**	65	L	0.015	NC	0.83	NC	NC	12
Total monitored load (excluding North Johnstone River at Old Bruce Highway Bridge (Goondi)# and Comet River at Comet Weir#)				1127		0.94	17	45	1.3	0.32	350

n = the number of grab samples used to calculate loads; NC = a load was not calculated as there were insufficient samples (<3) where concentration detections were above 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.

North Johnstone River at Old Bruce Highway Bridge (Goondi) is a sub-catchment monitoring site located upstream of the Johnstone River at Coquette Point monitoring site and the Comet River at Comet Weir is located upstream of the Fitzroy River at Rockhampton monitoring site and has therefore these sub-catchment sites have not been included in the calculation of total monitored load.

Table 7.5 The monitored annual loads calculated for the additional pesticides: metribuzin, metsulfuron methyl, prometryn, propazin-2-hydroxy, simazine and triclopyr. Text in bold refer to end-of-catchment sites and the corresponding data, all others refer to sub-catchment sites.

NRM region	Basin	Catchment	River and site name	N	Method	Metribuzin (kg)	Metsulfuron methyl (kg)	Prometryn (kg)	Propazin-2-hydroxy (kg)	Simazine (kg)	Triclopyr (kg)
Wet Tropics	Mulgrave-Russell	**Mulgrave River**	**Mulgrave River at Deeral**	82	L	1.4	0.62	NC	NC	NC	2.2
		Russell River	**Russell River at East Russell**	115	L	2.1	0.85	NC	NC	NC	2.1
	Johnstone	**Johnstone River**	**Johnstone River at Coquette Point**	74	L	NC	1.8	NC	NC	5.4	19
		North Johnstone River	North Johnstone River at Old Bruce Highway Bridge (Goondi) #	55	L	NC	NC	NC	NC	NC	1.4
	Tully	**Tully River**	**Tully River at Euramo**	141	L	5.0	6.0	NC	NC	4.4	17
	Herbert	**Herbert River**	**Herbert River at Ingham**	58	L	NC	NC	NC	NC	NC	5.7
Burdekin	Haughton	**Haughton River**	**Haughton River at Powerline**	18	B	NC	NC	NC	NC	NC	1.3
		Barratta Creek	**Barratta Creek at Northcote**	104	L	4.4	0.012	NC	0.098	0.24	0.48
	Burdekin	**Burdekin River**	**Burdekin River at Home Hill**	32	L	NC	NC	NC	NC	NC	NC
Mackay Whitsunday	O'Connell	**O'Connell River**	**O'Connell River at Caravan Park**	37	L	0.36	0.044	NC	0.016	NC	0.40
	Pioneer	**Pioneer River**	**Pioneer River at Dumbleton Pump Station**	82	L	2.6	0.11	NC	NC	0.50	2.5
	Plane	**Sandy Creek**	**Sandy Creek at Homebush**	140	L	7.8	0.52	0.013	0.014	0.16	0.56
Fitzroy	Fitzroy	**Fitzroy River**	**Fitzroy River at Rockhampton**	24	B	NC	NC	NC	NC	NC	NC
		Comet River	Comet River at Comet Weir#	21	L	NC	0.00048	NC	0.0014	0.21	NC
Burnett Mary	Burnett	**Burnett River**	**Burnett River at Ben Anderson Barrage Head Water**	21	L	NC	NC	NC	NC	NC	1.4
	Mary	**Mary River**	**Mary River at Home Park**	58	L	NC	0.62	NC	NC	1.8	11
		Tinana Creek	**Tinana Creek at Barrage Head Water**	65	L	0.049	NC	NC	0.015	NC	2.5
Total monitored load (excluding North Johnstone River at Old Bruce Highway Bridge (Goondi)# and Comet River at Comet Weir#)				1127		24	11	0.013	0.14	13	66

n = the number of grab samples used to calculate loads; NC = a load was not calculated as there were insufficient samples (<3) where concentration detections were above 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.

North Johnstone River at Old Bruce Highway Bridge (Goondi) is a sub-catchment monitoring site located upstream of the Johnstone River at Coquette Point monitoring site and the Comet River at Comet Weir is located upstream of the Fitzroy River at Rockhampton monitoring site and has therefore these sub-catchment sites have not been included in the calculation of total monitored load.

Table 7.6 The monitored annual loads calculated for the additional pesticides: total atrazine and its metabolites atrazine, desethyl atrazine and desisopropyl atrazine, and total diuron including its metabolites diuron and 3,4-dichloroaniline. Text in bold refer to end-of-catchment sites and the corresponding data, all others refer to sub-catchment sites.

NRM region	Basin	Catchment	River and site name	n	Method	Total atrazine (kg)			Total diuron (kg)	
						Atrazine (kg)	Desethyl atrazine (kg)	Desisop-ropyl atrazine (kg)	Diuron (kg)	3,4 dichl-oroaniline (kg)
Wet Tropics	Mulgrave-Russell	**Mulgrave River**	**Mulgrave River at Deeral**	82	L	12	2.3	0.6	14	NC
		Russell River	**Russell River at East Russell**	115	L	23	4.9	NC	81	NC
	Johnstone	**Johnstone River**	**Johnstone River at Coquette Point**	74	L	18	1.6	0.43	45	NC
		North Johnstone River	North Johnstone River at Old Bruce Highway Bridge (Goondi)#	55	L	0.73	NC	NC	4.6	NC
	Tully	**Tully River**	**Tully River at Euramo**	141	L	38	11	0.44	140	0.85
	Herbert	**Herbert River**	**Herbert River at Ingham**	58	L	20	6.0	4.2	58	NC
Burdekin	Haughton	**Haughton River**	**Haughton River at Powerline**	18	B	22	2.5	0.86	4.4	NC
		Barratta Creek	**Barratta Creek at Northcote**	104	L	110	11	4.3	9.3	0.38
	Burdekin	**Burdekin River**	**Burdekin River at Home Hill**	32	L	33	2.8	NC	4.8	NC
Mackay Whitsunday	O'Connell	**O'Connell River**	**O'Connell River at Caravan Park**	37	L	14	2.4	0.74	4.1	0.038
	Pioneer	**Pioneer River**	**Pioneer River at Dumbleton Pump Station**	82	L	150	17	7.5	170	0.42
	Plane	**Sandy Creek**	**Sandy Creek at Homebush**	140	L	46	7.6	3.5	54	1.2
Fitzroy	Fitzroy	**Fitzroy River**	**Fitzroy River at Rockhampton**	24	B	100	23	13	58	NC
		Comet River	Comet River at Comet Weir#	21	L	12	1.7	1.3	0.6	NC
Burnett Mary	Burnett	**Burnett River**	**Burnett River at Ben Anderson Barrage Head Water**	21	L	18	1.4	0.0023	4.2	NC
	Mary	**Mary River**	**Mary River at Home Park**	58	L	8.1	0.79	0.38	3.6	NC
		Tinana Creek	**Tinana Creek at Barrage Head Water**	65	L	14	1.1	0.51	6.9	0.11
Total monitored load (excluding North Johnstone River at Old Bruce Highway Bridge (Goondi)# and Comet River at Comet Weir#)				1127		630	95	36	660	3.0

Data shaded blue (atrazine, desethyl atrazine, desisopropyl atrazine and diuron and 3,4-dichloroaniline) have already been incorporated in the calculation of total atrazine and total diuron and have been presented in the main body of this report. n = the number of grab samples used to calculate loads; NC = a load was not calculated there were insufficient samples (<3) where concentration detections were above 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.

North Johnstone River at Old Bruce Highway Bridge (Goondi) is a sub-catchment monitoring site located upstream of the Johnstone River at Coquette Point monitoring site and the Comet River at Comet Weir is located upstream of the Fitzroy River at Rockhampton monitoring site and therefore these sub-catchment sites have not been included in the calculation of total monitored load.

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Garzon-Garcia, A., Wallace, R., Huggins, R., Turner, R. D. R, Smith, R. A., Orr, D., Ferguson, B., Gardiner, R., Thomson, B. and Warne, M. St. J. (2015). Total suspended solids, nutrient and pesticide loads (2013–2014) for rivers that discharge to the Great Barrier Reef – Great Barrier Reef Catchment Loads Monitoring Program. Department of Science, Information Technology and Innovation. Brisbane.

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Appendix B Notification of reported exceedances of pesticide water quality guidelines in 2015–2016.

For pesticides and many other chemicals of environmental concern, published guideline values provide thresholds of risk to specific environmental values. Within Great Barrier Reef catchments, several environmental values have been identified for which published guideline values are available. These environmental values include aquatic ecosystems, water for irrigation use and drinking water. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000) provide guidelines for the protection of aquatic ecosystems and irrigation water and the Australian Drinking Water Guidelines (NHMRC, NRMMC 2011) provide guidelines for drinking water.

As an outcome of an agreement between the Department of Natural Resources and Mines, Department of Environment and Heritage Protection, Department of Agriculture and Fisheries and the Department of Premier and Cabinet from the Queensland Government and the Australian Cane Farmers Association, CANEGROWERS and the Australian Pesticide and Veterinary Medicines Authority, the Department of Science Information Technology and Innovation committed to report pesticide exceedances against irrigation guidelines. An exceedance report is released when,

- pesticides are detected at concentrations that exceed current irrigation residue water quality guidelines, and
- where pesticides are also detected above aquatic ecosystem protection guidelines and drinking water quality guidelines within those samples, these data are also included.
- where pesticides are detected at concentrations above the aquatic ecosystem protection and drinking water guidelines, but do not exceed the irrigation residue guidelines, these data are not reported.

Importantly, it is highlighted that there are very few irrigation residue guidelines available for pesticides detected by the current LC-MS analytical method, and as a consequence, an exceedance report is initiated only when the concentration of diuron exceeds the diuron irrigation guideline value. Of the 54 pesticides detected, current ecosystem protection guidelines are only available for 12 of the monitored pesticides.

All notifications released by the Department of Science Information Technology and Innovation during the 2015–2016 monitoring year relating to exceedances of pesticide water quality guidelines in monitored reef catchments, are provided below.

I. Notification of Reported Exceedances of Pesticide Water Quality Guidelines in 2015–2016 No.1

Water Quality and Investigations – Great Barrier Reef Catchment Loads Monitoring Program and the South East Queensland Catchment Loads Monitoring Program

Recently, Water Quality and Investigations (WQI) received results from the Queensland Health Forensic and Scientific Services (QHFSS) for surface water samples collected at Barratta Creek in the Haughton basin, south of Townsville, Queensland between the 6th and 12th November 2015. Samples collected over these dates contained pesticides at concentrations that exceeded some Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000; NHMRC and NRMMC, 2011). These exceedances are detailed below.

Barratta Creek

One sample was collected during ambient conditions (low/base flow) on 6th November 2015 and seven samples were collected during an event (high flow), 10th–12th November 2015 (Figure 1). The measured aqueous concentrations of atrazine, diuron and metolachlor exceeded at least one guideline value from the Australian and New Zealand Water Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000) and/or the Australian Drinking Water Quality Guidelines (NHMRC and NRMMC, 2011).

Similar exceedances of these trigger values in Barratta Creek have been reported previously.

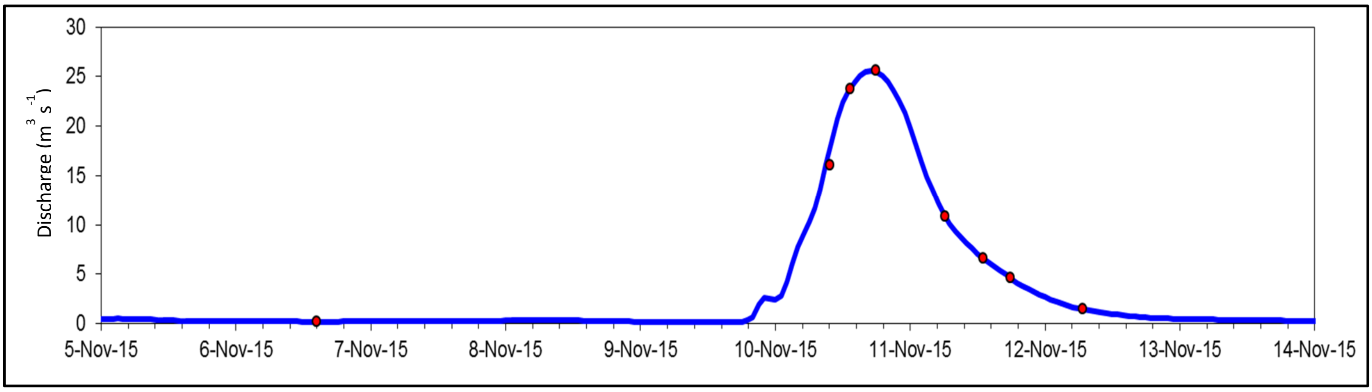

Figure 1 Hydrograph showing the discharge of Barratta Creek at the Northcote monitoring site between the 6th and 12th November, 2015 and when the water samples were collected.

For atrazine, all seven event samples exceeded the ecosystem protection guideline value (13 µg/L, Table 1) (ANZECC and ARMCANZ, 2000) and the Australian drinking water quality guideline for human health (20 µg/L) (NHMRC and NRMMC, 2011). It is important to note that these samples are untreated surface water, and the drinking water quality guideline for human health applies only to water consumed by humans. Any exceedance of the drinking water quality guidelines would only be relevant if this surface water is used as the permanent source of drinking water by someone not connected to a treated tap water supply. Although the drinking water quality guideline for human health has been exceeded, at this stage, drinking water has not been identified as an environmental value for Barratta Creek.

This is the fourth time that the Great Barrier Reef Catchment Monitoring Program has measured concentrations that exceeded the drinking water quality guidelines. The previous exceedance occurred on 27th June 2015.

For diuron, all eight samples exceeded the Australian and New Zealand ecosystem protection water quality guideline (0.2 µg/L, Table 1), whilst six out of eight samples exceeded the irrigation water quality guidelines (2 µg/L, Table 1) (ANZECC and ARMCANZ, 2000). Exceedances of the ecosystem protection and irrigation water quality guidelines for diuron have been reported previously in Barratta Creek.

During this event, all samples exceeded the current Australian and New Zealand ecosystem protection guideline value for metolachlor (0.02 µg/L, Table 1).

Table 1. Measured concentrations of atrazine, diuron and metolachlor at Barratta Creek and the water quality guidelines for various uses that were exceeded. Bold text indicates that the sample concentration exceeded at least one of the following water quality guidelines – ecosystem protection, irrigation and human drinking water.

Date and time of sample collection	Atrazine (µg/L)	Diuron (µg/L)	Metolachlor (µg/L)
06/11/2015 14:20	2.1	0.26	**0.09**
10/11/2015 09:45	**35**	**1.3**	**0.26**
10/11/2015 13:15	**40**	**2.1**	**0.29**
10/11/2015 17:55	**46**	**2.5**	**0.24**
11/11/2015 06:15	**32**	**2.2**	**0.18**
11/11/2015 12:55	**33**	**2.2**	**0.15**
11/11/2015 17:50	**37**	**2.3**	**0.16**
12/11/2015 06:40	**33**	**2.1**	**0.11**
Ecosystem protection WQG	13 (MR)	0.2 (LR)	0.02 (LR)
Drinking WQG (human health)	20	20	300
Irrigation WQG	-	2	-

- = no guideline value for that combination of chemical and use of the water,
MR = moderate reliability guideline value, LR = low reliability guideline value (Warne et al. 2015).

References

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NHMRC and NRMMC, 2011. Australian drinking water guidelines - Paper 6, National Water Quality Management Strategy. National Health and Medical Research Council, and National Research Management Ministerial Council, Commonwealth of Australia, Canberra.

Warne MStJ, Batley GE, van Dam RA, Chapman JC, Fox DR, Hickey CW and Stauber JL (2015). Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants. Department of Science, Information Technology, Innovation and the Arts, Brisbane, Queensland, 36 pp.

II. Notification of Reported Exceedances of Pesticide Water Quality Guidelines in 2015–2016 No.2

Water Quality and Investigations – Great Barrier Reef Catchment Loads Monitoring Program and the South East Queensland Catchment Loads Monitoring Program

Recently, Water Quality and Investigations (WQI) received results from the Queensland Health Forensic and Scientific Services (QHFSS) for surface water samples collected at Sandy Creek in the Plane basin, south of Mackay, Queensland between the 17th and 19th November 2015. Samples collected over these dates contained pesticides at concentrations that exceeded some Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000). These exceedances are detailed below.

Sandy Creek

Twelve samples were collected during an event (high flow) between the 17th and 19th November 2015 (Figure 1). The measured aqueous concentrations of diuron and metolachlor exceeded at least one guideline value from the Australian and New Zealand Water Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000). Similar exceedances of these trigger values have been reported previously in Sandy Creek.

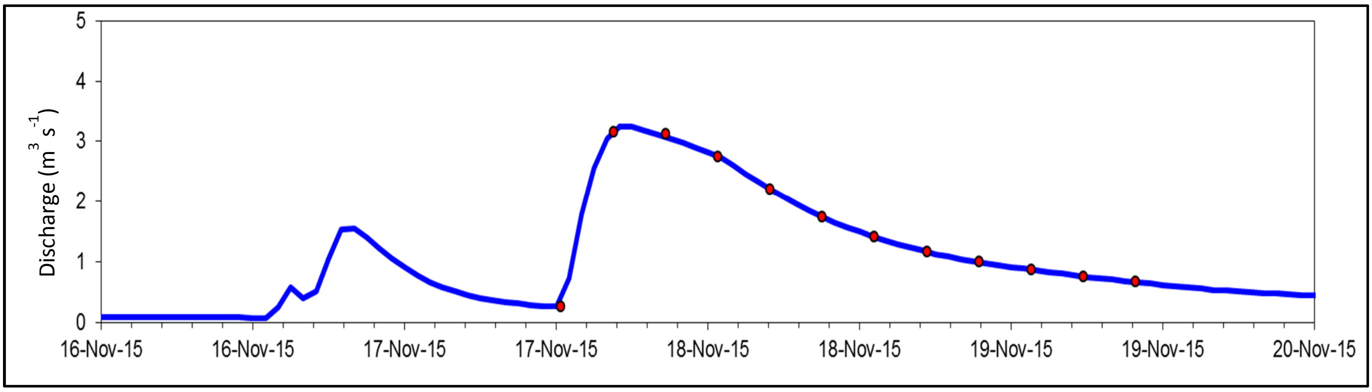

Figure 1. Hydrograph showing the discharge of the Sandy Creek at Homebush monitoring site between the 17th and 19th November, 2015 and when the water samples were collected.

For diuron, all twelve event samples exceeded the ecosystem protection guideline value (0.2 µg/L, Table 1) (ANZECC and ARMCANZ, 2000), and nine out of the twelve samples exceeded the irrigation water quality guidelines (2 µg/L, Table 1) (ANZECC and ARMCANZ, 2000). Although one sample came close (17/11/2015 12:23), the Australian drinking water quality guideline value for diuron was not exceeded (20 µg/L, Table 1).

Exceedances of the ecosystem protection and irrigation water quality guidelines for diuron have been reported previously in Sandy Creek. During this event, all twelve samples exceeded the current Australian and New Zealand ecosystem protection guideline value for metolachlor (0.02 µg/L, Table 1).

Table 1. Measured concentrations of diuron and metolachlor at Sandy Creek and the water quality guidelines for various uses that were exceeded. Bold text indicates that the sample concentration exceeded at least one of the following water quality guidelines – ecosystem protection, irrigation and human drinking.

Date and time of sample collection	Diuron (µg/L)	Metolachlor (µg/L)
17/11/2015 12:23	**19**	**0.54**
17/11/2015 16:31	**2.2**	**0.21**
17/11/2015 20:39	**0.64**	**0.38**
18/11/2015 00:47	**0.82**	**0.17**
18/11/2015 04:55	**1.1**	**0.14**
18/11/2015 09:03	**3.3**	**0.39**
18/11/2015 13:11	**4.1**	**0.58**
18/11/2015 17:19	**3.4**	**0.64**
18/11/2015 21:27	**3.4**	**0.57**
19/11/2015 01:35	**3.6**	**0.56**
19/11/2015 05:43	**3.6**	**0.49**
19/11/2015 09:51	**3.5**	**0.44**
Ecosystem protection WQG	0.2 (LR)	0.02 (LR)
Drinking WQG (human health)	20	300
Irrigation WQG	2	-

- = no guideline value for that combination of chemical and use of the water.
LR = low reliability guideline value (Warne et al. 2015).

References

ANZECC and ARMCANZ, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Vol. 1. The Guidelines, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

NHMRC and NRMMC, 2011. Australian drinking water guidelines - Paper 6, National Water Quality Management Strategy. National Health and Medical Research Council, and National Research Management Ministerial Council, Commonwealth of Australia, Canberra.

Warne MStJ, Batley GE, van Dam RA, Chapman JC, Fox DR, Hickey CW and Stauber JL, 2015. Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants. Department of Science, Information Technology, Innovation and the Arts, Brisbane, Queensland, 36 pp.

III. Notification of Reported Exceedances of Pesticide Water Quality Guidelines in 2015–2016 No.3

Water Quality and Investigations – Great Barrier Reef Catchment Loads Monitoring Program and the South East Queensland Catchment Loads Monitoring Program

Recently, Water Quality and Investigations (WQI) received results from the Queensland Health Forensic and Scientific Services (QHFSS) for surface water samples collected at Barratta Creek in the Haughton basin, south of Townsville, Queensland on the 30th November 2015 and the 7th December 2015. Samples collected on these dates contained pesticides at concentrations that exceeded some Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000; NHMRC and NRMMC, 2011). These exceedances are detailed below.

Barratta Creek

Two samples were collected during ambient conditions (low/base flow) on 30th November 2015 and 7th December 2015 (Figure 1). The measured aqueous concentrations of atrazine, diuron and metolachlor exceeded at least one guideline value from the Australian and New Zealand Water Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000) and/or the Australian Drinking Water Guidelines (NHMRC and NRMMC, 2011).

Similar exceedances of these trigger values in Barratta Creek have been reported previously.

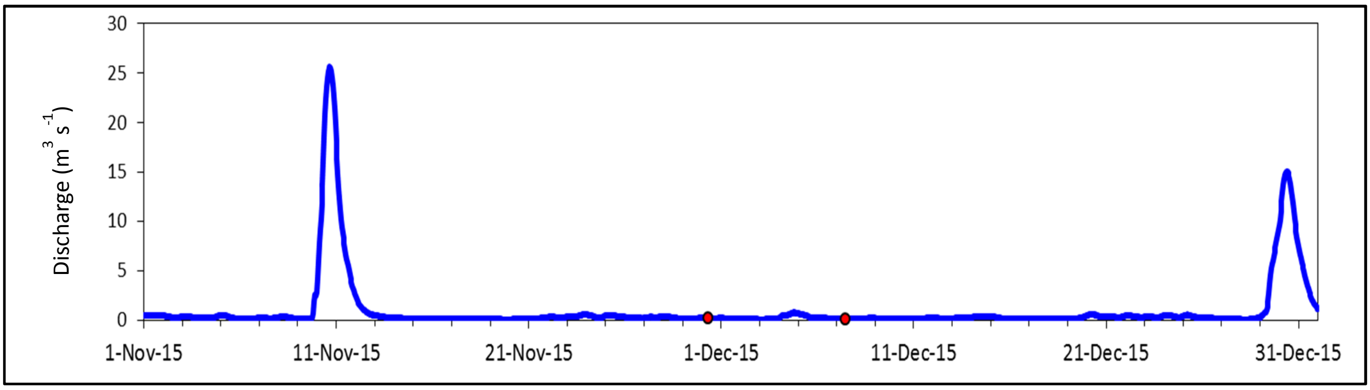

Figure 1. Hydrograph showing the discharge of Barratta Creek at the Northcote monitoring site and when the water samples were collected (red dot). Flow data is unverified telemetry data.

For atrazine, the ambient sample collect on 30th November 2015 exceeded the ecosystem protection guideline value (13 µg/L, Table 1) (ANZECC and ARMCANZ, 2000) and the Australian drinking water quality guideline for human health (20 µg/L) (NHMRC and NRMMC, 2011). It is important to note that these samples are untreated surface water, and the drinking water quality guideline for human health applies only to water consumed by humans. Any exceedance of the drinking water quality guidelines would only be relevant if this surface water is used as the permanent source of drinking water by someone not connected to a treated tap

water supply. Although the drinking water quality guideline for human health has been exceeded, at this stage, drinking water has not been identified as an environmental value for Barratta Creek (Dight, 2009).

This is the twelfth time that the Great Barrier Reef Catchment Monitoring Program has measured atrazine concentrations at Barratta Creek that exceeded the drinking water quality guidelines since 2013. The most recent previous exceedance occurred on 12th November 2015.

For diuron, samples on both the 30th November and 7th December 2015 exceeded the Australian and New Zealand ecosystem protection water quality guideline (0.2 µg/L, Table 1). Exceedances of the ecosystem protection water quality guideline for diuron have been reported previously in Barratta Creek. The previous exceedance occurred on 12th November 2015. On that previous occasion, the irrigation water quality guideline (2 µg/L, Table 1) was also exceeded. On this occasion, the irrigation guideline has not been exceeded.

During ambient conditions (low/base flow), both samples exceeded the current Australian and New Zealand ecosystem protection guideline value for metolachlor (0.02 µg/L, Table 1).

Table 1. Measured concentrations of atrazine, diuron and metolachlor at Barratta Creek and the water quality guidelines for various uses that were exceeded. Bold text indicates that the sample concentration exceeded at least one of the following water quality guidelines – ecosystem protection, irrigation and human drinking water.

Date and time of sample collection	Atrazine (µg/L)	Diuron (µg/L)	Metolachlor (µg/L)
30/11/2015 07:55	**52**	**0.43**	**0.05**
07/12/2015 11:30	8.4	**0.27**	**0.04**
Ecosystem protection WQG	13 (MR)	0.2 (LR)	0.02 (LR)
Drinking WQG (human health)	20	20	300
Irrigation WQG	-	2	-

- = no guideline value for that combination of chemical and use of the water.

MR = moderate reliability guideline value, LR = low reliability guideline value (Warne et al. 2015).

References

ANZECC and ARMCANZ, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Vol. 1. The Guidelines, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Dight, I, 2009. Burdekin Water Quality Improvement Plan Catchment Atlas. NQ Dry Tropics, Townsville. 148pp.

NHMRC and NRMMC, 2011. Australian drinking water guidelines - Paper 6, National Water Quality Management Strategy. National Health and Medical Research Council, and National Research Management Ministerial Council, Commonwealth of Australia, Canberra.

Warne MStJ, Batley GE, van Dam RA, Chapman JC, Fox DR, Hickey CW and Stauber JL 2015. Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants. Department of Science, Information Technology, Innovation and the Arts, Brisbane, Queensland, 36pp.

IV. Notification of Reported Exceedances of Pesticide Water Quality Guidelines in 2015–2016 No.4

Water Quality and Investigations – Great Barrier Reef Catchment Loads Monitoring Program and the South East Queensland Catchment Loads Monitoring Program

Recently, Water Quality and Investigations (WQI) received results from the Queensland Health Forensic and Scientific Services (QHFSS) for surface water samples collected at Sandy Creek in the Plane basin, south of Mackay, Queensland between the 8th and 10th December 2015. Samples collected over these dates contained pesticides at concentrations that exceeded some Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000). These exceedances are detailed below.

Sandy Creek

Twelve samples were collected during an event (high flow), between the 8th and 10th December 2015 (Figure 1). The measured aqueous concentrations of diuron and metolachlor exceeded at least one guideline value from the Australian and New Zealand Water Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000). Similar exceedances of these trigger values in Sandy Creek have been reported previously.

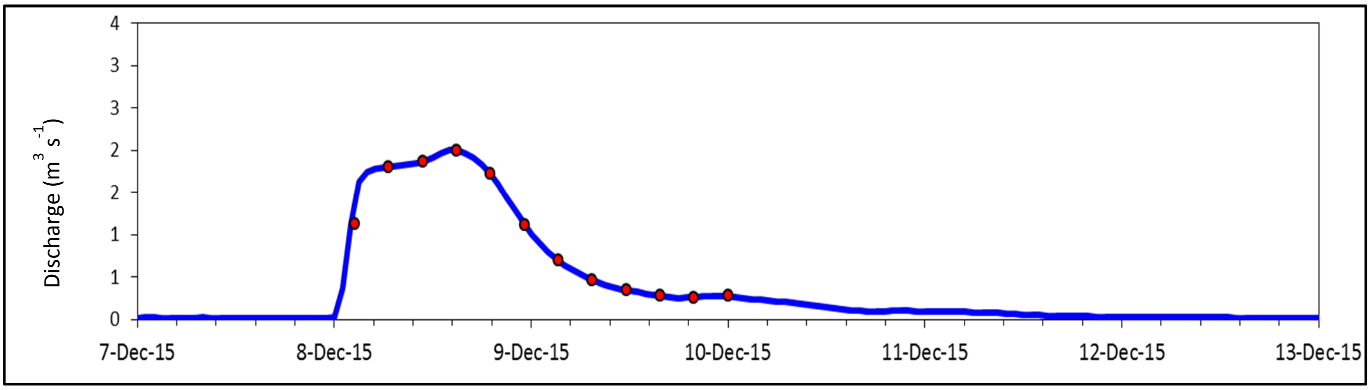

Figure 1. Hydrograph showing the discharge of the Sandy Creek at Homebush monitoring site and when the water samples were collected (red dot). Flow data is unverified telemetry data.

For diuron, all twelve event samples exceeded the ecosystem protection guideline value (0.2 µg/L, Table 1) (ANZECC and ARMCANZ, 2000), and one out of the twelve samples exceeded the irrigation water quality guidelines (2 µg/L, Table 1) (ANZECC and ARMCANZ, 2000). Exceedances of the ecosystem protection and irrigation water quality guidelines for diuron have been reported previously in Sandy Creek. The most recent exceedance occurred on 19th November 2015. On that previous occasion the irrigation water quality guideline (2 µg/L, Table 1) was also exceeded.

During this high flow event, four out of the twelve samples exceeded the current Australian and New Zealand ecosystem protection guideline value for metolachlor (0.02 µg/L, Table 1).

Table 1. Measured concentration of diuron and metolachlor at Sandy Creek and the water quality guidelines for various uses that were exceeded. Bold text indicates that the sample concentration exceeded at least one of the following water quality guidelines – ecosystem protection, irrigation and human drinking.

Date and time of sample collection	Diuron (µg/L)	Metolachlor (µg/L)
08/12/2015 02:31	**0.89**	**0.07**
08/12/2015 06:39	**2.2**	**0.19**
08/12/2015 10:47	**1.8**	**0.15**
08/12/2015 14:55	**0.69**	**0.04**
08/12/2015 19:03	**0.46**	0.02
08/12/2015 23:11	**0.39**	0.02
09/12/2015 03:19	**0.38**	0.02
09/12/2015 07:27	**0.36**	0.02
09/12/2015 11:35	**0.36**	0.02
09/12/2015 15:43	**0.39**	0.02
09/12/2015 19:51	**0.36**	0.02
09/12/2015 23:59	**0.36**	0.02
Ecosystem protection WQG	0.2 (LR)	0.02 (LR)
Drinking WQG (human health)	20	300
Irrigation WQG	2	-

- = no guideline value for that combination of chemical and use of the water.
LR = low reliability guideline value (Warne et al. 2015).

References

ANZECC and ARMCANZ, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Vol. 1. The Guidelines, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

NHMRC and NRMMC, 2011. Australian drinking water guidelines - Paper 6, National Water Quality Management Strategy. National Health and Medical Research Council, and National Research Management Ministerial Council, Commonwealth of Australia, Canberra.

Warne MStJ, Batley GE, van Dam RA, Chapman JC, Fox DR, Hickey CW and Stauber JL (2015). Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants. Department of Science, Information Technology, Innovation and the Arts, Brisbane, Queensland, 36 pp.

V. Notification of Reported Exceedances of Pesticide Water Quality Guidelines in 2015–2016 No.5

Water Quality and Investigations – Great Barrier Reef Catchment Loads Monitoring Program and the South East Queensland Catchment Loads Monitoring Program

Recently, Water Quality and Investigations (WQI) received results from the Queensland Health Forensic and Scientific Services (QHFSS) for surface water samples collected at Sandy Creek in the Plane basin, south of Mackay, Queensland. Samples collected between the 4th and 11th January 2016 contained pesticides at concentrations that exceeded some Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000). These exceedances are detailed below.

Sandy Creek

Thirty samples were collected during two runoff events, between 5th and 11th January 2016 (Figure 1). The measured aqueous concentrations of diuron and metolachlor exceeded at least one guideline value from the Australian and New Zealand Water Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000). Similar exceedances of these trigger values in Sandy Creek have been reported previously.

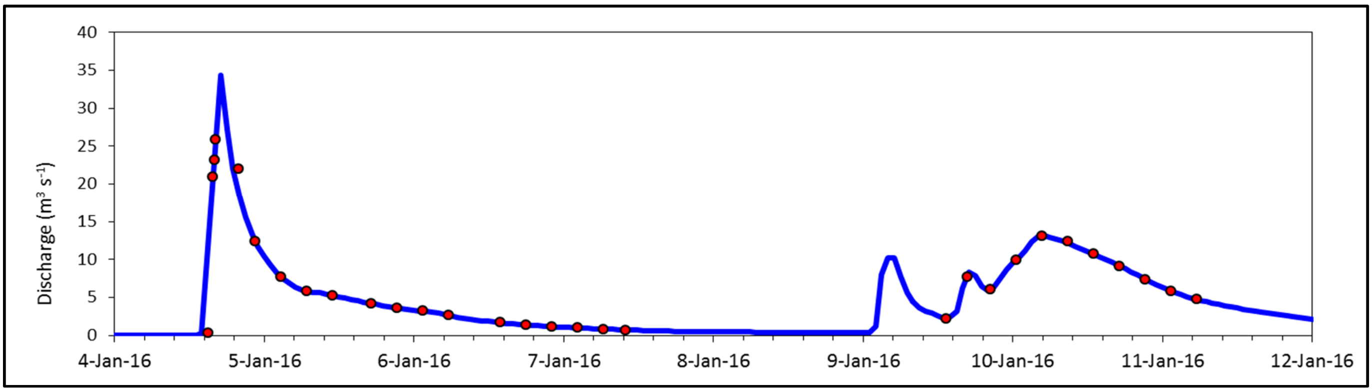

Figure 1. Hydrograph showing the discharge of Sandy Creek at the Homebush monitoring site and when the water samples were collected (red dots). Flow data are unverified telemetry data. Flow data extracted from Hydstra had two data points missing (04/01/2016 15:00 and 04/01/2016 16:00), and therefore, four hours of flow data were calculated via linear interpolation.

For diuron, 24 of 30 event samples exceeded the ecosystem protection guideline value (0.2 µg/L, Table 1) (ANZECC and ARMCANZ, 2000) and the irrigation water quality guideline value (2 µg/L, Table 1) (ANZECC and ARMCANZ, 2000). Exceedances of the ecosystem protection and irrigation water quality guidelines for diuron have been reported previously in Sandy Creek. The most recent reported exceedance occurred on the 9th December 2015, when the ecosystem protection guideline value (0.2 µg/L, Table 1) was exceeded. The most recent reported exceedance of the irrigation water quality guideline value (2 µg/L, Table 1) occurred on the 8th December 2015.

During the period 5th to 11th January 2016, 28 of 30 event samples also exceeded the Australian and New Zealand ecosystem protection guideline value for metolachlor (0.02 µg/L, Table 1). The most recent reported

exceedance occurred on the 8th December 2015, when the ecosystem protection guideline value (0.02 µg/L, Table 1) was exceeded.

Table 1. Measured concentrations of diuron and metolachlor at Sandy Creek in the Plane basin and the water quality guidelines for various environmental values. Bold text indicates that the sample concentration exceeded at least one of the following water quality guidelines – ecosystem protection, irrigation

Date and time of sample collection	Diuron (µg/L)	Metolachlor (µg/L)
04/01/2016 14:59	0.17	0.01
04/01/2016 15:49	0.14	<0.01
04/01/2016 16:01	**2.5**	**0.04**
04/01/2016 16:15	**2.9**	**0.04**
04/01/2016 19:57	**3.3**	**0.24**
04/01/2016 22:37	**3**	**0.94**
05/01/2016 2:45	**2.9**	**0.82**
05/01/2016 6:53	**3.7**	**0.52**
05/01/2016 11:01	**3.6**	**0.55**
05/01/2016 17:09	**3.7**	**0.85**
05/01/2016 21:17	**4**	**0.73**
06/01/2016 1:25	**4.5**	**0.71**
06/01/2016 5:33	**5**	**0.67**
06/01/2016 13:49	**5.6**	**0.6**
06/01/2016 17:57	**6.6**	**0.6**
06/01/2016 22:05	**6.2**	**0.56**
07/01/2016 2:13	**6.6**	**0.54**
07/01/2016 6:21	**6.5**	**0.56**
07/01/2016 10:00	**6.5**	**0.57**
09/01/2016 13:24	0.83	**0.08**
09/01/2016 16:42	1.4	**0.13**
09/01/2016 20:28	1.5	**0.14**
10/01/2016 0:36	2	**0.37**
10/01/2016 4:44	**3.6**	**1.3**
10/01/2016 8:52	**3.9**	**1.2**
10/01/2016 13:00	**5.2**	**1.1**
10/01/2016 17:08	**4.5**	**0.97**
10/01/2016 21:16	**4.4**	**1**
11/01/2016 1:24	**4.5**	**1**
11/01/2016 5:32	**4.4**	**1**
Ecosystem protection WQG	0.2 (LR)	0.02 (LR)
Drinking WQG (human health)	20	300
Irrigation WQG	2	-

- = no guideline value for that combination of chemical and use of the water.
LR = low reliability guideline value (Warne et al. 2015).

References

ANZECC and ARMCANZ, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Vol. 1. The Guidelines, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

NHMRC and NRMMC, 2011. Australian drinking water guidelines - Paper 6, National Water Quality Management Strategy. National Health and Medical Research Council, and National Research Management Ministerial Council, Commonwealth of Australia, Canberra.

Warne MStJ, Batley GE, van Dam RA, Chapman JC, Fox DR, Hickey CW and Stauber JL (2015). Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants. Department of Science, Information Technology, Innovation and the Arts, Brisbane, Queensland, 36 pp.

VI. Notification of Reported Exceedances of Pesticide Water Quality Guidelines in 2015–2016 No.6

Water Quality and Investigations – Great Barrier Reef Catchment Loads Monitoring Program and the South East Queensland Catchment Loads Monitoring Program

Recently, Water Quality and Investigations (WQI) received results from the Queensland Health Forensic and Scientific Services (QHFSS) for surface water samples collected at Sandy Creek in the Plane basin, south of Mackay, Queensland. Samples collected between the 18th and 19th January 2016 contained pesticides at concentrations that exceeded some Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000). These exceedances are detailed below.

Sandy Creek

Seven samples were collected during a small runoff event, between the 18th and 19th January 2016 (Figure 1). The measured aqueous concentrations of diuron and metolachlor exceeded at least one guideline value from the Australian and New Zealand Water Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000). Similar exceedances of these trigger values in Sandy Creek have been reported previously.

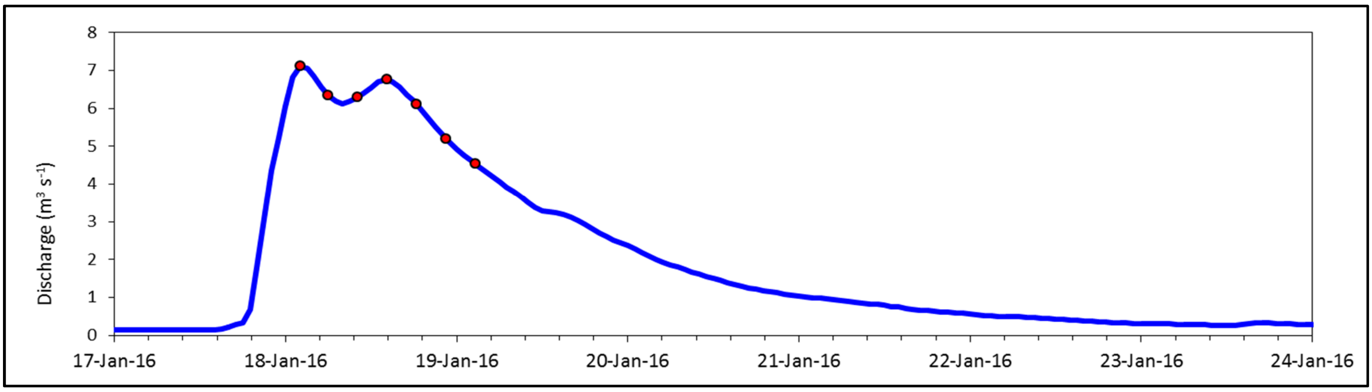

Figure 1. Hydrograph showing the discharge of Sandy Creek at the Homebush monitoring site and when the water samples were collected (red dots). Flow data are unverified telemetry data.

For diuron, all of the event samples exceeded the ecosystem protection guideline value (0.2 µg/L, Table 1) (ANZECC and ARMCANZ, 2000), and two of seven event samples also exceeded the irrigation water quality guideline value (2 µg/L, Table 1) (ANZECC and ARMCANZ, 2000). Exceedances of the ecosystem protection and irrigation water quality guidelines for diuron have been reported previously in Sandy Creek. The most recent reported exceedance occurred on the 11th December 2015, when the ecosystem protection guideline value (0.2 µg/L, Table 1) and the irrigation water quality guideline value (2 µg/L, Table 1) was exceeded (see Exceedance Notice No. 7, 2016).

The measured concentrations of metolachlor in all event samples also exceeded the Australian and New Zealand ecosystem protection guideline value (0.02 µg/L, Table 1). The most recent reported exceedance of metolachlor also occurred on the 11th December 2015, when the ecosystem protection guideline value (0.02 µg/L, Table 1) was exceeded (see Exceedance Notice No. 7, 2016).

Table 1. Measured concentrations of diuron and metolachlor at Sandy Creek and the water quality guidelines for various environmental values. Bold text indicates that the sample concentration exceeded at least one of the following water quality guidelines – ecosystem protection, irrigation.

Date and time of sample collection	Diuron (µg/L)	Metolachlor (µg/L)
18/01/2016 2:06	2.4	**0.49**
18/01/2016 5:59	1.9	**0.35**
18/01/2016 10:07	2.4	**0.21**
18/01/2016 14:15	1.9	**0.38**
18/01/2016 18:23	1.5	**0.35**
18/01/2016 22:31	1.5	**0.3**
19/01/2016 2:39	2	**0.27**
Ecosystem protection WQG	0.2 (LR)	0.02 (LR)
Irrigation WQG	2	-

- = no guideline value for that combination of chemical and use of the water.
LR = low reliability guideline value (Warne et al. 2015).

References

ANZECC and ARMCANZ, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Vol. 1. The Guidelines, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Warne MStJ, Batley GE, van Dam RA, Chapman JC, Fox DR, Hickey CW and Stauber JL (2015). Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants. Department of Science, Information Technology, Innovation and the Arts, Brisbane, Queensland, 36 pp.

VII. Notification of Reported Exceedances of Pesticide Water Quality Guidelines in 2015–2016 No.7

Water Quality and Investigations – Great Barrier Reef Catchment Loads Monitoring Program and the South East Queensland Catchment Loads Monitoring Program

Recently, Water Quality and Investigations (WQI) received results from the Queensland Health Forensic and Scientific Services (QHFSS) for surface water samples collected at Barratta Creek in the Haughton basin, south of Townsville, Queensland between 28th January 2016 and 11th February 2016. Samples collected on these dates contained pesticides at concentrations that exceeded some Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000). These exceedances are detailed below.

Barratta Creek

Twenty-eight samples were collected during ambient conditions (low/base flow) and an event (high flow) between 28th January 2016 and 11th February 2016 (Figure 1). The measured aqueous concentrations of diuron and metolachlor exceeded at least one guideline value from the Australian and New Zealand Water Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000).

Similar exceedances of these trigger values in Barratta Creek have been reported previously.

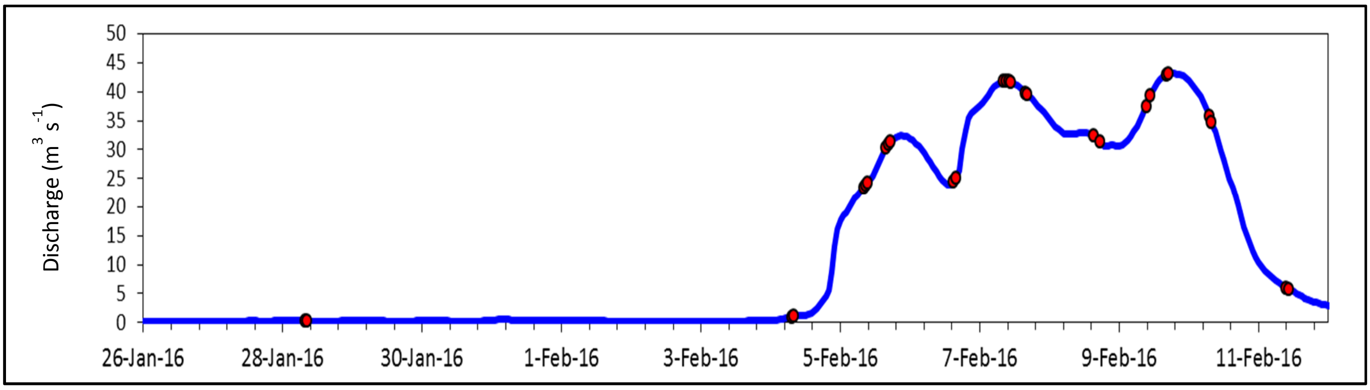

Figure 1 Hydrograph showing the discharge of Barratta Creek at the Northcote monitoring site and when the water samples were collected (red dots). Flow data are unverified telemetry data.

For diuron, one of 28 samples exceeded the ecosystem protection guideline value (0.2 µgL^{-1}, Table 1) (ANZECC and ARMCANZ, 2000) and the irrigation water quality guidelines (2 µgL^{-1}, Table 1) (ANZECC and ARMCANZ, 2000). Exceedances of the ecosystem protection water quality guideline for diuron have been reported previously in Barratta Creek. The most recent previous reported exceedance of the irrigation water quality guideline value (2 µgL^{-1}, Table 1) occurred on the 12th November 2015 (see Exceedance Notice No. 1, 2015).

During the event, six of 28 samples exceeded the current Australian and New Zealand ecosystem protection guideline value for metolachlor (0.02 µgL^{-1}, Table 1).

Table 1. Measured concentrations of diuron and metolachlor at Barratta Creek and the water quality guidelines for various environmental values. Bold text indicates that the sample concentration exceeded at least one of the following water quality guidelines – ecosystem protection, irrigation.

Date and time of sample collection	Diuron (µgL^{-1})	Metolachlor (µgL^{-1})
28/01/2016 7:50	0.05	0.02
28/01/2016 8:15	0.05	0.02
04/02/2016 7:25	0.03	0.01
04/02/2016 7:55	0.03	**0.05**
05/02/2016 8:10	0.41	0.01
05/02/2016 8:45	**3.1**	**0.12**
05/02/2016 9:20	0.21	**0.03**
05/02/2016 15:50	< 0.01	< 0.01
05/02/2016 16:40	0.2	**0.04**
05/02/2016 17:15	0.18	**0.03**
06/02/2016 14:55	0.01	0.01
06/02/2016 15:50	0.1	0.02
07/02/2016 8:05	< 0.01	< 0.01
07/02/2016 9:10	0.05	0.02

Date and time of sample collection	Diuron (μgL^{-1})	Metolachlor (μgL^{-1})
07/02/2016 10:10	0.05	0.01
07/02/2016 10:45	0.03	< 0.01
07/02/2016 15:49	0.05	0.01
07/02/2016 16:15	0.05	< 0.01
08/02/2016 15:15	0.07	0.03
08/02/2016 17:35	0.07	0.03
09/02/2016 9:35	0.05	0.02
09/02/2016 10:45	0.05	**0.03**
09/02/2016 16:25	< 0.01	< 0.01
09/02/2016 16:50	< 0.01	< 0.01
10/02/2016 7:05	0.06	0.02
10/02/2016 7:45	0.06	0.02
11/02/2016 9:35	0.06	0.02
11/02/2016 10:30	0.07	0.02
Ecosystem protection WQG	0.2 (LR)	0.02 (LR)
Irrigation WQG	2	-

- = no guideline value for that combination of chemical and use of the water.
LR = low reliability guideline value (Warne et al. 2015).

References

ANZECC and ARMCANZ, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Vol. 1. The Guidelines, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Warne MStJ, Batley GE, van Dam RA, Chapman JC, Fox DR, Hickey CW and Stauber JL (2015). Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants. Department of Science, Information Technology, Innovation and the Arts, Brisbane, Queensland, 36 pp.

Appendix C Calculation of discharge

At monitoring sites located at Queensland Department of Natural Resources and Mines gauging stations, discharge was calculated using an area velocity method. During the 2015–2016 monitoring year, river gauge height was recorded by gauging stations using a float or a pressure sensor at intervals of approximately 15 minutes. 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.

Discharge as extracted from the Queensland Government surface water database is calculated following the equation:

Equation 1

$$q = va$$

where,

q is the discharge ($m^3 s^{-1}$),

v= average velocity of the flow in the cross-sectional area (ms^{-1}) and

a = the cross-sectional area of the river (m^2).

Flow records were extracted for from the Queensland Government electronic data management system (Hydstra).

Appendix D Discharge data quality

The total period (hours) during the 2015–2016 monitoring year for which discharge was calculated from interpolated height data is provided in Table 7.7 . Discharge that was calculated from interpolated height data were assigned a quality code of 59 or 60 (Table 7.8).

Table 7.7 Per cent of annual discharge period calculated using interpolated discharge. Text in bold relate to end-of-catchment sites and gauging stations and the corresponding data, all others relate to sub-catchment sites.

Basin	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**			
Barron	**110001D**	**Barron River at Myola**			
Mulgrave-Russell	**1110056**	**Mulgrave River at Deeral[$]**	NA	NA	NA
	1111019	**Russell River at East Russell[$]**	NA	NA	NA
Johnstone	**1120054**	**Johnstone River at Coquette Point[#]**	NA	NA	NA
	1120049	North Johnstone River at Old Bruce Highway Bridge (Goondi)			
	112101B	South Johnstone River at Upstream Central Mill			
Tully	**113006A**	**Tully River at Euramo**	69	60	<1
	113015A	Tully River at Tully Gorge National Park			
Herbert	**116001F**	**Herbert River at Ingham**	28 38	130 60	<1 <1
Haughton	**119003A**	**Haughton River at Powerline**	515	60	6
	119101A	**Barratta Creek at Northcote**			
Burdekin	**120001A**	**Burdekin River at Home Hill**			
	120002C	Burdekin River at Sellheim	301	60	3
	120205A	Bowen River at Myuna			
O'Connell	**1240062**	**O'Connell River at Caravan Park**	871^ 20*	130 60	10 <1
Pioneer	**125013A**	**Pioneer River at Dumbleton Pump Station**			
Plane	**126001A**	**Sandy Creek at Homebush**			
Fitzroy	**1300000**	**Fitzroy River at Rockhampton**			
	130206A	Theresa Creek at Gregory Highway			
	130302A	Dawson River at Taroom			
	130504B	Comet River at Comet Weir			
Burnett	**136014A**	**Burnett River at Ben Anderson Barrage Head Water**			
	136002D	**Burnett River at Mt Lawless**			
Mary	**138014A**	**Mary River at Home Park**			
	138008A	**Tinana Creek at Barrage Head Water[#]**	NA	NA	NA

1 Quality codes are explained in Table 7.8; # modelled discharge was used in the calculation of loads for this site; and $ modelled and measured flow were used in the calculation of loads at these sites; NA = not applicable as discharge was calculated using flow measured flow and modelled discharge; ^ Andromache River GS 124003A; * O'Connell River GS 124001B (see Table 2.5).

Table 7.8 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
130	Not coded value
160	Suspect

Appendix E Calculation of discharge in the Mulgrave River and Russell River

New monitoring sites were installed in the Mulgrave River and Russell River by the Great Barrier Reef Catchment Loads Monitoring Program in early 2015. Installation of these sites was made possible through partnership funding provided by Terrain Natural Resource Management and Department of Science, Information Technology and Innovation.

Measured flow by Horizontal Acoustic Doppler Current Profiler

Flow during flood events at the Russell River and Mulgrave River monitoring sites were measured by Horizontal Acoustic Doppler Current Profilers. These sites are heavily affected by tidal flows and discharge monitoring was made possible due to the installation of Horizontal Acoustic Doppler Current Profiler technology at these sites. The Horizontal Acoustic Doppler Current Profiler units are permanently mounted at the side of the river and measure stream velocity in a horizontal plane. It is necessary to calibrate the measured velocities against the actual mean velocity for the river. The channel velocity is calculated by measuring the channel flow with manned boat Acoustic Doppler Current Profiler, then dividing the measured discharge by the standard cross sectional area.

In accordance with national standards, cross sectional area is surveyed annually where there is a mobile bed and also following a flood event. To prevent an abrupt change in area when a new cross section is surveyed, time series area data is created by a phased change from the current year's cross section into the next. It is assumed, in the absence of significant flood events, that the ebb and flow would gradually alter the cross section over the year.

When Horizontal Acoustic Doppler Current Profiler velocities are plotted against actual channel velocities, a Velocity Index relationship can be calculated by regression analysis. Data from more than 200 measurements, collected across a range of flow conditions, were used to develop Velocity Index relationships at the Russell and Mulgrave River monitoring sites. Calibrated velocities were then multiplied by the instantaneous cross sectional area to create continuous discharge data.

Horizontal Acoustic Doppler Profilers are able to measure velocities during almost all flow conditions, however in tidal areas sensors are periodically above the low tide water level base flow conditions. When the sensor is out of the water for short periods (<6 hours per day), the velocities can be reasonably interpolated between the last outgoing tide and the next incoming tide. In estuarine locations, the semidiurnal nature of the tides has a strong influence on flow rates. During low flows the underlying flow signal can be drowned out by a strong tidal signal. In these circumstances, mean daily modelled flows are used instead. During high flow event conditions the Horizontal Acoustic Doppler Current Profiler is able to continuously measure flows and the tidal signal is reduced. Use of these measured data enables significantly more precise load calculations during flood events (compared with modelled flow only) as sample concentrations can be applied to an instantaneous flow rate rather than a modelled daily rate.

Mulgrave River at Deeral

The record of velocity data has been adjusted to reflect the Velocity Index relationship found between the average velocity recorded by the Horizontal Acoustic Doppler Current Profiler at this site and the average velocity (Q/area) of the whole river measured with a RDI River Ray in a manned boat during 118 sections gauged over the period 11/02/15 and 30/06/16.

- Measured flows ranged from -129 to 159 m^3s^{-1}.
- Measured channel velocities ranged from -0.455 to 0.667 ms^{-1}.

The Velocity Index relationship between the gauged velocities (x) and the Horizontal Acoustic Doppler Current Profiler velocities (y) in these measurements is described by:

Equation 2

$$y = 0.9311x + 0.0015 \ (R^2 = 0.9907)$$

Russell River at East Russell

The record of velocity data has been adjusted to reflect the Velocity Index relationship found from 88 sections gauged over the period 11/02/15 and 10/02/16.

- Measured flows ranged from -70.1 to 232 m^3s^{-1}.
- Measured average velocities ranged from -0.18 to 0.72 ms^{-1}.

The relationship between the gauged velocities (x) and the Horizontal Acoustic Doppler Current Profilers velocities (y) in these measurements is described by:

Equation 3

$$y = 0.7801x + 0.0082 \ (R^2 = 0.9904)$$

Modelled river discharge

Daily discharge for the Mulgrave and Russell rivers were simulated and calibrated by the Department of Natural Resources and Mines using the Source Catchments platform Sacramento rainfall runoff model coupled with the Parameter Estimation Software Tool (PEST) for the period 1 July 1981 to 30 June 2016, following the approach detailed in Zhang et al. (2013). Zhang et al. (2013) demonstrated that the Sacramento model provides better performance in reproducing long-term daily discharge and high flow event scenarios than the Source Catchments platform alternate models Simhyd and GR4J.

The hydrology statistics used to calibrate the Mulgrave and Russell catchments (based on three upstream gauging stations) are provided in Table 7.9 (Zhang 2015). The calibration site at the Mulgrave River at Peets Bridge is the lowest gauged site within the catchment. Similarly within the Russell catchment, Russell River at

Bucklands and Babinda Creek at Babinda are the two lowest gauges on the primary tributaries in the Russell catchment.

Table 7.9 Summary hydrology statistics used to calibrate the Sacramento rainfall runoff model in the Mulgrave-Russell basin for the period 1 July 1981 to 30 June 2016.

Basin	Gauging station	River and site name	R^2	NSE*	Bias of total flow	Bias of high flow
Mulgrave-Russell	110007A	Mulgrave River at Peets Bridge	0.91	0.83	0.0%	-0.2%
	111001D	Russell River at Bucklands	0.94	0.89	-2.5%	-3.3%
	111102B	Babinda Creek at Babinda	0.90	0.81	-6.2%	-4.5%

* Nash-Sutcliffe coefficient of efficiency for daily simulated flow versus observed on a 1:1 line.

References

Zhang, X., Waters, D. and Ellis, R. (2013). Evaluation of Simhyd, Sacramento and GR4J rainfall runoff models in two contrasting Great Barrier Reef catchments. 20th International Congress on Modelling and Simulation, Adelaide, Australia.

Zhang, X. (2015). Calibration of Source Models for Wet Tropics Catchments: Summary of Calibration of Hydrology for Source Model of Wet Tropics Catchments, Department of Science, Information Technology and Innovation, Queensland Government.

Appendix F Hydrograph plots of discharge and sample collection points

Figures in Appendix F are presented in the order of the location of the catchment in Queensland from north to south.

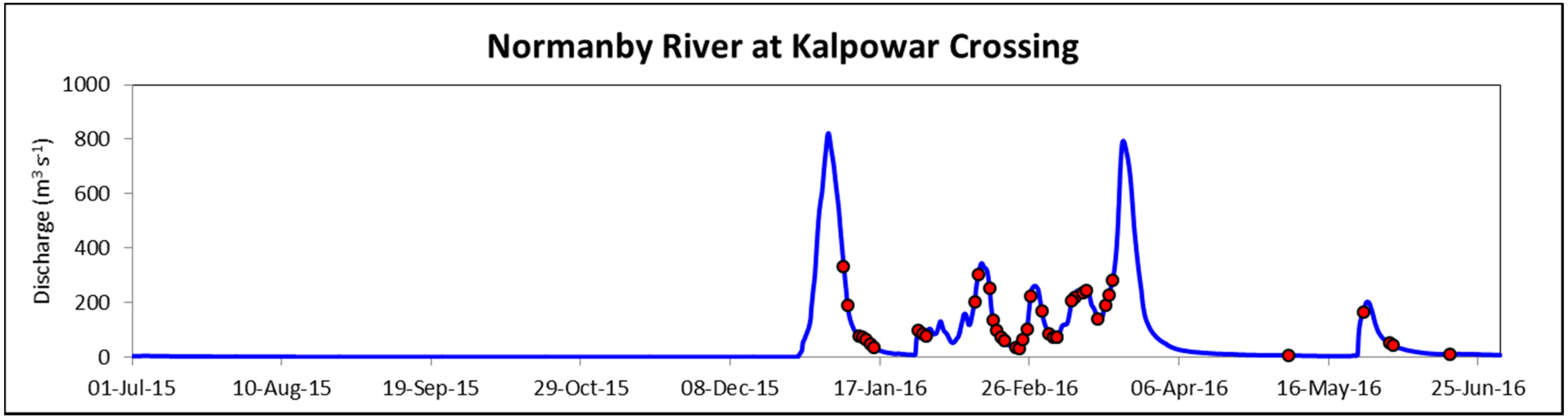

Figure 7.1 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids (red circles) in the Normanby River at Kalpowar Crossing between 1 July 2015 and 30 June 2016. Representivity rating was moderate for total suspended solids.

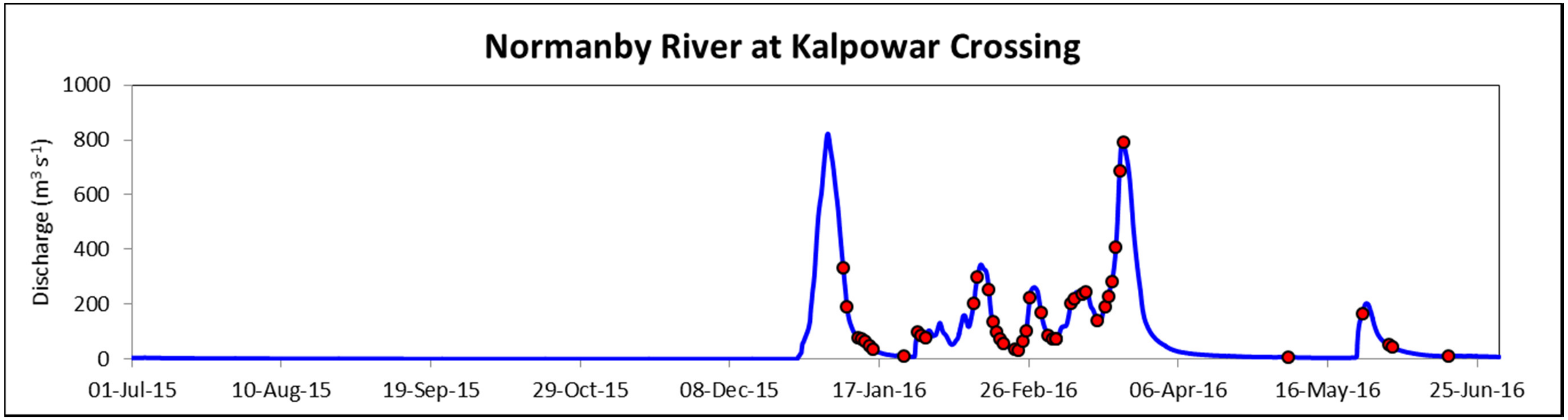

Figure 7.2 Hydrograph showing discharge (blue line) and sample coverage for total nutrients, dissolved and particulate nutrients (red circles) in the Normanby River at Kalpowar Crossing between 1 July 2015 and 30 June 2016. Representivity rating was good for all nutrient analytes.

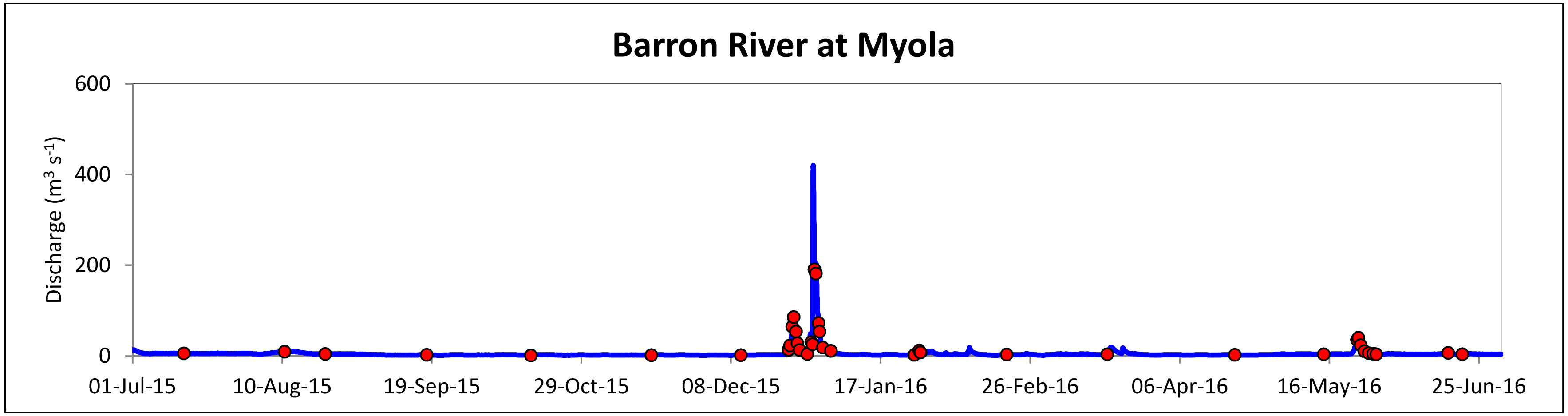

Figure 7.3 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Barron River at Myola between 1 July 2015 and 30 June 2016. Representivity rating was good for all analytes.

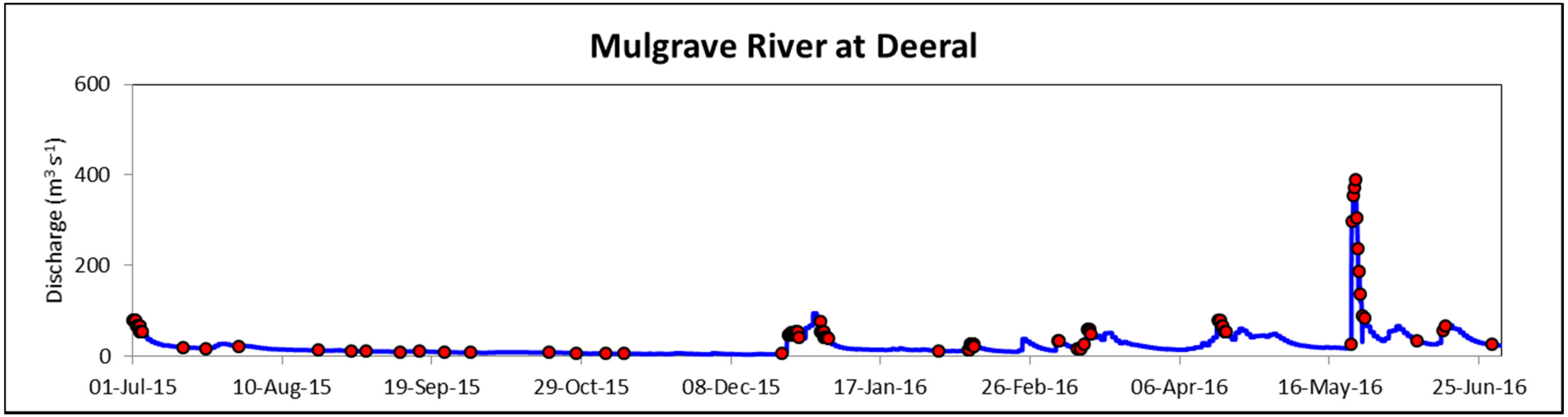

Figure 7.4 Hydrograph showing measured and modelled discharge (blue line) (Appendix E) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Mulgrave River at Deeral between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes.

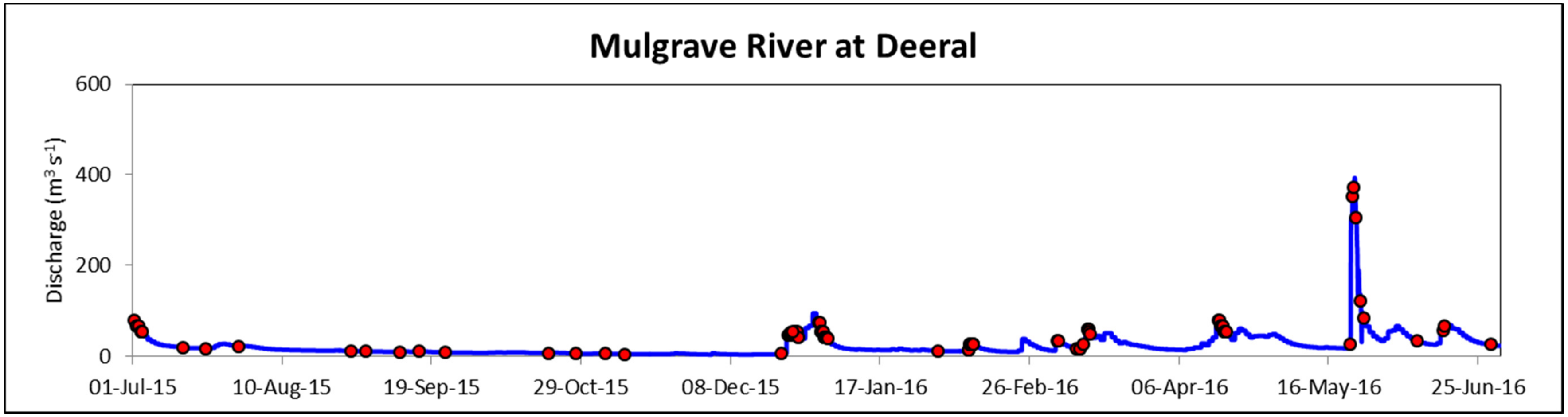

Figure 7.5 Hydrograph showing measured and modelled discharge (blue line) (Appendix E) and sample coverage for photosystem II inhibiting herbicides (red circles) in the Mulgrave River at Deeral between 1 July 2015 and 30 June 2016. Sample representivity was not assessed for pesticides.

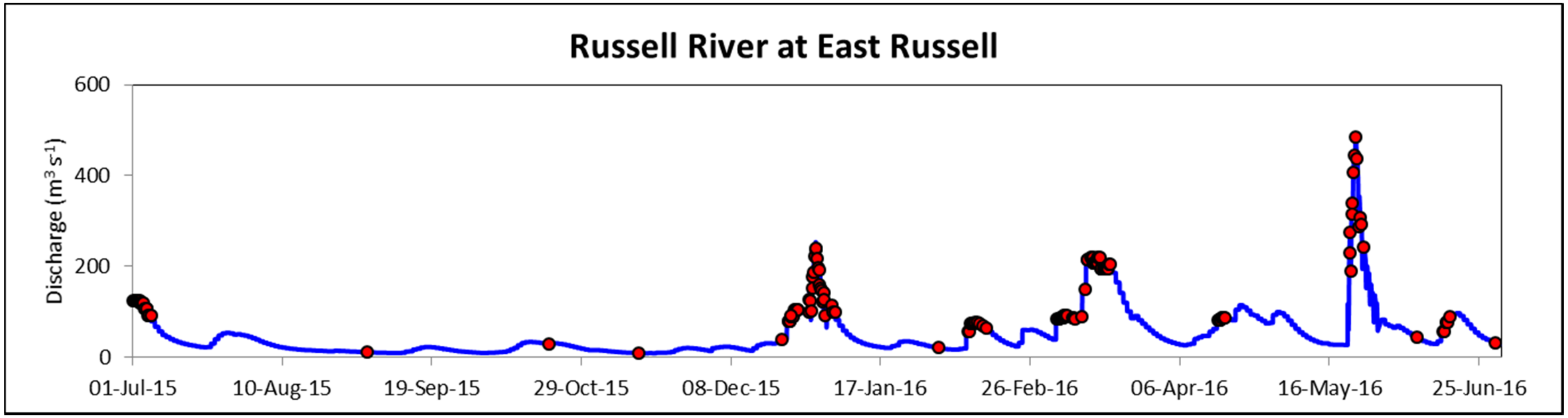

Figure 7.6 Hydrograph showing measured and modelled discharge (blue line) (Appendix E) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Russell River at East Russell between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes.

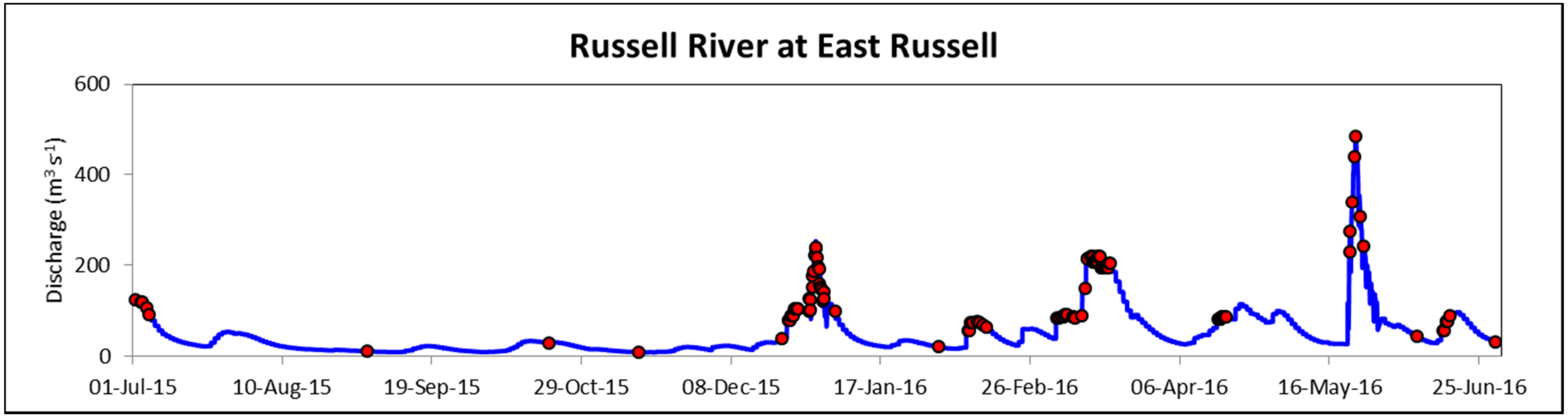

Figure 7.7 Hydrograph showing measured and modelled discharge (blue line) (Appendix E) and sample coverage for photosystem II inhibiting herbicides (red circles) in the Russell River at East Russell between 1 July 2015 and 30 June 2016. Sample representivity was not assessed for pesticides.

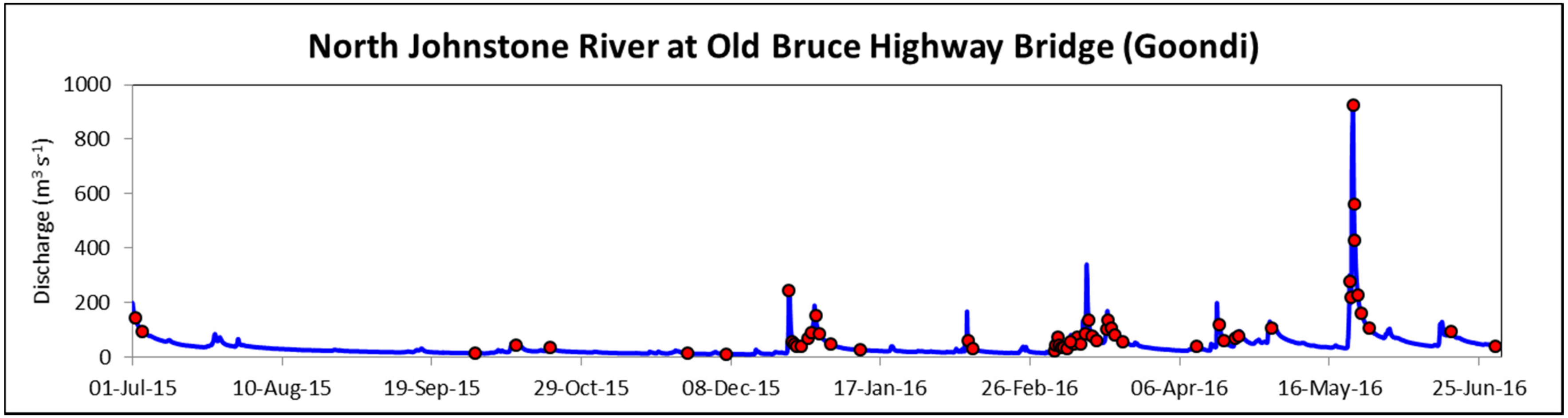

Figure 7.8 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved, particulate nutrients (red circles) in the North Johnstone River at Old Bruce Highway Bridge (Goondi) between 1 July 2015 and 30 June 2016. Representivity rating was good for all analytes.

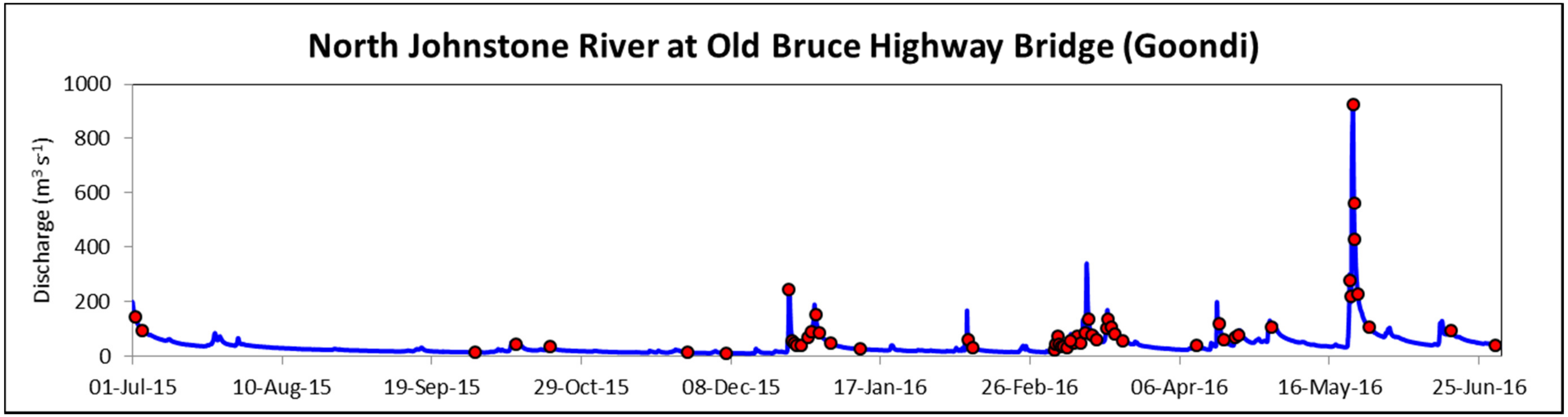

Figure 7.9 Hydrograph showing discharge (blue line) and sample coverage for photosystem II inhibiting herbicides (red circles) in the North Johnstone River at Old Bruce Highway Bridge (Goondi) between 1 July 2015 and 30 June 2016. Sample representivity was not assessed for pesticides.

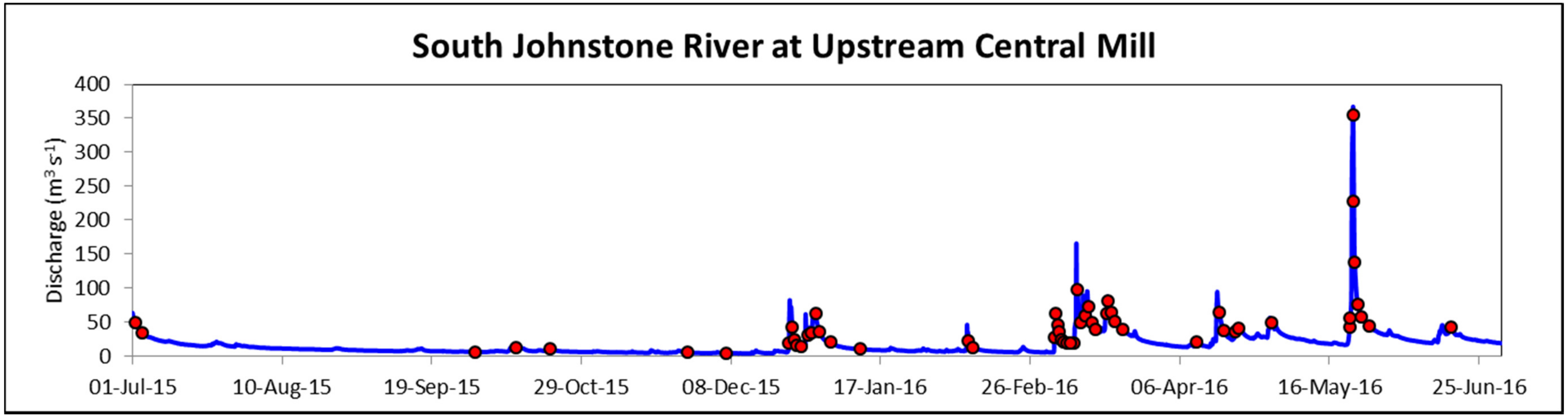

Figure 7.10 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the South Johnstone River at Upstream Central Mill between 1 July 2015 and 30 June 2016. Representivity rating was good for particulate nitrogen, dissolved organic nitrogen, particulate phosphorus and dissolved organic phosphorus. Representivity rating was excellent for all other analytes.

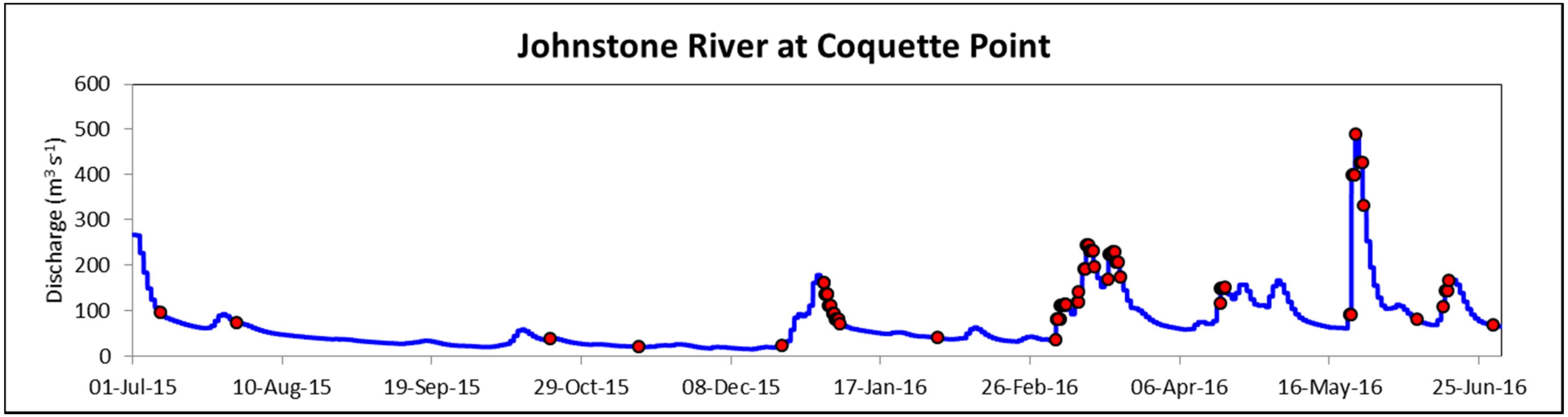

Figure 7.11 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Johnstone River at Coquette Point between 1 July 2015 and 30 June 2016. Representivity rating was good for all analytes.

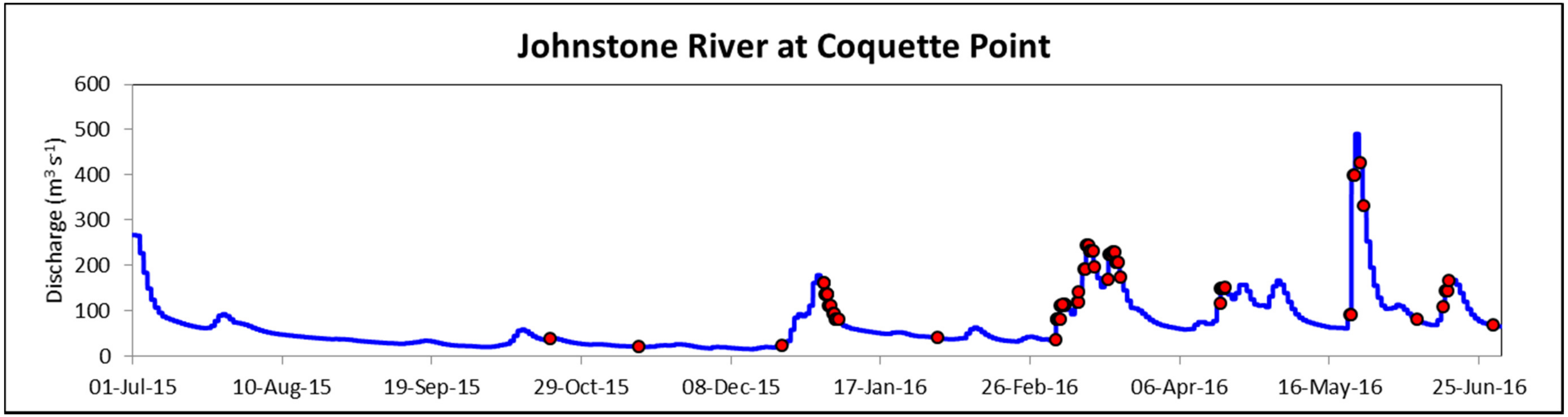

Figure 7.12 Hydrograph showing discharge (blue line) and sample coverage for photosystem II inhibiting herbicides (red circles) in the Johnstone River at Coquette Point between 1 July 2015 and 30 June 2016. Sample representivity was not assessed for pesticides.

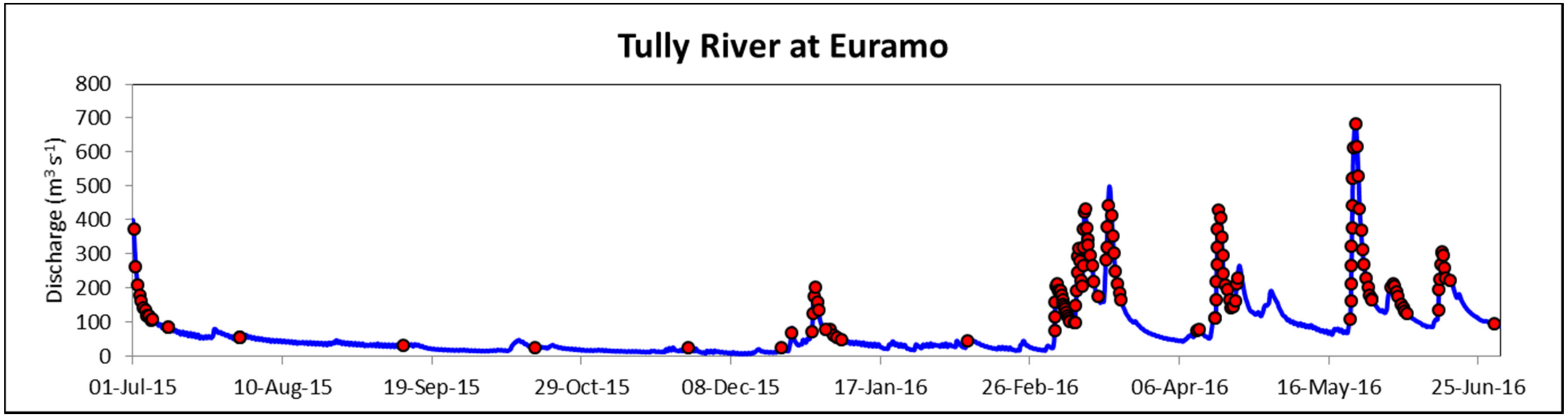

Figure 7.13 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Tully River at Euramo between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes.

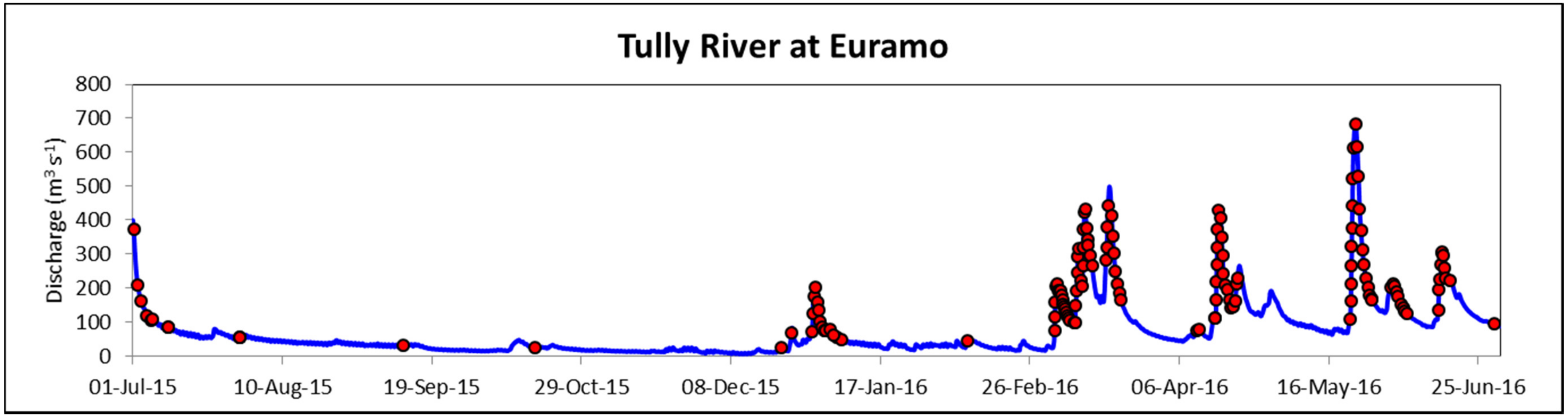

Figure 7.14 Hydrograph showing discharge (blue line) and sample coverage for photosystem II inhibiting herbicides (red circles) in the Tully River at Euramo between 1 July 2015 and 30 June 2016. Sample representivity was not assessed for pesticides.

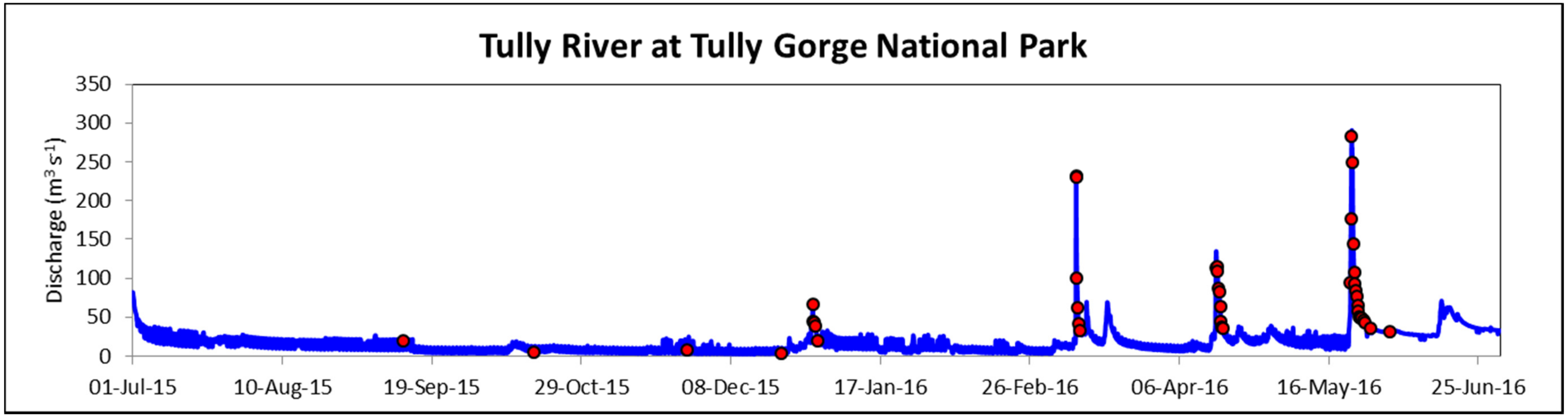

Figure 7.15 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Tully River at Tully Gorge National Park between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes.

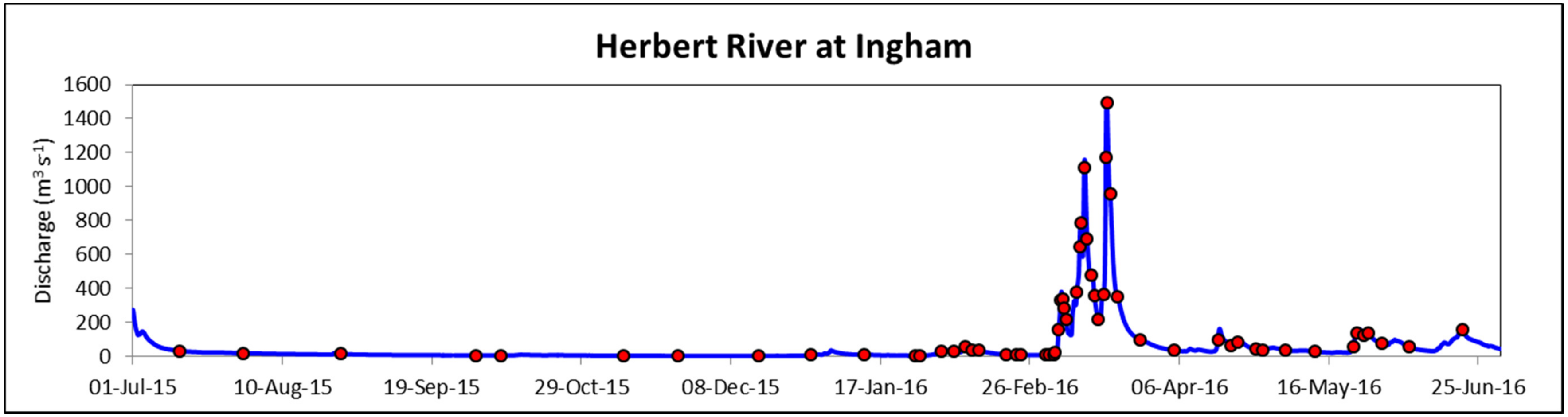

Figure 7.16 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients and photosysterm II inhibiting herbicides (red circles) in the Herbert River at Ingham between 1 July 2015 and 30 June 2016. Representivity rating was good for all analytes. Sample representivity was not assessed for pesticides.

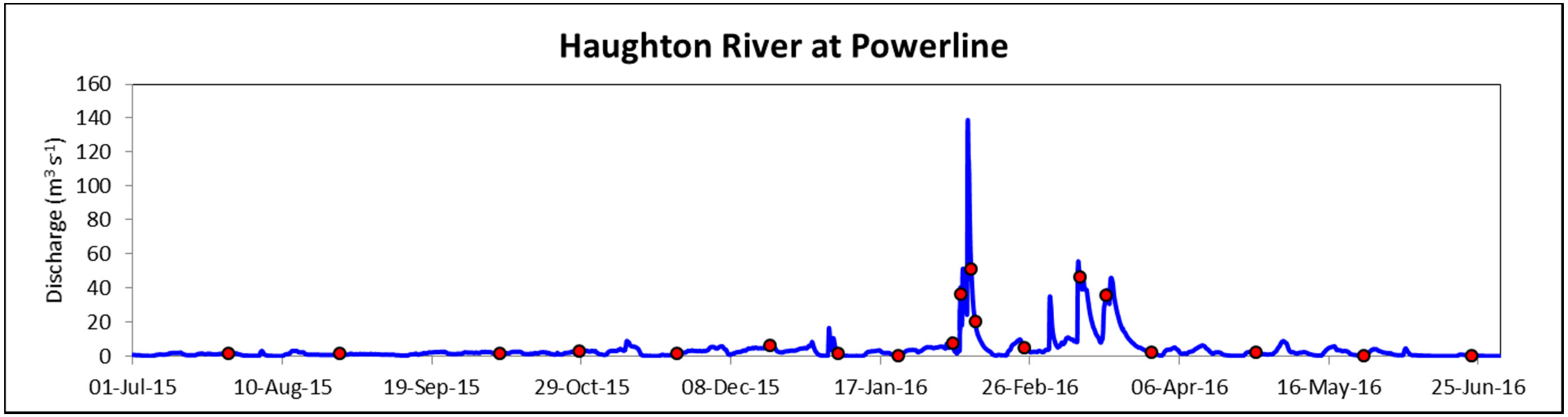

Figure 7.17 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Haughton River at Powerline between 1 July 2015 and 30 June 2016. Representivity rating was indicative for all analytes.

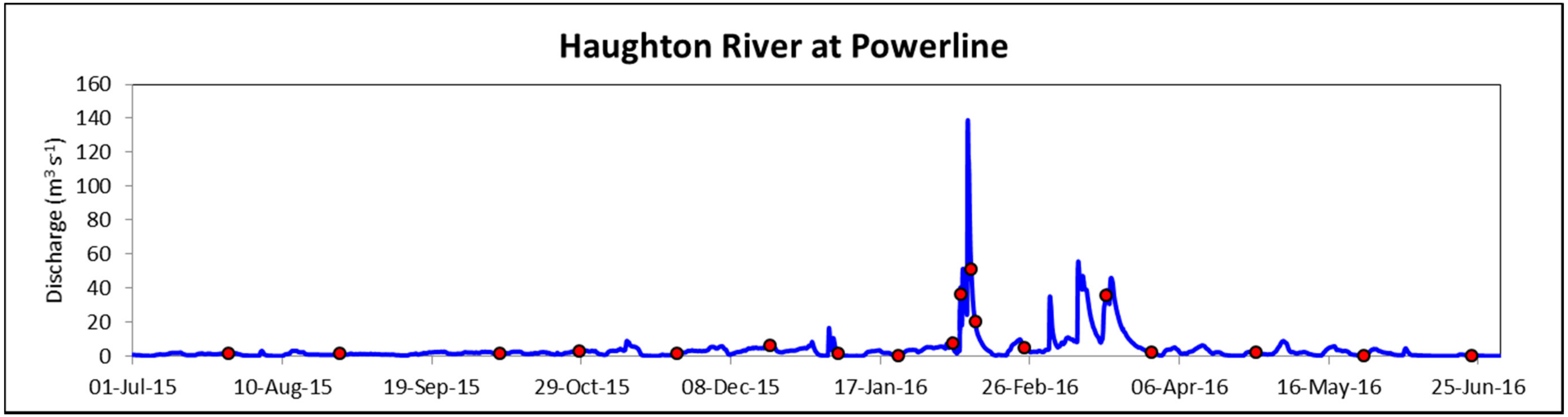

Figure 7.18 Hydrograph showing discharge (blue line) and sample coverage for photosystem II inhibiting herbicides (red circles) in the Haughton River at Powerline between 1 July 2015 and 30 June 2016. Sample representivity was not assessed for pesticides.

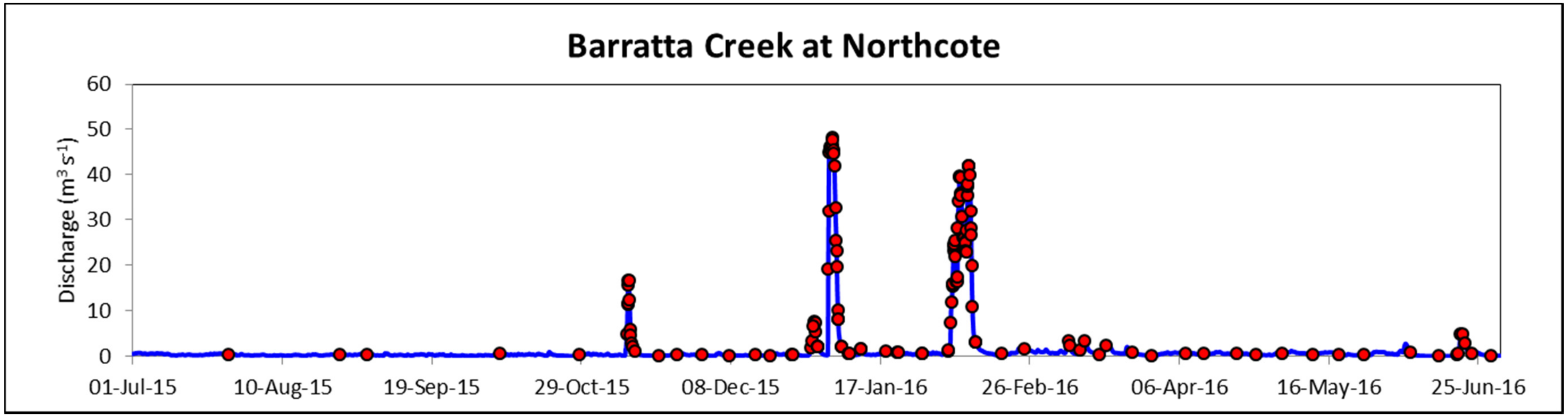

Figure 7.19 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in Barratta Creek at Northcote between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes.

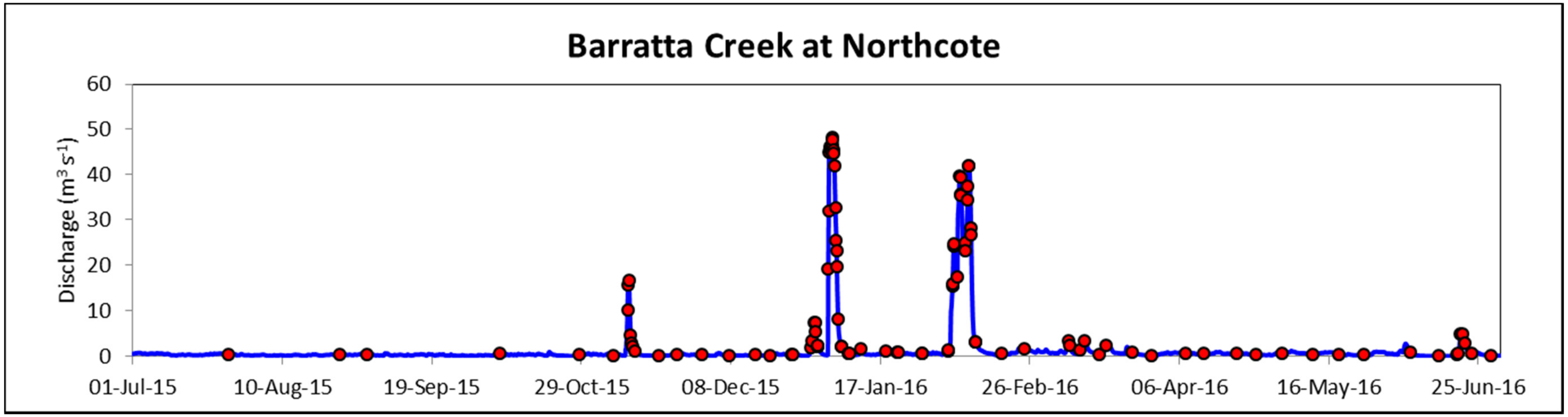

Figure 7.20 Hydrograph showing discharge (blue line) and sample coverage for photosystem II inhibiting herbicides (red circles) in Barratta Creek at Northcote between 1 July 2015 and 30 June 2016. Sample representivity was not assessed for pesticides.

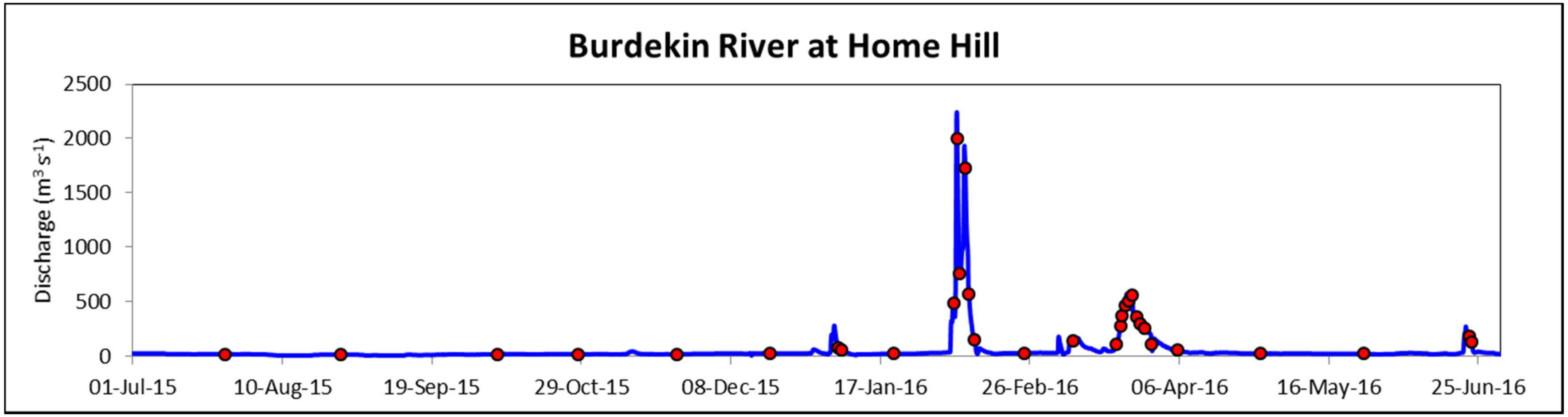

Figure 7.21 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients and photosystem II inhibiting herbicides (red circles) in the Burdekin River at Home Hill between 1 July 2015 and 30 June 2016. Representivity rating was good for all analytes. Sample representivity was not assessed for pesticides.

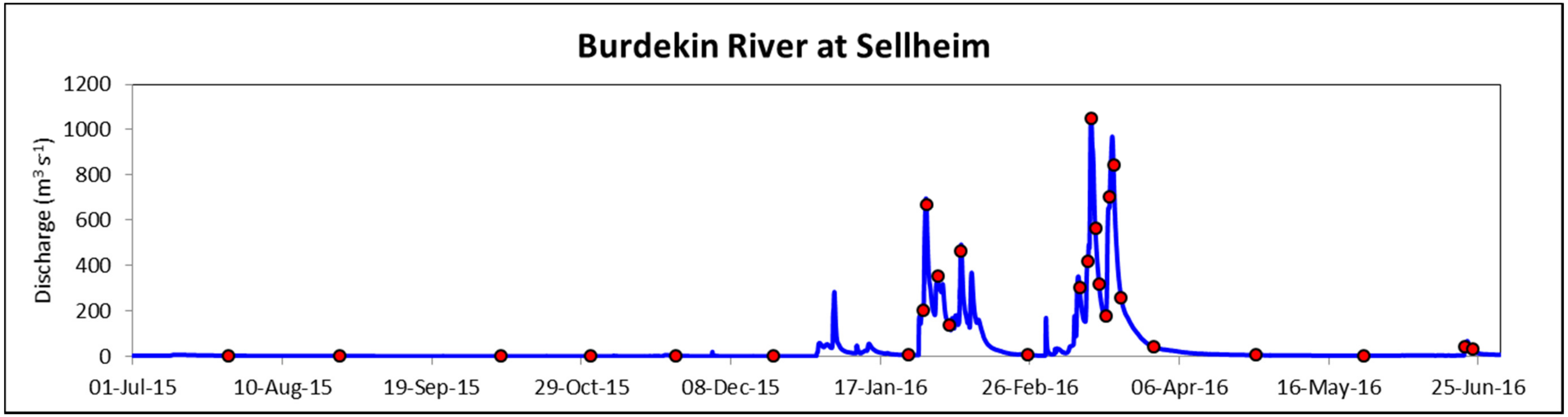

Figure 7.22 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients and photosystem II inhibiting herbicides (red circles) in the Burdekin River at Sellheim between 1 July 2015 and 30 June 2016. Representivity rating was good for all analytes. Sample representivity was not assessed for pesticides.

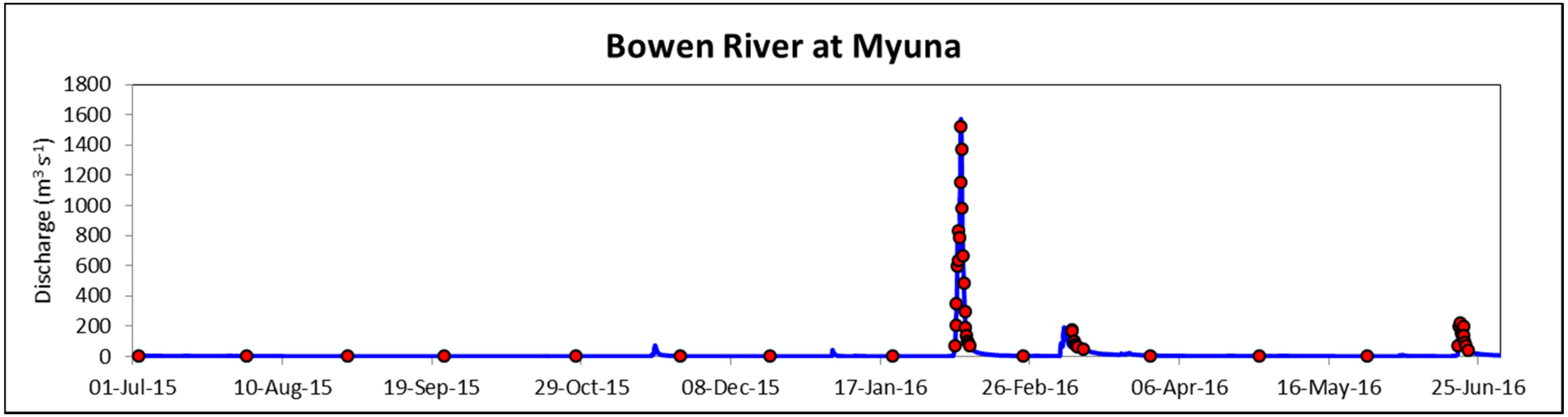

Figure 7.23 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Bowen River at Myuna between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes.

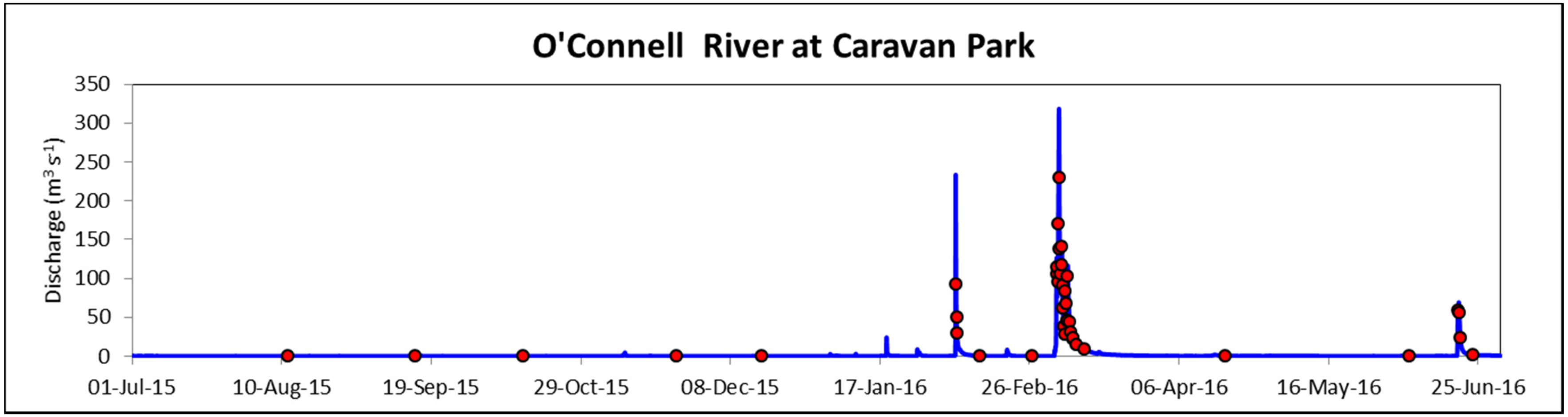

Figure 7.24 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the O'Connell River at Caravan Park between 1 July 2015 and 30 June 2016. Representivity rating was good for all analytes.

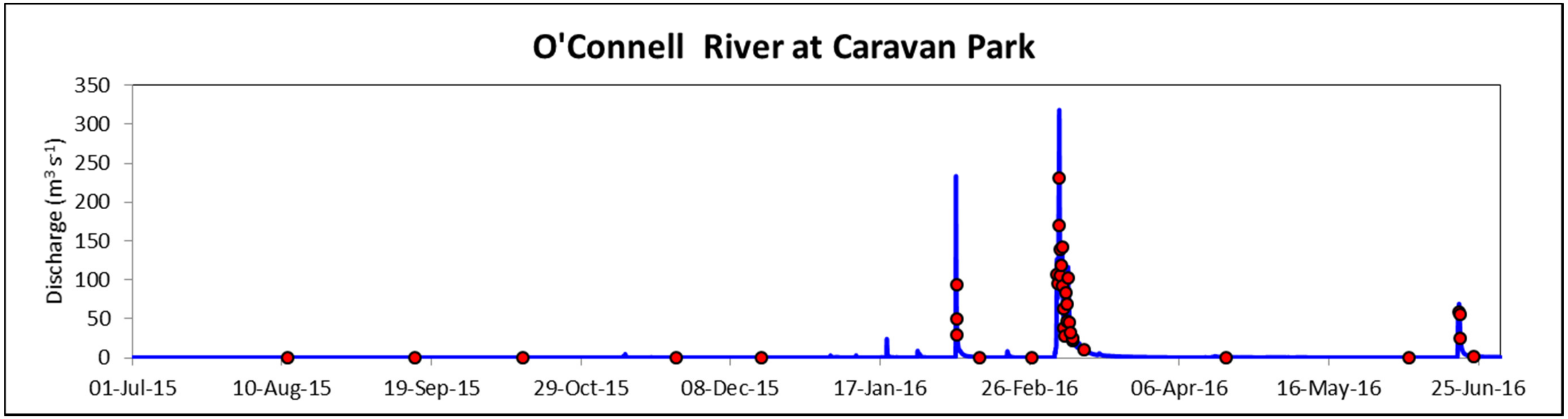

Figure 7.25 Hydrograph showing discharge (blue line) and sample coverage photosystem II inhibiting herbicides (red circles) in the O'Connell River at Caravan Park between 1 July 2015 and 30 June 2016. Sample representivity was not assessed for pesticides.

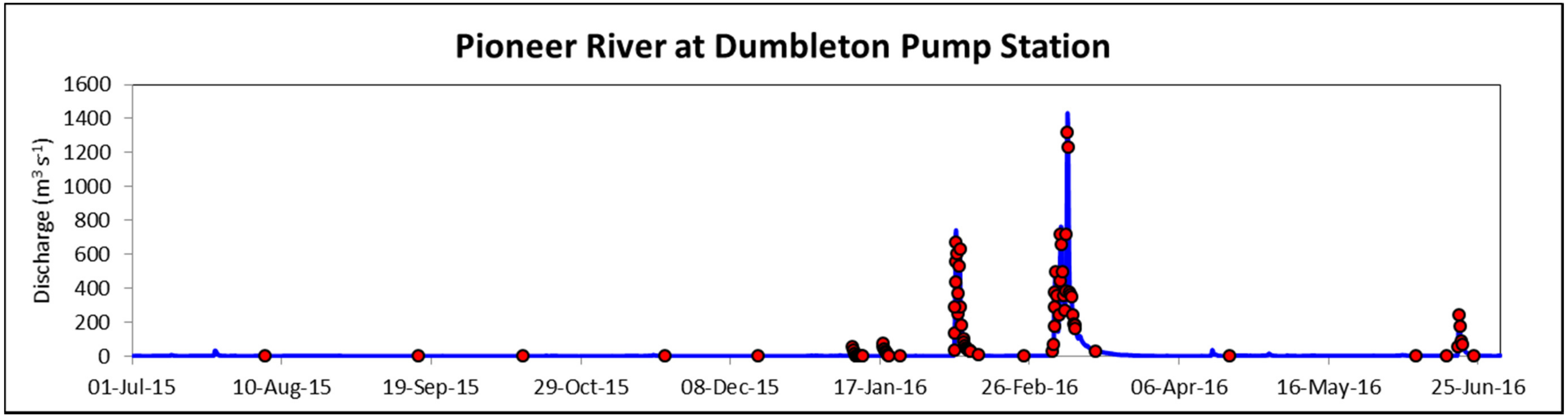

Figure 7.26 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids and total nutrients (red circles) in the Pioneer River at Dumbleton Pump Station between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes.

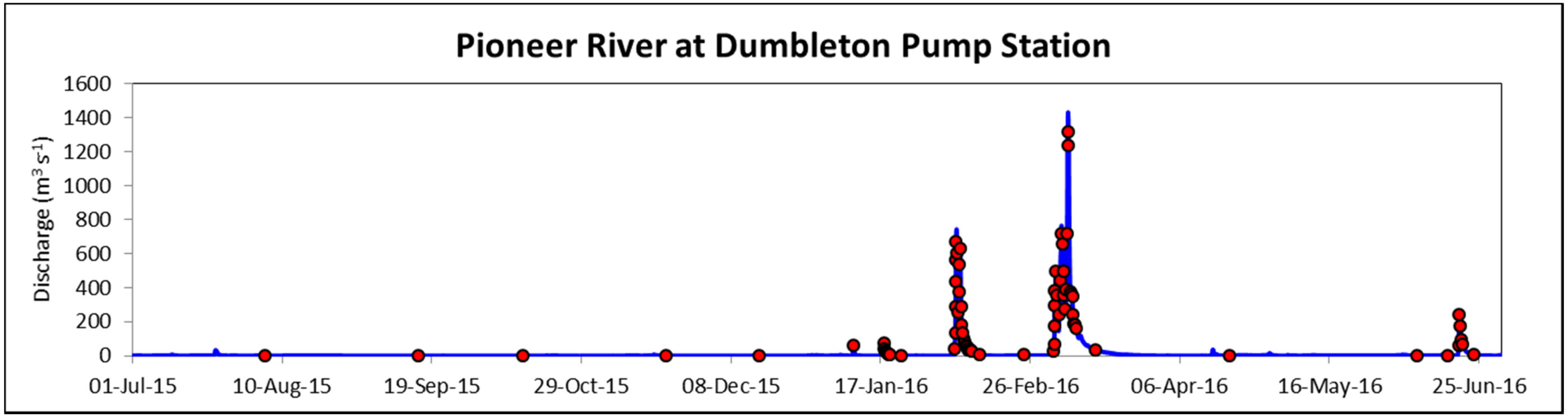

Figure 7.27 Hydrograph showing discharge (blue line) and sample coverage for dissolved and particulate nutrients (red circles) in the Pioneer River at Dumbleton Pump Station between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes.

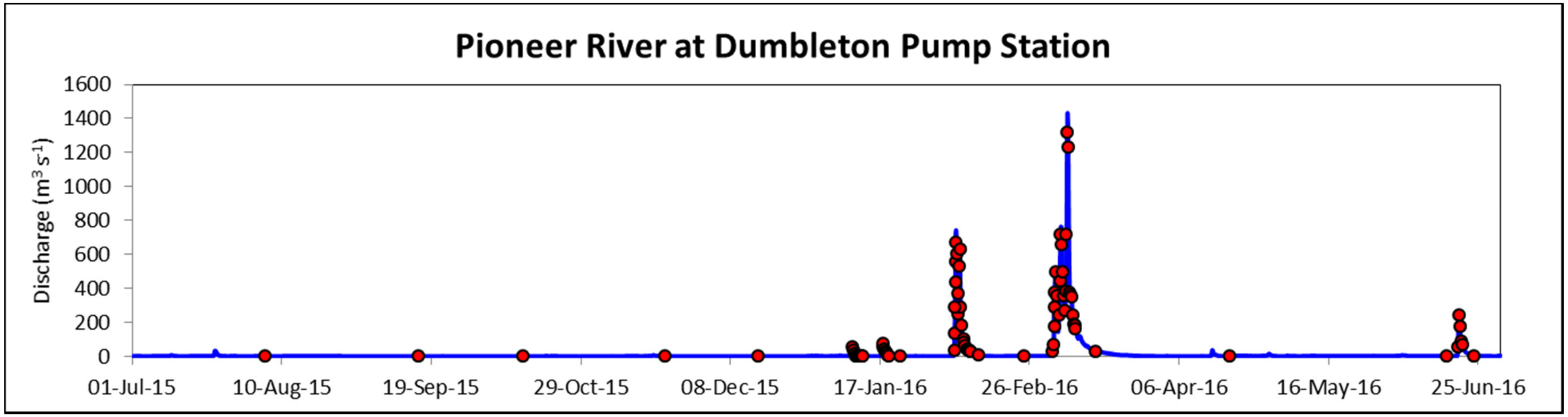

Figure 7.28 Hydrograph showing discharge (blue line) and sample coverage photosystem II inhibiting herbicides (red circles) in the Pioneer River at Dumbleton Pump Station between 1 July 2015 and 30 June 2016. Sample representivity was not assessed for pesticides.

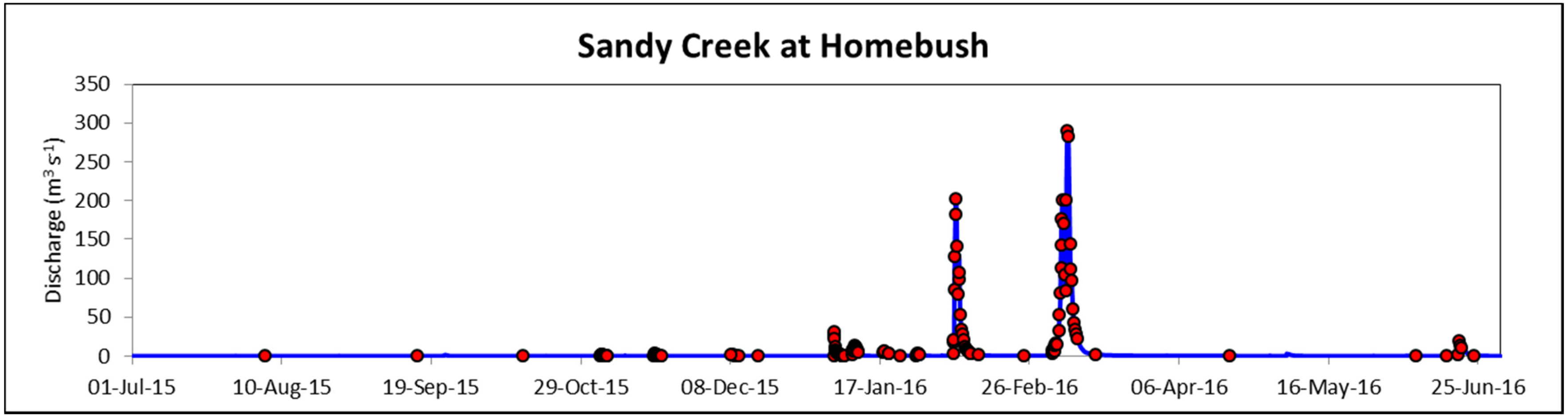

Figure 7.29 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients and photosystem II inhibiting herbicides (red circles) in Sandy Creek at Homebush between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes. Sample representivity was not assessed for pesticides.

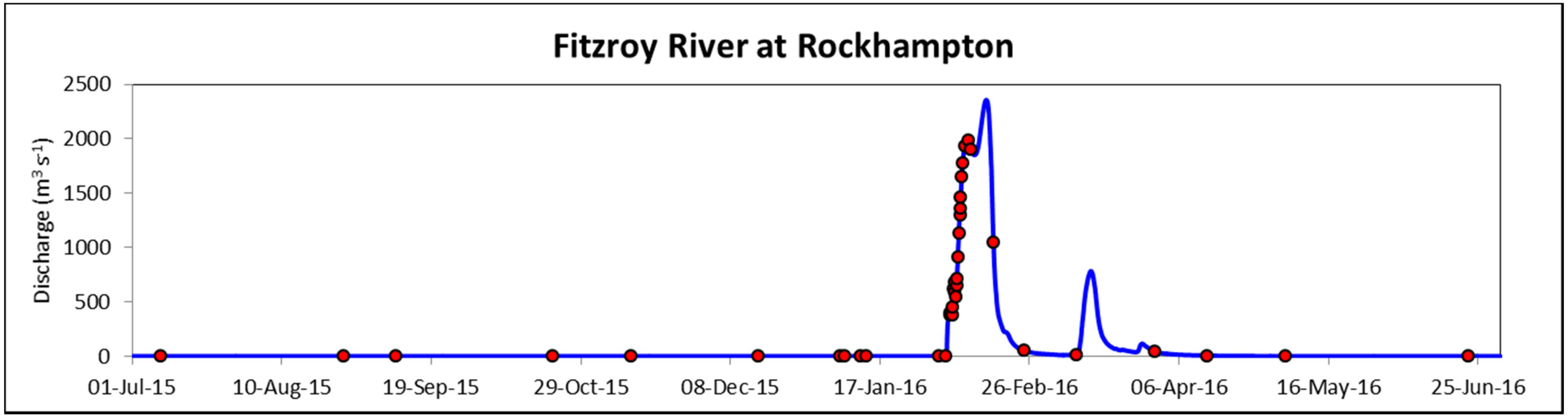

Figure 7.30 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids and total nutrients (red circles) in the Fitzroy River at Rockhampton between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes.

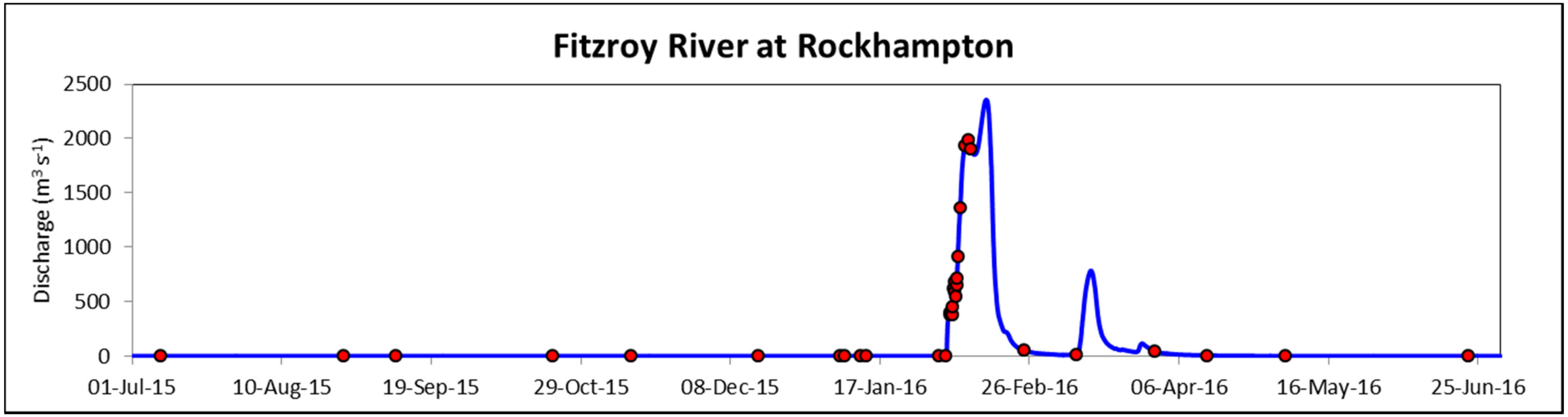

Figure 7.31 Hydrograph showing discharge (blue line) and sample coverage for dissolved and particulate nutrients (red circles) in the Fitzroy River at Rockhampton between 1 July 2015 and 30 June 2016. Representivity rating was good for all analytes.

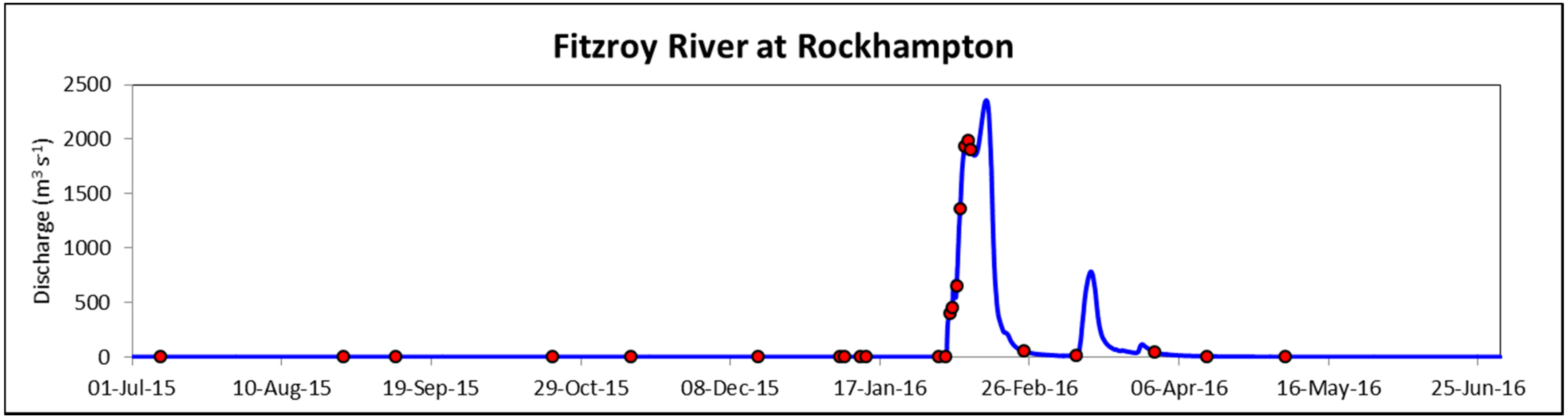

Figure 7.32 Hydrograph showing discharge (blue line) and sample coverage photosystem II inhibiting herbicides (red circles) in the Fitzroy River at Rockhampton between 1 July 2015 and 30 June 2016. Sample representivity was not assessed for pesticides.

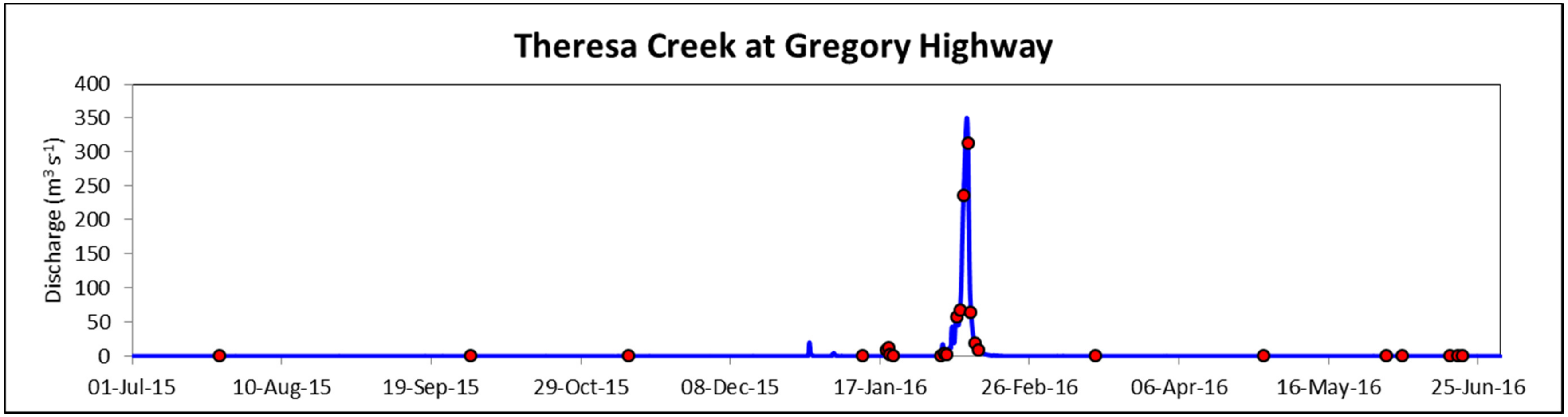

Figure 7.33 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in Theresa Creek at Gregory Highway between 1 July 2015 and 30 June 2016. Representivity rating was good for all analytes.

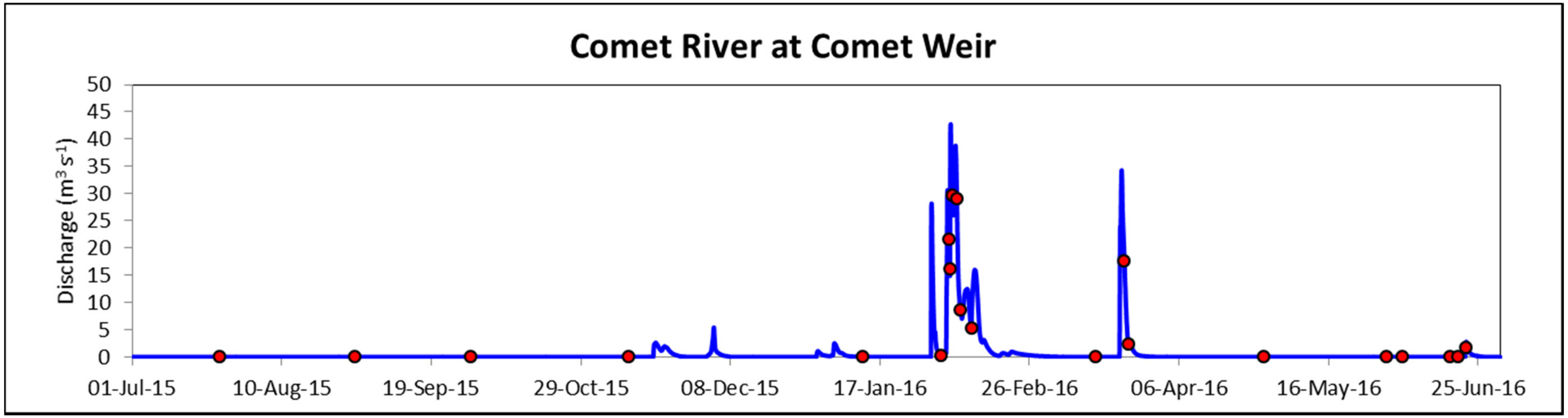

Figure 7.34 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients and photosystem II inhibiting herbicides (red circles) in the Comet River at Comet Weir between 1 July 2015 and 30 June 2016. Representivity rating was moderate for all analytes. Sample representivity was not assessed for pesticides.

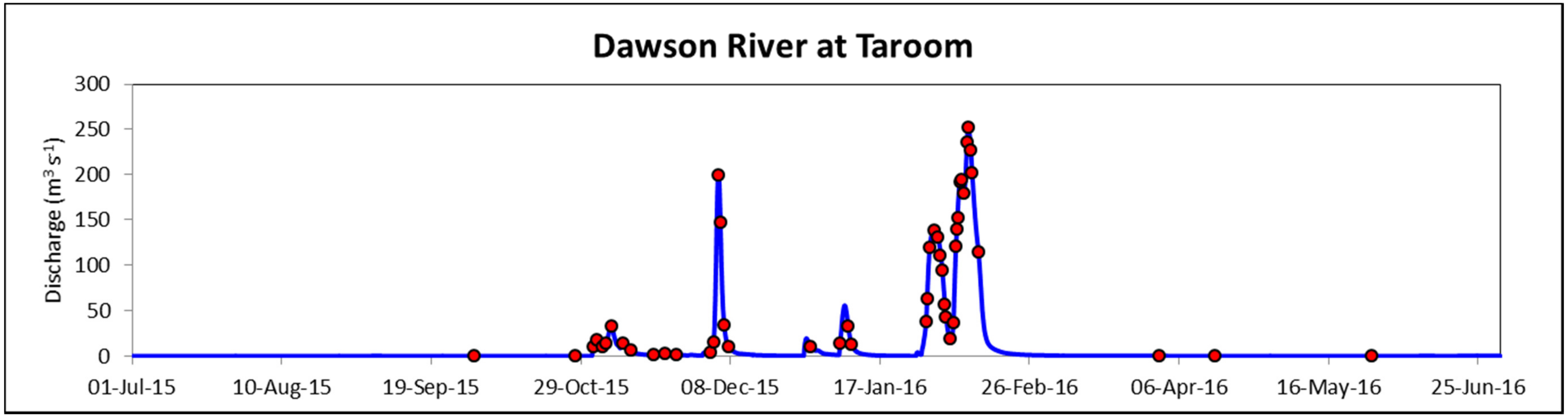

Figure 7.35 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids and total nutrients (red circles) in the Dawson River at Taroom between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes.

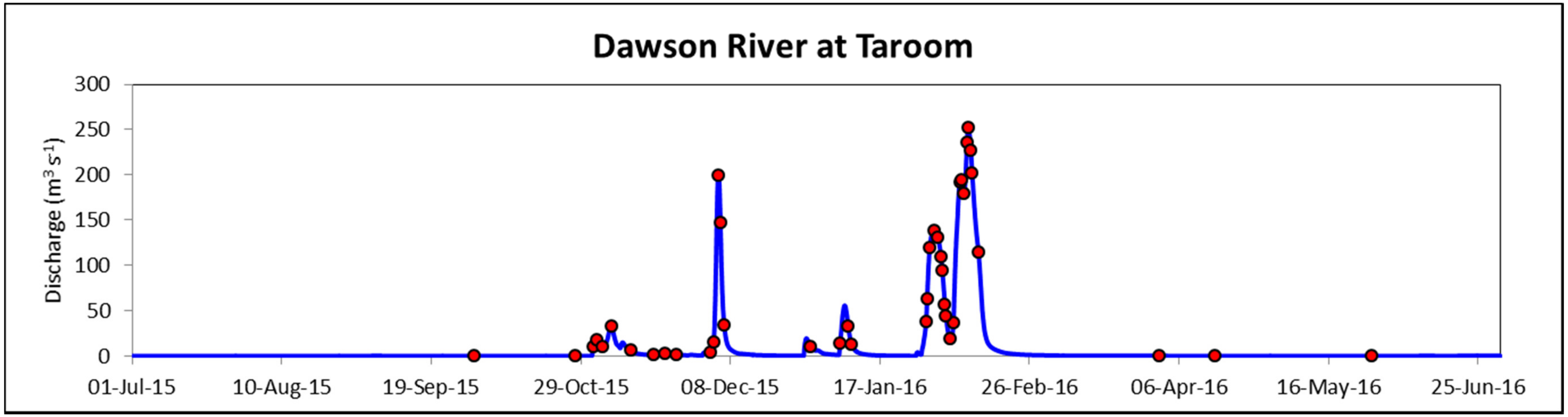

Figure 7.36 Hydrograph showing discharge (blue line) and sample coverage for dissolved and particulate nutrients (red circles) in the Dawson River at Taroom between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes.

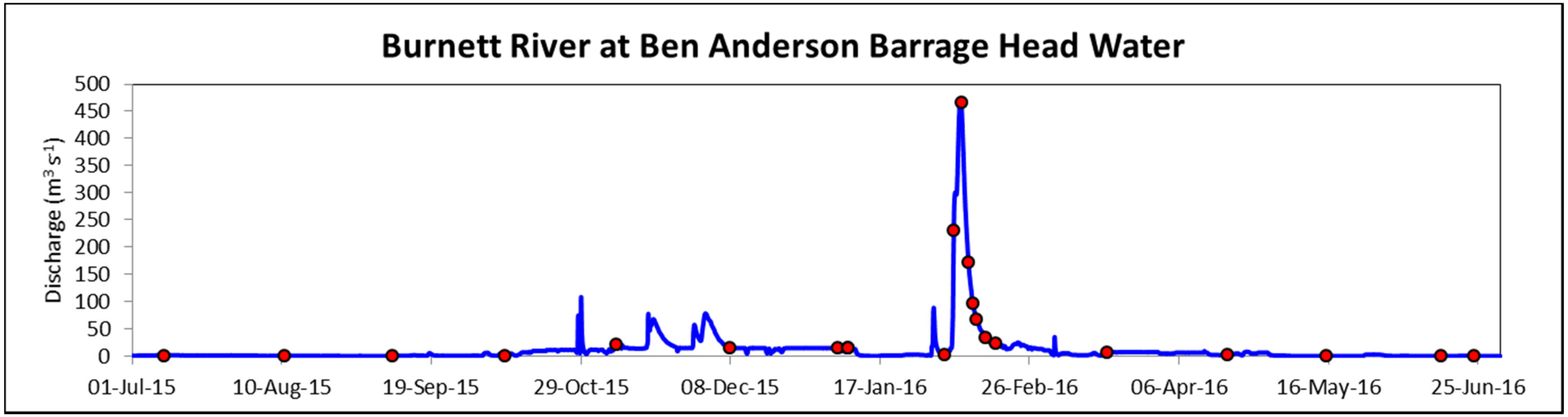

Figure 7.37 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids (red circles) in the Burnett River at Ben Anderson Barrage Head Water between 1 July 2015 and 30 June 2016. Representivity rating was good for all analytes.

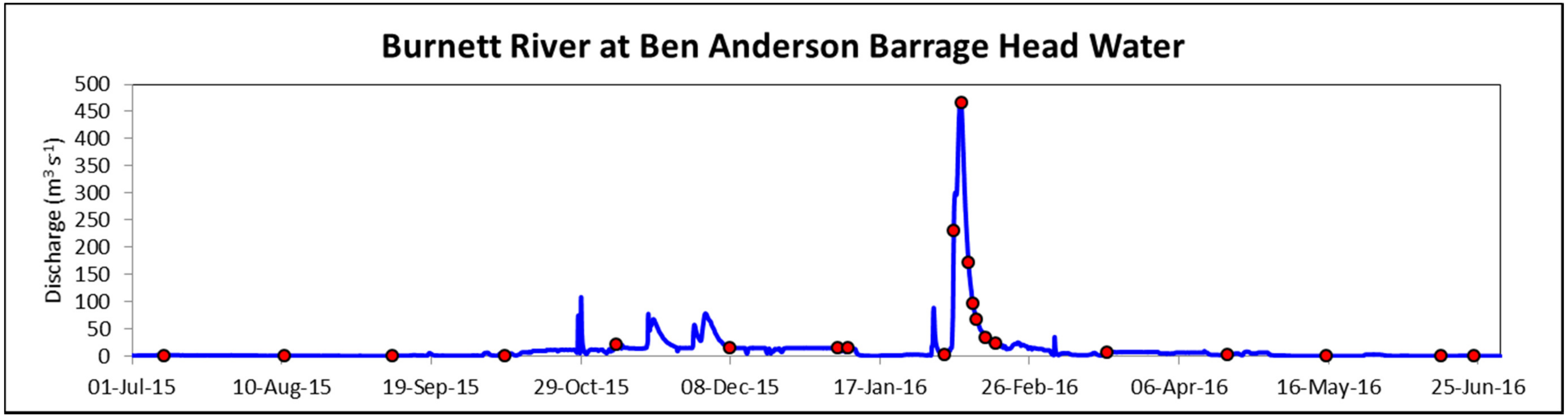

Figure 7.38 Hydrograph showing discharge (blue line) and sample coverage for total nutrients, dissolved and particulate nutrients, and photosystem II inhibiting herbicides (red circles) in the Burnett River at Ben Anderson Barrage Head Water between 1 July 2015 and 30 June 2016. Representivity rating was good for all analytes. Sample representivity was not assessed for pesticides.

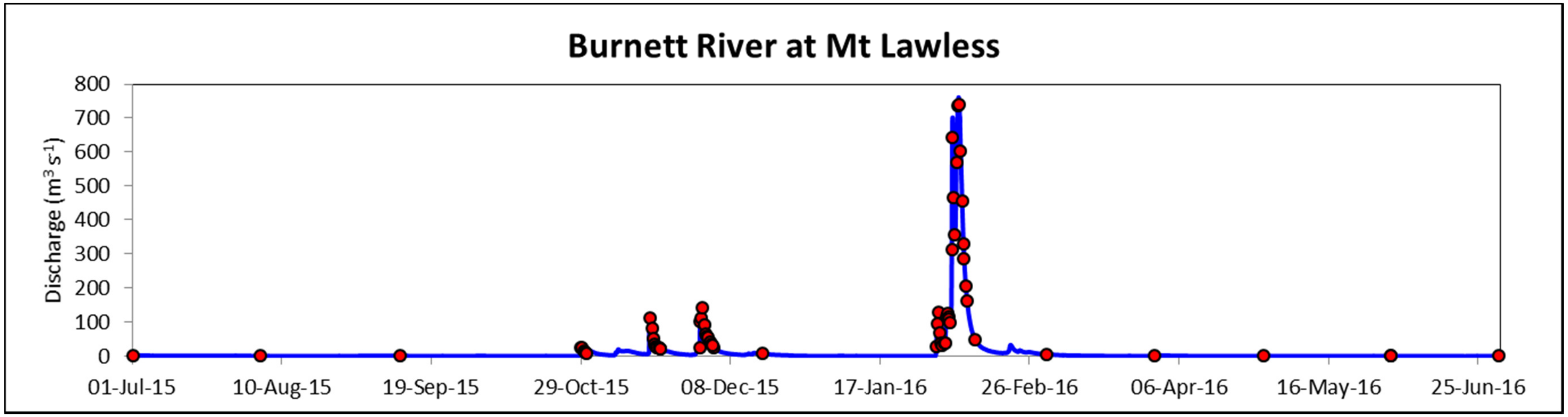

Figure 7.39 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients (red circles) in the Burnett River at Mt Lawless between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes.

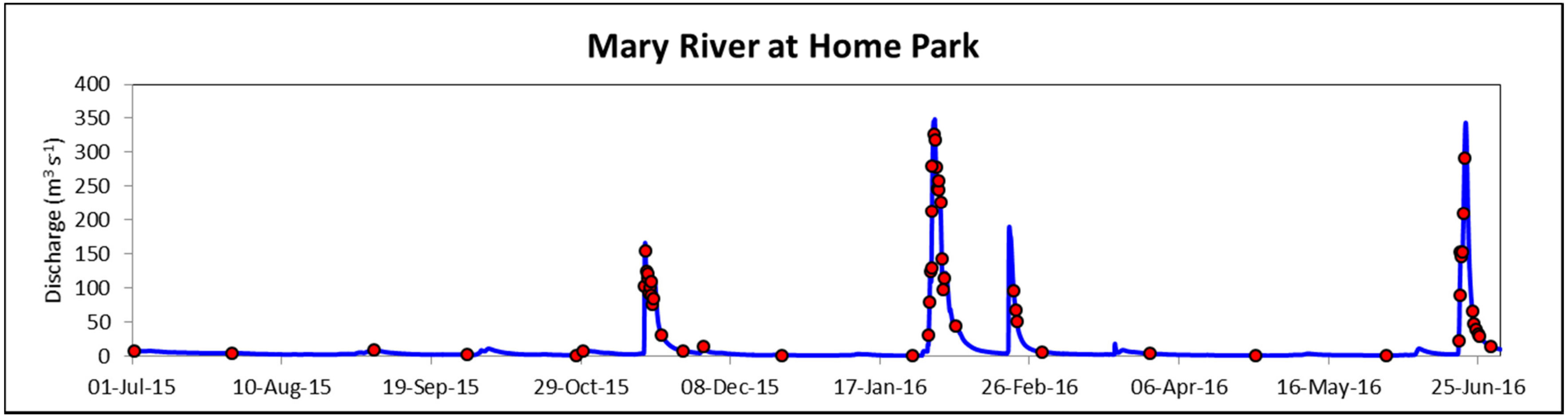

Figure 7.40 Hydrograph showing discharge (blue line) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients and photosystem II inhibiting herbicides (red circles) in the Mary River at Home Park between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes assessed. Sample representivity was not assessed for pesticides.

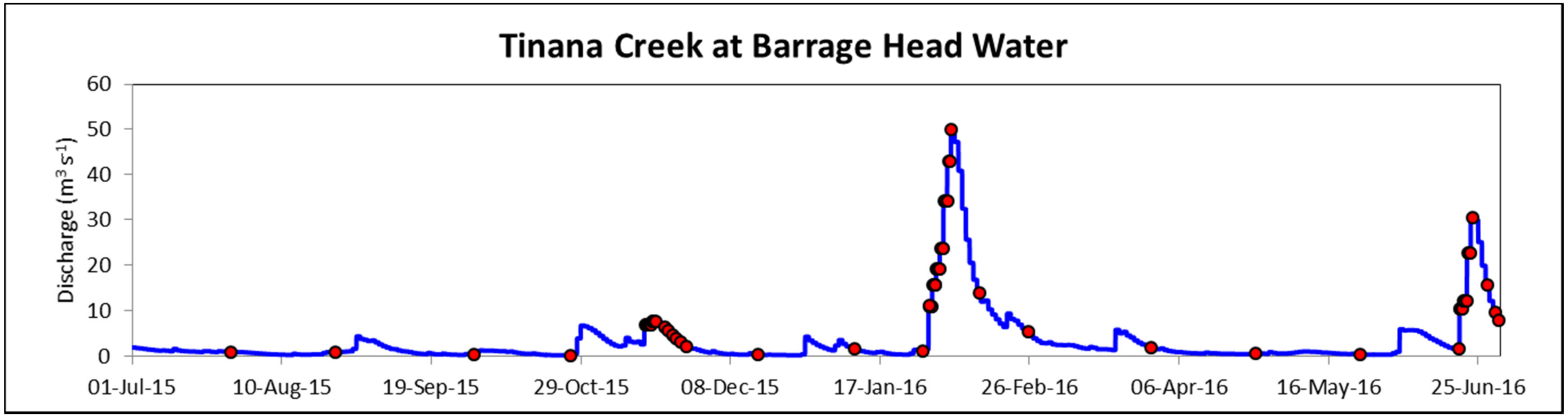

Figure 7.41 Hydrograph showing modelled discharge (blue line) (Section 2.6) and sample coverage for total suspended solids, total nutrients, dissolved and particulate nutrients and photosystem II inhibiting herbicides (red circles) in Tinana Creek at Barrage Head Water between 1 July 2015 and 30 June 2016. Representivity rating was excellent for all analytes assessed. Sample representivity was not assessed for pesticides.

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

Table 7.10 The number of samples collected and the representivity rating for monitored sites in 2015–2016. Text in bold relate to end-of-catchment sites and the corresponding data, all others relate to sub-catchment sites. Green shading = excellent or good representivity; orange shading = moderate representivity; red shading = indicative representivity.

NRM region	Basin	Catchment	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	**Normanby River**	**Normanby River at Kalpowar Crossing**	40	moderate	44	good	44	good	44	good	44	good	44	good
Wet Tropics	Barron	**Barron River**	**Barron River at Myola**	41	good	41	good	41	good	41	good	41	good	41	good
	Mulgrave-Russell	**Mulgrave River**	**Mulgrave River at Deeral**	102	excellent	102	excellent	101	excellent	102	excellent	102	excellent	102	excellent
		Russell River	**Russell River at East Russell**	144	excellent	146	excellent	146	excellent	146	excellent	146	excellent	146	excellent
	Johnstone	**Johnstone River**	**Johnstone River at Coquette Point%**	85	good	85	good	82	good	85	good	85	good	85	good
		North Johnstone	North Johnstone River at Old Bruce Highway	56	good	56	good	56	good	56	good	56	good	56	good
		South Johnstone	South Johnstone River at Upstream Central	55	excellent	55	excellent	53	good	55	excellent	55	excellent	55	excellent
	Tully	**Tully River**	**Tully River at Euramo**	147	excellent	146	excellent	143	excellent	147	excellent	147	excellent	147	excellent
		Tully River	Tully River at Tully Gorge National Park	42	excellent	42	excellent	42	excellent	42	excellent	42	excellent	42	excellent
	Herbert	**Herbert River**	**Herbert River at Ingham**	58	good	58	good	57	good	58	good	58	good	58	good
Burdekin	Haughton	**Haughton River**	**Haughton River at Powerline**	19	indicative	19	indicative	19	indicative	19	indicative	19	indicative	19	indicative
		Barratta Creek	**Barratta Creek at Northcote**	136	excellent	137	excellent	137	excellent	137	excellent	137	excellent	137	excellent
	Burdekin	**Burdekin River**	**Burdekin River at Home Hill**	32	good	32	good	32	good	32	good	32	good	32	good
		Burdekin River	Burdekin River at Sellheim	27	good	27	good	27	good	26	good	27	good	26	good
		Bowen River	Bowen River at Myuna	48	excellent	48	excellent	45	excellent	45	excellent	45	excellent	45	excellent
Mackay Whitsunday	O'Connell	**O'Connell River**	**O'Connell River at Caravan Park**	39	good	39	good	39	good	39	good	39	good	39	good
	Pioneer	**Pioneer River**	**Pioneer River at Dumbleton Pump Station**	84	excellent	85	excellent	73	excellent	74	excellent	74	excellent	74	excellent
	Plane	**Sandy Creek**	**Sandy Creek at Homebush**	137	excellent	142	excellent	140	excellent	141	excellent	141	excellent	141	excellent
Fitzroy	Fitzroy	**Fitzroy River**	**Fitzroy River at Rockhampton**	40	excellent	40	excellent	34	good	34	good	34	good	34	good
		Theresa Creek	Theresa Creek at Gregory Highway	25	good	25	good	25	good	25	good	25	good	25	good
		Dawson River	Dawson River at Taroom	47	excellent	48	excellent	41	excellent	47	excellent	47	excellent	47	excellent
		Comet River	Comet River at Comet Weir	21	moderate	21	moderate	21	moderate	21	moderate	21	moderate	21	moderate
Burnett Mary	Burnett	**Burnett River**	**Burnett River at Ben Anderson Barrage**	22	good	21	good	21	good	21	good	21	good	21	good
		Burnett River	Burnett River at Mt Lawless	63	excellent	63	excellent	63	excellent	63	excellent	63	excellent	63	excellent
	Mary	**Mary River**	**Mary River at Home Park**	59	excellent	59	excellent	56	excellent	59	excellent	59	excellent	59	excellent
		Tinana Creek	**Tinana Creek at Barrage Head Water%**	66	excellent	66	excellent	66	excellent	66	excellent	66	excellent	66	excellent

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)); and % Loads in the Johnstone River and Tinana Creek catchment were classified as indicative due to the use of modelled flow in the calculation of all loads; NA = not assessed. The methods used to calculate the representivity ratings are explained in detail in Section 2.7.1.

Table 7.11 The number of samples collected and the representivity rating for monitored sites in 2015–2016. Text in bold relate to end-of-catchment sites and the corresponding data, all others relate to sub-catchment sites. Green shading = excellent or good representivity; orange shading = moderate representivity; red shading = indicative representivity.

NRM region	Basin	Catchment	River and site name	DON		TP		DIP		PP		DOP	
				n	Rating	n	Rating	n	Rating	n	Rating	n	Rating
Cape York	Normanby	**Normanby River**	**Normanby River at Kalpowar Crossing**	44	good	44	good	44	good	44	good	44	good
Wet Tropics	Barron	**Barron River**	**Barron River at Myola**	41	good	41	good	41	good	41	good	41	good
	Mulgrave-Russell	**Mulgrave River**	**Mulgrave River at Deeral**	101	excellent	102	excellent	102	excellent	101	excellent	101	excellent
		Russell River	**Russell River at East Russell**	146	excellent	146	excellent	146	excellent	146	excellent	146	excellent
	Johnstone	**Johnstone River**	**Johnstone River at Coquette Point[%]**	82	good	85	good	85	good	82	good	82	good
		North Johnstone River	North Johnstone River at Old Bruce Highway Bridge (Goondi)	56	good	56	good	56	good	56	good	56	good
		South Johnstone River	South Johnstone River at Upstream Central Mill	53	good	55	excellent	55	excellent	53	good	53	good
	Tully	**Tully River**	**Tully River at Euramo**	143	excellent	146	excellent	147	excellent	143	excellent	143	excellent
		Tully River	Tully River at Tully Gorge National Park	42	excellent	42	excellent	42	excellent	42	excellent	42	excellent
	Herbert	**Herbert River**	**Herbert River at Ingham**	57	good	58	good	58	good	57	good	57	good
Burdekin	Haughton	**Haughton River**	**Haughton River at Powerline**	19	indicative	19	indicative	19	indicative	19	indicative	19	indicative
		Barratta Creek	**Barratta Creek at Northcote**	137	excellent	137	excellent	137	excellent	137	excellent	137	excellent
	Burdekin	**Burdekin River**	**Burdekin River at Home Hill**	32	good	32	good	32	good	32	good	32	good
		Burdekin River	Burdekin River at Sellheim	27	good	27	good	27	good	27	good	27	good
		Bowen River	Bowen River at Myuna	45	excellent	48	excellent	45	excellent	45	excellent	45	excellent
Mackay Whitsunday	O'Connell	**O'Connell River**	**O'Connell River at Caravan Park**	39	good	39	good	39	good	39	good	39	good
	Pioneer	**Pioneer River**	**Pioneer River at Dumbleton Pump Station**	74	excellent	85	excellent	74	excellent	74	excellent	74	excellent
	Plane	**Sandy Creek**	**Sandy Creek at Homebush**	140	excellent	142	excellent	141	excellent	140	excellent	140	excellent
Fitzroy	Fitzroy	**Fitzroy River**	**Fitzroy River at Rockhampton**	34	good	40	excellent	34	good	34	good	34	good
		Theresa Creek	Theresa Creek at Gregory Highway	25	good	25	good	25	good	25	good	25	good
		Dawson River	Dawson River at Taroom	41	excellent	48	excellent	47	excellent	41	excellent	41	excellent
		Comet River	Comet River at Comet Weir	21	moderate	21	moderate	21	moderate	21	moderate	21	moderate
Burnett Mary	Burnett	**Burnett River**	**Burnett River at Ben Anderson Barrage Head Water**	21	good	21	good	21	good	21	good	21	good
		Burnett River	Burnett River at Mt Lawless	63	excellent	63	excellent	63	excellent	63	excellent	63	excellent
	Mary	**Mary River**	**Mary River at Home Park**	57	excellent	59	excellent	59	excellent	57	excellent	57	excellent
		Tinana Creek	**Tinana Creek at Barrage Head Water[%]**	66	excellent	66	excellent	66	excellent	66	excellent	66	excellent

n = the number of concentration data points used for the load calculation of DON = dissolved organic nitrogen; TP = total phosphorus; DIP = dissolved inorganic phosphorus; PP = particulate phosphorus; DOP = dissolved organic phosphorus; and % Loads in the Johnstone River and Tinana Creek catchment were classified as indicative due to the use of modelled flow in the calculation of all loads; NA= not assessed. The methods used to calculate the representivity ratings are explained in detail in Section 2.7.1

Appendix H Monthly rainfall summary during 2015–2016

Rainfall in July 2015 was above average for the Cape York region and below average across the rest of Queensland. A broad low pressure trough across northern Australia produced daily totals exceeding 50 mm in large areas of central Queensland extending to the north east coast over the 15th and 16th, with record high July totals for Mackay. Further isolated, heavy rainfall was recorded, with falls in excess of 250 mm on the 17th, resulting in the wettest July day on record for Rockhampton (BoM 2015a).

August rainfall was above to very much above average across most of Queensland. A strong cold front and associated low pressure troughs extended to the north eastern coast with moderate falls on the 25th (BoM 2015b).

September rainfall was below average for much of Queensland, although some parts of the inland Cape York region received above average rainfall. Moist onshore airflow produced the only rainfall on the north tropical coast (Wet Tropics region) on the 25th (BoM 2015c).

Total rainfall was average in north eastern Queensland during the month of October. A high pressure system to the east of Australia and associated air flow produced showers in the Cairns region on the 20th (BoM 2015d).

November rainfalls were average for most areas in north east Queensland with only the Mackay Whitsunday region experiencing above average rainfall. A broad low pressure trough and low centres resulted in extended showers along the east coast of Queensland from the 5th till the 10th. Areas of cloud and rain associated with a broad surface trough resulted in extended widespread rainfall from the 11th. Onshore flow brought moderate falls in parts of the north east coast between the 18th and 25th (BoM 2015d).

The Cape York region experienced above average rainfall for the month of December with other regions ranging from very much below average to below average for the Mackay Whitsunday, Burdekin, Fitzroy and Burnett Mary regions. Moderate rainfalls were recorded at the beginning of the month across the Cape York and Wet Tropics regions. A monsoon trough located across the tropical north of the country brought with it low pressure systems that resulted in moderate to heavy rainfall with the highest falls recorded in northern Queensland on the 29th (BoM 2015e).

The Great Barrier Reef catchments experienced average to below average rainfall during the month of January. A weakening tropical low, broad trough and cloud tracked across eastern Australia at the beginning of January with areas south of Townsville recording moderate falls on the 4th. Another trough triggered isolated thunderstorms over parts of the Cape York region between the 8th and the 12th. Rainfall was heavy over much of eastern mainland Australia, with weekly totals from the 25th ranging from 25 to 100 mm. A deep trough and an accompanying severe thunderstorm produced heavy rainfall over the Burnett Mary region on the 29th (BoM 2016f).

Parts of the Burdekin and Fitzroy regions received above average rainfall during February with the rest of the regions experiencing average to below average rainfall. An active monsoon trough north of the mainland produced widespread thunderstorms and heavy rainfall across much of the Queensland at the start of the February, with over 100 mm rain in an hour recorded in part of the Townsville area, heavy falls in the southern parts of the Wet Tropics region, Lower Burdekin and Burnett Mary regions. A surface trough produced moderate falls in the Burnett Mary region on the 19th. An upper-level trough over the Wet Tropics on the 24th, and a surface trough over the Coral Sea produced moderate to heavy falls between Cooktown and Innisfail. A low pressure system produced thunderstorms and showers across the Wet Tropics from the 25th until the end of the month (BoM 2016g).

Parts of the Cape York, Wet Tropics, Mackay Whitsunday, Burdekin and lower Fitzroy received above average to very much above average rainfall during the month of March. The remnant of tropical cyclone Winston brought significant rainfall to the Queensland's north at the start of March, resulting in moderate flood levels at Yatton on the Isaac River in the Fitzroy region. Thunderstorms also produced heavy rainfall in the Burnett Mary region in early March (BoM 2016h).

Rainfall for the month of April was very much below average to below average over the Mackay Whitsunday, Burdekin, Fitzroy and Burnett Mary regions. Other areas received average rainfall. Moist onshore air enhanced by a lingering surface trough over Queensland produced showers and moderate falls along the Wet Tropics and from the 7th to the 17th. The wettest day was at Tully with more than 100mm recorded on the 16th (BoM 2016i).

The Cape York and northern Wet Tropics received above average rainfall in May with the rest of the regions experiencing below average to very much below average totals. Between the 21st and 23rd, an upper-level trough brought heavy rainfall to parts of the Wet Tropics and the Cape York region. River levels began to rise in the Wet Tropics (Tully, Daintree and Mulgrave–Russell catchments) as a result of heavy rainfall which reached moderate flood levels (BoM 2016j).

All regions experienced above average to very much above average rainfall during June 2016. An upper level trough and associated surface trough caused heavy rainfall from the 4th to the 7th. A strong upper level trough and a deep surface trough produced widespread moderate to heavy falls over most of Queensland on the 19th (BoM 2016k).

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