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Mackay Whitsunday Healthy Waterways

Baseline Monitoring Program Regional Report 2008

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Mackay Whitsunday Healthy Waterways

Baseline Monitoring Program Regional Report 2008

The baseline monitoring component of the Integrated Monitoring Program

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EXECUTIVE SUMMARY

The Mackay Whitsunday region is located within the Central Queensland coast and occupies an area of approximately 9000 km^2, extending from Bowen in the north to Clairview in the south. The region is approximately 300 km in length, 80 km in width at its widest point (Eungella National Park – Pioneer catchment) and incorporates the major rivers of the Pioneer, O’Connell / Andromache and Proserpine.

The Mackay Whitsunday Natural Resource Management Group (MWNRM) has formulated a Natural Resource Management Plan to preserve the health and integrity of the regions natural and cultural assets by developing actions and partnerships to manage them effectively (MWNRM, 2005). The lack of localised water quality data for the Mackay Whitsunday region was the main driver behind the implementation of the Baseline Monitoring Program as part of *Integrated Monitoring Program*. This assessment informs the Water Quality Improvement Plan (WQIP) by aiding in the establishment of goals, objectives and targets for ambient physico-chemical parameters, sediment, nutrients and herbicides to provide a current condition status of aquatic ecosystem health. The WQIP is the main driver behind the implementation of the Reef Water Quality Protection Plan (RWQPP) in the region.

It has been established that the quality of water and in-stream aquatic environment is influenced greatly by surrounding land-use practices. The main land uses characterizing the region are intensive cropping (primarily sugar cane farming), bushland (national park reference sites), cattle grazing and various mixtures of these.

Fish kills induced by low dissolved oxygen, mangrove dieback and algal blooms have been identified in previous studies throughout the Mackay Whitsunday region. They are examples of significant events that have been correlated with general water quality issues. This decline in overall water quality is partly due to the increased sediment, nutrient and herbicide concentrations which may have been exacerbated by surrounding land use practices.

Project officers involved in the Healthy Waterways Baseline Monitoring Program have been effectively monitoring water quality in the Mackay Whitsunday region since July, 2006. These project officers are housed within Whitsunday Catchment Landcare Inc, Pioneer Catchment Landcare Group Inc and Sarina Landcare Catchment Management Association Inc. These Landcare groups are located in the 3 dominant catchments making up the Mackay Whitsunday region. The project officers are well trained in all aspects of Workplace Health and Safety as well as quality assurance (QA) and quality control (QC) standards and procedures.

Monthly baseline sampling was undertaken at 13 sites associated with the primary land use classifications within the region. *In-situ* water quality parameters (dissolved oxygen, pH, water temperature and electrical conductivity), total suspended solids (TSS), total and filtered nutrients and herbicides were sampled at each of the 13 sites. These sites were selected on a variety of factors based on stream order or “ecological value”, dominant surrounding land uses and their proximity to stream flow gauging stations.

Minimum, maximum and 20th, 50th and 80th percentile values of all *in-situ* water quality parameters, TSS, nutrients and herbicides were analysed and reported.

The major findings for the first 12 months (July 2006 – June 2007) of baseline sampling include:

- Relatively uniform ranges in water temperatures across the majority of sites and land uses. This indicates that this parameter is largely governed by the physical structure of the creek (stream depth, stream width and riparian shading etc.) as well as seasonal variation rather than the surrounding land use practice.

- Great variability between individual sites and land uses with regard to dissolved oxygen. Intensively cropped sites (Sandy Creek, Myrtle Creek and Bakers Creek) exhibited very low dissolved oxygen levels with none of the sites reaching the minimum central Queensland water quality guideline value of 80% saturation on any occasion. Intensively cropped sites collectively displayed a median DO value of 34.2% saturation.

- pH levels from all land-use categories were well within the central Queensland water quality range (6.5 – 8.0) on 50% of occasions, with the larger majority falling within guideline range on 80% of occasions. The Andromache River was the only site whose median pH value was higher than the guideline range. This may be attributed to extensive macrophyte growth at this site as well as high calcium in the groundwater due to intermediate soils present in the upper Andromache River.

- Great variability with regards to electrical conductivity was evident between individual sites and land uses. Bushland sites displayed the lowest median value with the Impulse Creek site being the highest due to groundwater influences. Intensively cropped sites portrayed the highest median electrical conductivity values.

- TSS was consistently low, with a collective median level of 4.8 mg/L from intensively cropped catchments. Maximum TSS concentrations which were higher than the guideline value can be correlated to periods of high rainfall or excessively drier times. The low TSS levels reinforce the fact that high clarity is prevalent in waters throughout the Mackay Whitsunday region.

- Nutrient concentrations were higher at intensively cropped sites, particularly after substantial rainfall events. Intensively cropped sites, primarily Sandy Creek and Bakers Creek, exhibited the highest median and maximum concentrations for the majority of Nitrogen and Phosphorus species (eg. DIN and FRP).

- Herbicide concentrations were highest in intensively cropped sites, often after substantial rainfall. Ametryn, atrazine, hexazinone and diuron were the most commonly detected herbicides in the Mackay Whitsunday region. Bakers Creek portrayed some extremely high atrazine and diuron detections after rainfall (both 14 µg/L).

1 INTRODUCTION

Over the past 100 years, the Mackay Whitsunday region has seen dramatic catchment changes in the form of massive agricultural development and increasing urban pressures affecting the regions waterways. Water quality issues, including improved land management and reduced sediment, nutrient and herbicide runoff have been paramount and at the forefront of natural resource management issues relating to waterways in the Mackay Whitsunday region. Extensive water quality monitoring is of fundamental importance to the health of the aquatic environment. One monitoring program set up to assess the current condition and aid in the setting of goals, objectives and targets for each major catchment is the "Baseline Monitoring Program".

The Mackay Whitsunday Baseline Monitoring Program is funded by the Natural Heritage Trust and Coastal Catchments Initiative and is a component of the Mackay Whitsunday Natural Resource Management Groups (MWNRM) *Healthy Waterways Integrated Monitoring Program*. The initiative seeks to monitor water quality from a multitude of freshwater rivers, streams and creeks within the region through a cooperative program between federal, state and local governments. The MWNRM Group is one of fifteen Natural Resource Management groups in Queensland and is one organisation delivering on components of the Reef Water Quality Protection Plan (Galea *et al.* 2008a).

A Natural Resource Management Plan has been produced by the MWNRM Group which aims to protect and restore natural and cultural assets. It outlines goals for the protection and management of waterways in the region. Through a bi-lateral agreement with the Natural Heritage Trust, the following objectives have been established:

- Biodiversity Conservation – "*The conservation of Australia's biodiversity by the protection and restoration of terrestrial, freshwater, estuarine and marine ecosystems and habitat for native plants and animals*" (MWNRM 2005)

- Sustainable use of Natural Resources – "*The sustainable use and management of Australia's land, water and marine resources to maintain and improve the productability and profitability of resource based industries*" (MWNRM 2005)

These objectives reinforced the need for the *Mackay Whitsunday Healthy Waterways Integrated Monitoring Program* as a long-term integrated monitoring regime aimed at improving these resources.

Baseline water quality sampling is undertaken on a monthly basis. It is apparent that rivers throughout the central Queensland region will differ in topography, climate and lithology, therefore water quality guidelines should not be applied as a universal template across this expansive area. This baseline monitoring program will aid in the development of a localised set of guidelines which are more spatially relevant than the Queensland Water Quality Guidelines (QWQG) and ANZECC 2000 guidelines used in this report (EPA 2006).

Objectives of the Baseline Monitoring Program are to:

(i) Create linkages with various key stakeholders and increase community awareness of water quality and aquatic ecosystem issues within the Mackay Whitsunday region.

(ii) Monitor ambient physico-chemical parameters, sediment as well nutrient and herbicide levels influenced by surrounding land-use practices.

(iii) Inform the WQIP by aiding in the establishment of current condition, objectives and targets for ambient physico-chemical parameters, sediment, nutrients and herbicide concentrations to provide a current condition status of aquatic ecosystem health.

(iv) Aid in the establishment of a localised set of water quality guidelines pertaining to the Mackay Whitsunday region, therefore being more relevant than existing national or state guidelines.

The implementation and on-ground actions necessary to successfully implement this program is undertaken by three catchment project officers housed within the dominating catchments (Whitsunday, Pioneer and Plane) making up the region. They provide support to a full time project officer situated within the Department of Natural Resources and Water (Figure 1).

This report outlines the results and main findings of the baseline water quality monitoring component of the *Mackay Whitsunday Healthy Waterways Integrated Monitoring Program.* Other components, reported separately, include the ambient community volunteer network (Galea *et al.* 2008a), event-based water quality monitoring (Rohde *et al.* 2008) and plot-scale monitoring of cane management practices (Masters *et al.* 2008). These reports are supporting documents for the Mackay Whitsunday region's Water Quality Improvement Plan (Drewry *et al.* 2008).

Figure 1 Mackay Whitsunday Healthy Waterways Integrated Monitoring Program organisational flow chart

2 REGIONAL DESCRIPTION

The Mackay Whitsunday region occupies the coastal strip from Bowen in the north to just south of Clairview in the south. This expanse of coastline is approximately 300 kilometres in length and has a maximum width of 80 kilometres. It encompasses the well renowned tourist areas of Finch Hatton Gorge and Eungella National Park. The region covers an extensive area of 9000 km^2 and contains the Whitsunday, Pioneer and Plane catchments (Figure 2 - left) (Rohde *et al.* 2006).

The river systems within the region rise in the Connors and Clarke ranges to the west, cross the coastal plain and eventually discharge into the Coral Sea. The Pioneer, O'Connell /Andromache and Proserpine are the major rivers in the region (Oldmeadow 2004). Extensive wetlands, riparian areas, national parks, waterfalls and dynamic mangrove and seagrass areas are natural assets which are well represented within the region.

The Whitsunday (Proserpine and O'Connell basins), Pioneer and Plane catchments are 3 of the top 10 high risk catchments illustrated in the Reef Water Quality Protection Plan (RWQPP, 2003). The Reef Plan aims to address the decline of water quality entering the Great Barrier Reef World Heritage Area by addressing diffuse pollution from broad scale land use, particularly nutrients and sediments (The State of Queensland and Commonwealth of Australia 2003).

The Mackay Whitsunday region is one of the most intensively developed agricultural areas in Queensland. The region is the centre of extensive agricultural development (primarily sugar cane farming), with numerous small townships and communities associated with sugar production based out of Mackay and Proserpine. Widespread cattle grazing contributes to the region, occupying the fringes of the sugar cane farming areas (Figure 2 - right). Cooler temperatures and higher than average rainfall have ensured that rainforests and Notophyll vine forests have colonised the Clarke, Conway and Connors ranges.

Temperatures within the region bare resemblance of a subtropical coastal zone with long durations of warm temperatures before, during and after the wet season and short periods of cool weather during June, July and August. Temperatures range from a mean overnight low of 23ºC to a mean maximum of 30ºC in January, to a mean overnight low of 13ºC to a mean maximum of 21ºC in July.

The region has reasonably high, but extremely variable rainfall, with elevated range areas receiving around 3000mm per year, to less than 1000mm per year in inland areas. The coastal township of Mackay receives 1600mm per year on average (Brodie 2002).

Streamflow within the region is variable, depending on climatic conditions. As a general trend, flows peak during the wet season (December – April) and then reside to low or no flow during the dry season (May – November). Within the region, the Pioneer and O'Connell Rivers display the highest mean annual discharges (900,000 ML and 200,000 ML, respectively) (Arthington *et al.* 2001).

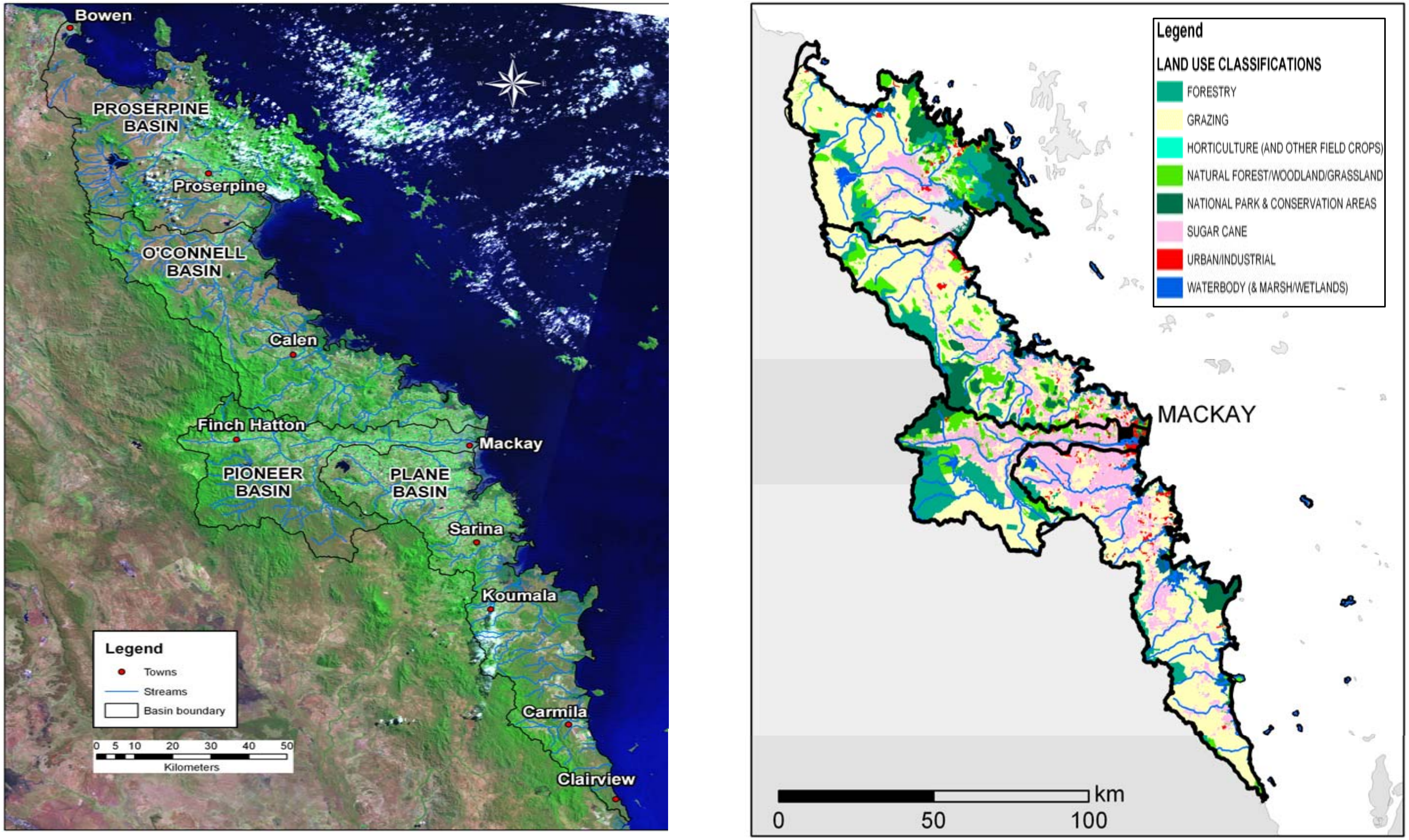

Figure 2 Mackay Whitsunday region showing the major catchments (left) and land uses (right)

2.1 Whitsunday Catchment

The Proserpine (Australian Water Resource Council basin number “122”) and O’Connell / Andromache Rivers (AWRC Basin number 124) are the major rivers in the Whitsunday catchment (Figure 3). These rivers, along with a number of lower order streams, discharge directly into Repulse Bay. The Andromache River is the main tributary of the O’Connell River and their confluence is the tidal limit. Myrtle Creek, Impulse Creek, and the Gregory River are smaller streams which are also located within this catchment.

The Proserpine River flows north and then east from Mount Quandong to Lake Proserpine and discharges into the Coral Sea, 4 kilometres east of Proserpine. It is regulated by Peter Faust Dam which is situated 28 kilometres upstream from the river mouth, has a storage capacity of 491,400 ML and occupies an area of 4350 ha. Peter Faust Dam provides the town drinking water supply as well as irrigation for the township of Proserpine and surrounds (Brodie 2004).

Sugarcane farming and cattle grazing represent the major land uses in the Whitsunday catchment. The townships of Proserpine, Cannonvale and Airlie Beach are the main urban centres.

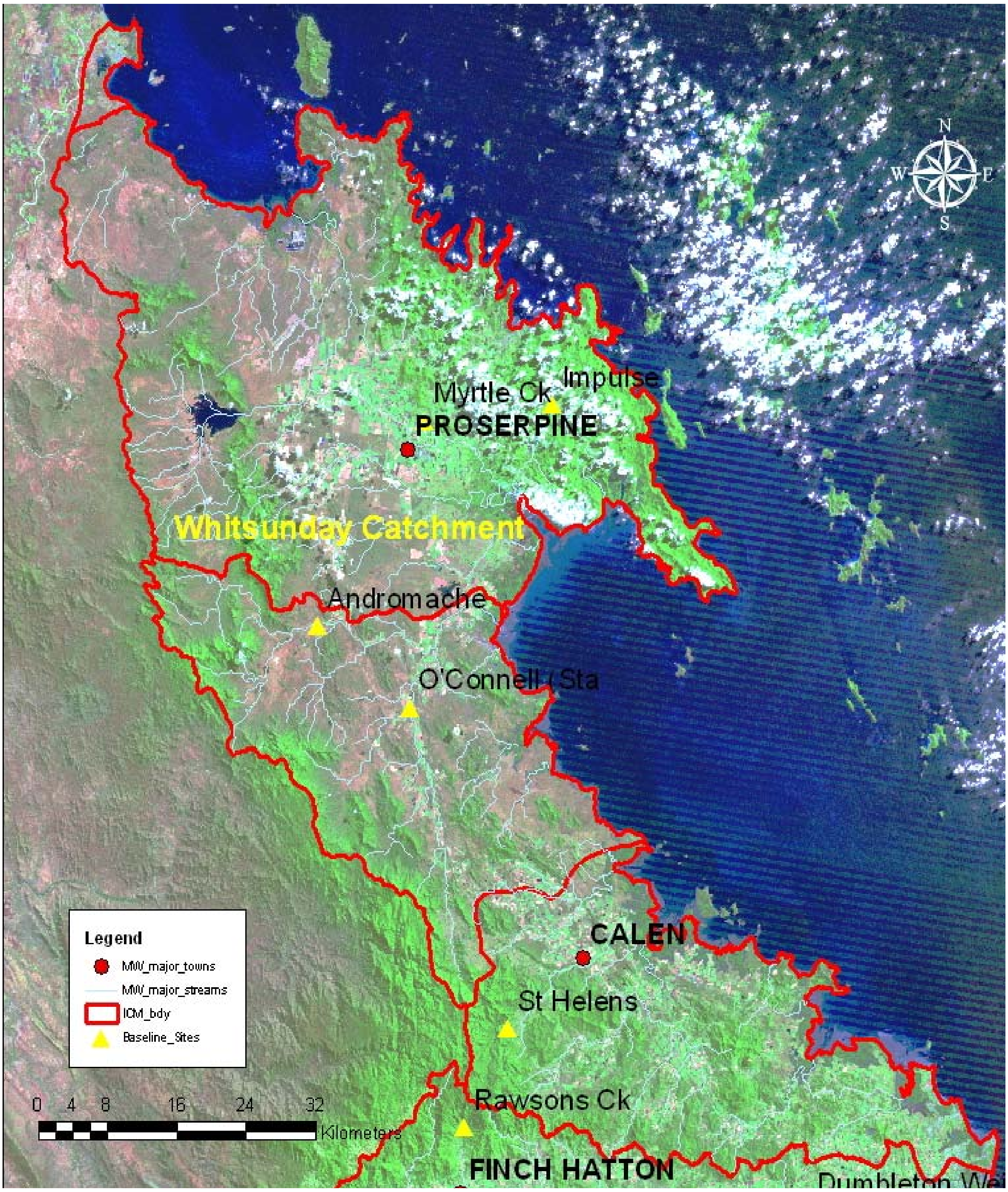

Figure 3 Whitsunday catchment, incorporating the Baseline sampling sites, major towns and streams

2.2 Pioneer Catchment

The Pioneer River (AWRC Basin 125) is 120 km in length and has a catchment area of 1550 km^2 (Figure 4). It rises in the Pinnacle ranges, 63 km south-west of Mackay, travels north until it reaches Mirani where it swings east, travels through Mackay and discharges into the Coral Sea. The Pioneer River is highly regulated, supplying water for extensive sugarcane farming throughout the Pioneer valley. Cattle grazing is also prevalent in the middle reaches.

Teemburra Dam is located within the Pioneer catchment with Kinchant Dam (off-stream storage) being located in the neighbouring Plane catchment. The Pioneer River contains 3 weirs (Mirani, Marian and Dumbleton) and its major tributaries include Finch Hatton Creek (a tributary of Cattle Creek) and Blacks Creek (Brodie 2004).

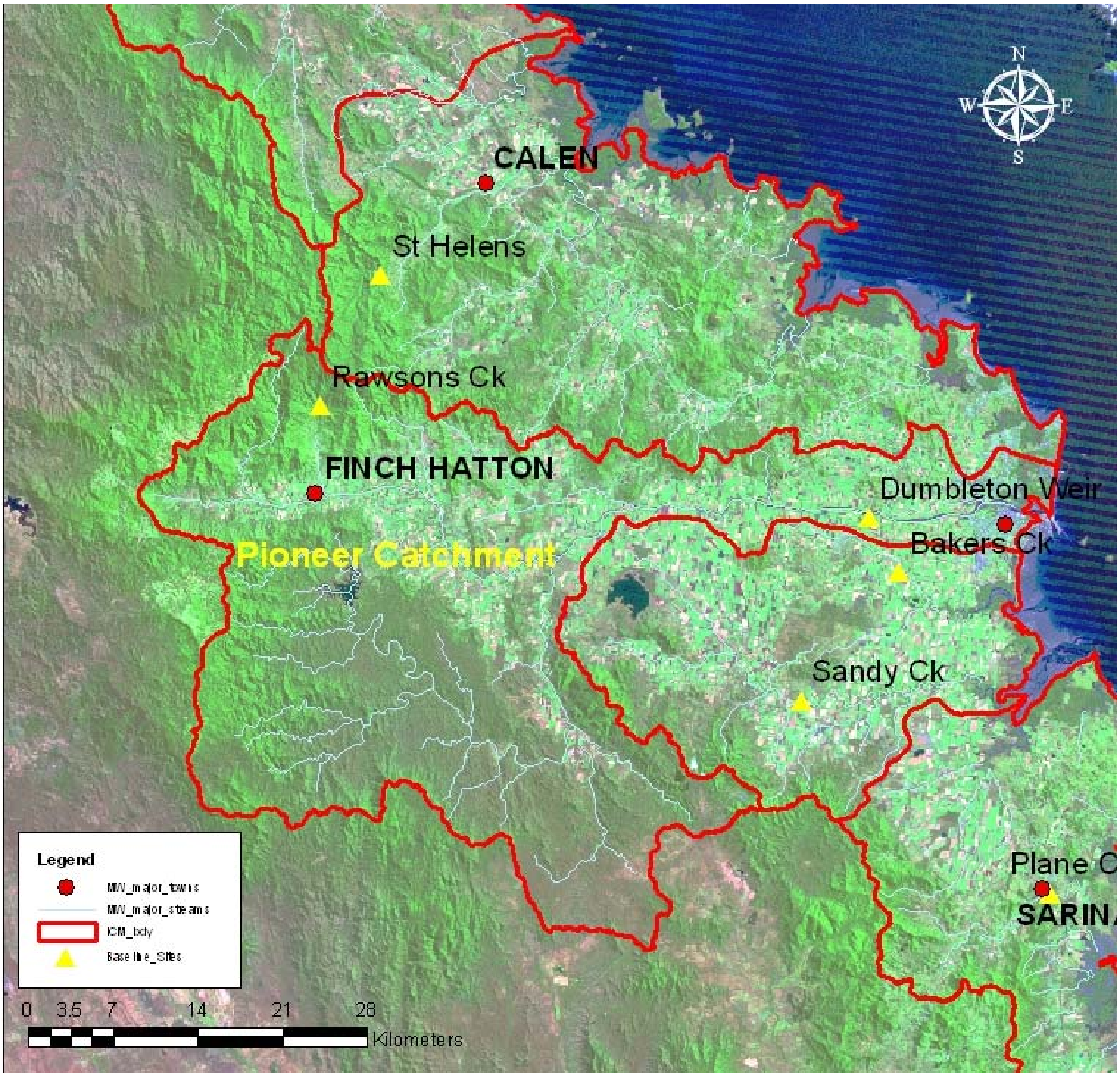

Figure 4 Pioneer catchment, incorporating the Baseline sampling sites, major towns and streams

2.3 Plane Catchment

The Plane catchment (Figure 5) (AWRC Basin 126) is bordered by Sandy Creek in the north, Clairview in the south and by the Connors Range in the west. The major streams include Plane Creek, Rocky Dam Creek, Basin Creek, and Carmila Creek. Sugarcane dominates the northern land use while cattle grazing dominates the southern part of the catchment. Plane Creek exhibits a high degree of regulation over its 35 kilometre length with one dam (Middle Creek Dam) and four weirs. The township of Sarina is located at the lower part of Plane Creek (Brodie 2004).

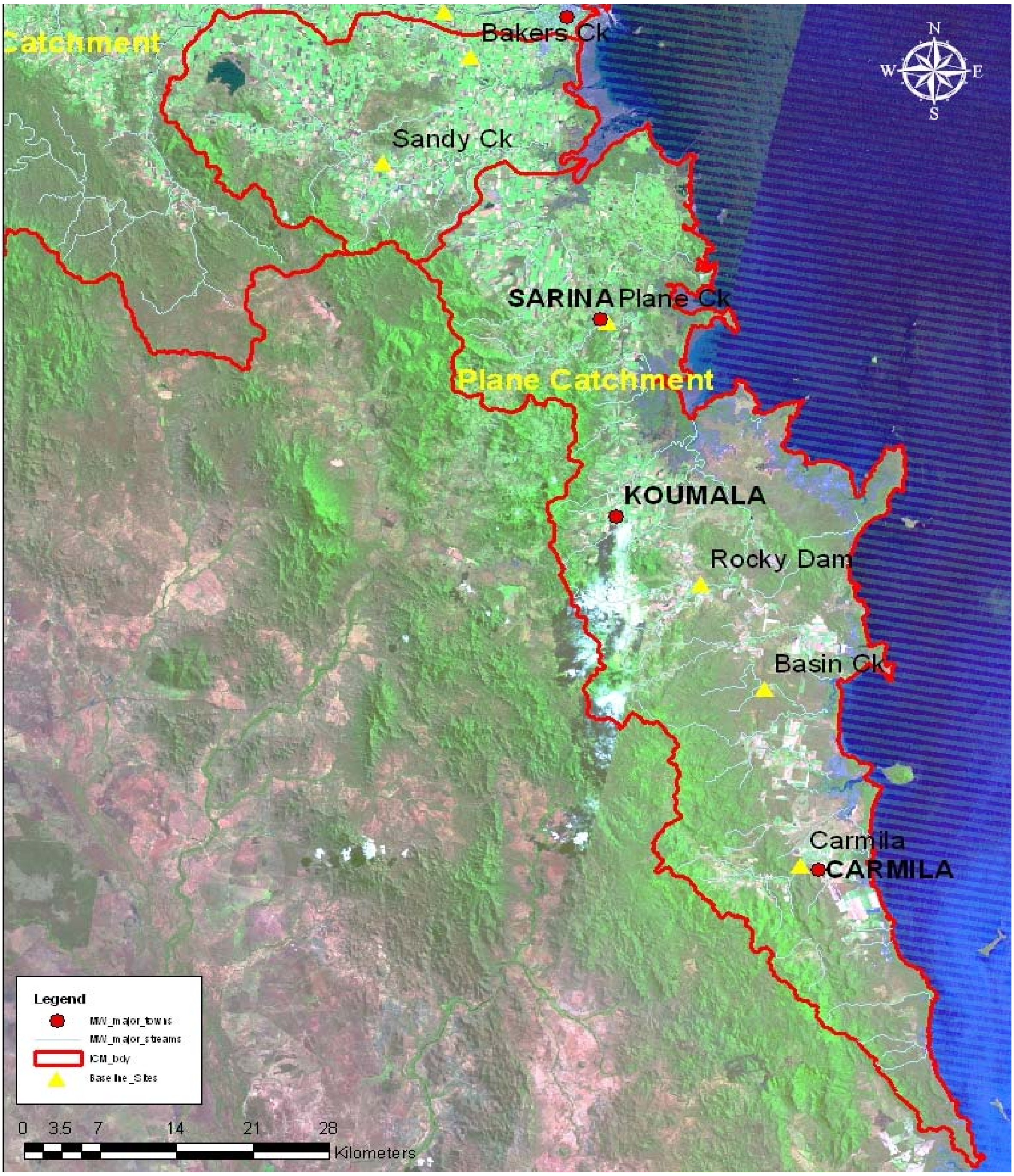

Figure 5 Plane catchment, incorporating the Baseline sampling sites, major towns and streams

3 METHODOLOGY

The monitoring strategy for the Mackay Whitsunday WQIP has been developed in accordance with the National Water Quality Monitoring Strategy 2000 and the Environmental Protection Policy 1997 (EPA, 1999). The Healthy Waterways Baseline Monitoring Program meets the requirements set out in the Australian and New Zealand Standard AS/NZS 5667.11:1998 Water Quality – Sampling – Guidance on sampling rivers and streams; and Queensland's Department of Natural Resources and Water, Water Monitoring Collection Standards, May 2003 (AS/NZS 5667.11:1998) (DNR 2003; DNRM 2006).

It fulfils the requirements of the Reef Plan 2003 and the Mackay Whitsunday Natural Resource Management Plan 2005.

The baseline monitoring program is one component of the Integrated Monitoring Program. Its primary aim is to collect baseline water quality data from catchments exhibiting a dominant land use category. Data collected in this program will be used to determine current condition as well as set regional water quality guidelines for a range of indicators including *in-situ* water quality parameters (water temperature, dissolved oxygen, pH and electrical conductivity), TSS, nutrients and herbicides.

3.1 Monitoring Strategy

The baseline monitoring program is coordinated between local, regional and state Natural Resource Management groups. Whitsunday Catchment Landcare (WCL), Pioneer Catchment Landcare (PCL) and Sarina Landcare Catchment Management Association (SLCMA) are the 3 individual catchment groups which make up the region. Project officers employed by these catchment groups are responsible for the on-ground implementation of this program. They undertake this monitoring and provide data and support to the full time project officer housed within the Department of Natural Resources and Water (NRW). This project officer ensures all aspects of quality assurance, workplace health and safety and training is provided to the individual catchment project officers in order to safely and consistently implement the monitoring program across the region.

Thirteen sites throughout the region were selected (Table 1). The dominant land uses at these sites include bushland, grazing, intensive cropping as well as mixed grazing / intensive cropping catchments. Bushland (forest) sites are located in the catchments headwaters whilst sugarcane and grazing dominate the midstream and lowland reaches.

Table 1 Baseline monitoring site locations

REGIONAL CATCHMENT	G.S NUMBER	SITE NAME	LAND USE
Whitsunday	1220041	Impulse Creek @ Conway State Forest	Bushland
	1220035	Myrtle Creek @ Bennetts Road	Intensive Cropping
	124003A	Andromache River @ Jochheims	Grazing
	124001B	O'Connell River @ Staffords Crossing	Grazing / Intensive Cropping
Pioneer	126001A	Sandy Creek @ Homebush	Intensive Cropping
	1260052	Bakers Creek @ Mackays	Intensive Cropping
	125013A	Pioneer River @ Dumbleton	Intensive Cropping / Grazing
	1250047	Rawsons Creek @ Finch Hatton Gorge *	Bushland
	1240061	St. Helens Creek @ Pettina Pools	Bushland
Plane	126002A	Plane Creek @ Sarina	Grazing / Intensive Cropping
	126007A	Rocky Dam Creek @ Mt. Christian	Intensive Cropping / Grazing
	1260003	Basin Creek @ Bruce Highway	Grazing
	126003A	Carmila Creek @ Carmila	Grazing / Intensive Cropping

GS- Gauging Station
* Referred to as "Finch Hatton Creek" throughout document

Project officers sample their respective sites in the second full week of every month and at the same time of the day each sampling round. Commencing the sampling trip at the same time of the day helps to limit potential discrepancies and variability within the physico-chemical parameters, particularly water temperature and dissolved oxygen.

Indicators sampled include water temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), total suspended solids (TSS), nitrogen species, phosphorus species and herbicides.

Project officers are provided with a sampling kit which contains accurate and reliable WTW water quality meters and probes (including calibration solutions), sampling bottles, syringes, filters, tape measure, esky, bucket, data sheets and all necessary instructions (Figure 6). The sample is taken from the top 50 centimetres of the water column and sample containers are rinsed 3 times with site water. The rinse water is discarded away from the sampling area to avoid contamination. The collected sample is taken to a shaded area and sub-sampled for TSS, total nutrients (unfiltered), dissolved nutrients (filtered through 0.45 µm Minisart cellulose acetate Micro-pore filters) and herbicides.

All samples are stored in ice filled esky's immediately after sampling. After arrival back at the office, the total and filtered nutrients are frozen and TSS and herbicide samples are refrigerated. The samples are packed in ice then air freighted over night to their respective laboratories, where they are analysed.

Figure 6. Sampling kits containing all relevant equipment for sample collection (left) and *in-situ* measurements (right)

3.2 Quality Assurance and Quality Control

Quality Assurance and Quality Control (QA/QC) procedures are essential elements in all phases of a monitoring program. Adequate QA/QC procedures have been developed and followed to ensure that the data generated from the sampling is accurate and reliable. This guarantees the highest statistical integrity possible to provide a clearer idea of stream condition in the selected waterways within the Mackay Whitsunday region.

The Healthy Waterways Baseline Monitoring Program meets the requirements set out in the Australian and New Zealand Standard AS/NZS 5667.11:1998 Water Quality – Sampling – Guidance on sampling rivers and streams; and Queensland's Department of Natural Resources and Water, Water Monitoring Collection Standards, May 2003 (AS/NZS 1998; DNR 2003). All field sample collection, handling, storage and processing meets the guidelines set out in these protocols.

Quality Assurance Activities

- Maintenance of accurate records
- Training of staff in sampling techniques and equipment use
- Development of data quality objectives

Quality Control Activities

- Replicate samples
- Duplicate Samples
- Equipment calibration
- Calibration solution inspection

Relevant Occupational Health and Safety requirements are addressed and followed in all aspects of the monitoring program.

3.3 Meter Calibration

The WTW water quality meters are calibrated to the manufacturer's requirements before each sampling trip. This involves the calibration of the EC meter every 6 hours, the pH meter calibrated once in the morning and once in the afternoon and the DO meter calibrated at every site. This calibration record is written on the data sheet and archived.

Catchment project officers apply a full maintenance routine to the WTW water quality meters on a bi-monthly basis. This involves the chemical cleaning of probes, calibration of meters and the changing of calibration solutions.

3.4 Training

Initial training on the use of the WTW water quality meters and on the sampling of herbicides and nutrients was provided to the catchment project officers by NRW and MWNRM staff. Project officers adhere to QA / QC procedures throughout all sampling.

A risk assessment is completed during these first 3 sampling rounds. It steps through the major risks and hazards at each individual site. A risk / likelihood matrix is followed which produces a ranked score in order of its severity.

An annual refresher training course is provided to the catchment project officers by the regional NRW project officer. This training ensures all standards are maintained. The last training session of this nature was conducted in October 2007 and had the following components.

- Equipment Calibration
- Sampling Methodology
- Bi-monthly Kit Maintenance
- Occupational Health and Safety
- Volunteer Training (Applicable to MWHW Ambient Monitoring Program)

3.5 Laboratory Methodologies

TSS, electrical conductivity and nutrient samples were analysed by the Australian Centre for Tropical Freshwater Research (ACTFR) at James Cook University, Townsville.
Nutrient samples were analysed for:

- Total Nitrogen (TN)
- Total Dissolved Nitrogen (TDN)
- Dissolved Organic Nitrogen (DON)
- Nitrite (NO_2)
- Nitrate (NO_3)
- Ammonia (NH_4)
- Total Phosphorus (TP)
- Total Dissolved Phosphorus (TDP)
- Dissolved Organic Phosphorus (DOP)
- Filterable Reactive Phosphorus (FRP)

TN/TDN and TP/TDP were digested using the Alkaline Persulfate Oxidation technique (kjeldahl autoclave digestion standard) (modified from (Hosomi and Sudo 1987)).
The resulting solution was then simultaneously analysed for NO_x (=TN/TDN) and FRP (=TP/TDP) by segmented flow auto-analysis using an ALPKEM Flow Solution II (Alpkem Corporation, Wilsonville, Oregon, USA).

NO_x, Ammonia and FRP were also analysed using standard segmented flow auto-analysis techniques (APHA, 1998). Particulate (N/P) nutrient concentrations were calculated by subtracting the TDN / TDP concentration from the TN / TP concentration. DON was calculated by subtracting NO_x + Ammonia from TDN and DOP by subtracting FRP from the TDP concentration.

TN – Total Nitrogen (= TDN + Particulate N)
TDN – Total Dissolved Nitrogen (= DON + NOx + Ammonia)
TP – Total Phosphorus (=TDP + Particulate P)
TDP- Total Dissolved Phosphorus (=DOP + FRP)

Herbicide samples were analysed via Liquid Chromatography and Mass Spectrometry by Queensland Health Scientific Services (QHSS), located at Coopers Plains in Brisbane.

3.5.1 *In-situ* Water Quality Parameters

3.5.1.1 Water Temperature

Water temperature has direct and indirect effects on nearly all aspects of stream ecology. Dissolved oxygen is governed by water temperature due to the fact that cooler water holds more oxygen than warmer water. Temperature also influences the rate of macrophyte photosynthesis within the water body. The metabolic rate of aquatic fauna is also largely dominated by water temperature. Temperature is measured in degrees Celsius (ºC).

3.5.1.2 Dissolved Oxygen

Dissolved oxygen (DO) is the level of oxygen dissolved in a water body. It is essential to fish, micro-organisms, plants and all forms of aquatic flora and fauna for respiration.

Oxygen infiltrates the water via diffusion from the surrounding air, by rapid water movement or by in-stream macrophyte photosynthesis. In general, dissolved oxygen levels increase during the day when the sun is out and aquatic plants are actively photosynthesising. When night falls, oxygen is removed from the water as a result of animal, plant and bacterial respiration (Faithful 2003).

DO levels are generally indicative of water quality. Extremely low concentrations are hazardous as fish kills may occur (acute asphyxiation). Conversely, high concentrations can cause oxygen narcosis or air bubbles in the fish's bloodstream, thus harming circulation (Faithful 2003). DO is measured in milligrams per litre (mg/L) or percentage saturation (% saturation).

3.5.1.3 pH

pH is a measure of the acidity or alkalinity of water and ranges from 1-14, 1 being acidic, 7 being neutral, and 14 being alkaline. The optimal pH for most organisms in Australian freshwaters is 6.5 – 8.0 (EPA 2006). A reduction in species diversity will occur if the pH is outside this range, as more sensitive species would not be able to withstand the aquatic condition. Skin irritation, ulcers and impaired gill function will occur in fish communities where low or acidic pH levels are present. pH also affects the solubility of heavy metals (lead, copper, cadmium etc.) present in water and the concentrations of total dissolved solids in waterways.

Carbon dioxide is taken up and used in the process of photosynthesis so the pH increases as the water acidity is reduced. In contrast, the decaying of organic matter lowers the pH concentration of a water body (Faithful 2003).

3.5.1.4 Electrical Conductivity

Electrical conductivity (EC) is the ability for water to conduct an electric current. The greater the quantity of dissolved salts present in the water, the greater the conductivity. Dissolved salts can include chlorides, sulphates, and carbonates of sodium, magnesium, calcium and potassium.

Groundwater influences, local geology, evaporation and rainfall are all natural phenomenon which will cause changes in electrical conductivity. Groundwater and evaporation will cause electrical conductivity to increase whereas rainfall events cause a reduction in electrical conductivity. Appropriate concentrations of these salts are essential to the health of aquatic plants and animals (Fries 2007). EC is measured in micro-siemens per centimetre (µS/cm).

3.5.2 Total Suspended Solids (TSS)

As TSS levels increase, a water body begins to lose its ability to support a diversity of aquatic life. Suspended solids absorb heat from sunlight, which increases water temperature and subsequently decreases dissolved oxygen levels. Increased turbidity decreases light penetration and photosynthetic processes. Flow on effects from high TSS levels can potentially be disastrous. Less oxygen is produced by plants and algae which causes a decline in dissolved oxygen (DO). Suspended solids may also destroy fish habitat, settling to the bottom and blanketing the river bed. Suspended solids can smother fish eggs and aquatic insects as well as suffocate newly-hatched insect larvae. It can also harm fish directly by clogging gills, reducing growth rates, and lowering resistance to disease.

Inshore coral reefs suffer from TSS blanketing and siltation when sediment plumes flow off the land and out to sea during substantial rainfall events. This smothering leads to coral bleaching and ultimately the death of the coral (Pearson *et al.* 2003).

Well mixed TSS samples are filtered through a standard pre-weighed GF/C (1.2 µm) glass fibre filter with the residue being retained on the filter, oven dried for a period of 24hours at a temperature of 103-105 ºC.

3.5.3 Nutrients

3.5.3.1 Major forms of nutrients

Nitrogen (N) and Phosphorus (P) exist naturally in the aquatic environment but these can be increased to higher levels through agricultural land-use practices, abundant rainfall or water stratification. Nitrogen occurs in dissolved organic and inorganic forms (nitrate, nitrite and ammonia) and particulate forms. N and P are vital components in the conversion of sunlight to energy by in-stream macrophytes and phytoplankton. The additional information provided by the speciation components of N and P provides an indicator of the processes occurring within the water body. Dissolved forms of N and P are readily available for biological processes. Excess amounts of these nutrients can cause eutrophication which may result in toxic algal blooms that are detrimental to the aquatic environment (Kelley *et al.* 2006).

Particulate N is typically processed by sediment dwelling biota (filter feeding organisms and macro-invertebrates). It is presented in the form of leaf litter and fine particulate matter that is transferred throughout the water body. It is mainly bio-available in the long term as it can be eaten by micro-organisms and filter feeding animals.

Particulate P consists of organic, inorganic as well particulate and colloidal material. This may include bacteria, algae, detritus, clay, zooplankton, plant material and sediment. PP is also available in the long term.

DON is an important source of Nitrogen in the aquatic environment. DON is small to medium in molecular structure, typically representing around 50% of the N in streams but can represent up to 85% (Brodie and Mitchell, 2005). The leaching of DON may represent a significant “N Leak” which occurs due to the fact that plants and microbes cannot prevent DON losses even in times of high N demand (Brodie and Mitchell, 2005).

DIN is comprised of nitrite + nitrate + ammonia and is highly bio-available. Low concentrations are found in natural waters whereas high concentrations are found where human pollution is evident (fertiliser or sewage).

DOP is similar in principle to DON, however, it has a higher availability than DON.

Filterable Reactive Phosphorus (FRP) exhibits low concentrations in natural waters but high concentrations where fertiliser and/or sewage discharge is apparent (Table 2).

Table 2 General nutrient concentrations from various land use dominated sites in northern Australia (Brodie and Mitchell 2005)

CATCHMENT DESCRIPTION	NUTRIENT	LEVEL	CONCENTRATION
Bushland	DON	Moderate	30 - 400 µg N/L
	DOP	Moderate	1- 30 µg P/L
	PN	Low - Moderate	2 - 400 µg N/L
	PP	Low - Moderate	1 - 100 µg P/L
	DIN	Low	5 - 80 µg N/L
	FRP	Low	0.3 -7 µg P/L
Grazing	DON	Moderate	200 - 600 µg N/L
	DOP	Moderate	5 - 30 µg P/L
	PN	Moderate - High	300 - 3000 µg N/L
	PP	Moderate - High	100 - 2000 µg P/L
	DIN	Low - Medium	100 - 800 µg N/L
	FRP	Low - Medium	10 - 100 µg P/L
Intensive Cropping	DON	Moderate	100 - 1000 µg N/L
	DOP	Moderate	10 - 100 µg P/L
	PN	High	100 - 1000 µg N/L
	PP	High	50 - 150 µg P/L
	DIN	Very High	1000 - 15000 µg N/L
	FRP	Moderate - High	50 - 500 µg P/L

3.5.4 Herbicides

Herbicides are used to control perennial grasses, broad –leafed and woody weeds in intensively cropped fields and grazing pastures (Table 3).

Major harm can be caused to surrounding aquatic life once herbicides are present within a water body. Herbicide effects on algae can be detrimental, affecting the entire aquatic food chain. Algae are the most important primary producers in aquatic systems and account for nearly the same percentage of total global net primary production of carbon annually as cultivated plants (Arthington *et al.* 1997). In addition, algae represent the basal component of aquatic food webs, since they are consumed by a variety of invertebrates or directly by fish. These attributes of algae make them fundamentally important to aquatic ecosystems (Hamilton and Haydon 1996; Mitchell *et al.* 2005).

Inshore coral reefs can be adversely affected by herbicide concentrations during rainfall / runoff events. There is evidence of herbicide accumulation within cores of *Porites* corals. Other less sensitive corals may expel their algal symbiont (Zooxanthellae) causing bleaching and ultimately death. (Hamilton and Haydon 1996).

Table 3 Main uses of the herbicides detected in the analysed samples

HERBICIDE	USE
Ametryn	Controls grasses and other broad-leafed weeds
Atrazine	Controls grasses and other broad-leafed weeds
Desisopropyl Atrazine *	Controls annual grasses
Desethyl Atrazine *	Controls annual grasses
Diuron	Controls grasses and other broad-leafed weeds
Hexazinone	Controls grasses, broad-leafed weeds and woody plants
Tebuthiuron	Controls brush and weeds
Bromacil	Controls brush on non-cropland areas
Simazine	Controls grasses and other broad-leafed weeds
Terbutryn	Controls grasses and other broad-leafed weeds

***** Degradation product of Atrazine

3.6 Percentile Values

The water quality data for each parameter has been analysed for the minimum and maximum readings as well as the 20th, 50th and 80th percentiles. Percentiles are values in a given set of observations that divides the data into 100 equal parts. A percentile value means that for a given percentage of sampling occasions, the data points are below the resulting value. For example, a 50th percentile is found by arranging the values in ascending order and then selecting the one in the middle. The 50th percentile (or median) is a useful number in cases where the distribution has very large extreme values which skew the data. The extremities are the minimum and maximum values which occur in the data set. The variability within the data is illustrated as the range between the minimum and maximum value.

Box and whisker plots are graphical displays which are used to illustrate the water quality results. They are constructed entirely out of the percentile values (Figure 7). The top edge of the box represents the 80th percentile and the bottom of the box represents the 20th percentile. The line in the middle indicates the median value of the data. The ends of the vertical lines or "*Whiskers*" indicate the minimum and maximum data values. The letter "n" represents the number of times the parameter was sampled at that particular site or within the particular land use type.

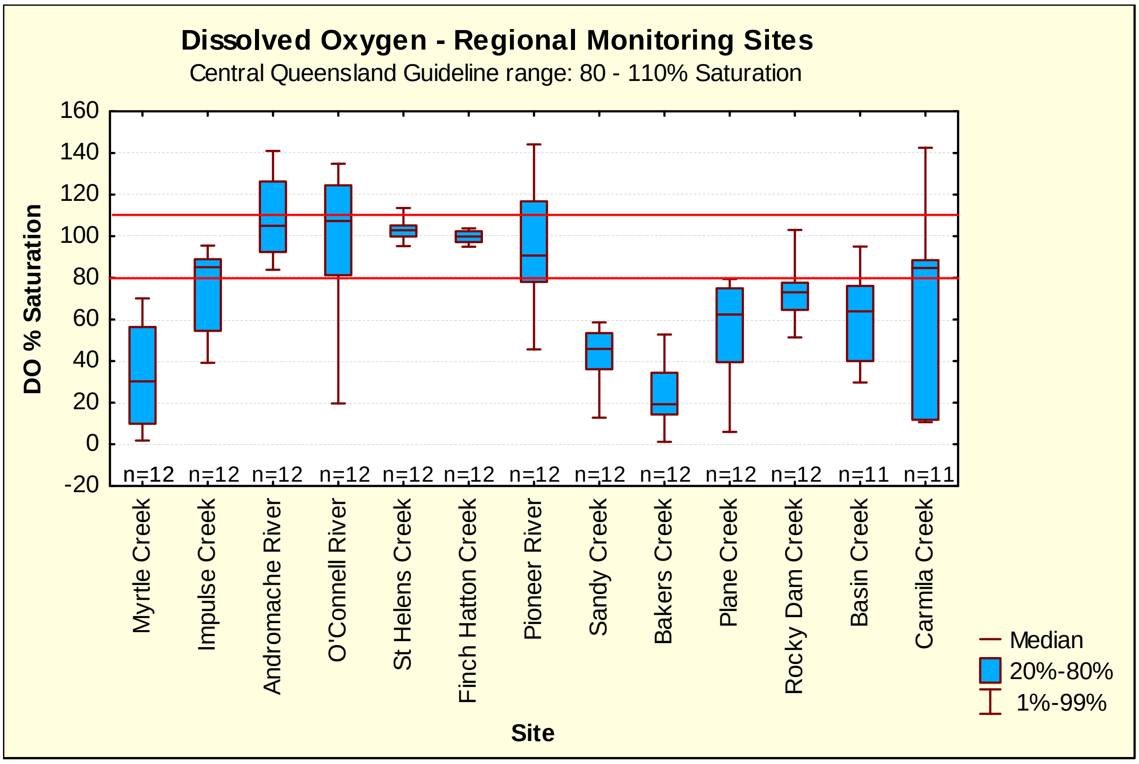

Figure 7 An example of a box and whisker plot

Figure 7 is an example of a box and whisker plot illustrating dissolved oxygen within the region. The site "Myrtle Creek" exhibits a minimum of 1.8% saturation and maximum of 70% saturation. The 80th percentile value is 57% saturation. The median value is 30% saturation. The 20th percentile (bottom of the box) is 10% saturation. The site was sampled 12 times (n=12). The red lines indicate the central Queensland water quality guideline range for the parameter of dissolved oxygen (80 – 110%). In this particular scenario, Myrtle Creek does not satisfy the minimum guideline value on any occasion.

3.7 Water Quality Guidelines

The process used in establishing water quality objectives is based on recommendations by the National Water Quality Management Strategy (NWQMS). The NWQMS aims to achieve the sustainable use of water resources pertaining to Australia and New Zealand via the general protection and enhancement of overall water quality while still catering for economic and social development.

The Environmental Protection Agency (EPA) has been collecting water quality data since 1992. The collaboration of this data and similar data from other states allowed for the development of the ANZECC 2000 guidelines which provides guideline values for various water quality indicators to protect aquatic ecosystems and the primary uses of waters at a national scale (ANZECC and ARMCANZ 2000). These include recreation, drinking, agriculture and stock supply. This national framework emphasized the need for the development of more locally relevant guidelines which pertain to the rivers at a localised rather than a national scale (Drewry *et al.* 2008; EPA 2006).

It was through this critical requirement that the Queensland Water Quality Guidelines (QWQG) were developed. The central Queensland water quality guidelines were obtained from the QWQG and were used as the guideline values for this report (Figure 8). The QWQG provides a framework whereby a local (Mackay Whitsunday) set of guidelines can be constructed. Establishing a Central Queensland or regional guideline value for the *in-situ* parameter of water temperature may prove difficult due to the fact it is highly dependant on stream characteristics such as water depth, stream width, flow rate and riparian shade rather than surrounding land use practices.

Central Queensland water quality guidelines are presently available for various *in-situ* water quality parameters and Nitrogen and Phosphorus species (Table 4), however, at this stage no guideline values have been established for herbicide concentrations.

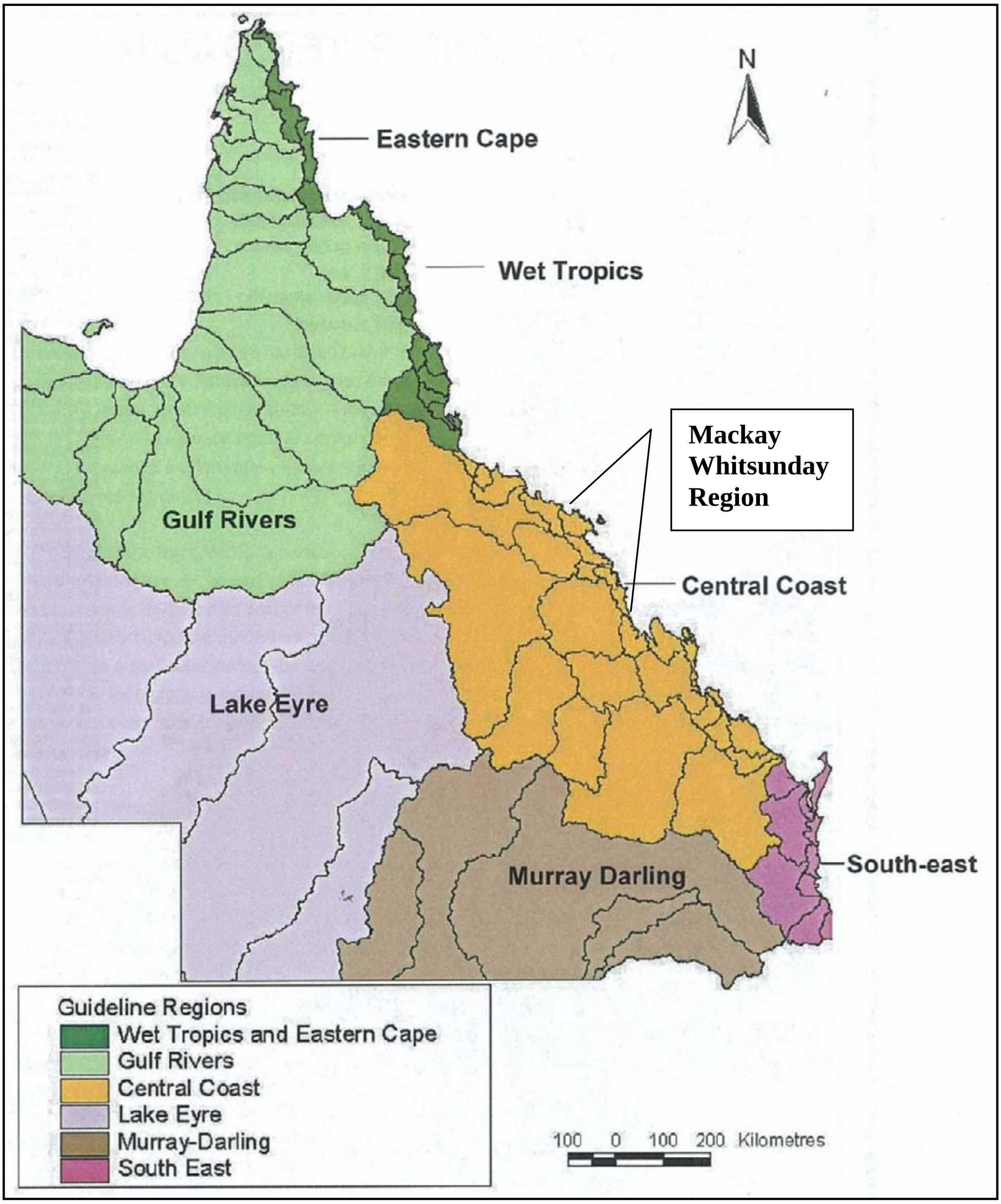

Figure 8 Regional break down of Queensland in the Queensland Water Quality Guidelines (Mackay Whitsunday is in the Central Coast region)

Table 4 Central Queensland water quality guidelines for various nutrients and in-situ water quality parameters (EPA 2006).

Central region water type	Amm N	Oxid N	Org[6] N	Total N	FiltR P	Total P	Chl-a	DO (% sat[8]) [1,2,3] lower	DO upper	Turb	Secchi	SS	pH [4,5] lower	pH upper	Conductivity	Temperature[11]
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	lower	upper	NTU	m	mg/L	lower	upper		°C
Open coastal	6	3	130	140	6	20	1.0	95	105	1	5.0	10.0	8.0	8.4	n/a	Managers need to define their own upper and lower guideline values, using the 80[th] and 20[th] percentiles, respectively, of ecosystem temperature distribution (ANZECC 2000).
Enclosed coastal	8	3	180	200	6	20	2.0	90	100	6	1.5	15	8.0	8.4	n/a	
Mid-estuarine and tidal canals, constructed estuaries, marinas and boat harbours	10	10	260	300	8	25	4.0	85	100	8[8]	1.0[8]	20[8]	7.0	8.4	n/a	
Upper estuarine	30	15	400	450	10	40	10.0	70	100	25[8]	0.4[8]	25[8]	7.0	8.4	n/a	
Lowland streams[10]	20	60	420	500	20	50	5.0	85	110	50	n/a	10	6.5	8.0	See Appendix G	
Upland streams[10]	10	15	225	250	15	30	n/a	90	110	25	n/a	–	6.5	7.5	See Appendix G	
Freshwater lakes/ reservoirs	10	10	330	350	5	10	5.0	90	110	1–20	nd	nd	6.5	8.0	See Appendix G	
Wetlands[7]	Nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	

Physico-chemical indicator (see Appendix E) and guideline[9] value (slightly-moderately disturbed systems)

Note 1 Note that DO guidelines (% saturation) for freshwaters should only be applied to flowing waters, including those with significant subsurface flows. Stagnant pools in intermittent streams naturally experience values of DO below 50% saturation.

Note 2 DO Guideline values in the Table above apply to daytime conditions. Lower values may occur at night but this should not be more than 10 % –15% less than daytime values.

4 RESULTS and DISCUSSION

Many parameters were sampled and analysed, however, only graphical representations for the water quality indicators used to produce water quality objectives will be produced in this report. These are: ***In-Situ*** - dissolved oxygen, pH, electrical conductivity, **TSS**, **Nutrients -** PN, DIN, FRP, PP, **Herbicides -** ametryn, atrazine, diuron, hexazinone and tebuthiuron. These are the water quality indicators used as water quality objectives in the Water Quality Improvement Plan.

4.1 *In-Situ* Parameters

4.1.1 Water Temperature

The temperature of a water body is of fundamental importance as it is a governing factor over many chemical and biological processes. Neither ANZECC 2000 or Central Queensland water quality guidelines have been established for this parameter due to the fact that it can be extremely variable depending on the physiological structure of the water body. It has been found that factors such as the seasonality, time of the day, cloud cover, riparian shade, water depth and stream width greatly influence the in-stream water temperature more so than the surrounding land use practice.

Relatively uniform annual median water temperatures were evident with limited variability between land uses being exhibited throughout the 5 dominant land use categories in the Mackay Whitsunday region. Median temperatures ranged between 19.9ºC and 26.6ºC regardless of land use classification. The minimum recorded temperature was 14.2ºC on July 19th, 2006 at Finch Hatton Creek – a bushland reference site, located at the base of Eungella National Park.

Extreme temperatures ranged from 14.2ºC to 31.5ºC on one off occasions, with extreme minimums in winter and extreme maximums in summer.

Bushland sites exhibited the lowest median temperature of 21.5ºC. These bushland sites are situated in elevated parts of the catchment and are generally cooler than lower lying streams. Extensive riparian shade and fast flow from steeply sloped banks ensures cooler temperatures. Bushland sites were followed closely by intensive cropping (21.9ºC), grazing (23.1ºC), intensive cropping / grazing (24.6ºC) and grazing / intensive cropping (25.5ºC). This range between land uses is relatively marginal given the inclusion of seasonal variation.

The Andromache River, O’Connell River and Pioneer River all exhibit higher median temperatures than the other streams (25.8 ºC, 26 ºC and 26.6 ºC respectively). These streams have a larger width than the rest and thus the greater surface allows the stream to capture and retain more of the suns energy and warmth. The higher median temperatures present in the Andromache and O’Connell Rivers may also be due to the fact that they were sampled in the afternoon on every sampling occasion.

Note: Grazing / intensive cropping and intensive cropping / grazing sites may appear to be the same, however the land use mentioned first in the classification is the dominating land use acting upon the site with a smaller percentage of the second land use acting upon the site.

4.1.2 Dissolved Oxygen

The amount of oxygen present in a water body available for in-stream processes is largely affected by the time of day, available sunlight and water depth. Dissolved oxygen levels generally tend to peak in the afternoon when photosynthetic processes and sunlight are at their peak. DO levels build up throughout the morning then decrease during the evening when macrophytes respire (Faithful 2003).

Dissolved oxygen concentrations were extremely variable throughout the Mackay Whitsunday region with 7 out of the 13 sites falling within the Central Queensland water quality guideline range of 80 – 110% saturation, 50% of the time (Figure 9).

All bushland sites (Impulse Creek, St Helens Creek and Finch Hatton Creek) rated highly, exhibiting low variability. St Helens Creek fell within the guideline range 80% of the time and Finch Hatton Creek fell within this range on every sampling occasion. The narrow span of the whiskers is indicative of consistent readings within the allocated range.

Impulse Creek is located in the headwaters of Conway National Park in the Whitsunday catchment. Although it is a national park reference site, it exhibited minimum DO readings as low as 39.2% saturation on various occasions. This indicates that Impulse Creek is moderately hypoxic in behaviour when compared with the other two bushland sites. This may be due to the fact that this site is restricted to a shallow pool environment with abundant algal growth and no flow for the majority of the year.

The Andromache River, O'Connell River, Pioneer River and Carmila Creek are within the guideline range at least 50% of the time. These sites have also displayed readings much higher than the upper guideline limit on occasions, with maximum values between 134.8% saturation and 144.1% saturation. The high DO readings attributed to the Andromache River and O'Connell River may be due to sampling occurring at 3pm on over 30ºC days when macrophyte oxygen production is at its peak. Extremely high oxygen concentrations such as these can be harmful to aquatic biota causing narcosis or air bubbles within a fish's bloodstream.

Poor DO levels in intensively cropped sites were prevalent throughout the Mackay Whitsunday region (Figure 10). DO concentrations failed to reach the minimum guideline value on any occasion. Dissolved oxygen levels are consistently poor at these sites all year round but were at their lowest at the end of the sugar cane harvesting season. Reports of fish kills downstream of intensively cropped areas have been confirmed by past studies and are most likely due to depleted oxygen levels from sugar juice lost during mechanical cane harvesting (Rayment 2003). Most concerning is the movement of water containing sugar to waterways when harvesting during wet weather or soon after harvest. DO levels can be dramatically reduced for a number of days after a rainfall event. This sucrose promotes bacterial growth which severely diminishes oxygen levels within the waterway.

Myrtle Creek in particular is devoid of plant life with large amounts of rotting vegetation. It is a non-flowing, pooled environment for prolonged periods of the year. It also captures used irrigation water. These are possible suggestions for the poor DO at Myrtle Creek .

Bakers Creek is one of the most intensively cropped catchments in the Mackay Whitsunday region (61% cane). Bakers Creek exhibited the lowest minimum (1.2% saturation), lowest median (19.25% saturation) and lowest maximum (52.7% saturation). This indicates that Bakers Creek would exhibit very poor species diversity and would not be able to support higher order aquatic taxa such as fish populations.

Intensive cropping / grazing sites as well as grazing / intensive cropping sites exhibited median DO concentrations of 77.8% saturation and 79.4% saturation which is just below minimum guideline value. These land uses exhibit respective maximum concentrations of 144.1% saturation and 142.5% saturation.

Grazing sites displayed a median concentration of 89.6% saturation, therefore lay within guideline range, however, this land use did display a maximum concentration of 140.9% saturation. This high concentration was collected from the Andromache River. The Andromache River consistently displays high DO concentrations which can be attributed to photosynthetic and respiratory processes from the extensive abundance of macrophytes present at this site.

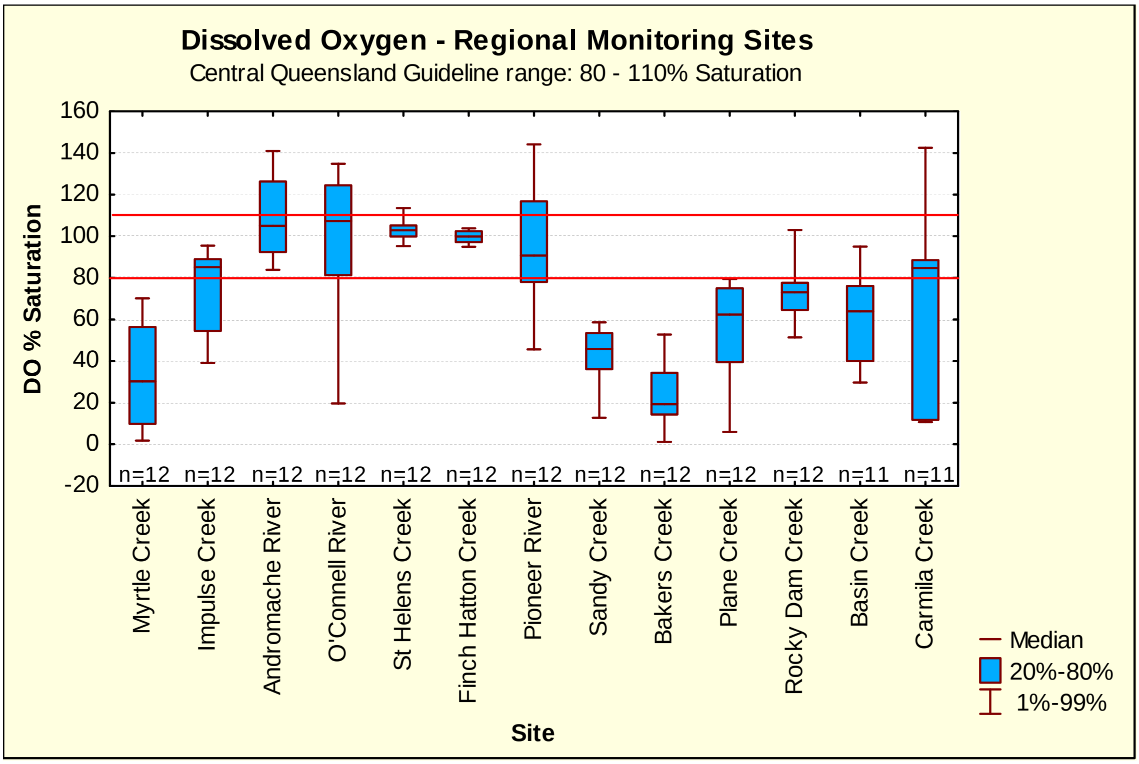

Figure 9 Dissolved oxygen – regional monitoring sites

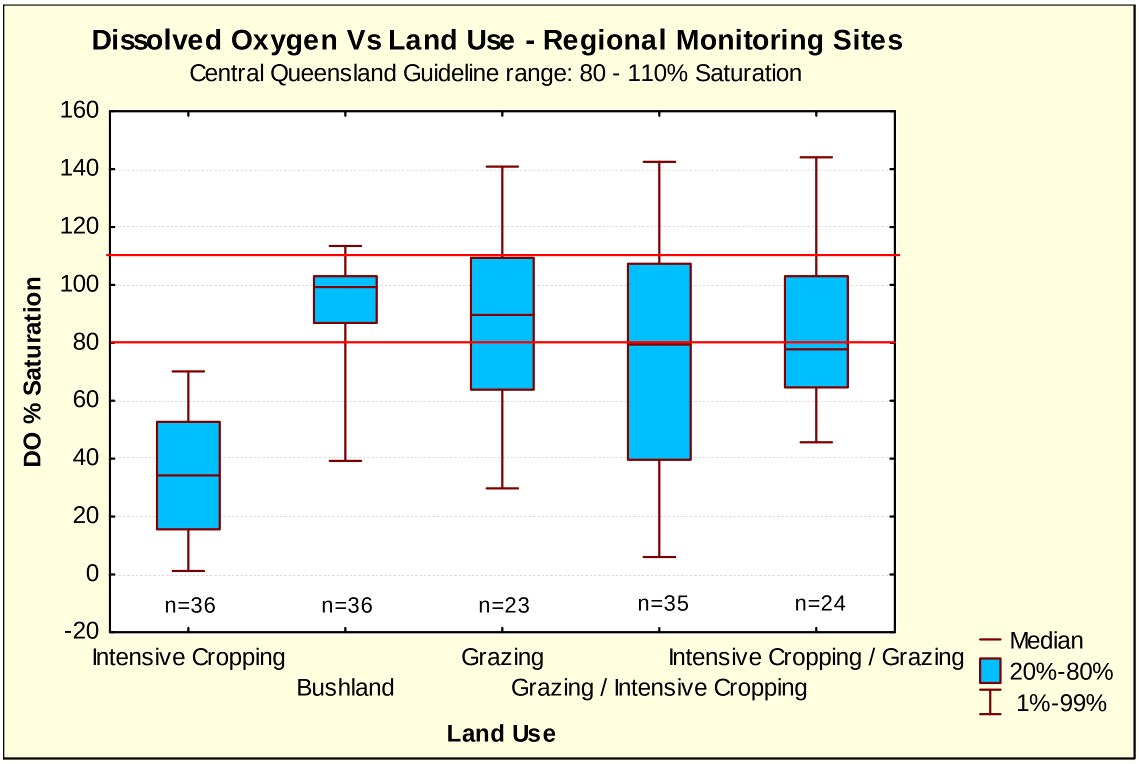

Figure 10 Dissolved oxygen Vs land use – regional monitoring sites

4.1.3 pH

All sites, with the exception of the Andromache River, were within the central Queensland water quality guideline range of 6.5 – 8.0, at least half of the time. The majority of sites occurred within this range 80% of the time. Their positioning within this guideline range is extremely variable.

pH levels for the Andromache River were consistently high on every sampling occasion with readings ranging from 7.8 – 8.8 and a median value of 8.2 (Figure 11). These high readings may be from the soils and groundwater in the upper Andromache River. Calcium percolates into groundwater from soils and is then carried into streams. High calcium carbonate concentrations have caused consistently high pH values (>8) in the Andromache River over the past 27 years (Faithful, 2003). Extensive macrophyte growth and photosynthetic processes at this location may also contribute to these high readings.

Bakers Creek and Basin Creek are slightly acidic in nature. This may be due to dissolving organic matter, presence of nutrients and carbon as well as seasonal variation. The acidic influence at Basin Creek may have been exacerbated by the Melaleuca trees which dominate the riparian zone.

Intensively cropped sites exhibited the lowest median pH level (7.19), followed by bushland (7.43), intensive cropping / grazing (7.65), grazing / intensive cropping (7.69) and grazing sites (7.76) (Figure 12).

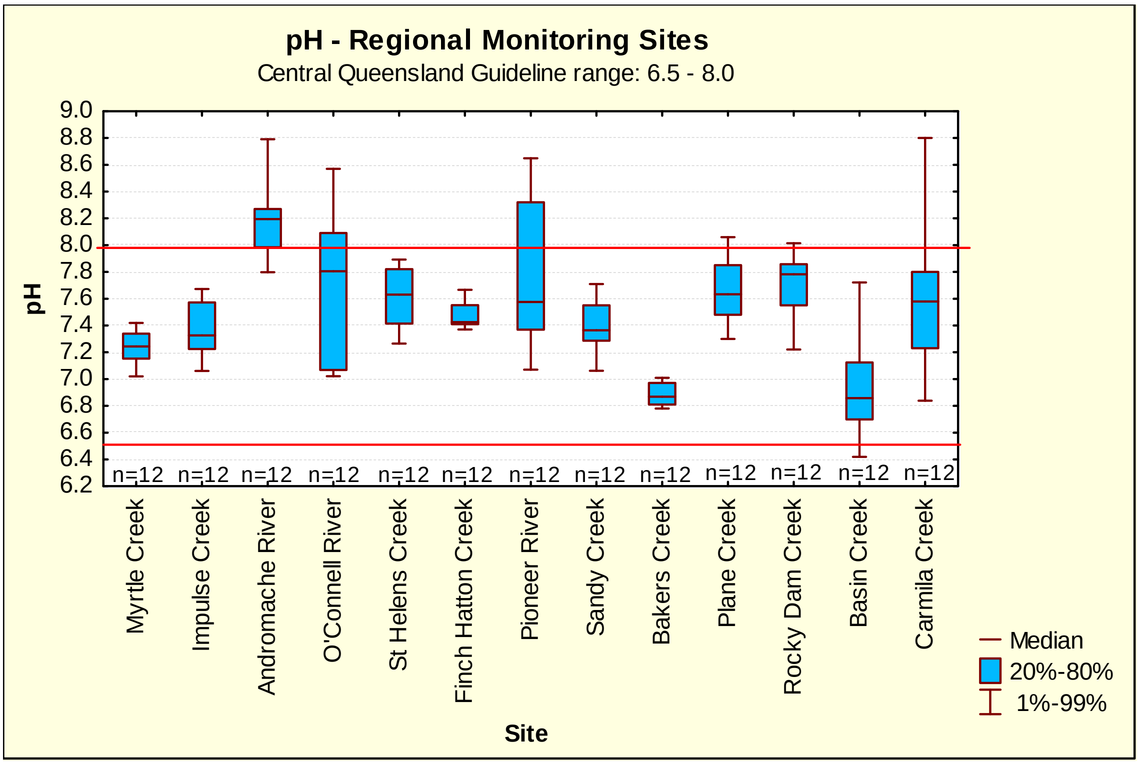

Figure 11 pH – regional monitoring sites

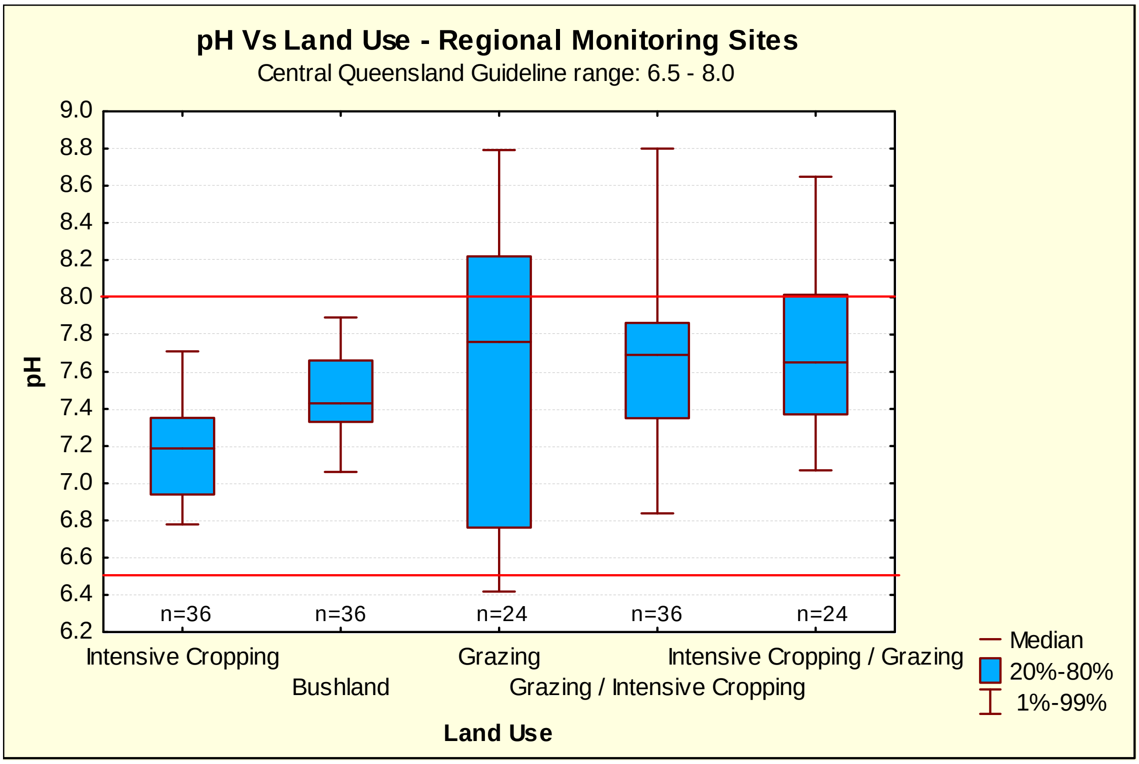

Figure 12 pH Vs land use – regional monitoring sites

4.1.4 Electrical Conductivity

Median EC values across the region ranged from 44.3 µS/cm (Finch Hatton Creek) to 697 µS/cm (Rocky Dam Creek) (Figure 13). An aquatic ecosystem guideline value has not been established for EC at this point in time.

St Helens Creek and Finch Hatton Creek are bushland sites and showed extremely low variability. They record consistently low readings on every sampling occasion. Samples taken at these 2 sites were very “fresh”, portraying EC readings below 70 µS/cm on every occasion. Low values such as this can be expected from bushland sites as they are generally located in elevated sections of the region where there is higher than average rainfall. The granite dominated geology of the area may also contribute to these low readings.

Impulse Creek is a bushland site but had a high EC variation. Its range is from 135 to 915 µS/cm (Figure 13). The site had a median EC value of 255 µS/cm. This is considered to be relatively high for a bushland site, however Impulse Creek is influenced by groundwater discharge and volcanic geology which may account for the high EC levels.

The O’Connell River exhibited the greatest inter-percentile range, ranging from 203 to 1084 µS/cm. It is the highest range but is still well within reasonable freshwater limits.

Excluding Impulse Creek and the O’Connell River, whose variability is most likely due to groundwater discharge during the dry season, Myrtle Creek also exhibited a large range from 182 - 825 µS/cm. This range illustrates instability within the waterway and can be caused by dissolving organic matter, presence of nutrients and carbon as well as seasonal variation. These flow modified pools also cater for irrigational purposes. This pumping frequently changes the water level thus affecting the electrical conductivity within Myrtle Creek.

Bushland sites exhibited the lowest median EC readings but high maximum readings due to the groundwater influence at Impulse Creek.

Grazing / intensive cropping was the land use which displayed the highest maximum reading.

Intensively cropped sites exhibited the highest median value of 494 µS/cm (Figure 14).

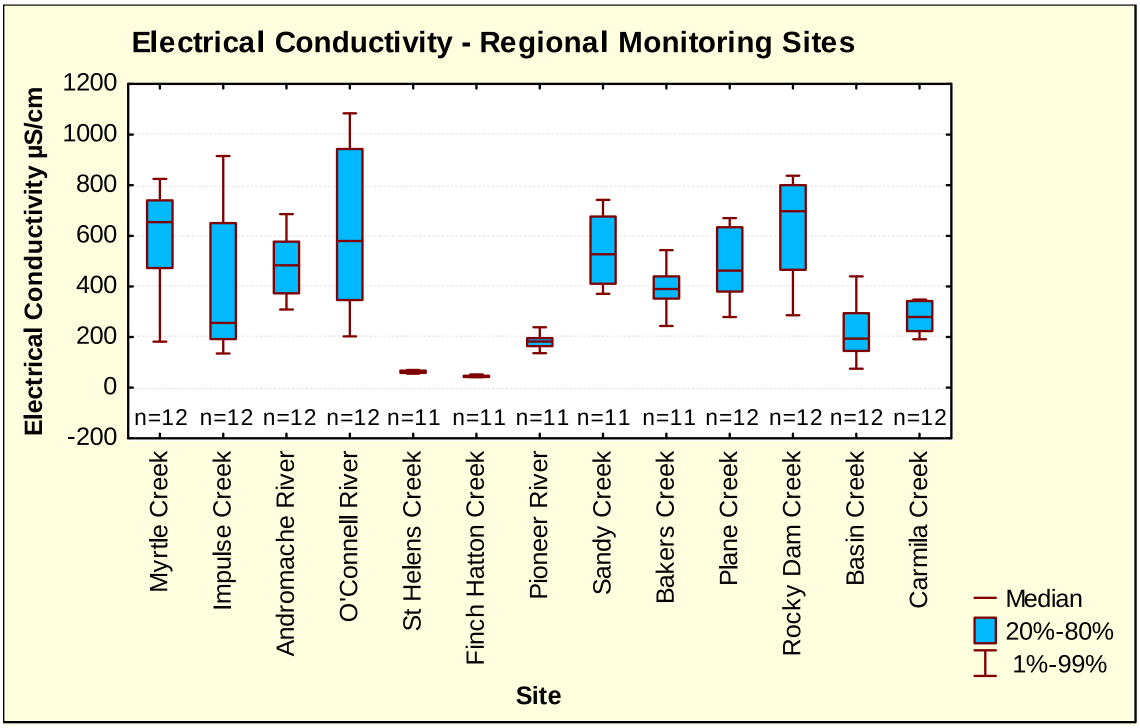

Figure 13 Electrical conductivity – regional monitoring sites

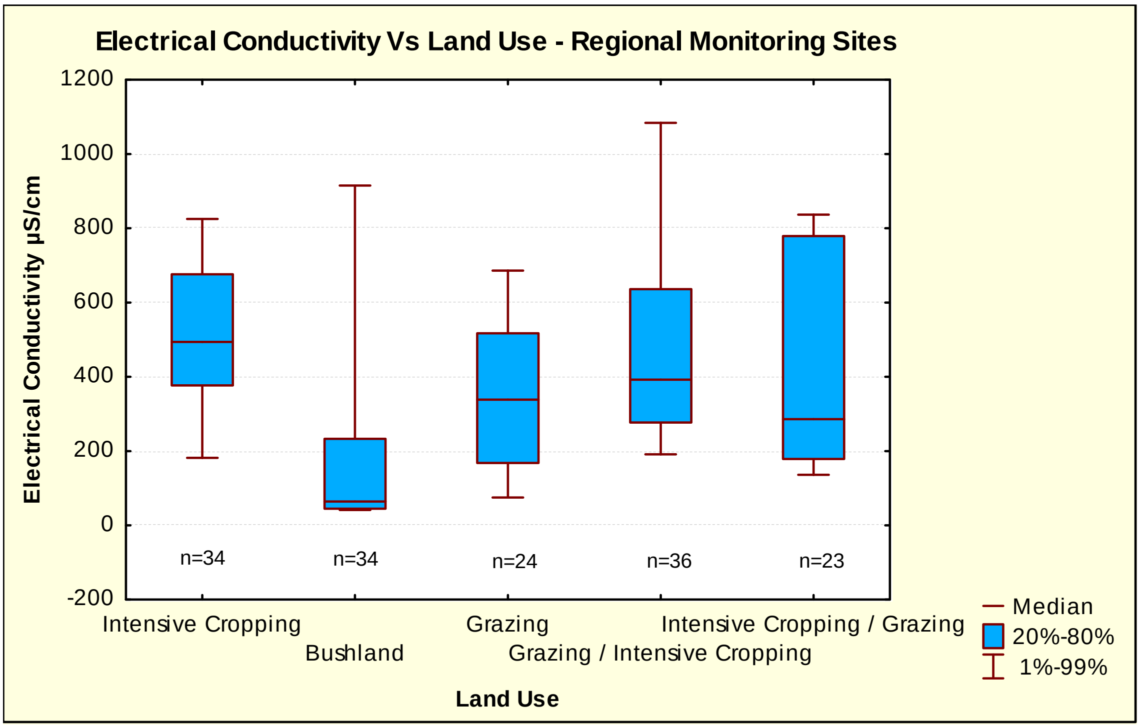

Figure 14 Electrical conductivity Vs land use – regional monitoring sites

4.2 Total Suspended Solids (TSS)

TSS can be organic or inorganic matter, which may include silt, plankton and industrial waste.

High TSS levels can have negative effects on the in-stream environment. Photosynthetic processes dramatically decrease and so does oxygen production. The clogging of fish gills, smothering of benthos (including eggs and larvae) and the general decrease in resistance to diseases by aquatic life such as fish are just a few potentially hazardous effects caused by high TSS levels within a waterway (Brodie 2004; Faithful 2003).

Data obtained highlights very low TSS throughout all monitored sites and land uses in the Mackay Whitsunday region (Figure 15). All median concentrations were below the central Queensland water quality guideline of 10 mg/L, with the majority of sites below guideline value on 80% of occasions. This illustrates that high water clarity is prevalent throughout the Mackay Whitsunday region.

Maximum readings from the majority of sites and land uses (except bushland sites) have breached this guideline value on occasions, however TSS levels were below this figure on the majority of instances.

Bushland sites were well below guideline value on all occasions and portrayed the lowest median concentration of 0.7 mg/L followed by grazing (1.3 mg/L), grazing / intensive cropping (2.1 mg/L), intensive cropping / grazing (4.05 mg/L) and intensive cropping (4.8 mg/L) (Figure 16). Bushland sites exhibited the smallest range (0 – 4.4 mg/L), which is well beneath guideline value on every sampling occasion. This is largely due to the extensive ground cover present at these sites.

All other land uses exhibited higher TSS levels above guideline value on various occasions. A direct correlation has been made where higher TSS levels were found to have been caused by recent rainfall or excessive dry periods where the sampling site was reduced to a series of shallow muddy pools. The highest TSS level recorded was 50 mg/L which occurred at Basin Creek on November 13th, 2006. At this time, the water level was low (restricted to a shallow pool environment), with an absence of recent rainfall being prevalent.

Results indicate that high TSS levels are attributed to periods of high rainfall or drier times and are not greatly affected by the surrounding land use practice. This may not have always been the case as intensively cropped sites have had considerably higher TSS levels occurring in the past. Increasing awareness of issues posed by excessive TSS in waterways has led to encouraging results from intensively cropped sites. With the widespread adoption of green cane trash blanketing and minimum tillage, soil erosion has decreased dramatically (Rohde *et al.* 2006).

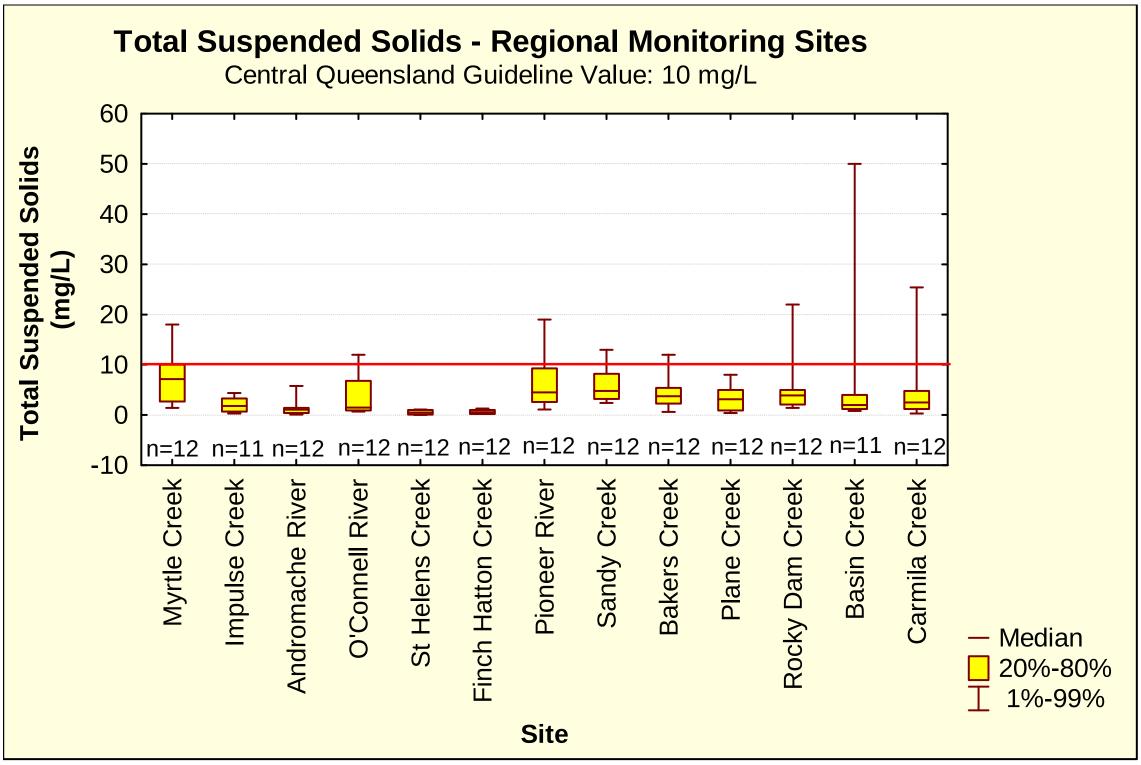

Figure 15 Total suspended solids – regional monitoring sites

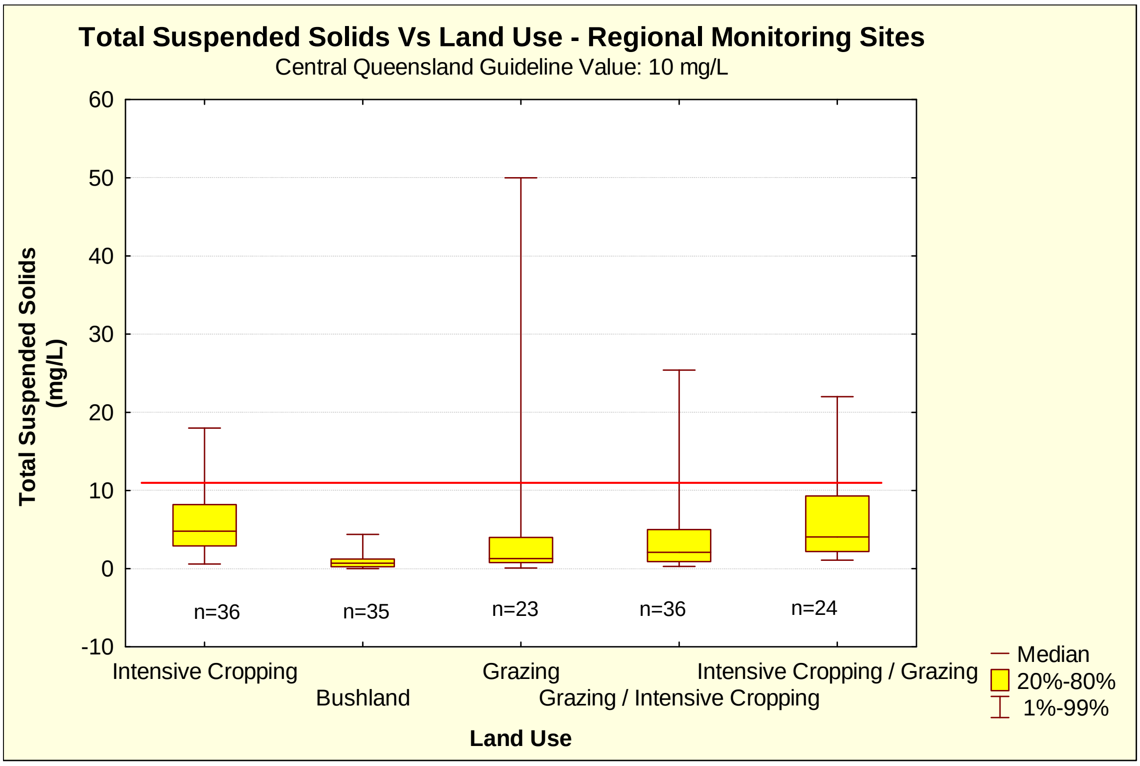

Figure 16 Total suspended solids Vs land use – regional monitoring sites

4.3 Nutrients

4.3.1 Total Nitrogen (TN)

Bushland sub-catchments can be used as a baseline water quality reference for comparisons between other land use types throughout the Mackay Whitsunday region. In saying that, it should be noted that the extreme maximum nutrient concentrations present for TN, PN, TP and PP for the St Helens Creek site should be disregarded as this is possibly a contamination error. This may have occurred in the field or from the laboratory.

The following information supports this:

1. Ignoring this large figure, the TN range for St Helens Creek would be 69 – 141 µg N/L which is far more typical of this environment.

2. TSS levels for the same period equal <0.2 mg/L

Despite this outlier, bushland sites exhibited the lowest median TN concentration of 111.5 µg N/L, followed by grazing (201 µg N/L), grazing / intensive cropping (289 µg N/L), intensive cropping / grazing (356 µg N/L) and intensive cropping (957 µg N/L).

TN concentrations were below the central Queensland water quality guideline of 500 µg N/L at all of the sampling sites except for intensively cropped sites. The median concentration for Myrtle Creek was 854 µg N/L, Sandy Creek 709 µg N/L and Bakers Creek 1996 µg N/L. Bakers Creek possesses a maximum which is nearly 4 times the guideline value. These high TN values may be proportional to the amount of sugar cane comprising the catchment the stream lays within (Myrtle Creek 32% sugar cane, Sandy Creek 51% sugar cane and Bakers Creek 61% sugar cane). The Bakers Creek catchment is the most intensively cropped catchment in the entire Mackay Whitsunday region.

An extremely high TN concentration of 6091 µg N/L occurred at Bakers Creek on December 13th, 2006. This concentration was approximately three times higher than the median. On this date, the creek was moderately flowing as a result of 70 mm of rain falling within the week previous to sampling. One month after this extremely high level of TN, an extremely low dissolved oxygen level of 1.2% saturation was recorded (the lowest recorded at this site). This may have been due to an algal bloom which occurred as a result of the extremely high TN concentrations 1 month earlier.

The long term application of N–based fertilisers in intensively cropped catchments may account for these high concentrations.

4.3.2 Particulate Nitrogen (PN)

PN concentrations were moderately variable between individual sites, however little variation between median land use concentrations was present.

Median values for individual sites were below 245 µg N/L, with the highest median value occurring at Bakers Creek (Figure 17). Sandy Creek and Myrtle Creek all displayed slightly lower but still relatively high median concentrations of 110 µg N/L and 112 µg N/L respectively. These 3 sites collectively make up the intensive cropping land use category which exhibits the highest median (142.5 µg N/L) (Figure 18). Intensive cropping / grazing, grazing / intensive cropping, grazing and bushland sites exhibited median PN concentrations of 114 µg N/L, 66.5 µg N/L, 44.5 µg N/L and 22 µg N/L respectively.

The Andromache River (grazing) presented relatively low and consistent PN concentrations which may be reflective of consistently good ground cover.

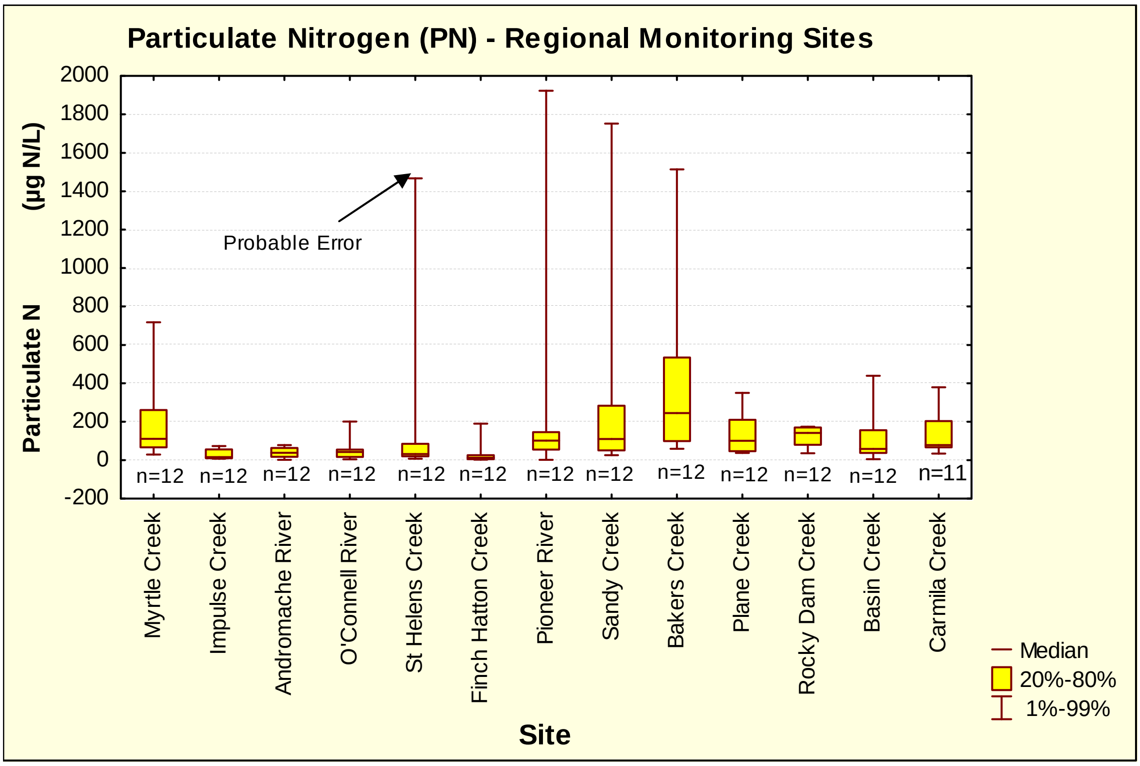

Figure 17 Particulate nitrogen – regional monitoring sites

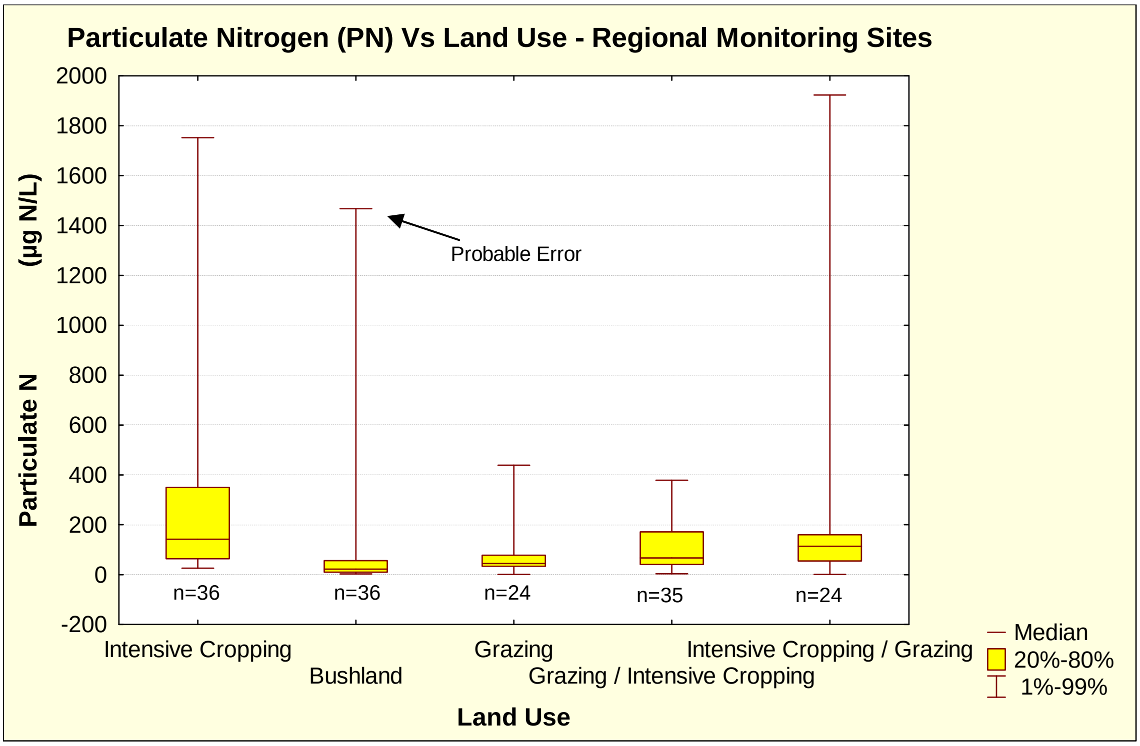

Figure 18 Particulate nitrogen Vs land use – regional monitoring sites

4.3.3 Dissolved Organic Nitrogen (DON)

DON concentrations within bushland sites were similar, with concentrations ranging from 11 – 174 µg N/L. Impulse Creek had the highest median concentration of 111.5 µg N/L.

Intensively cropped sites portrayed the highest median value of 290 µg N/L, with an extreme value of 1744 µg N/L at Sandy Creek and 3891 µg N/L occurring at Bakers Creek. Both of these high readings were obtained from samples collected on December 13th, 2006, where 70 mm of rain had fallen within the week previous.

Grazing sites (Basin Creek and the Andromache River) exhibited medians of 124 and 170 µg N/L respectively. These sites showed limited variability with concentrations ranging between 68 and 295 µg N/L.

Grazing / intensive cropping and intensive cropping / grazing sites were similar with medians of 161 µg N/L and 193 µg N/L respectively with ranges between 60 – 520 µg N/L and 30 – 444 µg N/L.

4.3.4 Ammonia

Median ammonia concentrations were low between land uses. Bushland, grazing, grazing / intensive cropping and intensive cropping / grazing sites displayed medians of 4 µg N/L, 6 µg N/L, 5 µg N/L and 3 µg N/L respectively. Elevated concentrations of ammonia were more evident in intensively cropped catchments with a median concentration of 34.4 µg N/L. Like DON, the elevated ammonia levels of 533 µg N/L and 477 µg N/L for Sandy Creek and Bakers Creek can be attributed to runoff from the 70 mm of rain which fell the week previous to sampling on December 13th, 2006.

4.3.5 Nitrite

Nitrite is a highly toxic form of nitrogen and is formed by the breakdown of ammonia and ultimately results in the formation of nitrate which is a much more stable, less toxic form of N. The conversion of ammonia to nitrite usually occurs approximately 10 days into the cycle (Kelley *et al.* 2006).

Low nitrite concentrations occurred between intensive cropping, bushland, grazing, grazing / intensive cropping and intensive cropping / grazing sites. Median concentrations were 5.15 µg N/L, 1 µg N/L, 0.85 µg N/L, 1 µg N/L and 0.90 µg N/L, respectively. The highest concentrations occurred at Sandy Creek and Bakers Creek after rainfall.

4.3.6 Nitrate

A central Queensland water quality guideline value of 420 µg N/L exists for this particular species of N.

Low concentrations of nitrate were found at bushland and grazing sites. Collectively, bushland sites had a median concentration of 6 µg N/L and a maximum of 46 µg N/L which was from St Helens Creek. Very similar results were exhibited from grazing sites, with a median of 4.55 µg N/L and maximum concentration of 48 µg N/L.

Intensive cropping / grazing sites displayed a median concentration of 3.5 µg N/L and maximum value of 273 µg N/L, illustrating concentrations below the guideline value on every occasion.

Grazing / intensive cropping sites displayed a median concentration of 5.5 µg N/L with a maximum concentration of 669 µg N/L, therefore above the guideline value on one occasion. This result came from the Carmila Creek site.

Myrtle Creek and Sandy Creek display similar median concentrations of 125.5 µg N/L and 115.5 µg N/L, however the third intensively cropped site, Bakers Creek, portrayed a much higher median value of 665 µg N/L which is well over the guideline value. Bakers Creek also possesses an extremely high maximum concentration of 3013 µg N/L. The median value for intensive cropping was 305 µg N/L, which is still below the central Queensland water quality guideline value.

4.3.7 Dissolved Inorganic Nitrogen (DIN)

The intensively cropped sites of Myrtle Creek, Sandy Creek and Bakers Creek collectively portrayed the highest range between 4 and 3056 µg N/L, with a median of 364 µg N/L. This maximum concentration was more than four times higher than that of the next highest maximum concentration, which occurred in the grazing / intensively cropped site of Carmila Creek (692 µg N/L) (Figure 19). This maximum concentration of 3056 µg N/L occurred at Bakers Creek on May 24^{th}, 2007, after rainfall. Median concentrations of 153.7 and 213.1 µg N/L occurred at Myrtle Creek and Sandy Creek whereas a significantly larger median was recorded at Bakers Creek (805.7 µg N/L). Consistently higher readings throughout the 12 months sampling at Bakers Creek may be attributed to the higher proportion of cane within the catchment (61%) and the high adoption of N-based fertilisers within this primary land use. DIN is commonly very high in intensively cropped catchments.

Similarly, low medians were prevalent in bushland and grazing dominated sites (11 and 11.25 µg N/L, respectively) (Figure 20). Ranges were also low (3.5 – 54.2 µg N/L and 2 – 69.3 µg N/L respectively).

Grazing / intensive cropping and intensive cropping / grazing sites had concentration ranges from 3 – 692 µg N/L and 2.75 – 327 µg N/L, respectively. Their medians were 20.2 and 8 µg N/L. Higher DIN concentrations tend to exist in intensively cropped catchments, however there were also high levels in grazing / intensive cropping catchments and intensive cropping / grazing catchments. The high maximum of 692 µg N/L from Carmila Creek (grazing / intensive cropping) only occurred on one occasion, February 13th, 2007, after rainfall.

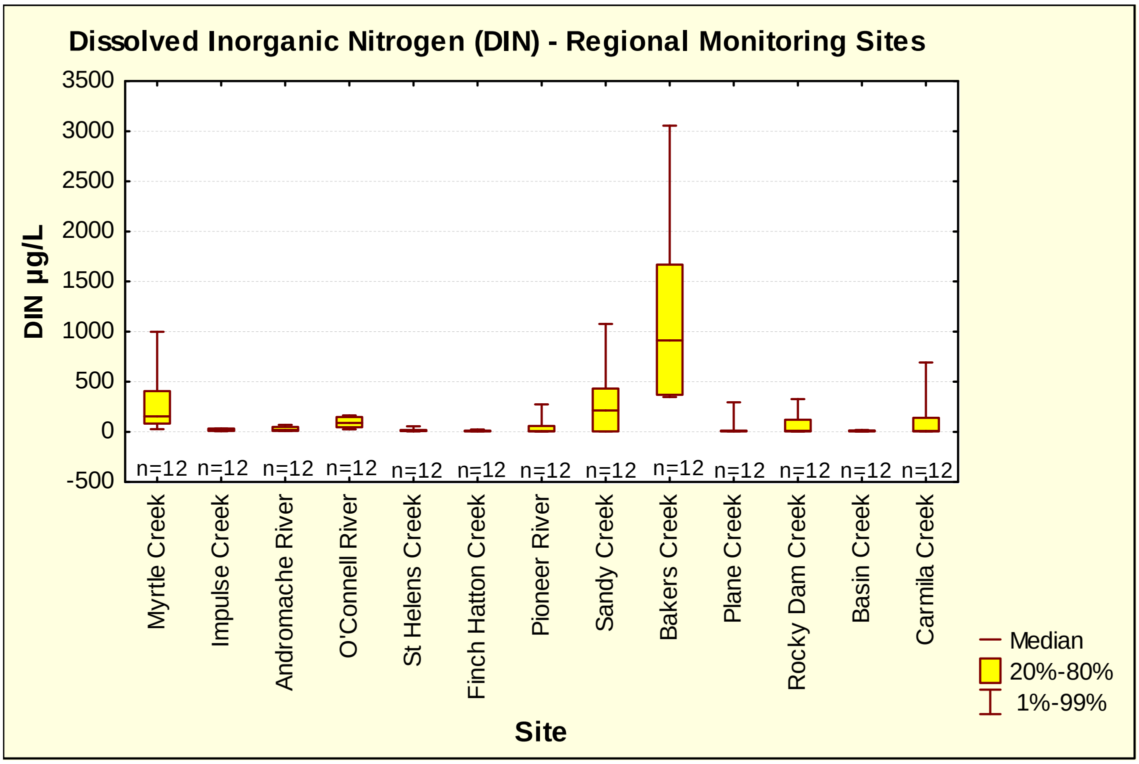

Figure 19 Dissolved inorganic nitrogen - regional monitoring sites

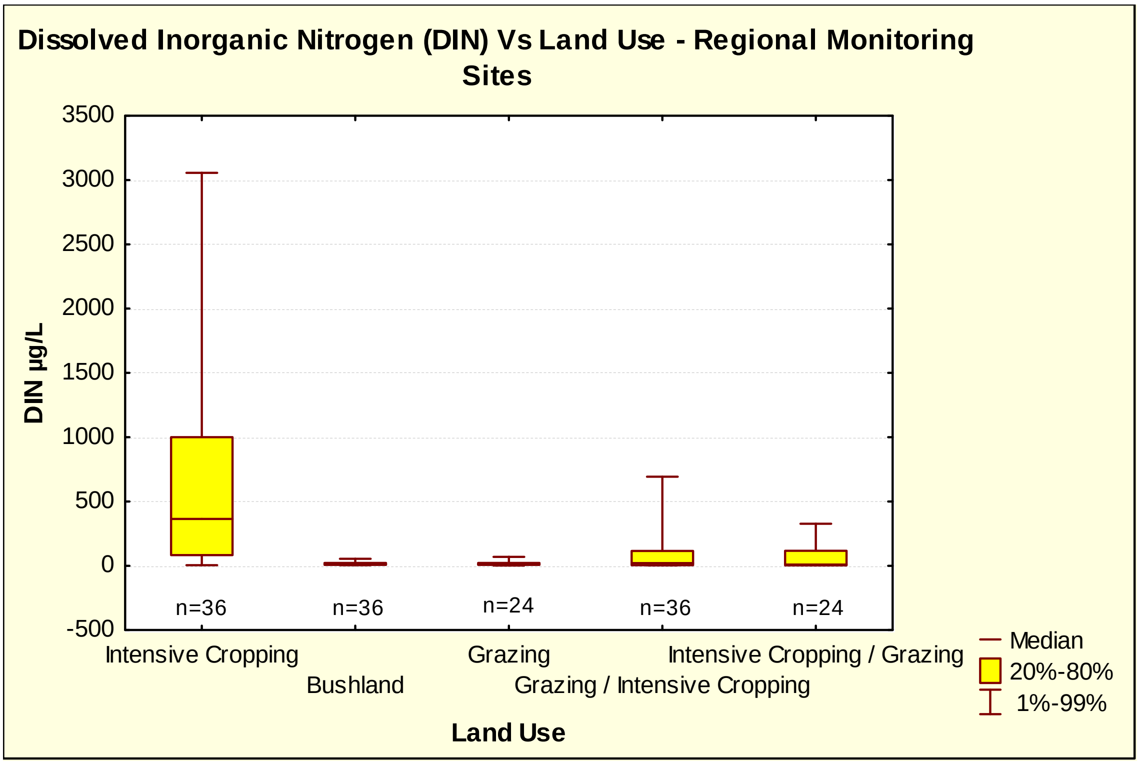

Figure 20 Dissolved inorganic nitrogen Vs land use – regional monitoring sites

4.3.8 NO_x

Low NO_x concentrations were present at bushland and grazing sites. Bushland sites ranged from 0.5 – 46.0 µg N/L with a collective median concentration of 7.15 µg N/L. St Helens Creek exhibited the highest bushland maximum of 46.0 µg N/L.

Grazing sites were reflective of bushland sites with ranges from 0.5 – 50 µg N/L and a collective median concentration of 5 µg N/L.

NO_x concentrations for intensively cropped sites were higher than any other land use types. They exhibited a median concentration of 324 µg N/L and high range (2 - 3027 µg N/L).

Grazing / intensive cropping sites and intensive cropping / grazing sites once again shared very similar median concentrations of 6 µg N/L and 4.5 µg N/L respectively, however, the Carmila Creek site displayed a reasonably high maximum concentration of 679 µg N/L which occurred on February 13th, 2007. The sample was taken almost 2 weeks after substantial rainfall (>200mm) had fallen which caused a significant rise in water height within the creek (Figure 21). Rainfall associated with these flows may have washed excess N from the surrounding land into the waterway.

The continual high concentrations of various species of N (primarily from intensively cropped catchments) illustrates the wide spread use of N based fertilisers in farming practices.

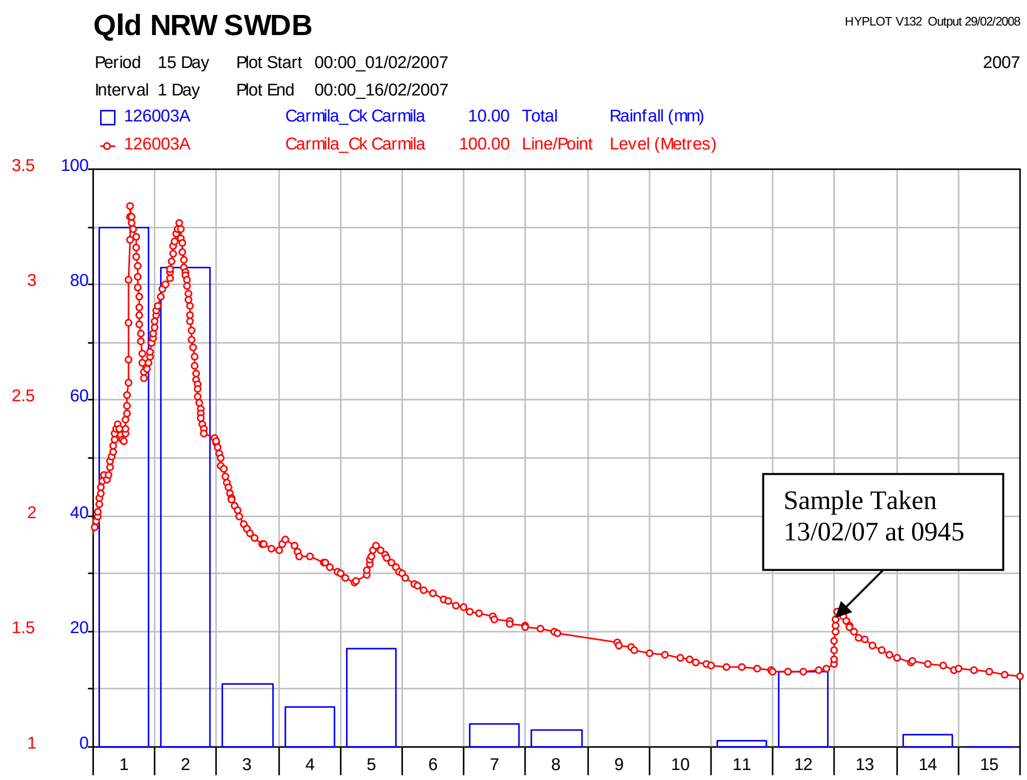

Figure 21 Carmila Creek hydrograph and rainfall plot illustrating the point at which the sample was collected

4.3.9 Total Phosphorus (TP)

St Helens Creek is a bushland site located at the base of Eungella National Park. A high TP concentration was detected in the sample obtained on May 24th, 2007. This high level of TP may be an error due to the fact that <0.2 mg/L TSS was present in the same sample. Impulse Creek ranged from 16 – 80 µg P/L and had a median of 34.9 µg P/L. The concentrations at Impulse Creek are considered to be relatively high, indicating that there are significant natural sources of P presumably from the geology of this catchment (predominantly volcanic).

Consistently high TP levels were displayed at each of the 3 intensively cropped sites. Myrtle Creek had a range between 32 and 461 µg P/L, Sandy Creek 45 - 439 µg P/L and Bakers Creek 54 - 910 µg P/L. These sites had median values of 110 µg P/L, 119 µg P/L and 138 µg P/L which are more than double the guideline value of 50 µg P/L. This indicates P-based fertilisers have been widely adopted throughout the Mackay Whitsunday region. As better nutrient management practices are adopted, the P source available for transportation to the waterway from intensively cropped areas will reduce. There is likely to be a lag time from when such practices are implemented to a marked improvement of water quality at the end of system.

Grazing sites, grazing / intensive cropping sites and intensive cropping / grazing sites contain collective medians of 38 µg P/L, 28 µg P/L, and 37 µg P/L respectively with higher maximum concentrations of 152 µg P/L obtained from grazing and grazing / intensive cropping sites on occasions.

4.3.10 Particulate Phosphorus (PP)

Bushland sites exhibited a range from 1 – 51 µg P/L, excluding an extreme value of 183 µg p/L. However as previously mentioned this extremity of 183 µg P/L can be attributed to a contamination error from St Helens Creek on May 25th, 2007. A median of 4 µg P/L was found for this site.

Bakers Creek displayed an extreme concentration 536 µg P/L which is more than 3 times higher than the next highest concentration of 159 µg P/L (Figure 22). Myrtle Creek displayed the highest 80th percentile illustrating consistently high concentrations at this site. This may be attributed to the large amount of detrital matter present at this site.

Intensively cropped sites contained the highest concentration with a collective range from 1 – 536 µg P/L and a median concentration of 42 µg P/L. (Figure 23).

Grazing sites exhibited a concentration range between 1 and 93 µg P/L and had a median concentration of 10 µg P/L.

Grazing / intensive cropping sites displayed a range between 0 and 75 µg P/L and had a median of 11 µg P/L.

Intensive cropping / grazing sites portrayed a range between 1 and 61 µg P/L and had a median concentration of 22 µg P/L. Low variability and consistent readings are prevalent throughout the intensive cropping / grazing sites.

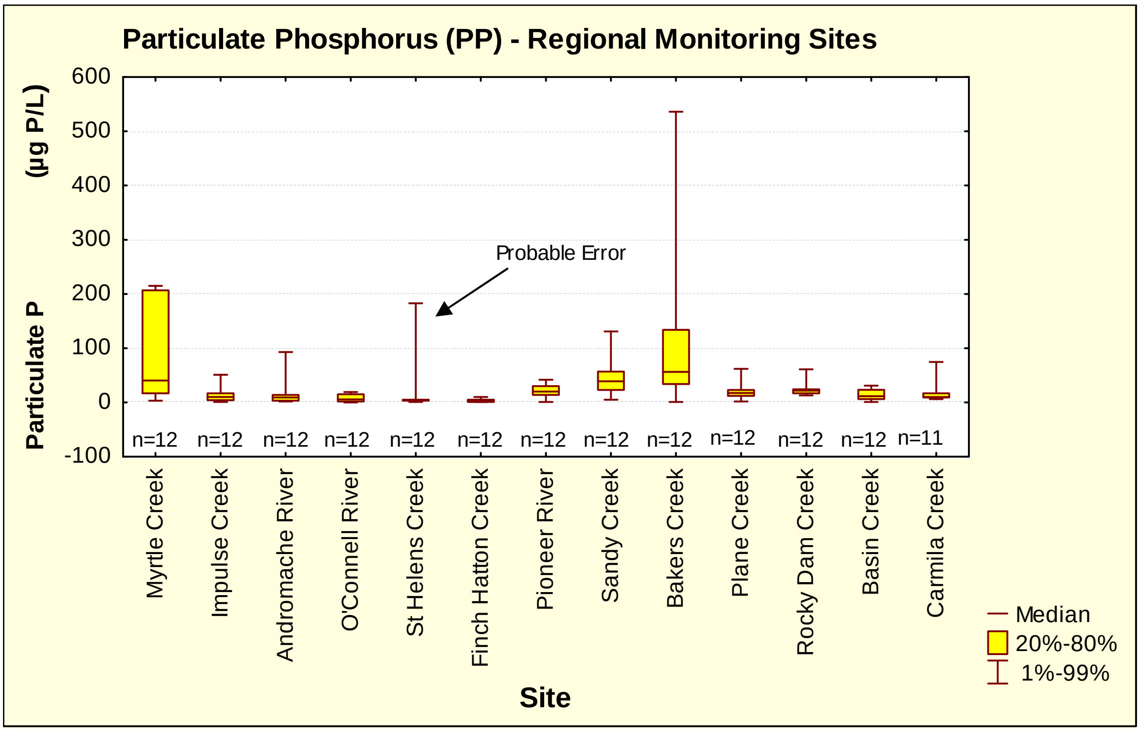

Figure 22 Particulate phosphorus – regional monitoring sites

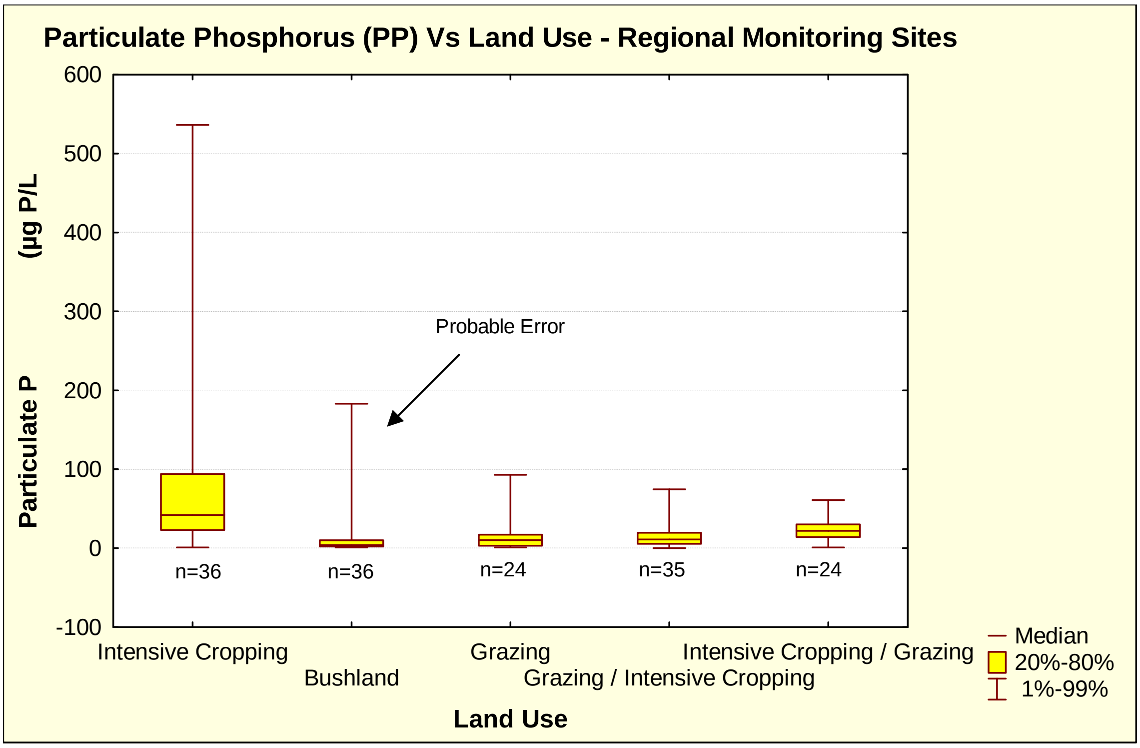

Figure 23 Particulate phosphorus Vs land use – regional monitoring sites

4.3.11 Dissolved Organic Phosphorus (DOP)

DOP concentrations were relatively consistent between the 3 bushland sites with a range between 0 and 20 µg P/L and collective median of 5 µg P/L.

The greatest range came from intensive cropping sites (2 – 601 µg P/L) with a median concentration of 22.5 µg P/L. Myrtle Creek, Sandy Creek and Bakers Creek had median concentrations of 34.5 µg P/L, 24 µg P/L and 18 µg P/L respectively. Bakers Creek displayed a maximum concentration of 601 µg P/L which was sampled on December 13th, 2006.

Grazing sites exhibited a collective range between 4 and 46 µg P/L with a median concentration of 15 µg P/L. The Andromache River and Basin Creek differ significantly with the median concentration for the Andromache River being 24.9 µg P/L and 7 µg P/L for Basin Creek.

The median concentration for the Andromache River is actually higher than the intensively cropped sites of Sandy and Bakers Creek. Results obtained throughout 12 months of sampling at the Andromache River indicates consistently high variability, with higher concentrations prevalent after rainfall. The headwaters of the Andromache River catchment have previously been known to exhibit naturally high P concentrations (Faithful 2003).

Grazing / intensive cropping and intensive cropping / grazing sites have very similar median concentrations of 8.8 and 9 µg P/L respectively. Intensive cropping / grazing sites have a very similar range (0.5 – 19 µg P/L) indicating consistent readings.

Grazing / intensive cropping sites had a higher range (1 – 64 µg P/L) with the maximum occurring at the O'Connell River. The median DOP concentration for this land use was 8.8 µg P/L.

4.3.12 Filterable Reactive Phosphorus (FRP)

FRP is the most readily available form of phosphorus used by aquatic plants. Flow on effects from high phosphorus levels within a waterway can be potentially devastating to all forms of aquatic life. Increased nutrient levels or "eutrophication" can cause toxic algal blooms, thus lowering dissolved oxygen concentrations through the night when algae respires (Brodie 2004). A central Queensland water quality guideline value of 20 µg P/L exists for FRP.

Naturally high P levels are common at the Andromache River site (Faithful, 2003) accounting for the higher than guideline, median concentration of 21.5 µg P/L (Figure 24). The Andromache River is the only site with the exception of Myrtle Creek, Sandy Creek and Bakers Creek (intensive cropping sites) that is higher than guideline value.

Median FRP concentrations between bushland, grazing, grazing / intensive cropping and intensive cropping / grazing sites were similar (Figure 25). These low concentrations were 6.5 µg P/L, 5 µg P/L, 5 µg P/L and 6 µg P/L respectively. A median concentration of 47 µg P/L was present for intensively cropped sites. FRP makes up a substantial proportion of the P signature which indicates that land management is of fundamental importance in the reduction of P to neighbouring waterways.

Previous studies have indicated that there is a substantial lag between the application of land management strategies in intensive cropping sites to improvements of detectable levels in downstream water quality, especially for P, due to high residual concentrations of P in cane fields.

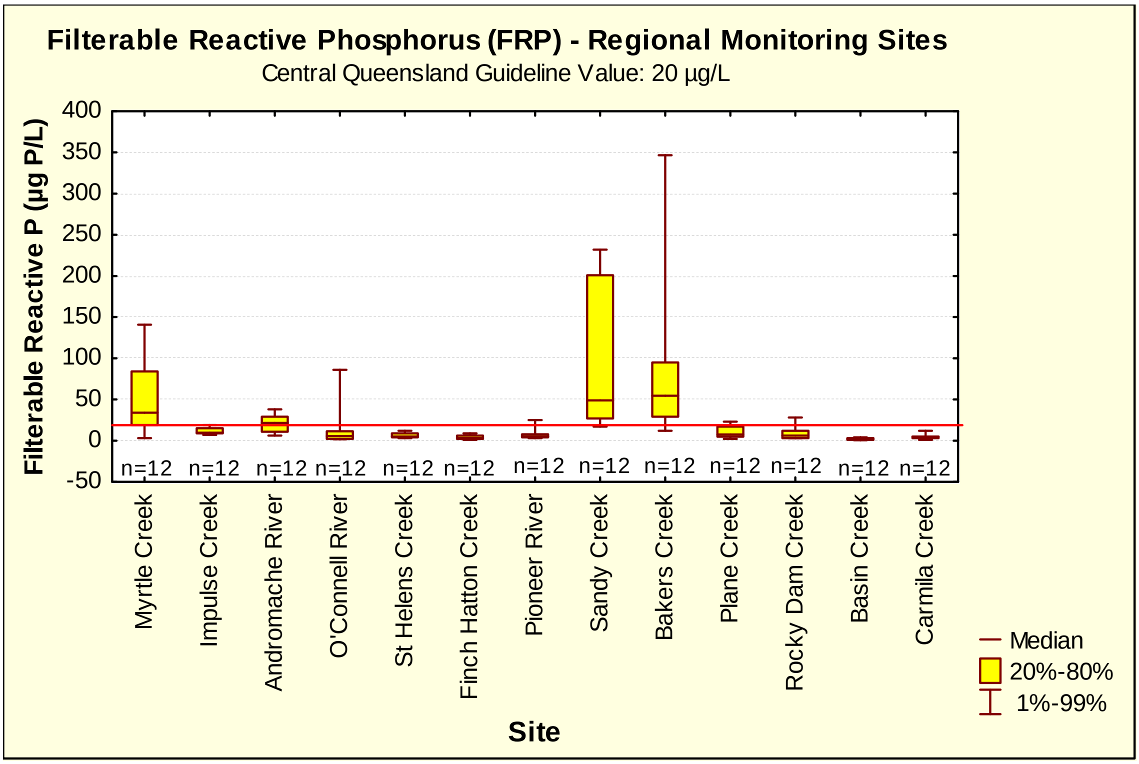

Figure 24 Filterable reactive phosphorus – regional monitoring sites

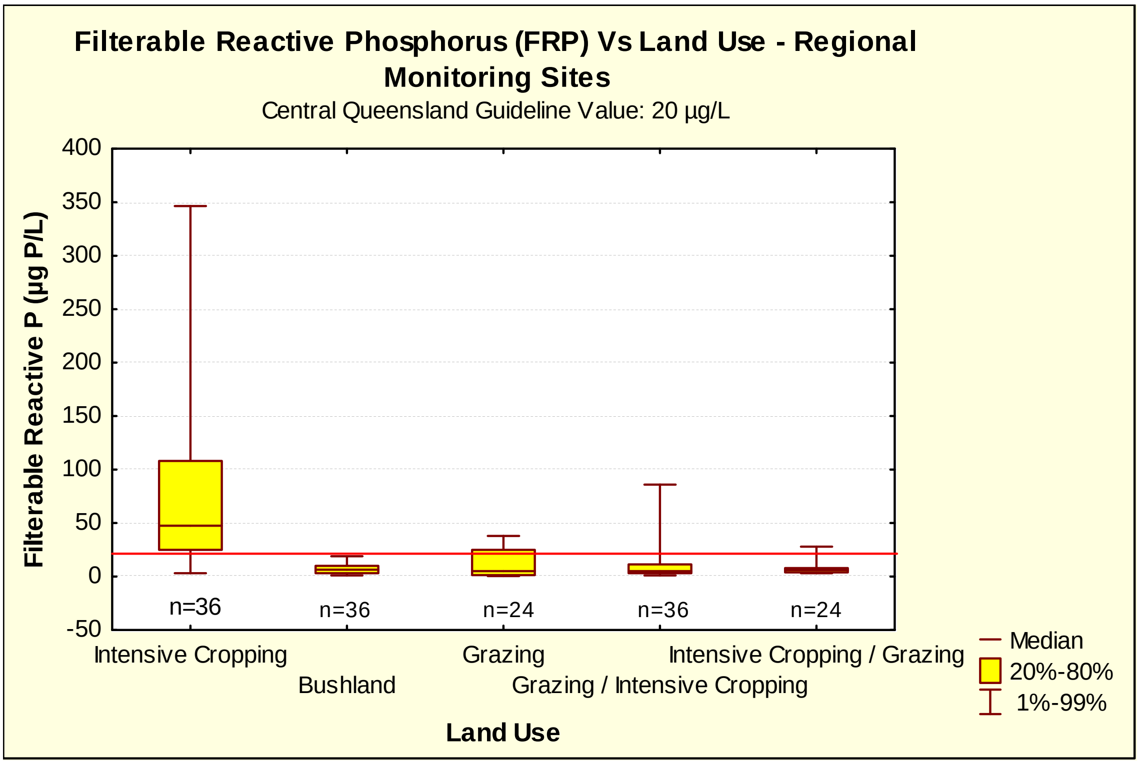

Figure 25 Filterable reactive phosphorus Vs land use– regional monitoring sites

4.4 Herbicides

4.4.1 Ametryn

Intensively cropped sites exhibited the highest range and highest median concentrations of ametryn. The range was between <0.01 - 0.47 µg/L, with a median concentration of 0.02 µg/L. Myrtle Creek and Sandy Creek exhibited median concentrations of 0.04 and 0.02 µg/L, respectively (Figure 26). Lower concentrations were obtained from Bakers Creek, with a median concentration of 0.01 µg/L. Ametryn is highly soluble in water, therefore leaches when high amounts of water is present.

Ametryn was not detected from bushland sites, except for a single detection of 0.03 µg/L at Impulse Creek. This sample was taken on May 14th, 2007. On this sampling occasion the water level in the creek was high and rainfall occurred within 24 hours previous to sampling, and may be a result of the spraying of weeds within the National Park.

Ametryn was not detected at any of the grazing sites (Figure 27).

Grazing / intensive cropping sites exhibited a range between <0.01 - 0.03 µg/L.

Intensive cropping / grazing sites had a range between <0.01 - 0.11 µg/L, and exhibited a median concentration of 0.01 µg/L. Rocky Dam Creek had a median of 0.02 µg/L, and the Pioneer River <0.01 µg/L. Rocky Dam Creek exhibited consistent ametryn concentrations on every sampling occasion whereas the Pioneer River only had the one reading of 0.05 µg/L.

Ametryn is one of the 4 most heavily used herbicides in intensively cropped catchments within the Mackay Whitsunday region.

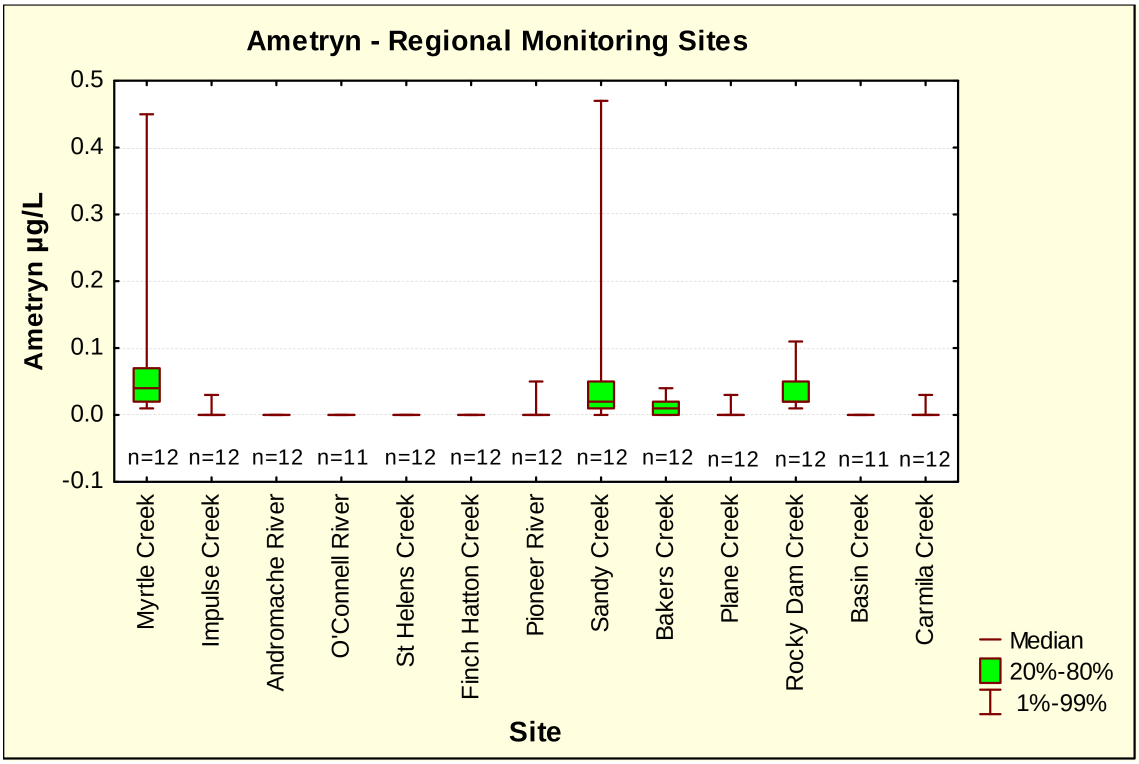

Figure 26 Ametryn – regional monitoring sites

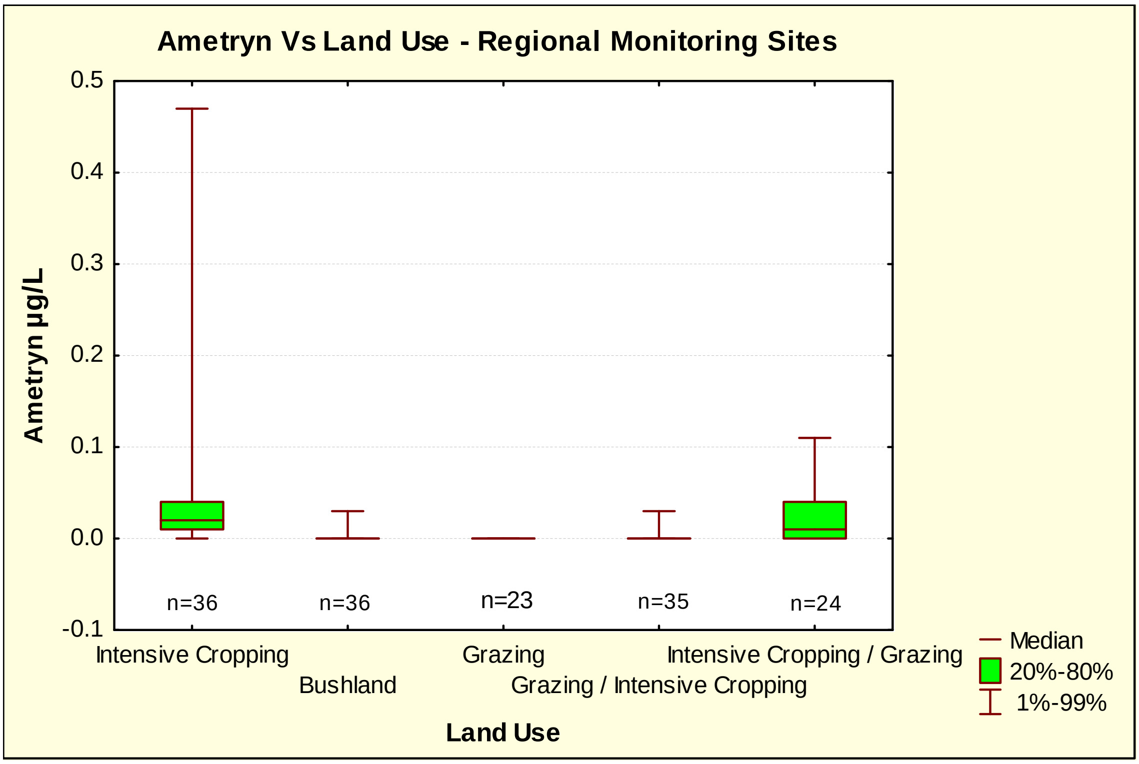

Figure 27 Ametryn Vs land use – regional monitoring sites

4.4.2 Atrazine

Intensively cropped sites displayed a concentration range between 0.01 – 14 µg/L with a median concentration of 0.11 µg/L. The concentration of 14 µg/L occurred at Bakers Creek on October 18th, 2006 (Figure 28).

Atrazine was only detected on one occasion at bushland sites (Impulse Creek, 0.02 µg/L)

Atrazine was below detectable limits at all grazing sites (Figure 29).

Grazing / intensive cropping sites displayed a range between <0.01 – 2.2 µg/L, with a median of <0.01 µg/L. The O'Connell River ranged from <0.01 – 0.03 µg/L, Carmila Creek ranged from <0.01 – 0.05 µg/L and Plane Creek exhibited the highest range within this land use of <0.01 – 2.2 µg/L.

Intensive cropping / grazing sites exhibited a range between <0.01 – 1.7 µg/L and a median concentration of 0.01 µg/L. Median concentrations for the Pioneer River and Rocky Dam Creek were similar (0.015 µg/L and <0.01 µg/L respectively) however there was a maximum of 1.7 µg/L occurring in the Pioneer River.

Atrazine is one of the 4 most heavily used herbicides adopted for use in intensively cropped catchments within the Mackay Whitsunday region.

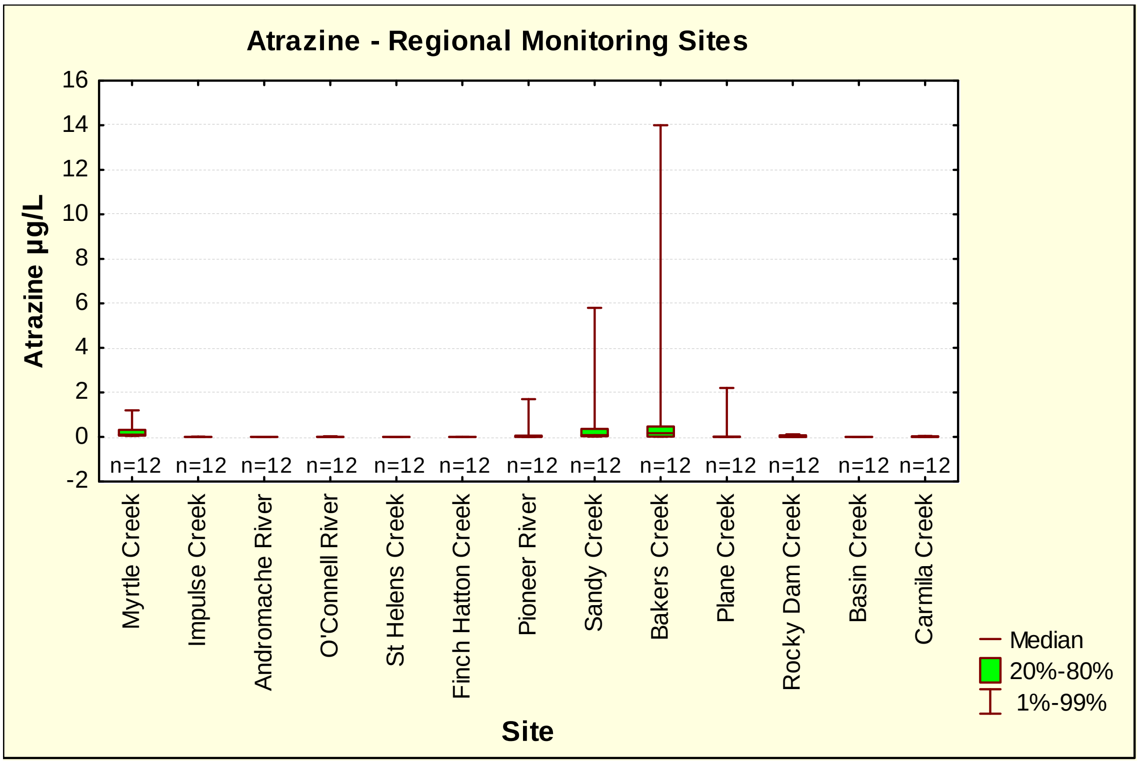

Figure 28 Atrazine – regional monitoring sites

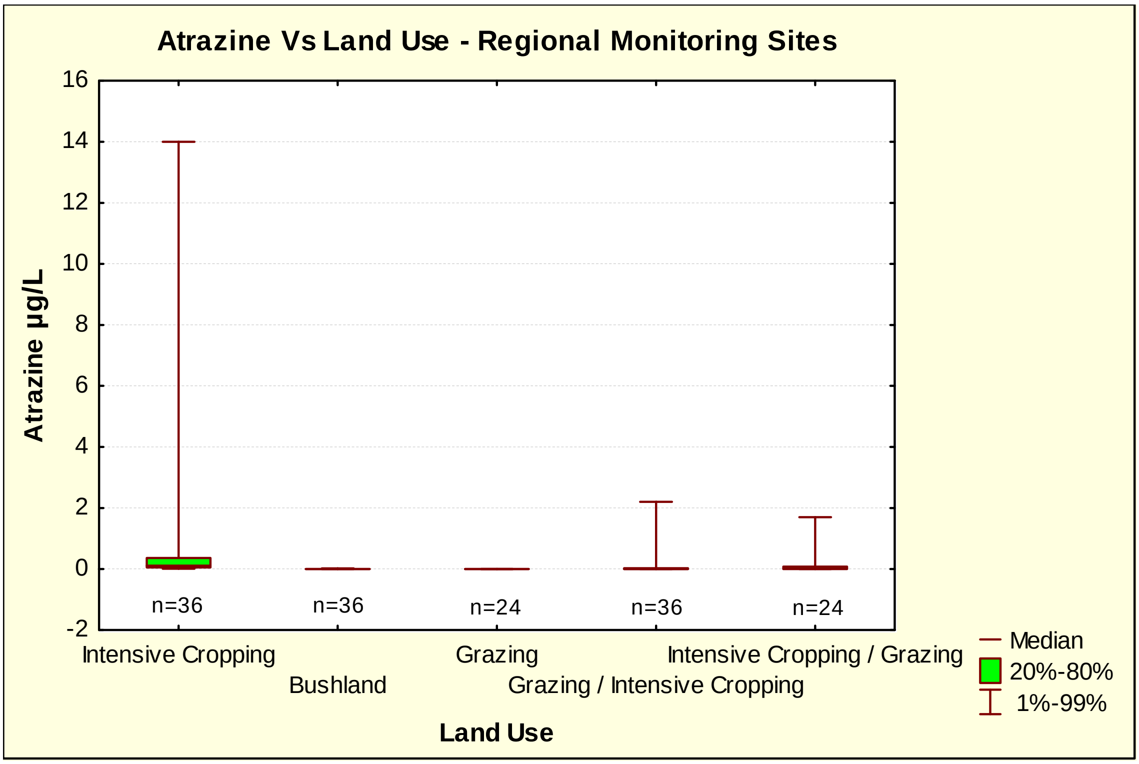

Figure 29 Atrazine Vs land use – regional monitoring sites

4.4.2.1 Desisopropyl Atrazine

Intensively cropped sites exhibited a range <0.01 – 0.15 µg/L, with a median of <0.01 µg/L.

Desisopropyl Atrazine was not detected at any bushland and grazing dominated sites within the 12 months of sampling.

Grazing / intensive cropping sites exhibited a range <0.01 – 0.05 µg/L and median of <0.01 µg/L. These 3 individual sites varied with a low concentration of 0.01 µg/L at the O'Connell River and a concentration of 0.05 µg/L was sampled on one occasion from Plane Creek. Desisopropyl atrazine was not detected at Carmila Creek.

Intensive cropping / grazing sites displayed a range <0.01 – 0.05 µg/L with a median <0.01 µg/L.

4.4.2.2 Desethyl Atrazine

Intensively cropped sites displayed a range from 0.01 – 0.57 µg/L and exhibited a median concentration of 0.03 µg/L. Sandy Creek and Bakers Creek exhibited the highest maximum concentrations of 0.57 µg/L and 0.45 µg/L. These levels occurred after 70 mm of rainfall (Figure 30).

Desethyl atrazine was not detected at any of the bushland or grazing sites.

Grazing / intensive cropping sites ranged from <0.01 – 0.16 µg/L, with this highest concentration occurring at Plane Creek. A median of <0.01 µg/L was present from the O'Connell River and desethyl atrazine was not detected at Carmila Creek.

Intensive cropping / grazing sites displayed a median of <0.01 µg/L.

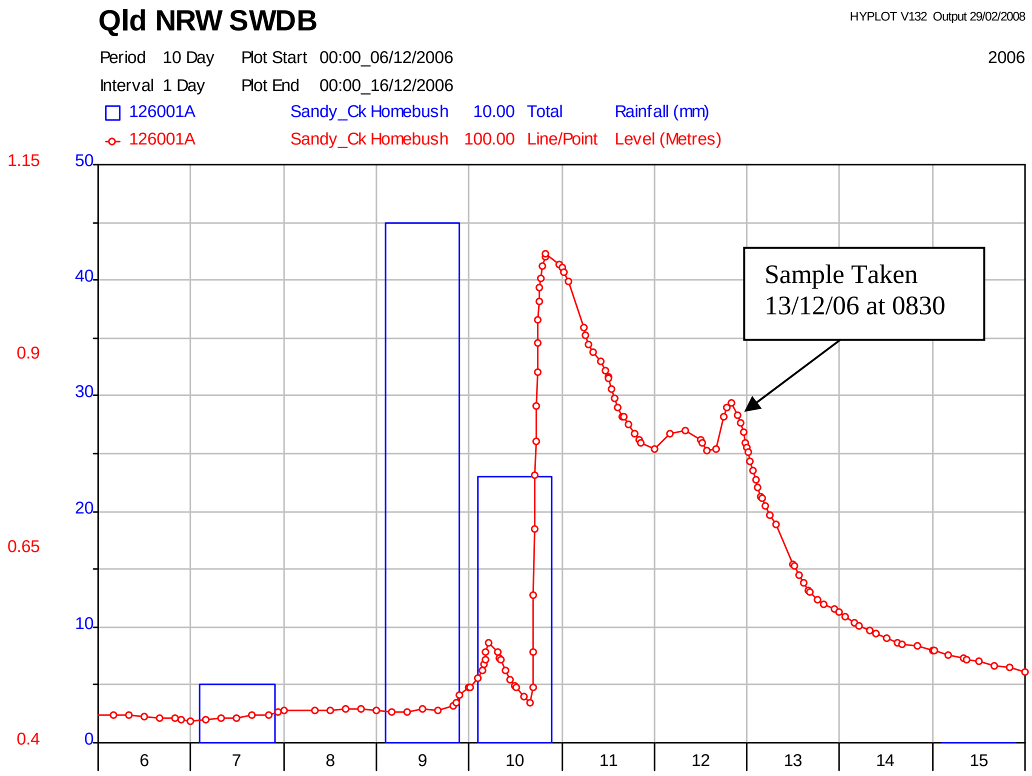

Figure 30 Sandy Creek hydrograph and rainfall plot illustrating the point at which the sample was collected (sample taken at 0830 on December 13th, 2006 – 0.57 µg/L)

4.4.3 Diuron

Effects of diuron on GBR corals and inshore marine organisms are of particular concern, due to its high solubility, long half-life and potential toxicity (Negri *et al.* 2005). A diuron toxicity study on GBR corals showed that some corals were extremely sensitive, exhibiting irreversible bleaching even at very low concentrations (Negri *et al.* 2005).

Intensively cropped catchments exhibited the largest range in diuron concentrations (0.05 – 14 µg/L) with an overall median of 0.12 µg/L. Myrtle Creek ranged from 0.05 – 0.58 µg/L, Sandy Creek 0.07 – 6.4 µg/L and Bakers Creek 0.06 – 14 µg/L (Figure 31). Median values were consistently low with regards to the maximum levels but relatively high compared to the other land uses. Medians between these 3 sites were: Myrtle Creek 0.105 µg/L, Sandy Creek 0.185 µg/L and Bakers Creek 0.11 µg/L.

Low diuron concentrations were found at one bushland and various grazing sites (Figure 32). The bushland site, Impulse Creek, recorded only one reading of 0.01 µg/L which occurred after 20 mm of localised rainfall. The grazing site, Basin Creek, had a concentration of 0.02 µg/L on one sampling occasion.

Grazing / intensive cropping sites ranged between <0.01 – 1.6 µg/L, with the maximum recorded at Plane Creek. The median was <0.01 µg/L.

The intensive cropping / grazing sites had a collective range of 0.01 – 2.2 µg/L, with individual sites exhibiting high variability (Pioneer River 0.01 – 2.2 µg/L and Rocky Dam Creek 0.04 – 0.37 µg/L). Median concentrations for these two sites were 0.02 and 0.06 µg/L respectively.

Diuron is one of the 4 most heavily adopted herbicides used in intensively cropped catchments within the Mackay Whitsunday region.

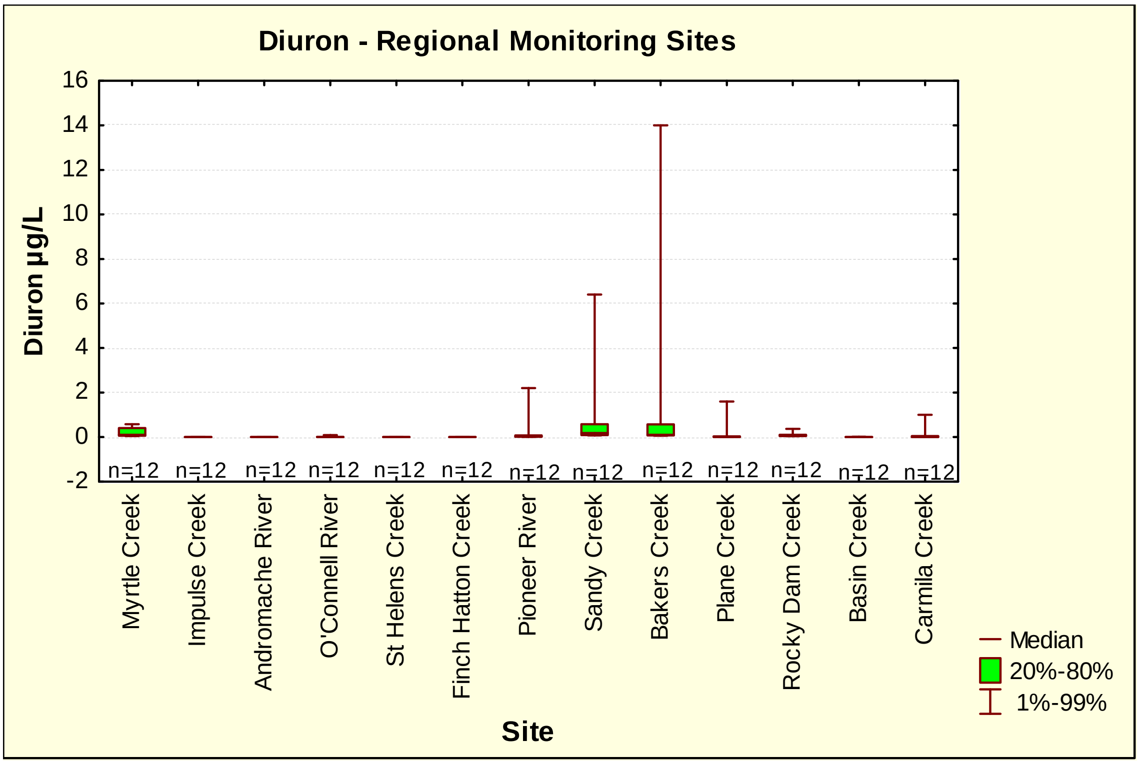

Figure 31 Diuron – regional monitoring sites

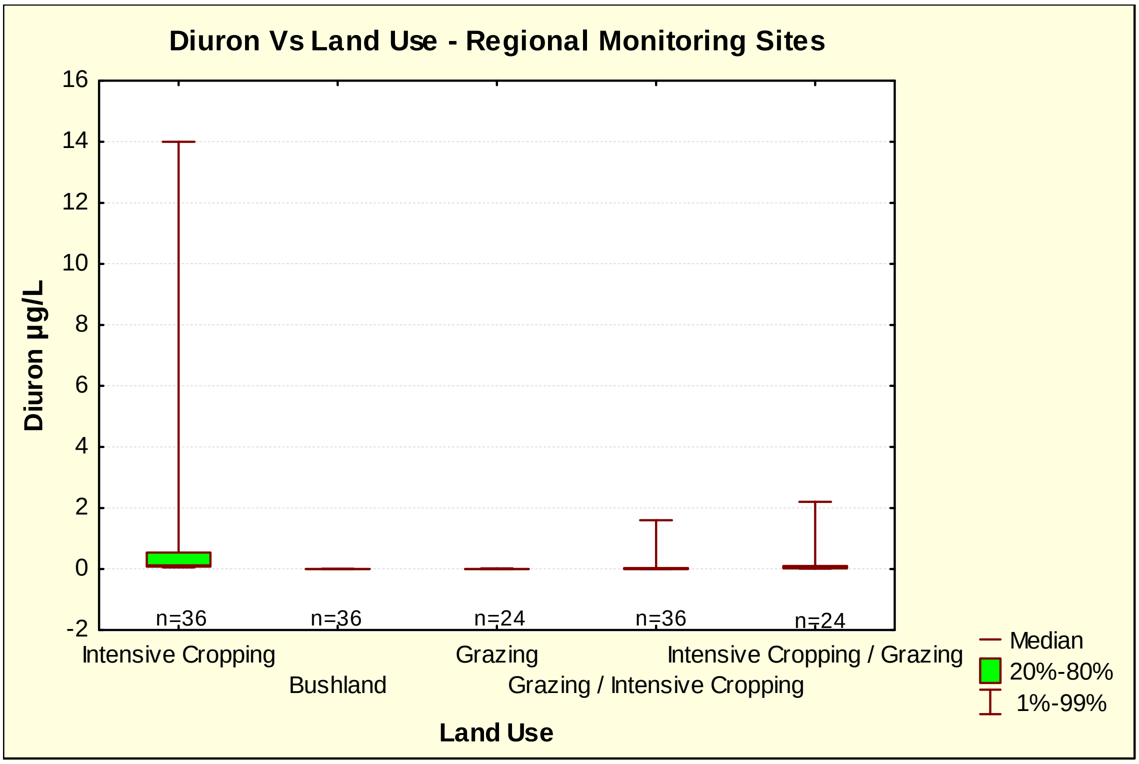

Figure 32 Diuron Vs land use – regional monitoring sites

4.4.4 Hexazinone

Intensively cropped sites ranged from 0.01 – 4.3 µg/L and exhibited a median concentration of 0.14 µg/L. Individual sites displayed similar median concentrations. (Myrtle Creek 0.08 µg/L, Sandy Creek 0.195 µg/L and Bakers Creek 0.14 µg/L) (Figure 33).

Hexazinone was not detected in any of the bushland or grazing dominated sites (Figure 34).

Significant variability occurred within the grazing / intensive cropping sites. The O'Connell River ranged from <0.01 – 0.04 µg/L, Plane Creek 0.02 – 1.2 µg/L and Carmila Creek <0.01 – 0.46 µg/L. Median concentrations were <0.01 µg/L, 0.04 µg/L and 0.01 µg/L respectively.

Intensive cropping / grazing sites collectively portrayed a range between <0.01 – 1.0 µg/L and had a median concentration of 0.10 µg/L. Individually, the Pioneer River exhibited a range between <0.01 – 1.0 µg/L (median 0.02 µg/L) and Rocky Dam Creek 0.09 – 0.38 µg/L (median 0.13 µg/L).

Hexazinone is one of the 4 most heavily adopted herbicides used in intensively cropped catchments within the Mackay Whitsunday region.

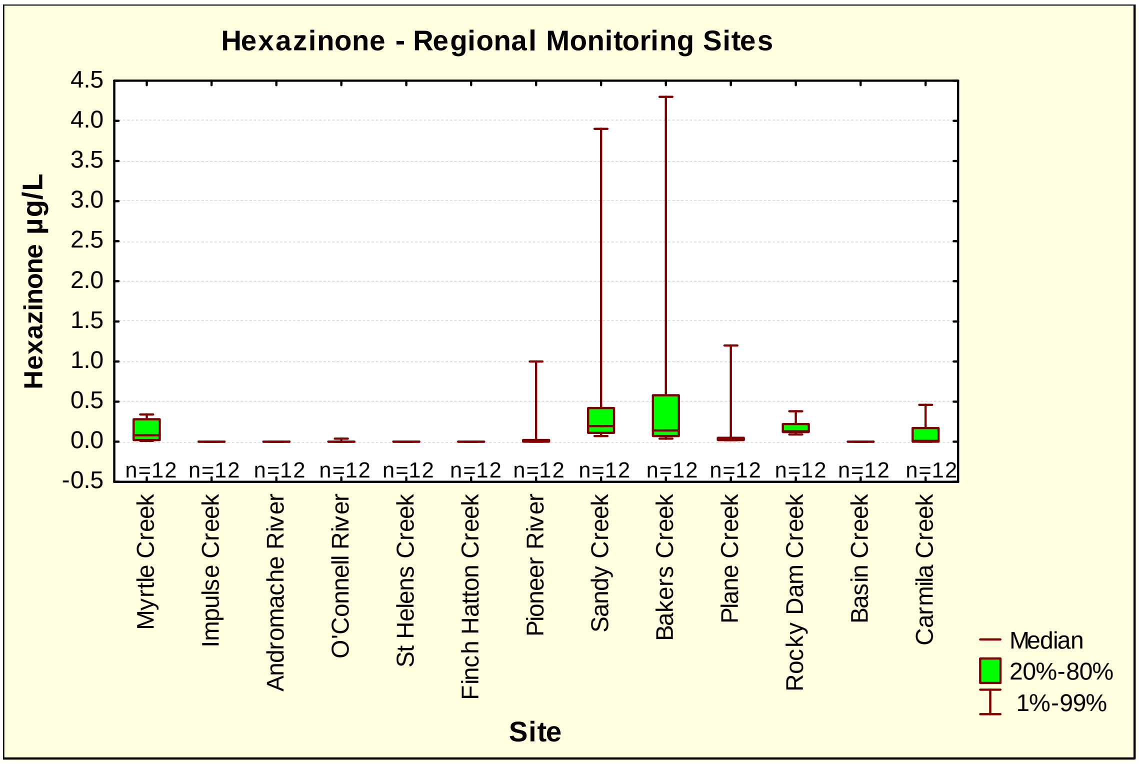

Figure 33 Hexazinone – regional monitoring sites

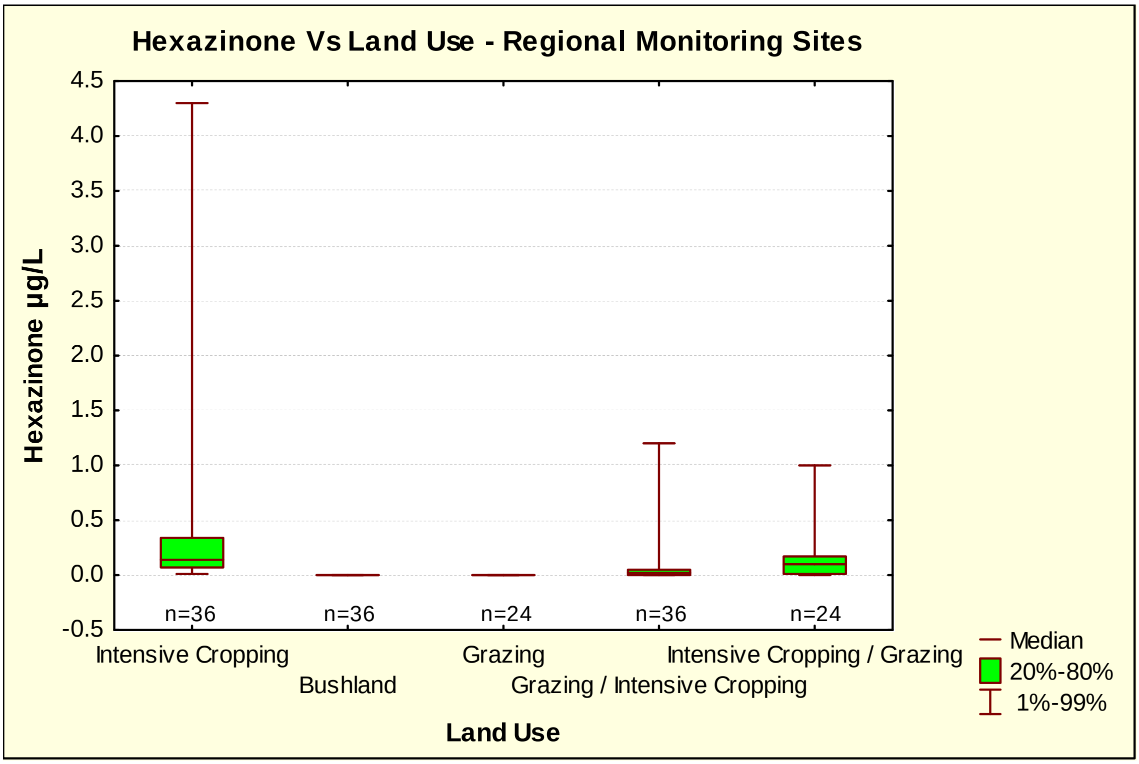

Figure 34 Hexazinone Vs land use – regional monitoring sites

4.4.5 Tebuthiuron

Intensively cropped sites ranged from <0.01 – 0.4 µg/L and displayed a median concentration of <0.01 µg/L. Individually, Tebuthiuron was not detected at Myrtle Creek, low concentrations on 3 out of the 12 sampling occasions were detected at Sandy Creek whereas Bakers Creek exhibited a low reading of 0.04 µg/L on just one occasion (Figure 35).

Tebuthiuron was not detected in any of the bushland sites (Figure 36).

Grazing sites exhibited a range from <0.01 – 0.02 µg/L. This maximum reading was only on the one sampling occasion and occurred at the Andromache River.

Tebuthiuron was not detected in any of the grazing / intensive cropping and intensive cropping / grazing sites.

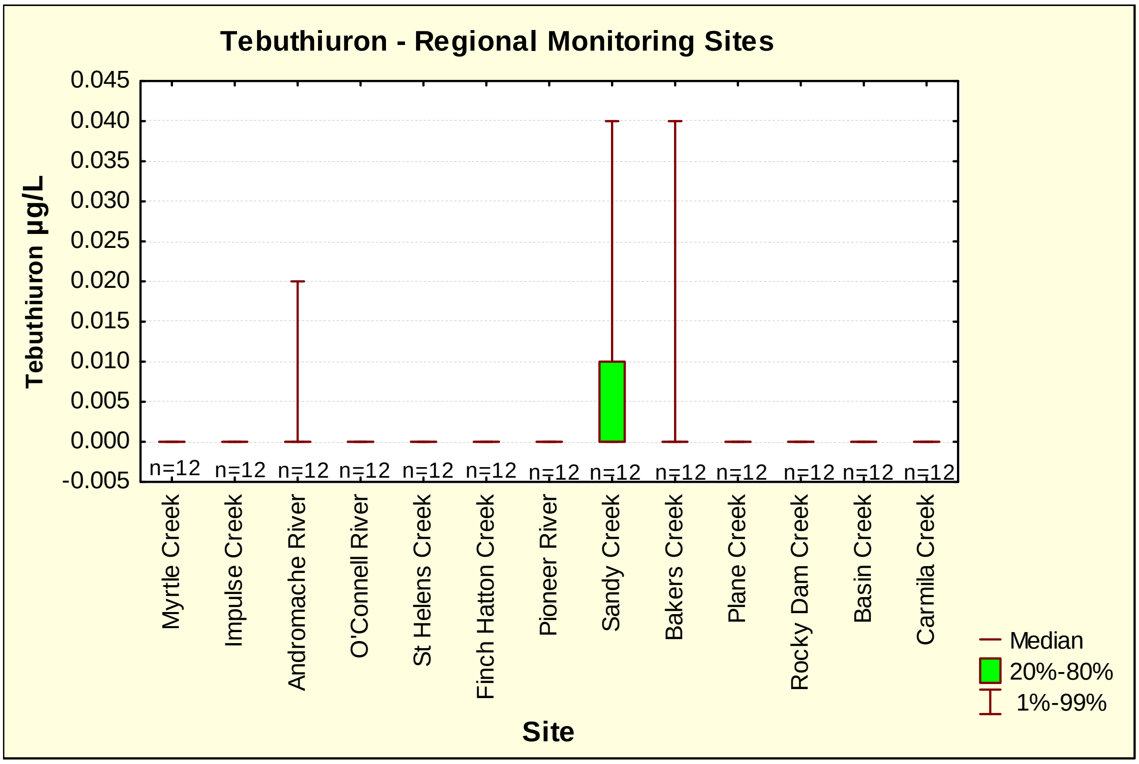

Figure 35 Tebuthiuron – regional monitoring sites

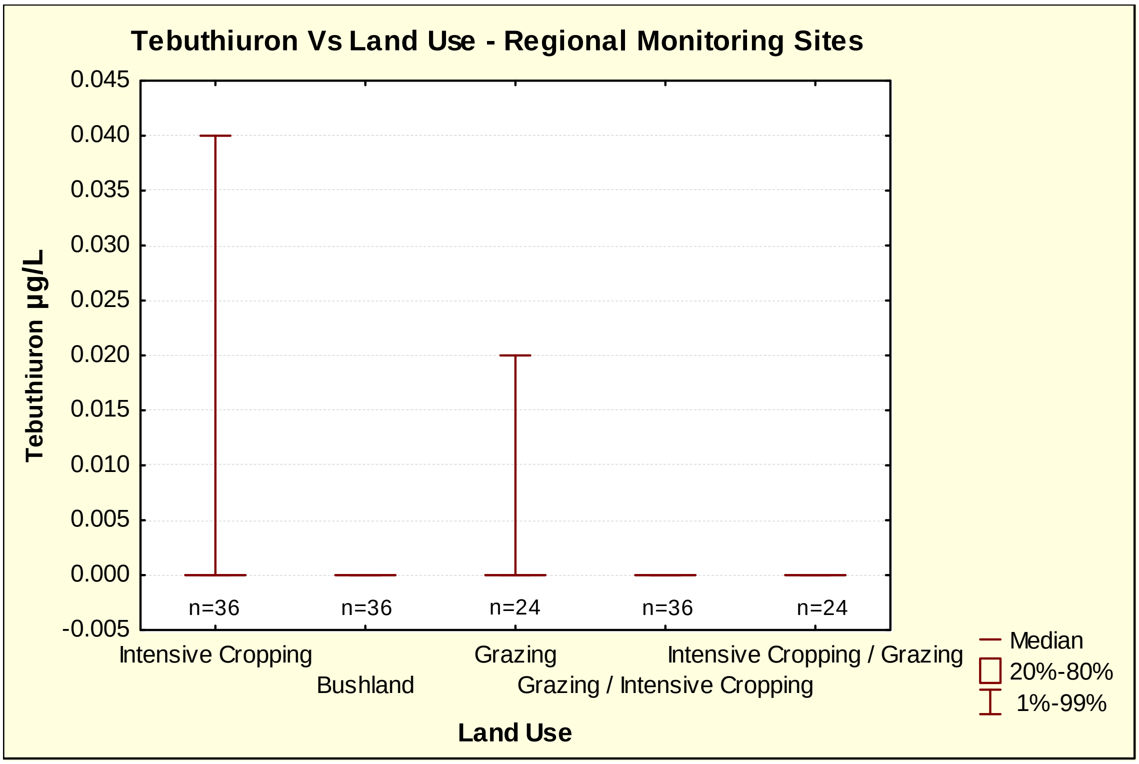

Figure 36 Tebuthiuron Vs land use – regional monitoring sites

4.4.6 Other Herbicides

4.4.6.1 Bromacil

Bromacil is not a widely used herbicide within the Mackay Whitsunday region. Low bromacil detections were found in the intensively cropped catchments of Myrtle Creek and Sandy Creek. A range between <0.01 – 0.02 µg/L and median concentration of 0.02 µg/L was prevalent at the Bakers Creek site.

Bromacil was not detected at any of the bushland or grazing dominated sites.

Grazing / intensively cropped sites exhibited a range of <0.01 – 0.7 µg/L and median of <0.01 µg/L. Bromacil was not detected at the O'Connell River and Carmila Creek, but was detected on two occasions at Plane Creek (0.06 µg/L and 0.07 µg/L).

Intensive cropping / grazing sites displayed a range between <0.01 – 0.18 µg/L and median of <0.01 µg/L. Bromacil was not detected at the Pioneer River site whereas 2 detections of 0.18 and 0.17 µg/L were found at Rocky Dam Creek. Medians of <0.01 µg/L were prevalent from these sites.

4.4.6.2 Simazine

Simazine concentrations at the intensively cropped sites ranged between <0.01 – 0.05 µg/L (median <0.01 µg/L), and was detected in 4 of the 36 samples.

Simazine was not detected at any of the bushland sites.

The range between grazing sites was <0.01 – 0.03 µg/L, displaying a median concentration of <0.01 µg/L. Individually, the Andromache River did not detect simazine whereas Basin Creek only had one detection (0.03 µg/L).

Grazing / intensively cropped sites displayed a range <0.01 – 0.05 µg/L and exhibited a median concentration of <0.01 µg/L.

Plane Creek and Carmila Creek exhibited low concentrations of 0.02 µg/L and 0.03 µg/L respectively on one occasion. The O’Connell River displayed 3 detections of 0.05 µg/L, 0.02 µg/L and 0.01 µg/L.

Simazine was not detected from intensively cropped / grazing sites throughout the 12 months of baseline sampling.

4.4.6.3 Terbutryn

Myrtle Creek was the only site which contained traces of terbutryn (0.01 µg/L) and was detected on only one occasion.

5 CONCLUSIONS

The major findings for the first 12 months (July 2006 – June 2007) of baseline sampling include:

- Relatively uniform annual median water temperatures across the majority of sites and land uses. This indicates that this parameter is largely governed by the physical structure of the creek (stream depth, stream width and riparian shading) as well as seasonal variation rather than the surrounding land use practice.

- Great variability between individual sites and land uses with regard to dissolved oxygen. Intensively cropped sites (Sandy Creek, Myrtle Creek and Bakers Creek) exhibited very low dissolved oxygen levels with none of the sites reaching the minimum central Queensland water quality guideline value of 80% saturation on any occasion. Intensively cropped sited collectively displayed a median DO value of 34.2% saturation.

- pH levels from all land-use categories were well within the central Queensland water quality range (6.5 – 8.0) on 50% of occasions, with the larger majority falling within guideline range on 80% of occasions. The Andromache River was the only site whose median pH value was higher than the guideline range. This may be attributed to extensive macrophyte growth at this site as well as high calcium in the groundwater due to intermediate soils present in the upper Andromache River.

- Great variability with regards to electrical conductivity was evident between individual sites and land uses. Bushland sites displayed the lowest median value and of these the Impulse Creek site was the highest due to groundwater influences. Intensive cropping sites portrayed the highest median electrical conductivity values.

- TSS was consistently low, with a collective median of 4.8 mg/L from intensively cropped catchments. Maximum TSS concentrations which were higher than the guideline value were related to either periods of high rainfall or excessively drier times. The low TSS levels reinforce the fact that high water clarity is prevalent throughout the Mackay Whitsunday region.

- Nutrient concentrations were higher in intensively cropped sites than other land uses, particularly after substantial rainfall events. Intensively cropped sites, primarily Sandy Creek and Bakers Creek, exhibited the highest median and maximum concentrations for the majority of nitrogen and phosphorus species (eg. DIN and FRP).

- Herbicide concentrations were highest in intensively cropped sites, often after substantial rainfall. Ametryn, atrazine, hexazinone and diuron were the most commonly detected herbicides in the Mackay Whitsunday region. Bakers Creek portrayed some extremely high atrazine and diuron detections after rainfall (both 14 µg/L).

6 REFERENCES

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7 APPENDICES

7.1 Minimum, maximum, 20th, 50th and 80th percentile in-situ values for each monitoring site

Land Use	Site	Percentile	Water Temperature °C	Dissolved Oxygen % Saturation	pH	Electrical Conductivity µS/cm
Intensive Cropping	Myrtle Creek	Minimum	17.2	1.8	7.0	182
		20th	17.5	11.6	7.2	505
		50th	**22.0**	**30.3**	**7.2**	**654**
		80th	24.5	56.1	7.3	730
		Maximum	24.8	70.1	7.4	825
	Sandy Creek	Minimum	14.5	12.8	7.1	371
		20th	16.9	36.7	7.3	411
		50th	**21.6**	**45.8**	**7.4**	**527**
		80th	25.2	53.2	7.5	676
		Maximum	27.9	58.6	7.7	742
	Bakers Creek	Minimum	15.5	1.2	6.8	244
		20th	17.0	14.6	6.8	352
		50th	**21.8**	**19.2**	**6.9**	**390**
		80th	24.5	34.3	7.0	440
		Maximum	25.8	52.7	7.0	544
Bushland	Impulse Creek	Minimum	16.2	39.2	7.1	135
		20th	17.6	55.6	7.2	196
		50th	**21.6**	**85.0**	**7.3**	**255**
		80th	24.4	88.9	7.6	612
		Maximum	26.5	95.5	7.7	915
	St Helens Creek	Minimum	15.8	95.2	7.3	55
		20th	16.9	99.8	7.4	59
		50th	**21.9**	**102.8**	**7.6**	**64**
		80th	24.5	105.0	7.8	68
		Maximum	28.5	113.0	7.9	70
	Finch Hatton Creek	Minimum	14.2	94.9	7.4	41
		20th	15.1	97.3	7.4	42
		50th	**19.5**	**99.8**	**7.4**	**44**
		80th	22.2	102.2	7.5	47
		Maximum	23.3	103.8	7.7	52

Land Use	Site	Percentile	Water Temperature °C	Dissolved Oxygen % Saturation	pH	Electrical Conductivity µS/cm
Grazing	Andromache River	Minimum	19.0	83.9	8.0	309
		20th	20.1	92.6	8.0	377
		50th	**25.8**	**105.0**	**8.2**	**483**
		80th	29.5	124.9	8.3	571
		Maximum	31.3	140.9	8.8	686
	Basin Creek	Minimum	14.9	29.7	6.4	75
		20th	17.7	40.0	6.7	147
		50th	**23.0**	**63.9**	**6.9**	**193**
		80th	26.2	76.1	7.1	294
		Maximum	30.3	95.0	7.7	440
Grazing / Intensive Cropping	O'Connell River	Minimum	19.0	19.6	7.0	203
		20th	21.1	82.3	7.2	358
		50th	**26.0**	**107.3**	**7.8**	**579**
		80th	27.8	124.2	8.1	912
		Maximum	31.2	134.8	8.6	1084
	Plane Creek	Minimum	18.3	6.0	7.3	279
		20th	19.5	41.7	7.5	385
		50th	**24.0**	**62.4**	**7.6**	**462**
		80th	27.5	74.8	7.8	619
		Maximum	29.7	79.4	8.1	670
	Carmila Creek	Minimum	18.4	10.7	6.8	191
		20th	19.9	11.8	7.2	233
		50th	**25.3**	**84.7**	**7.6**	**279**
		80th	26.0	88.5	7.8	342
		Maximum	30.3	142.5	8.8	348
Intensive Cropping / Grazing	Pioneer River	Minimum	19.7	45.6	7.1	136
		20th	20.9	79.0	7.4	164
		50th	**26.5**	**90.7**	**7.6**	**183**
		80th	29.6	114.8	8.3	196
		Maximum	31.5	144.1	8.6	239
	Rocky Dam Creek	Minimum	16.0	51.4	7.2	286
		20th	20.4	65.3	7.6	475
		50th	**23.8**	**73.0**	**7.7**	**697**
		80th	27.1	78.0	7.8	800
		Maximum	30.2	103.0	8.0	837

7.2 Minimum, maximum, 20th, 50th and 80th percentile TSS and nutrient concentrations for each monitoring site

Land Use	Site	Percentile	TSS (mg/L)	TN (µg N/L)	PN (µg P/L)	DON (µg N/L)	NH_3 (µg N/L)	NO_2 (µg N/L)	NO_3 (µg N/L)	DIN (µg N/L)	NO_x (µg N/L)	TP (µg P/L)	PP (µg P/L)	DOP (µg P/L)	FRP (µg P/L)
Intensive Cropping	Myrtle Creek	Minimum	1	189	29	1	9	0.25	0.5	26.6	2	32	3	10	3
		20th	3	326	70	127	13.8	1.36	21.6	84.84	23.4	61	19	13	19.4
		50th	**7**	**854**	**112**	**199**	**28.5**	**2.9**	**125**	**153.7**	**130**	**110**	**41**	**34**	**34**
		80th	10	968	247	403	67.4	5.48	371	397.8	374	297	178	52	83.8
		Maximum	18	1345	718	599	104	12	922	999.6	927	461	215	114	140
	Sandy Creek	Minimum	2	341	26	223	1	<0.01	1	4	2	45	5	2	17
		20th	3	495	53	273	4.2	0.3	3.4	8.05	4.2	67	24	12	29.6
		50th	**5**	**709**	**110**	**405**	**19.5**	**3.7**	**115**	**213.1**	**119**	**119**	**39**	**24**	**49**
		80th	8	1198	267	548	45.2	5.88	340	419	378	307	55	56	199
		Maximum	13	3280	1752	1744	533	238	414	1077	543	439	131	162	232
	Bakers Creek	Minimum	1	688	59	31	22	0.5	246	346.3	309	54	1	9	12
		20th	2	1064	104	137	29.2	9.68	308	418.5	358	89	34	14	29.4
		50th	**4**	**1996**	**245**	**279**	**40.5**	**21**	**664**	**912.2**	**696**	**138**	**57**	**18**	**54.5**
		80th	5	2203	498	542	48	29.1	1586	1646	1603	234	125	61	92
		Maximum	12	6090	1513	3891	477	295	3013	3056	3027	510	536	601	346
Bushland	Impulse Creek	Minimum	0.2	117	7	75	2	<0.01	1	6	2	16	1	2	7
		20th	1	119	10	78	3.6	0.82	5.2	9.5	6.2	22	4	5	9
		50th	**2**	**158**	**15**	**112**	**5**	**1**	**9**	**19.95**	**9.5**	**35**	**10**	**9**	**9.5**
		80th	3	204	52	147	9.6	1.28	20	31.28	21.1	41	17	17	14.6
		Maximum	4	230	74	174	20	10	23	34	25	80	51	20	19
	St Helens Creek	Minimum	<0.01	69	7	11	2	0.25	0.5	3.75	0.5	10	1	0.5	3
		20th	<0.01	82.8	21	45	3.2	0.42	3	7.52	4.2	12	3	3.4	4
		50th	**1**	**105**	**32**	**61**	**4**	**1.1**	**5.3**	**11.2**	**7.5**	**14**	**4**	**5**	**5**
		80th	1	141	81	67	5.8	2.36	7.8	16.92	10.6	20	5	6	8.6
		Maximum	1	1553	1467	97	8	3.4	46	54.25	46	200	183	13	12
	Finch Hatton Creek	Minimum	<0.01	41	3	14	1	0.5	2	3.5	3	2	1	<0.01	1
		20th	<0.01	49	6	35	1.9	0.8	2.2	5.16	3	8.1	1.2	1.8	2
		50th	**1**	**64**	**12**	**37**	**2**	**0.95**	**4.5**	**7.55**	**6**	**11**	**3.5**	**4**	**3**
		80th	1	82	26	53	2.8	1.48	6.9	12.84	8.8	15.6	5	6	5.8
		Maximum	1	261	190	66	6	2.3	16	22.8	16	23	10	9	9

Land Use	Site	Percentile	TSS (mg/L)	TN (µg N/L)	PN (µg P/L)	DON (µg N/L)	NH_3 (µg N/L)	NO_2 (µg N/L)	NO_3 (µg N/L)	DIN (µg N/L)	NO_x (µg N/L)	TP (µg P/L)	PP (µg P/L)	DOP (µg P/L)	FRP (µg P/L)
Grazing	Andromache River	Minimum	0.1	116	1	69	4	<0.01	2	8.25	3	34	2	16	6
		20th	0.4	143	21	79	6	1	3	9.49	5	43.6	3.6	18.2	11.7
		50th	**1.1**	**175**	**39**	**124**	**6.7**	**1**	**10**	**18.2**	**12**	**57**	**9**	**24.9**	**21.5**
		80th	1.4	252	62	149	9.4	2	20	45.74	21	67.8	13.4	38	28.2
		Maximum	5.8	285	78	201	36	4	48	69.3	50	152	93	46	38
	Basin Creek	Minimum	0.8	91	5	68	1	<0.01	0.5	2	0.5	9	1	4	0.5
		20th	1.2	153	39	99	2	<0.01	1.2	4.38	2	14.8	6.2	5.68	1
		50th	**2**	**248**	**58**	**170**	**3**	**1**	**4.1**	**9.25**	**4.9**	**20.5**	**11.5**	**7**	**2**
		80th	4	436	152	258	6.4	1	6.6	13.4	7.8	29.7	22	8.8	2.8
		Maximum	50	514	439	295	15	2	10	19.7	11	39	31	14	4
Grazing / Intensive Cropping	O'Connell River	Minimum	0.7	153	4	67	2	<0.01	6	25.2	7	10	<0.01	1.1	1.6
		20th	0.9	180	21	88	4.4	1	21	47.42	22	15.5	2.6	4.4	2.4
		50th	**1.5**	**225**	**43**	**105**	**8.1**	**1**	**64**	**89.28**	**65**	**21**	**5.5**	**7.7**	**5.5**
		80th	5.9	383	54	118	17	3	103	141	104	35.2	13.8	14.6	10.9
		Maximum	12	545	201	239	156	6	137	163.2	141	152	19.3	64	86
	Plane Creek	Minimum	0.4	227	38	158	1	<0.01	2	4.25	2	22	2	7	2
		20th	1.1	280	50	173	2	<0.01	2.2	4.6	3	29.2	12	8.08	4.8
		50th	**3.2**	**433**	**101**	**241**	**4**	**1**	**3**	**7.75**	**4**	**38.5**	**17.5**	**10**	**7.5**
		80th	4.9	669	194	447	6	1	4.8	11.53	5	46.2	22.8	19.8	16
		Maximum	8	822	350	520	7.9	8	281	295	289	99	62	33	23
	Carmila Creek	Minimum	0.3	207	34	60	1	<0.01	1	3	2	10	6	1	1
		20th	1.3	233	66	126	2	<0.01	1.2	4.45	2	15	9	3.2	3
		50th	**2.5**	**293**	**78**	**153**	**4.5**	**1**	**3**	**8.25**	**4**	**25**	**10**	**8.3**	**4.8**
		80th	4.5	482	204	233	9.2	2	93	117.9	96	36	17	10.8	5
		Maximum	25	664	379	291	28	10	669	692	679	87.8	74.5	15	12
Intensive Cropping / Grazing	Pioneer River	Minimum	1.1	151	1	30	1	<0.01	0.5	2.75	0.5	20	1	2.1	3
		20th	2.8	200	56	115	1.7	<0.01	1.5	3.46	2	26	14	5.2	4
		50th	**4.5**	**302**	**102**	**162**	**2.5**	**1**	**3.8**	**7.75**	**4.1**	**36.2**	**20**	**9**	**5**
		80th	8.8	413	143	193	5.8	5	46	53	50	40.4	29.2	12	7.5
		Maximum	19	2082	1923	296	36	9	229	274.4	239	65	42	19	25
	Rocky Dam Creek	Minimum	1.4	242	36	138	1	<0.01	0.5	2.75	0.5	22	13	0.5	3
		20th	2.2	343	83	192	2	<0.01	1.5	3.81	2	31	17.4	3.6	3.2
		50th	**3.9**	**381**	**142**	**215**	**5.5**	**1**	**3.5**	**10**	**4.5**	**37.6**	**22**	**9.1**	**6**
		80th	4.9	443	167	282	8.8	5	108	120.8	113	51.4	24	15.2	11
		Maximum	22	891	174	444	49	5	273	327	278	82	61	19	28

7.3 Minimum, maximum, 20^{th}, 50^{th} and 80^{th} percentile herbicide concentrations for each monitoring site

Land Use	Site	Percentile	Ametryn (µg/L)	Atrazine (µg/L)	Desisopropyl Atrazine (µg/L)	Desethyl Atrazine (µg/L)	Diuron (µg/L)	Hexazinone (µg/L)	Tebuthiuron (µg/L)	Bromacil (µg/L)	Simazine (µg/L)	Terbutryn (µg/L)
Intensive Cropping	Myrtle Creek	Minimum	0.01	0.05	<0.01	0.02	0.05	0.01	<0.01	<0.01	<0.01	<0.01
		20^{th}	0.022	0.062	<0.01	0.03	0.064	0.02	<0.01	<0.01	<0.01	<0.01
		50^{th}	**0.04**	**0.11**	**<0.01**	**0.03**	**0.105**	**0.08**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
		80^{th}	0.066	0.3	0.01	0.07	0.378	0.246	<0.01	<0.01	<0.01	0.002
		Maximum	0.45	1.2	0.05	0.19	0.58	0.34	<0.01	<0.01	<0.01	0.01
	Sandy Creek	Minimum	<0.01	0.02	<0.01	0.01	0.07	0.07	<0.01	<0.01	<0.01	<0.01
		20^{th}	0.01	0.034	<0.01	0.02	0.092	0.122	<0.01	<0.01	<0.01	<0.01
		50^{th}	**0.02**	**0.085**	**<0.01**	**0.035**	**0.185**	**0.195**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
		80^{th}	0.048	0.352	0.018	0.05	0.532	0.406	0.008	<0.01	<0.01	<0.01
		Maximum	0.47	5.8	0.15	0.57	6.4	3.9	0.04	<0.01	0.03	<0.01
	Bakers Creek	Minimum	<0.01	0.01	<0.01	0.01	0.06	0.04	<0.01	<0.01	<0.01	<0.01
		20^{th}	<0.01	0.026	<0.01	0.02	0.084	0.072	<0.01	0.008	<0.01	<0.01
		50^{th}	**0.01**	**0.17**	**<0.01**	**0.035**	**0.11**	**0.14**	**<0.01**	**0.02**	**<0.01**	**<0.01**
		80^{th}	0.018	0.428	0.042	0.132	0.564	0.512	<0.01	0.02	<0.01	<0.01
		Maximum	0.04	14	0.14	0.45	14	4.3	0.04	0.02	0.05	<0.01
Bushland	Impulse Creek	Minimum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		20^{th}	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		50^{th}	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
		80^{th}	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		Maximum	0.03	0.02	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	St Helens Creek	Minimum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		20^{th}	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		50^{th}	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
		80^{th}	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		Maximum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Finch Hatton Creek	Minimum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		20^{th}	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		50^{th}	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
		80^{th}	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		Maximum	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Land Use	Site	Percentile	Ametryn (µg/L)	Atrazine (µg/L)	Desisopropyl Atrazine (µg/L)	Desethyl Atrazine (µg/L)	Diuron (µg/L)	Hexazinone (µg/L)	Tebuthiuron (µg/L)	Bromacil (µg/L)	Simazine (µg/L)	Terbutryn (µg/L)
Grazing	Andromache River	Minimum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		20th	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		50th	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
		80th	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		Maximum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01
	Basin Creek	Minimum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		20th	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		50th	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
		80th	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		Maximum	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.03	<0.01
Grazing / Intensive Cropping	O'Connell River	Minimum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		20th	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		50th	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
		80th	<0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01
		Maximum	<0.01	0.03	0.01	0.01	0.09	0.04	<0.01	<0.01	0.05	<0.01
	Plane Creek	Minimum	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
		20th	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
		50th	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**0.01**	**0.04**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
		80th	<0.01	0.02	<0.01	<0.01	0.03	0.05	<0.01	0.01	<0.01	<0.01
		Maximum	0.03	2.2	0.05	0.16	1.6	1.2	<0.01	0.07	0.02	<0.01
	Carmila Creek	Minimum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		20th	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		50th	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
		80th	<0.01	0.03	<0.01	<0.01	0.05	0.17	<0.01	<0.01	<0.01	<0.01
		Maximum	0.03	0.05	<0.01	<0.01	1	0.46	<0.01	<0.01	0.03	<0.01
Intensive Cropping / Grazing	Pioneer River	Minimum	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		20th	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
		50th	**<0.01**	**0.02**	**<0.01**	**0.01**	**0.02**	**0.02**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
		80th	<0.01	0.06	<0.01	0.01	0.08	0.02	<0.01	<0.01	<0.01	<0.01
		Maximum	0.05	1.7	0.05	0.1	2.2	1	<0.01	<0.01	<0.01	<0.01
	Rocky Dam Creek	Minimum	0.01	<0.01	<0.01	<0.01	0.04	0.09	<0.01	<0.01	<0.01	<0.01
		20th	0.02	<0.01	<0.01	<0.01	0.05	0.12	<0.01	<0.01	<0.01	<0.01
		50th	**0.02**	**<0.01**	**<0.01**	**<0.01**	**0.06**	**0.13**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
		80th	0.05	0.08	<0.01	<0.01	0.11	0.21	<0.01	0.04	<0.01	<0.01
		Maximum	0.11	0.12	<0.01	0.02	0.37	0.38	<0.01	0.18	<0.01	<0.01