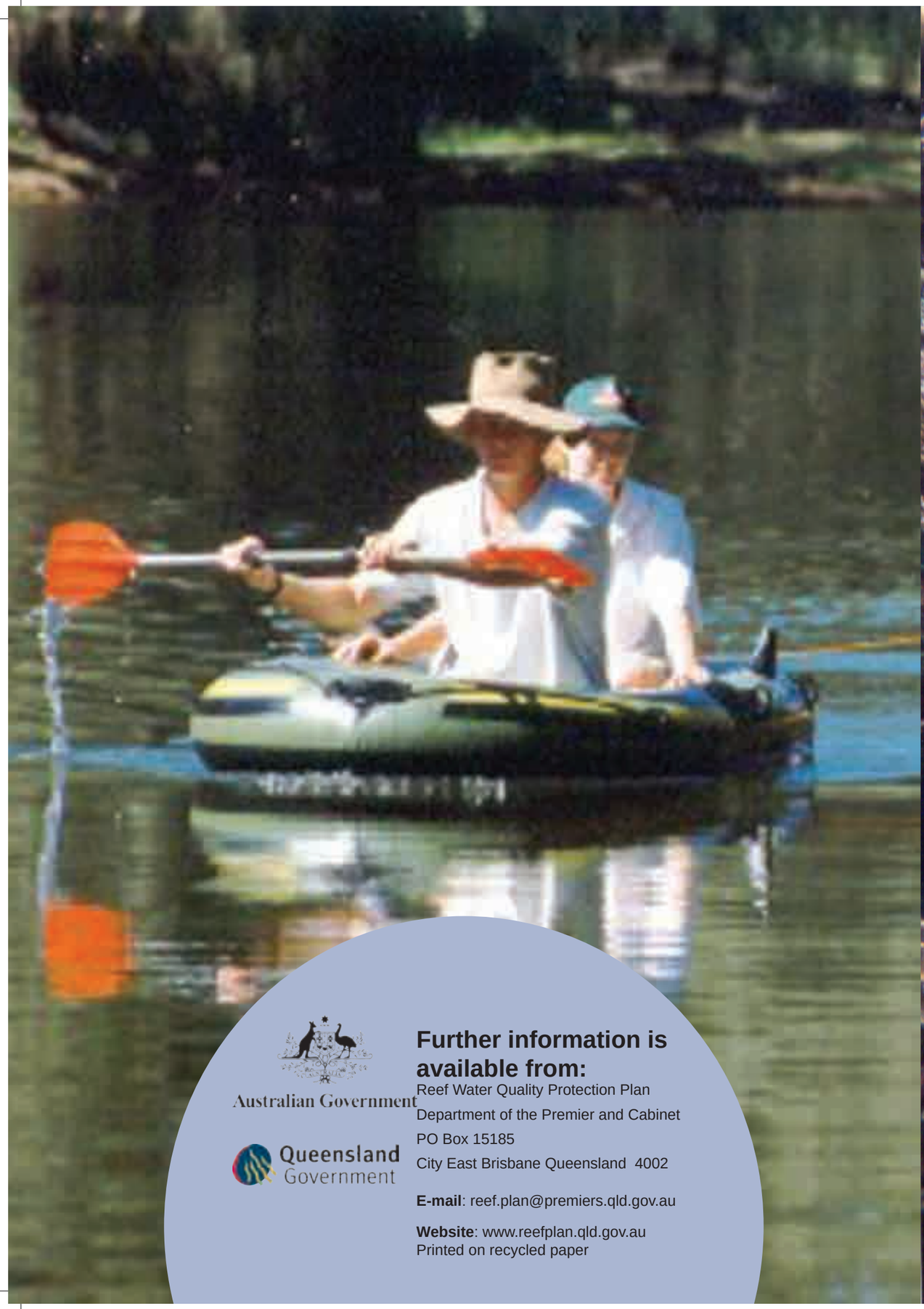

Reef Water Quality Protection Plan

Annual report 2005 – 2006

Appendix 1 – Case studies of on-ground successes in monitoring and modelling land condition and water quality

Australian Government

Queensland Government

Further information is available from:

Reef Water Quality Protection Plan
Department of the Premier and Cabinet
PO Box 15185
City East Brisbane Queensland 4002

E-mail: reef.plan@premiers.qld.gov.au

Website: www.reefplan.qld.gov.au

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Showcasing on ground successes

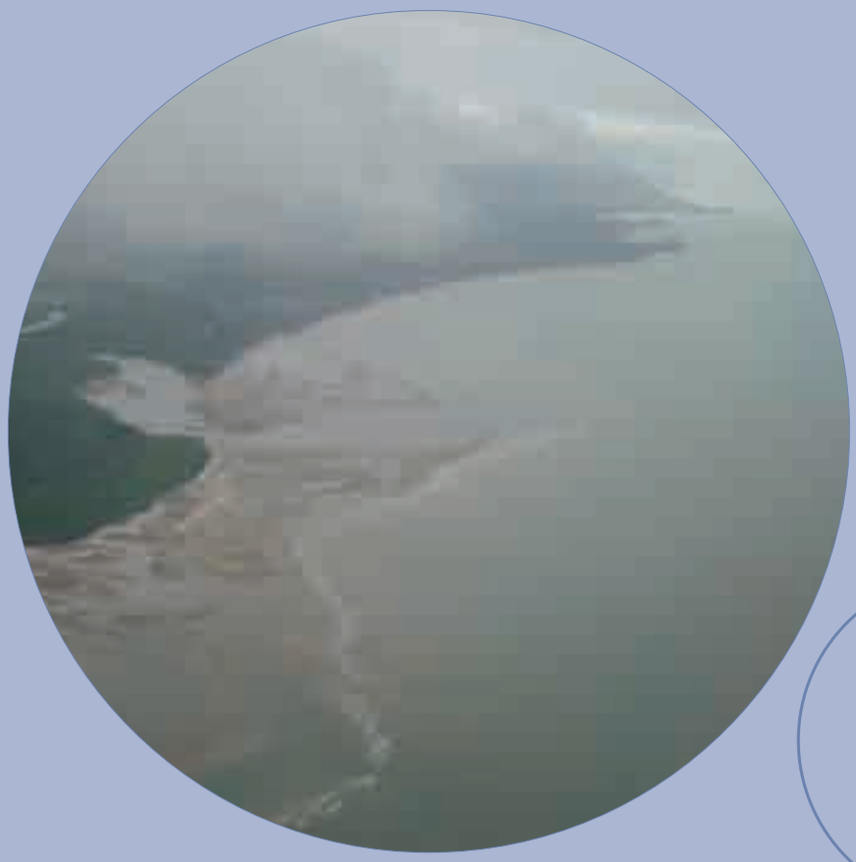
These case studies highlight on ground success in monitoring and modelling land condition and water quality in the Reef catchment.

The case studies have been designed to provide more detail about some of the success stories outlined in the Main Report of the Reef Plan Annual Report 2005 – 2006.

The projects chosen here link to Reef Plan goals and objectives, are based on government - community - industry partnership and reflect interaction between land-management actions and water quality.

Contents

Use of water quality monitoring as a tool for engaging with growers in the horticulture industry (AgSIP 16) 2
Short term modelling project in the Great Barrier Reef Lagoon 5
Fresh and Marine Water Quality in the Mackay Whitsunday Region 2004/2005 6
Douglas Water Quality Improvement Plan 9



Agricultural State-level Investment Project (AgSIP) 16

The AgSIP 16 project, linked to Reef Plan Action A4, aims to work with horticulture land managers to develop and implement best practice systems for the dry tropics catchments that contribute to catchment natural resource management targets. The first stage of the project was to conduct a scoping study of horticulture growers and service providers to identify key natural resource management issues affecting the industry. Water quality was one of the key issues identified, and a number of case studies and engagement strategies were developed to address this and other issues.

A highlight of the project to date is piloting the concept of Integrated Area Wide Management (IAWM) in diverse farming systems. This has included sampling rainfall runoff and ambient water quality in two coastal sub-catchments near Bundaberg; one predominantly horticulture tree crops, the other a mixed vegetable and cane farming system.

A key achievement of the project has been the use of water quality monitoring as a tool for engaging with growers. As a result, growers in the industry are becoming increasingly aware of the natural resource management issues beyond the boundaries of their farm and recognise their connectivity with the wider catchment.

The project has also instigated discussions regarding on-farm management decisions and practices potentially impacting on water quality in the landscape. AgSIP 16, particularly the IAWM component, has strong collaboration from Bundaberg Fruit & Vegetable Growers (the local horticulture industry organisation), Burnett Mary Regional Group (funding and in-kind support for the IAWM activity) and a local consultant.

Scoping study of natural resource management issues

The AgSIP 16 project team first engaged with the horticulture industry in the Burnett catchment by conducting semi-structured interviews with over 60 growers and industry service providers. The intent was to scope their current knowledge, attitudes and ideas about the environment. Although there is pressure for industries to address particular environmental concerns, the project team believed it was necessary to know what issues were important to growers. This knowledge will play a crucial role in engaging growers in the future as adoption rates increase when growers more clearly view improved practice as relevant to their business.

Following the interviews, the project team facilitated visits by small groups of growers and industry representatives to three other regions of environmental significance to investigate how growers in these regions addressed emerging environmental issues. One of these visits was to Emerald to observe the IAWM approach.

These activities resulted in grower groups prioritising the environmental issues most important for the local industry, including:

- water quality leaving the farm
- pesticide management
- soil heath
- water use efficiency.

Further information and results of this process can be found in the document *Growers' perceptions on natural resource management*, listed on the AgSIP website: http://www2.dpi.qld.gov.au/AgSIP/17645.html

Integrated Area Wide Management (IAWM) case study

Resulting from the scoping study, a group of tree crop growers approached the AgSIP 16 project team to pursue environmental initiatives in order to demonstrate their environmental stewardship. The project team and grower group agreed to test the IAWM process, as observed on the regional visit to Emerald.

The concept of IAWM is to provide a safe learning environment for growers to better understand the interactions between on-farm practices and the surrounding environment. Through interactive monitoring on a landscape basis, growers have the opportunity to learn and work together to minimise any adverse impacts that may exist – both from on-farm activities and through natural processes. This builds the industry's capacity to more effectively manage natural resources and gives growers ownership of the information and confidence to act on it.

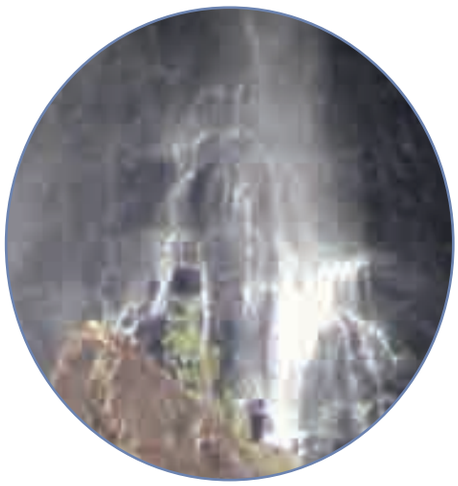
The Burnett Mary Regional Group (BMRG) supported this initiative across two dominant horticultural cropping systems – tree crop horticulture and vegetable and cane. Project information and outcomes are outlined in Table 1.

The project team's aim is to build the capacity of the region beyond the AgSIP 16 project. Refer to Table 1 for more detail on potential future grower involvement in this work.

Vegetable and cane production sub-catchment

Seven growers in a second sub-catchment have been approached to be part of an IAWM study of water runoff in a largely vegetable and cane growing area. The objective is to install automatic rising stage samplers in the creek running through this region and to prepare and install on-farm automatic samplers to collect runoff from particular farms in the sub-catchment. Two ambient in-stream samples have been collected. Table 1 provides more detail on grower involvement in this sampling process.

A survey of the creek and surrounding properties, and discussions with growers, have been undertaken to identify suitable sites for the sampling equipment. Rising stage samplers will be provided by BMRG.



Monitoring methods

Automated water quality sampling equipment has been installed at key sites in sections of each stream being monitored. Flow meters were also installed at these sites to provide an indication of water volume. Automated sampling equipment has been used to also collect surface water runoff from selected on-farm sites in each sub-catchment.

Since January 2006 monthly ambient samples of water have been taken manually from each sampling site in the tree crop sub-catchment. There have been two rainfall events during this period resulting in runoff, and samples were collected by the automatic sampling equipment during the rising stage and manually during the falling stage. All samples were sent for laboratory analysis.

A Reflectometer was purchased in collaboration with the AgSIP 05 project team. This instrument is being assessed for measuring nutrients as a possible tool growers could use to monitor water quality in the field. It is being validated against the National Association of Testing Authorities (NATA) accredited laboratory analysis. Some other simple tools will also be assessed for the same purpose.

Table 1: Details of IAWM processes and outcomes in two sub-catchments.

	Background	Outcomes
Horticulture tree crop sub-catchment	The horticulture tree crop industry (for example exotic fruit, macadamia nuts and citrus) is increasing in importance around Bundaberg and the industry is conscious of addressing their potential impact on water quality entering the Reef. The AgSIP 16 project team are monitoring water quality in one stream adjacent to tree crops for nutrients and sediment, with the results being related back to farming practices. Growers are interested and closely involved in developing management practices based on these results to minimise impact on water quality in the stream system.	AgSIP 16 project staff visited properties to take ambient water quality samples and also during run-off events. Samples were collated and interpreted for presentation to the participating growers to enable discussions with individual growers about surface runoff water quality and the implications for farming practices. Water sampling procedures and worker safety guidelines were documented for future training of potential local sampling personnel (possibly Industry Service Providers). The project team have encouraged grower involvement to build their ownership of the monitoring activities. Growers have been informed of all the monitoring activities, have visited the monitoring sites, and have discussed the implications of monitoring results with the project team. Growers have shown great interest in the activities and monitoring results and this has sparked robust discussion about the need to look after water quality in the catchment and continued development of sustainable practices that will achieve this. The next stage of the project is to conduct a participative risk analysis with growers to identify and discuss practices that will minimise negative impacts on water quality in the catchment. This information will be made available to the general industry.
Vegetable and cane cropping sub-catchment	The growers in this sub-catchment were not involved in the AgSIP 16 team's initial scoping interviews and visits to other regions. Hence the project team had to more actively engage with the growers individually through a series of on-farm visits to discuss environmental issues and drivers, and the process and benefits of monitoring runoff water from their property. Seven growers in this second sub-catchment have been approached and have agreed to be part of an IAWM study of water runoff.	The initial approach to ask for the grower's involvement has raised their awareness of water quality and natural resource issues. Insufficient monitoring data has been collected to date to feed back to the growers, but when available a similar process will be followed as applied in the tree crop sub-catchment. All the farmers were cooperative and keen to know the results of monitoring. However, most indicated they are too busy to take samples themselves. This was not unexpected for the initial pilot stage, however it is anticipated that as the benefit of this information is recognised by the growers their involvement will increase.

Other project activities

Other activities in the AgSIP 16 project include on-farm demonstrations and workshops addressing soil erosion, spray drift, soil health and the development of environmental management systems. These were identified through the project's initial scoping study as some of the top issues for industry to address.

Fact sheets and reports about practices addressing Natural Resource Management issues are being developed to support demonstrations and workshops. As the project continues, AgSIP 16 will develop collective recommendations towards a cost-effective industry driven and regionally co-funded water quality monitoring system. The project will also investigate effective extension strategies to help disseminate learning and technical messages for Natural Resource Management.

Short Term Modelling project - Using models for target setting and reducing nutrients and sediment entering the Great Barrier Reef lagoon.

In early 2005, the Joint Australian and Queensland Governments Steering Committee (for the Trust and NAPSWQ) approved a project to develop, conduct and deliver new information to guide the regional bodies' investment in effective and targeted actions to address the export of sediments and nutrients from diffuse sources to the Reef.

The Short Term Modelling project was undertaken by a team of scientists from several organisations working collaboratively and with funding from a number of sources. The team members included staff from Queensland Government departments, CSIRO, and the CRC Catchment Hydrology working with regional natural resource management bodies.

The Short Term Modelling project investigated the effects of different management scenarios that could potentially be undertaken by regional bodies within the Reef catchment to manage the delivery of sediment and nutrients to the Reef.

Method

Sediment and nutrient loads delivered to the Reef were modelled using SedNet/ANNEX.

The SedNet model was developed by the National Land and Water Resources Audit for modelling sediment and nutrient loss on a national scale. It is particularly useful for this application as it can account for sediment deposition and nutrient loss throughout the stream network and estimate the total export of sediment and nutrients to the estuary.

Sediment modelling was performed by teams located in each of the regional bodies' regions. The SedNet sediment model results were then used as an input to model the nutrient loads using ANNEX.

Having developed the modelling framework, the SedNet modelling team, in close dialogue with regional bodies and their industry advisors, constructed a suite of 'what-if' land management practices (scenarios) for each catchment. The scenarios predicted the impact of the range of practices including changed ground cover, riparian management and fertiliser management.

The project provides important information to support the setting of water quality targets in Reef catchments. The regional bodies have the latest information available on modelled outputs, which they can combine with other information (e.g. local and regional water quality information) to set targets.

Results

The model results show that the overwhelming majority of sediment and nutrient supplied to the Reef originates within 80-90 km of the coast. Total phosphorus loads were dominated by particulate phosphorus in all regions. Total nitrogen loads were more evenly comprised of both particulate and dissolved forms, with dissolved forms dominant in Far North Queensland and the Mackay Whitsunday regions. (Particulate nutrients are attached to sediment particles. Dissolved nutrient forms are more easily taken up by plants and therefore more likely to contribute to nuisance algal growth.)

In the Burdekin, Fitzroy and Burnett-Mary regions, grazing accounts for more than 75% of land use and particulate nitrogen is the dominant component of the total nitrogen load.

In the Mackay Whitsunday region, the scenario that resulted in a significant reduction in dissolved nitrogen loads was a 50% reduction in nitrogenous fertiliser application to cane land.

An increase in pasture cover to 80% (from an assumed value of 60%) on all grazing land resulted in the largest modelled reductions of sediment and particulate nutrient export in the Burnett-Mary, Burdekin, Fitzroy and Mackay Whitsunday regions.

In Far North Queensland, the modelling results estimated that implementing sugar cane best management practice (BMP) would result in a reduction of dissolved inorganic nitrogen (DIN) export of 31%. Implementation of BMP on sugar and banana land would also result in significant reductions in sediment export. Particulate nutrients were slightly reduced in the sugar and banana management scenarios. Restoring all riparian vegetation in all major tributaries resulted in a modelled reduction in sediment export of 15%.

Conclusions

The modelling work showed that management strategies targeting improved vegetation cover in grazing lands would deliver the greatest reductions in sediment and particulate nutrient loads. Implementation of best management practice (fertilizer application and tillage methods) would produce the greatest reduction in dissolved nutrient loads. For any particular catchment, effective management of sediment and nutrient loads may require separate strategies. What is effective for sediment often has little effect on dissolved and/or total nutrient loads.

The outputs from the modelling are part of a continuous improvement cycle, as new information on data inputs including monitored water quality information, groundtruthing, new spatial data and new management practices become available. Used in the context of continuous improvement, the modelling frameworks will provide a valuable and scientifically defensible basis for the setting of water quality targets in Reef catchments. As a result of this project, the regional bodies have the latest information available on modelled outputs, which can be integrated with other information (e.g. local and regional water quality information) to set targets and focus their regional investment strategies into the future.

Fresh and Marine Water Quality in the Mackay Whitsunday Region 2004/2005

A project in the Mackay Whitsunday Region has shown clear linkages between runoff of diffuse pollutants from different landuses and what reaches the coastal waters of the Reef. This has important implications on local and regional target setting for water quality improvement and improved land management practices.
The study is the first of its kind to assess water quality during adverse weather conditions across the entire Mackay Whitsunday region and also during the resulting flood plume formed along the coast.

The Fresh and Marine Water Quality in the Mackay Whitsunday Region 2004/2005 project was led by the Mackay Whitsunday Natural Resource Management Group (MWNRM) in conjunction with Natural Resources and Water (NRW) and the Australian Centre for Tropical Freshwater Research. The project would not have been possible however, without the support of a dedicated volunteer network spanning the region at strategic sites and conducting water sampling.

Figure 1: MODIS Satellite image of 2005 rainfall/runoff event

The Mackay Whitsunday region covers an area of approximately 9000 km2 along the central Queensland coast. The major drainage basins of the region include the Proserpine, O'Connell/ Andromache, Pioneer and Plane, with a number of smaller streams discharging directly into the Reef lagoon. Major land uses in the region include sugar cane, beef grazing and urban/industrial, with significant areas of national park and state forest. The MWNRM Group has produced a regional natural resource management plan which aims to protect and where necessary, restore both natural and cultural assets.

Method

An important feature of this project was community participation in the sampling process. Sampling was conducted with the assistance of land managers, local and state government staff, students and other interested individuals.

There were two events sampled in January 2005 – in early January, samples were collected from seven sites and 18 sites in late January. Twenty one sites were also selected to gauge runoff from single land use areas (forest, sugar cane, grazing and urban) and mixed land-use catchments.

Total suspended solids, nutrients and pesticide residues were the pollutants measured at most sites. Nutrients were analysed to give full speciation and the pesticides targeted were those known to be used in the region, particularly a number of herbicides.

The extent and nature of plumes in the marine environment were quantified using aerial over flight mapping and satellite imagery.

Figure 2:O'Connell River flood plume 01/05. Picture taken by Ken Rohde

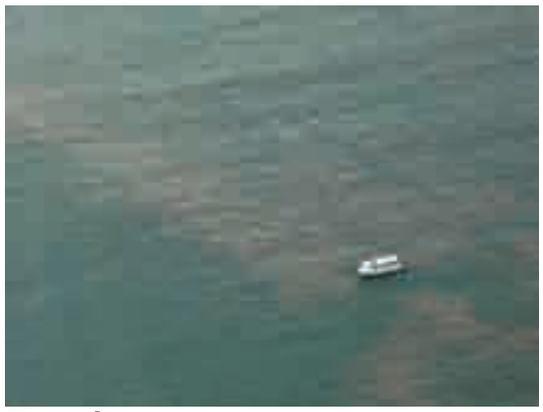


Figure 4: Sampling in the flood plume Jan 05. Picture taken by Ken Rohde

Results

Results from the monitoring study indicated the following conclusions.

In the study total suspended solids, nutrients, pesticide residues and organic compounds from event flows were measured from different land uses and catchments and compared to forest sub-catchments.

- Sugar cane areas, exported moderate to low concentrations of total suspended solids (TSS), high concentrations of dissolved nutrients (particularly nitrate and phosphate) and herbicides (particularly diuron)[1].
- Grazing areas, exported moderate concentrations of TSS, nutrients and low concentrations of Tebuthiuron[1].

For pollutants discharging on inshore areas of the Reef, based on 23-30 January, 210,000 ML flow the study found:

- Discharges from the Pioneer River to the inshore area, were approximately 32,000 tonnes of TSS, 315 tonnes of nitrogen, 45 tonnes of phosphorus, 310 kg of diuron and 95 kg of atrazine[1].

Figure 3:Pioneer River looking upstream from the Ron Camm Bridge Jan 05. Picture taken by Ken Rohde

1. Rohde, K., Masters, B., Brodie, J., Faithful, J., Noble, R. and Carroll, C. (2006). Fresh and Marine Water Quality in the Mackay Whitsunday Region 2004/2005. Mackay Whitsunday Natural Resource Management Group, Mackay, Australia.

- High concentrations (exceeding known effect levels and guidelines) of a number of herbicides in this flood plume[1].
- High concentrations of nutrients in the flood plume resulting in a massive phytoplankton bloom[1].
- Persistence of a visible flood plume (algal bloom) in a large area of the coastal waters (up to 100 km from river mouth) and surrounding the inshore reef systems (e.g. Brampton Island) for up to 10 days[1].
- Inshore marine ecosystems subject to multiple effects (synergistic or antagonistic) of a mixture of herbicides, nutrients, TSS, low salinity and organic matter[1].

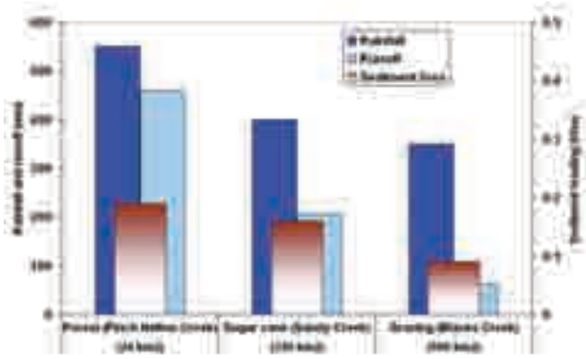


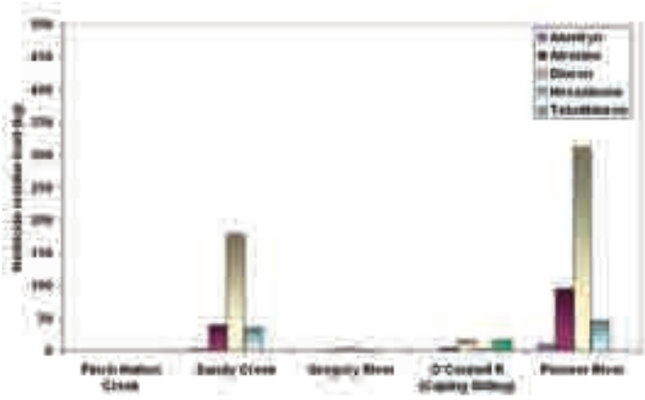
Figure 5: Rainfall (mm), runoff (mm) and sediment loss (t/ha) for the late January event, 2005 for forest, sugarcane and grazing sub-catchments[1]

The study collected significant baseline information to support regional and local target-setting and water quality improvement plans. It found:

- TSS concentrations in sugar cane areas were similar to forest areas (presumed to be a result of the adoption of green cane trash blanketing and minimum tillage over the past 20 years). Hence, the sugar cane industry is well placed to meet any future TSS water quality targets[1].
- In contrast, there is a potential to reduce nutrient and herbicide concentrations from sugar cane areas, as these were considerably higher than forest sub-catchments. This includes soluble inorganic forms of nutrients which have higher bioavailability and greater potential impact on rivers and reef water quality[1].

The data shows that herbicide application in the Reef catchment is an important issue for its managers. The data also shows that for a moderate flood event, offsite transport from agricultural catchments pose a significant risk to the health of inshore corals, seagrass and mangroves[1].

Figure 6: Herbicide residue loads (kg) for ametryn, atrazine, diuron, hexinone and tebuthiuron at Finch Hatton and Sandy Creeks and the Gregory, O'Connell (caping Siding) and Pioneer rivers for the late January event, 2005 .



Conclusions

A key finding of this research was the considerable differences in the concentrations of diffuse pollutants generated by each land use. This was especially notable for the detection of herbicides (and dissolved nutrients) from sugarcane (particularly diuron, atrazine, hexazinone and ametryn), grazing (tebuthiuron) and urbanised areas, and the subsequent detection of these substances in marine waters.

This project has not only provided valuable information on water quality within the Mackay Whitsunday region, but it has provided a model of an integrated community partnership approach. This project would not have been possible without the support of the dedicated volunteers and various organisations (private, local and state government, and the regional body) involved. This process has ensured that results from this work have been readily available to the community. Important lessons have been learnt on the effective delivery and coordination of a volunteer focused program, which has been shared with other regions through regional water quality coordinator and community forums/ workshops.

The information from this research provides important direction for future monitoring and investigation into improved land management practices. It will also provide valuable baseline data to validate sediment and nutrient models and to support water quality target setting through the Water Quality Improvement Plan.

1. Rohde, K., Masters, B., Brodie, J., Faithful, J., Noble, R. and Carroll, C. (2006). Fresh and Marine Water Quality in the Mackay Whitsunday Region 2004/2005. Mackay Whitsunday Natural Resource Management Group, Mackay, Australia.

Douglas Shire Council Water Quality Improvement Plan

The past 25 years has seen a transition of Douglas Shire Council as its economy has moved from one based on agriculture with major activities of sugar cane cropping and cattle grazing to a strong predominance of tourism and associated residential and commercial activities. The most important economic activity in the shire is tourism with a direct value of about $200 million per annum. The second most important activity is agriculture which had a gross value of production in the Shire of $11.9 million for crops, principally sugar cane, and $1.1 million for livestock for the year ending June 2001 (OESR, 2003).

Tourism is strongly based on the natural environment of the Wet Tropics and Reef and consequently, on the many opportunities for nature based recreational activities.

The Douglas Shire has four catchments draining to the Reef. The Shire has served as a pilot region for the Reef Plan through the development and implementation of the Douglas Shire Water Quality Improvement Plan (DSWQIP) funded under the Australian Government's Coastal Catchments Initiative.

Funding in the order of $2.6 million was provided for the initial research, planning and implementation of the program to improve water quality entering the Reef.

The major land based issues relating to marine pollutants in the Douglas Shire are diffuse sediment, nutrients and possibly pesticides from agriculture and other land based sources, plus discharge from aquaculture and sewage treatment.

Management of marine pollution in the Douglas Shire, primarily targets a reduction in the amount of nutrients and sediment entering the marine environment to levels more consistent with those that shaped the World Heritage values of the Reef. Research and modelling studies indicate that recent discharge levels from Douglas Shire rivers may be 1.8 times higher for sediment levels, 1.1 times higher for total nitrogen and 1.5 times higher for total phosphorus than those prior to European settlement.

The DSWQIP identifies the current status of pollutant loads, commits to management actions to achieve sustainable loads and develops modelling and monitoring systems with adaptive implementation strategies. Within a 25 year period, it aims to halve the anthropogenic (human-produced) loads of sediment, nitrogen and phosphorus entering the Reef from Douglas Shire.

Pollutant loads were selected as sound targets for the plan. The pollutant load indicates the total quantity of sediment and nutrients able to reach receiving waters, such as the Reef lagoon, over an extended period and directly relates to pollutant concentrations in Reef waters. The concentrations are difficult to monitor effectively as they are highly variable in the Reef water environment.

The DSWQIP required the establishment of local environmental values and local water quality objectives. The framework for setting environmental values and water quality objectives was established through the National Water Quality Management Strategy (NWQMS) and is embedded in the Queensland Environmental Protection (Water) Policy Act 1997.

The DSWQIP is progressed through projects designed to provide background information on Douglas Shire and current land management practices for use in determining management actions to reduce current impacts. Projects included:

- Identifying and trialling agricultural best management practices which will result in reductions in pollutant exported to the Reef, e.g. demonstration of agricultural best management practices in the Saltwater Creek catchment of Douglas Shire.
- Resourcing wetland and riparian restoration to reduce sediment and nutrient escape through the stabilisation of river banks and the development of vegetation buffers to trap pollutants through a prioritised program with a 25 year target of rehabilitation of 95% of riparian areas.
- Identifying and commencing work to implement possible reductions in point source discharges, by upgrading the Mossman Sewage Treatment plant to a tertiary level, with the objective of reducing total discharge levels for nitrogen and phosphorus.
- Managing sediment run-off from roads via grass verges or sediment traps.
- Estimating pre-European nutrient and sediment loads in waters discharging to coastal waters and identifying target reductions in the levels of pollutants exported to the Reef.
- Monitoring and modelling of sediment and nutrient flow within and from the waters of Douglas Shire through the Douglas Shire Council (DSC) Water Quality Monitoring Project.

Overview of DCS water quality monitoring component

A component of the DSWQIP was a water quality monitoring project which measured the concentration and loads of sediment and nutrients in the Daintree, Mossman, Saltwater and Mowbray river systems. Water quality samples were collected through community based monitoring and automatic water quality monitoring stations. Both ambient and event flows were monitored.

Automatic and community monitoring

An automatic monitoring infrastructure collected water quality samples providing quality data for in-stream stations and off-paddock flume systems. The ability to deliver up-to-date data to DSC water quality staff and CSIRO officers was a major contributor to the successful operation of the stations.

Samples collected by the community at 16 sites across the Douglas Shire were used to assess baseflow water quality condition in relation to Queensland Department of the Environmental Protection Agency Water Quality Guidelines and to raise awareness of water quality issues. In the future the community will continue with the collection of baseflow samples. These samples will be used to measure the physical instream health across the catchments.

Design of appropriate sampling strategies for automatic stations

Baseflow sampling showed concentrations of nutrients and sediment were relatively constant and a lot lower than during the large flow events. Hence, baseflow could be adequately represented by once monthly grab samples.

There was a general tendency for sediment and nutrient concentrations during peak flow events to fall and become less variable as the wet season progressed. However, while the concentrations were lower, the flow volume was higher thereby contributing loads at a higher level compared to ambient conditions. This was likely to be caused by the depletion of nutrient and sediment stores which accumulated over the dry season.

Although the concentration of nutrients and sediments peaked early in the wet season, the proportion of total load moved was still greater during the later part of the wet season when prolonged monsoonal events and tropical depressions resulted in high discharges.

While the Monitoring Strategy suggested that community sampling efforts would be best directed towards sampling of baseflow water quality at the automatic stations the community has indicated its interested in monitoring other parameters as well as sediment and nutrients.

Recommendations for future water quality monitoring

The main features identified for future monitoring strategy are:

- The need to focus loads based sampling on events as this is when the most variation in sediment and nutrient concentrations occurs and when the vast majority of loads are moved.
- The occurrence of strong seasonal flow changes, not just between the wet and dry season, but also during the wet when there are marked changes in flow volumes.
- The concentrations of nutrient and sediment loads peak early in the wet season during 'first flush' events. However, the proportion of total loads moved is still greater during the later part of the wet season when prolonged monsoonal events and tropical depressions result in high water discharges.
- The need to invest resources in the development of reliable discharge estimates.
- The need to deal with the influence of tidal incursions in the lower catchment sites.