

Water Quality Improvement Plan for the catchments of the Barron River and Trinity Inlet

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Fiona Barron and David Haynes

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Barron-Trinity Inlet Steering Committee

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Barron Falls (F. Barron)

Cattana Wetlands (F. Barron)

Low Isles (D. Haynes)

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Abbreviations and terms used

ACTFR	Australian Centre for Tropical Freshwater Research (James Cook University)
ANZECC	Australian and New Zealand Environment and Conservation Council
APVMA	Australian Pesticides and Veterinary Medicines Authority
BMP	Best Management Practice
BSES	Bureau of Sugar Experiment Stations
Chlorophyll	Chlorophyll is the photosynthetic pigment contained in most plants. It is used as an indirect measure of the amount of planktonic algae present in water and hence nutrient availability.
DERM	Queensland Government Department of Environment and Resource Management
DIN	Dissolved inorganic nitrogen includes nitrate, nitrite and total ammonia. DIN is completely bioavailable for phytoplankton uptake.
DIP	Dissolved inorganic phosphorus is available for plant growth, and is sometimes referred to as filtered reactive phosphorus (FRP).
DO	Dissolved oxygen, a measure of the amount of available oxygen in the water column
DON	Dissolved organic nitrogen
DOP	Dissolved organic phosphorus
DNRW	Queensland Government Department of Natural Resources and Water (now DERM)
DPI&F	Queensland Government Department of Primary Industries and Fisheries

E2

Software product for whole-of catchment modeling, subsequently developed into the advanced modeling package now called WaterCast

EMC

Event Mean Concentration (flow-weighted mean) of a water quality parameter

ESD

Ecologically Sustainable Development

EPA

Queensland Government Environmental Protection Agency (now DERM)

EPP Water

Environmental Protection (Water) Policy 1997

EP Act

Environmental Protection Act 1994

ESCP

Erosion and sediment control plan (usually in an urban context)

EVs

Environmental Values are those qualities of the waterway that make it suitable to support particular aquatic ecosystems and human uses (EPA 2005).

FRP

Filterable Reactive Phosphorus is the dissolved inorganic phosphorus available for plant growth, and is sometimes referred to as dissolved inorganic phosphorus.

FMS

Farm management systems

GBRMPA

Great Barrier Reef Marine Park Authority

HEV

High Ecological Value. HEV waters are usually associated with national parks, conservation reserves or inaccessible locations. Natural resource management targets for these systems aim to maintain no discernible change from their natural condition.

N

Nitrogen

NO₃

Nitrate is a form of bioavailable nitrogen

NO₂	Nitrite is a form of bioavailable nitrogen	TN	Total nitrogen
NO_x	Oxidised nitrogen composed of the total of nitrate plus nitrite	TOs	Traditional Owner groups. Traditionally, Aboriginal populations in the Barron River and Trinity Inlet areas were not evenly distributed, but found along watercourses. TO groups have strong social ownership and responsibility for the land and its associated water resources.
NWQMS	National Water Quality Management Strategy		
P	Phosphorus		
PN	Nitrogen attached to sediment or other particulate material	TP	Total phosphorus
PP	Particulate phosphorus commonly refers to P that does not pass through a 0.45 µm filter. PP is composed of both organic matter and inorganic material. The organic PP is bioavailable in the long term.	TSS	Total suspended sediment. The unconsolidated particulate material present in the water column.
Pesticide	General classification including herbicides, fungicides, rodenticides, insecticides etc for which many management practices apply.	Turbidity	Optical measure of light-absorbing materials in a water sample, a surrogate measure of suspended solids. Commonly measured with a Secchi disk.
Pollutant	when a contaminant is at concentrations known to cause environmental harm.	WaterCast	Next generation E2 modeling program
QDIP	Queensland Department of Infrastructure and Planning	WSUD	Water Sensitive Urban Design
Reef Plan	Australian and Queensland Government strategy for improvement to Reef water quality by 2013	WQ Guideline	Technically derived numerical concentration for indicators that protect stated EVs. This defines the characteristics of a water body that allow a specified use to be carried out (i.e. drinking water, stock watering etc).
STP	Sewage treatment plant	WQO	Water Quality Objectives are set to protect the environmental values of waterways in the study area. WQOs are based on the community's initial choices for EVs and the water quality guidelines to protect them.
Terrain NRM	Far North Queensland Natural Resource Management Group - regional body for the Wet Tropics region		
TIMP	Trinity Inlet Management Plan	WQ Target	A water quality target is the water quality condition estimated to be achievable given adoption of management actions and improved management practices. The Target may be the current condition of water quality if better than the WQO.
Toxicant	A chemical capable of producing an adverse response (effect) in a biological system at concentrations that might be encountered in the environment.		

About this document

The state of water quality in the Barron River and Trinity Inlet is the responsibility of all land and water users within the catchment *and* all those who consume the products derived from those uses. A very wide range of factors contribute to the current water quality in the catchments, from urban and industrial point sources, through to diffuse contributions from the wider landscape. A broader consideration of water quality also needs to be inclusive of a wide range of catchment health indicators, including instream and riparian ecosystem health, environmental flow requirements as well as a variety of various pollutant levels.

Current funding priorities to progress this Barron River and Trinity Inlet Water Quality Improvement Plan (Barron-Trinity Inlet WQIP) have directed our attentions in this instance to non-urban diffuse contributions to water quality and to nutrient, sediment and pesticide loads. It needs to be recognized, however, that there are a wider range of water quality parameters and contributions to them and that need to be included in a whole of catchment approach to the management of water quality. Both the Barron River Integrated Catchment Management Association (BRICMA) and Terrain NRM consider it important that this Water Quality Improvement Plan be only considered as a focused contribution to the wider catchment planning activities being progressed jointly by both parties and other catchment stakeholders.

As such, this document is primarily focused on diffuse source contributions to nutrient, sediment and pesticide pollution in the Barron and Trinity Inlet catchments. The technical and consultative input outlined in this document all contribute to the wider catchment planning process. In short, the document presents a summary of:

- The catchment's environmental values (identified by the community) for protection;
- Proposed catchment water quality objectives; and
- Recommended catchment management actions by which water quality is proposed to be protected and improved (under Reef Plan) in the Barron River and Trinity Inlet catchments (Figure 1).

To find out more about the large body of community, technical and scientific work underpinning this document, please take the time to explore the resources section at the end of the document.

Why care about water quality?

In previous studies conducted in the Wet Tropics Region, water quality is identified as an important ecological well-being factor for a majority of residents (Bohnet *et al.* 2007). For Aboriginal people, water and waterways and their associated stories are the orientation map to the lie of the land and to its socially derived meaning and significance. People everywhere increasingly understand that quality of life is enhanced by maintaining the quality of waterways and wetlands. Water supports people, crops and grazing, and is also critical to community wellbeing and the health of the whole ecosystem. Water connects places, processes and species. When water quality deteriorates, there are often impacts on downstream ecosystems and the communities that depend on the health of those environments.

As an example, when inorganic nitrogen escapes into waterways, its concentration adds to the total nitrogen load within the ecosystem. This high nutrient level may have environmental side-effects such as weed growth and fish kills due to low dissolved oxygen levels. Similarly, when pesticides enter waterways, they have the potential to damage plant and animal life in waterways. Downstream, all the sources of pollutants in a catchment combine to elevate the concentrations of nutrients, pesticides and sediments and degrade the water quality of streams and inshore marine environments. To protect the Great Barrier Reef and its environmental values from land based sources of pollution, the Australian and Queensland Governments jointly developed and launched the Reef Water Quality Protection Plan (Reef Plan) in late 2003. This Plan aims to “halt and reverse the decline in water quality entering the Reef within 10 years”.

What is a WQIP (Water Quality Improvement Plan)?

To halt and reverse the decline in water quality entering the Reef, Reef Plan promotes the development of Water Quality Improvement Plans (WQIPs) focused on diffuse source nutrient, sediment and chemical pollutants. WQIPs have been developed for the Douglas Shire and the Tully-Murray Rivers in north Queensland and for the Mackay-Whitsunday and Burdekin regions, and other Plans are currently being completed for the Black-Ross Basin as well as for the Burnett-Baffle region.

A WQIP helps identify critical local water quality issues that may affect the Great Barrier Reef. This process in turn means looking at the entire length of the catchment’s waterways – not only for current pollutant loads, but also for environmental values (EVs) – what the whole community (producers, the Traditional Owners, conservationists, tourism operators and people at large) values and uses these waterways for. This information provides a basis on which to establish load targets for water quality pollutants. Provided these pollutant targets are met, water quality will be improved (or maintained) and the environmental values of these waterways will be protected. An essential part of a WQIP is the identification of the most cost-effective and timely measures and actions needed to achieve these water quality objectives and pollutant load targets.

While the WQIP progresses actions that can be progressed and monitored, it is important to recognize that, in the absence of long term catchment monitoring, much of the science underpinning the document is based on modeling approaches. For this reason, significant qualification and a precautionary approach is required regarding the application and monitoring of key strategies. Terrain NRM and BRICMA particularly recommend that the establishment of long term, robust and durable monitoring programs is required to enable the assessment of the proposed actions as well as the long term refinement of models over time.

Overall, Water Quality Improvement Planning needs to be seen as an adaptive process. Additional benefits of WQIPs, however, include potentially greater economic efficiencies in local industries, greater collaboration between organizations, greater coordination of on-ground management activities, sustainable Reef based tourism and better water quality and ecological health in local freshwater systems.



Figure 1. Barron-Trinity Inlet WQIP area.

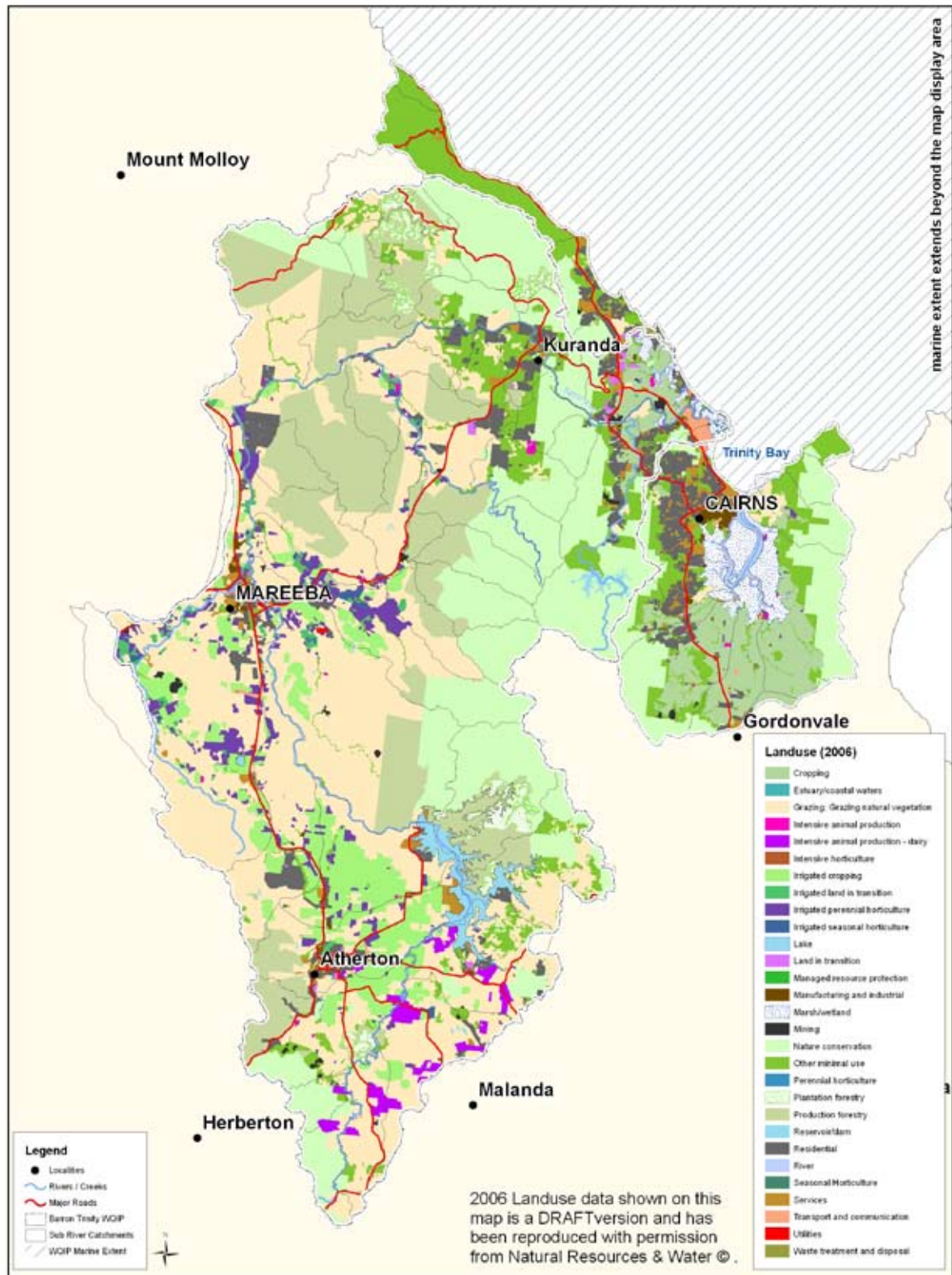


Figure 2. Land use types in the Barron-Trinity Inlet WQIP region.

Why have a WQIP for the Barron River and Trinity Inlet catchments?

The significant agricultural interests throughout the Barron catchment and expanding coastal development in the Cairns urban and surrounding areas are increasing pressure on in-stream water quality and ecosystem health of the Barron-Trinity Inlet WQIP area. In Reef Plan, the Barron River (Figure 1) was identified as one of the Great Barrier Reef catchments posing a high risk to the marine tourism industry. Each year, nearly two million domestic visitors and one million international tourists visit the Great Barrier Reef, generating over \$2 billion annually to the Australian and local economies. Many of these tourists visit the Reef adjacent to Cairns and Port Douglas. The Tablelands are a vital agricultural resource in north Queensland (Figure 2) and local farmers produce approximately \$750 million worth of crops and livestock annually with sugar, horticulture and grazing industries being the main agricultural land uses (Table 1).

Table 1. Areas by land-use, Barron-Trinity Inlet WQIP catchment (Hatley *et al.* 2009).

Land Use	Km ²	%
Forest	1178	46
Grazing	736	29
Cropping (including maize, potato, peanuts, fruits)	181	7
Urban	178	7
Sugarcane	145	6
Dairy Grazing	20	<1
Water	88	3
Plantation Forestry	33	1
Mining	9	<1
TOTAL	2570	100

The Barron-Trinity Inlet Catchment

At more than 165 km in length, the Barron River is one of the region's largest easterly-flowing waterways. Its catchment covers some 2,570 km² and spans the central portion of the Wet Tropics bioregion. The Barron-Trinity Inlet WQIP area encompasses the entire Barron River catchment, including Lake Tinaroo, Trinity Inlet, and the coastal plain to the north of the Barron River to Wangetti (the Northern Beaches). The Barron River is the most modified river in the Wet Tropics region and is heavily regulated by water supply infrastructure. The Cairns CBD is on the western bank of the Trinity Inlet estuary and the catchments of Trinity Inlet comprise the southern portion of Cairns City. The area also includes the Country of many Traditional Owner groups including: the *Ngadjon-Jii*, *Tablelands and Dulgubara Yidinydji*, *Koko Muluridji*, *Djabugay*, *Yirrganydji* and coastal *Yidinji* peoples, with the latter including the *Gimoy Walabura*, *Gungandji*, and *Mandingalbay* clans. Both the Barron River and Trinity Inlet are strong story places for their Aboriginal custodians.



Figure 3. Conceptual diagram of the Barron-Trinity Inlet WQIP area (Edgar and Collier, JCU).



Figure 4. Cattana Wetland (F. Barron).

Rapid Growth

The Far North Queensland region is one of the most dynamic growth areas of Australia with a diverse demographic structure. Currently, there are between 3,500 and 4,500 new residents moving into the region each year. Cairns City has a resident population of around 147,000 (as at 30th June 2006) and an annual tourism turnover of around 2 million visitors each year. It is a major residential, commercial and industrial centre in Far North Queensland. The local population is expected to increase by more than 30% between 2006 and 2025, with almost 80% of the increase expected to occur in Cairns (QDIP, 2008). This growth will continue to place significant pressure on the local environment, urban land availability, water and energy resources and infrastructure. In contrast, the Tablelands region is a predominantly rural area with a number of smaller towns spread throughout the landscape. These include Atherton, Yungaburra, Kairi, Mareeba and Kuranda. The Tablelands Regional Council resident population is about 44,350 (as at June 30th 2007; QDIP, 2008). The populations of Mareeba, Atherton and Malanda are predicted to double by 2025 (QDIP, 2008).

Who developed the Plan?

Operating within the context of BRICMA's broader catchment management strategy, the Barron-Trinity Inlet WQIP was funded by the Australian Government's Coastal Catchment Initiative (CCI) through the Department of the Environment, Water, Heritage and the Arts. The development and delivery of the WQIP has been managed by the Regional NRM Board (Terrain NRM), with support from BRICMA, Cairns Regional Council, the Tablelands Regional Council and the Barron-Trinity Inlet Steering Committee. The Steering Committee forms a vital partnership between Local, Regional, State and Federal stakeholders. Research underpinning the Barron-Trinity Inlet WQIP was conducted by JCU, AIMS and the QNRW (now DERM). In the context of the wider catchment management strategy, BRICMA and Terrain consider that it is important to point out three key limits to the focus of this WQIP:

- Environmental flow requirements have previously been dealt with in the context of the Barron Water Resource Plan, but this process itself requires ongoing adaption and refinement;
- The WQIP does not extensively deal with the issue of riparian and aquatic ecosystem health; and
- The WQIP does not extensively deal with the impact that changed hydrological characteristics of the catchment and its impact on both pollutant loads and ecological health of the catchment. We consider the general hardening of the catchment landscape since development began in the catchment and the increased speed of drainage creates the potential for significant ecological and social impacts.

All three of these issues, in addition to the findings of this WQIP, need to be, and will be, incorporated in whole of catchment planning processes for the Barron.



Figure 4. Marine extent of flood plumes: MODIS AQUA, 14 and 15th January 2009. Images developed by V. Brando, CSIRO (2009). Images EOS NASA; Map layers Geoscience Australia and GBRMPA.

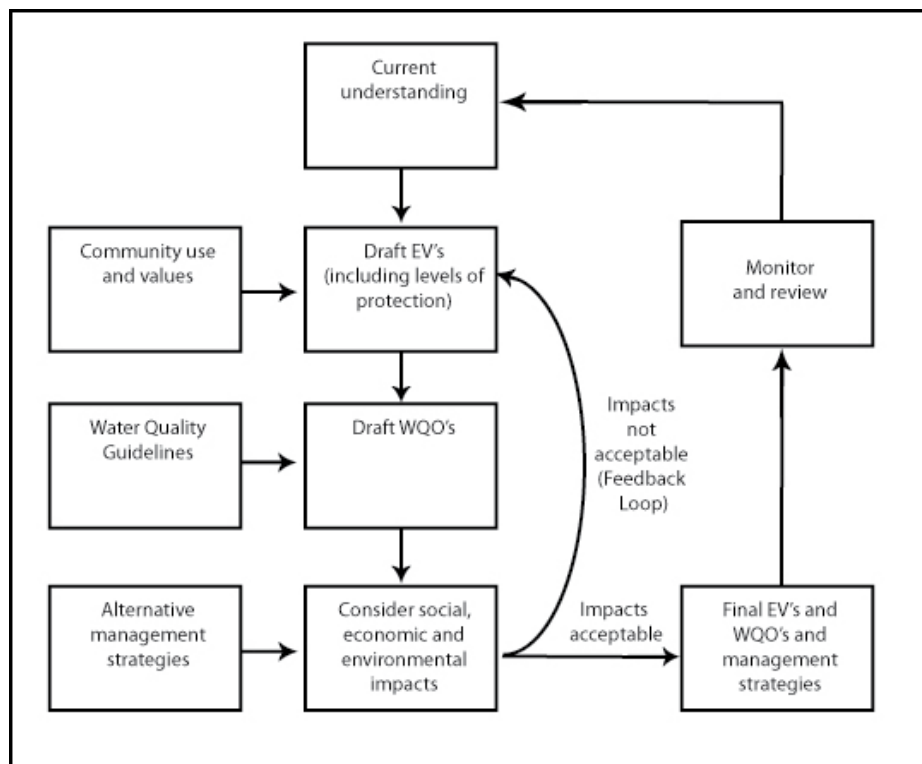


Figure 5. Water quality improvement planning process (J. Bennett).

Yorkey's Knob and East Trinity ASS Disturbance (D. Morrison and A. McElnea, DERM)

Acid sulfate soil (ASS) is the common name given to soils and sediments containing iron sulfides. If these types of soils are exposed to air when they are drained or disturbed, they produce sulfuric acid which releases aluminium and other heavy metals into adjacent waterways and groundwaters. An estimated 2.3 million ha of acid sulphate soils occur along 6500 km of the Queensland coastline. Many of these areas are under pressure for agricultural and urban development. The environmental problems caused by disturbance of acid sulfate soils are often long-term and expensive to reverse. A regional ASS WQIP has recently been released by the Queensland government (McClurg *et al.* 2009), and its recommendations are supported by the recommendations contained in this Barron WQIP.

Yorkey's Knob

An extensive area of severe acid sulfate soils exists near Yorkey's Knob, north of Cairns. The area has been cut off from regular tidal inundation by floodgates and roads, exposing acid sulfate soil to air and causing the release of toxic acid runoff. This site is strongly acidic and has very high concentrations of dissolved iron (Figure 6). These extreme levels have caused serious damage to concrete structures in both the upper and lower parts of Yorkey's Creek (Figure 7). Yorkey's Creek is a declared fish habitat area; however acidic and metal contaminants have severely degraded its environmental and habitat value. Most forms of aquatic life in Yorkey's Creek are likely to be adversely affected by these annual toxic discharges. NRW (now DERM) believes that Yorkey's Creek could be rehabilitated through controlled reintroduction of tidal water from both Yorkey's and Moon Creeks. In simple terms, reintroduction of tidal water could be achieved by way of installing adjustable flood gates across Yorkey's Creek and a larger pipe under Dunne Road. Any remedial works will require appropriate funding, scientific and technical support, specialist equipment and most importantly, a co-operative partnership between local landholder/cane growers, NRW, Cairns Regional Council, EPA, DPI&F, and Terrain.



Figure 6. Yorkey's Creek Acid Scald.



Figure 7. Floodgate on Yorkey's Creek.

Trinity Inlet

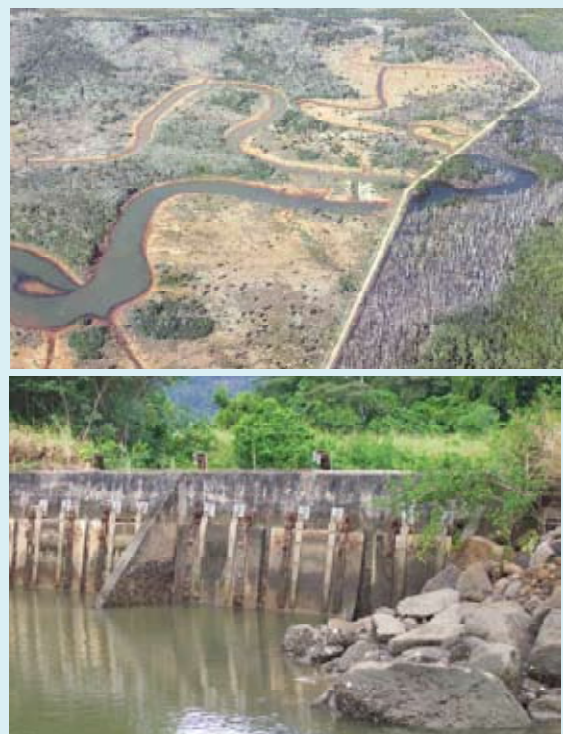
Another major ASS site is situated on the eastern side of Trinity Inlet, opposite the Cairns CBD (Figures 8 & 9). As was the case for the Yorkey's Knob site, East Trinity was cut off from tidal inundation, but this was done on a large (940 ha) scale. In an effort to grow sugar cane, a 7.2 km long earthen (bund) wall was constructed on the seaward perimeter of the site in the early 1970's. The bund incorporated a series of one-way floodgates, eliminating all tidal influence on the landward side of the bund (Figure 10). The plan was that saltwater could be washed from the system, enabling salt-sensitive sugarcane to be grown, however the silty clay soil which was proving so difficult to

remove the salt from also contained a toxic time-bomb in the form of the iron sulfide mineral, pyrite. As oxygen penetrated below ground oxidising the buried pyrite, the soil became highly acidic and cane continued to fail. Following a dry spell, the first heavy rains were commonly accompanied by fish kills in the creeks. The site was eventually abandoned in the early 1980's. For more than 20 years, acid and toxic metals continued to leach into Trinity Inlet and the creeks and channels on the site were effectively sterilised. In May 2000, the State Government purchased East Trinity and set about trying to remediate the highly acidified site. A principal element of the remediation strategy was an approach known as lime-assisted tidal exchange (or LATE-“better LATE than never”), a method of controlled, daily tidal flushing supplemented by the cautious addition of hydrated lime, $\text{Ca}(\text{OH})_2$. Where possible, acidified areas above the reach of the tide were treated with agricultural lime (CaCO_3).

The goal of the remediation strategy at East Trinity is to have water of acceptable quality ($\text{pH} > 6$) exiting the site on a consistent basis, in all seasonal conditions, under a self-managed tidal regime, without addition of lime. To achieve this goal, the strategy must permanently decrease the acid and metal production from acid sulfate soils on the site by neutralising the acid that has already been generated and prevent any further oxidation of pyrite. In the process of remediating the acid sulfate soils, the degraded and acidified, fresh/brackish-water environment is being transformed into a flourishing tidal wetland system. While acidic hotspots remain in some wetlands, monitoring shows that the water leaving the site is now of consistently good quality and fish life has returned in abundance. With continued remediation the situation will continue to be maintained and improve. East Trinity has been an unfortunate (and expensive) legacy borne out of ignorance and inappropriate development beginning almost 40 years ago. It is also a salutary lesson that coastal development needs to be predicated by caution and a detailed understanding of the natural system and the potential effects that disturbance can have in the coastal environment.



Figure 8. Trinity Inlet.



Figures 9 & 10. Trinity Inlet ASS affected areas and infrastructure.

What actions does the WQIP recommend to improve water quality in the Barron and Trinity Inlet catchments?

The Barron-Trinity Inlet Water Quality Improvement Plan is primarily concerned with reducing nutrient, pesticide and sediment loads entering Great Barrier Reef waters downstream of Trinity Inlet and the Barron River (Figure 3). The management actions for reduction of pollutant discharge recommended by the Barron-Trinity Inlet WQIP will help protect and improve the condition of local catchments, wetlands and marine environments. Effective monitoring systems to determine the impact of these actions are required.

Catchments

The Barron River basin is a complex and heavily utilised river system in the Wet Tropics bioregion, comprising a large upper catchment on the Tablelands and a smaller, lower catchment north of Cairns where it discharges into Trinity Bay. From its story birthplace in Mt. Hypipamee Crater, the initial stream feeds into Lake Tinaroo along with a number of upper tributaries including Mazlin, Petersen and Kauri Creeks. Rainforest, waterfalls and crater lakes are part of the unique characteristics of the river here. A major dam is situated at Tinaroo Falls at the northern end of this lake. Lake Tinaroo effectively divides the Barron River on the Atherton Tableland into two sections, above Tinaroo Falls Dam and below this dam. From a water quality perspective, the dam acts as a large freshwater wetland area, recycling nutrients and trapping pesticides and sediment from the upper reaches, including material from agricultural activities in this area and the townships of Atherton. From Tinaroo Falls Dam, the river continues north and is joined by Rocky, Granite and Emerald Creeks around the middle of the catchment in drier country, and then by other waterways including Clohesy River and Shanty and Flaggy Creeks above the Barron (*Din Din*) Falls. Below the Falls, Surprise Creek and Stoney Creek join the Barron River before Freshwater Creek at Freshwater, most of the way down the range. On the coastal plain, where most of the river is estuarine, Thomatis Creek now forms part of the deltaic discharge of the Barron River. Trinity Inlet is an estuarine inlet in the heart of Cairns CBD which is used as the harbour for the city. The narrow coastal plain to the north of Cairns is dominated by the Macallister Range that sources a number of short streams flowing directly to the coast.

Wetlands

There are a number of important freshwater wetlands on the Tablelands including: Hasties Swamp (near Atherton), Lakes Eacham, Tinaroo and Morris as well as Nardello's Lagoon (north of Walkamin) and the Delta is home to the Cairns Central Swamp (near the Cairns CBD) and Cattana Wetlands, which backs on to Moon Creek. There are also two areas listed on the Directory of Important Wetlands, Lake Eacham and the mangrove areas of the Trinity Bay foreshore. Between 1952 and 1996 there was a total net loss of about 16% of wetlands in the Barron River catchment.

Table 2. Potential waterway environmental values (EVs) (EPA 2006).

Environmental values		Supporting details	Questions
AQUATIC ECOSYSTEMS			
Aquatic ecosystems		Pristine (see HEV systems below) or modified Aquatic Ecosystems	
High conservation / ecological value systems (HEV)		Systems are largely unmodified or have undergone little change. Often found within national parks, conservation reserves or inaccessible locations.	Are any waterways largely unmodified or changed very little? Where are they?
Modified systems		Freshwater	What components of ecosystems do you want to protect e.g. turtles, fish, macroinvertebrates, riparian vegetation, instream habitats, flows?
Modified systems		Estuarine/Coastal/Marine	What components of ecosystems do you want to protect e.g. reefs, seagrasses, mangroves, dugongs, turtles, fish, shellfish?
HUMAN USES			
Primary industries		Irrigating crops such as sugar cane, lucerne, etc	Where is the water used for irrigation? What crops, etc are irrigated?
		Water for Farm Use such as in fruit packing or milking sheds, etc	Where is the water used around farms for washing down areas or fruit packing?
		Stock Watering	Where is the water used for watering stock? What type of stock?
		Water for Aquaculture such as barramundi, prawn or red claw farming	Where is the water used in aquaculture operations and what species are cultivated?
		Human Consumption of wild or stocked fish or crustaceans	Where is there consumption of wild or stocked fish or crustaceans?
Recreation and aesthetics		Primary recreation with direct contact with water such as swimming or snorkelling	Are there any recreational activities where people are fully immersed in the water e.g. swimming, snorkelling? If so, where?
		Secondary recreation with indirect contact with water such as boating, canoeing or sailing	Are there any recreational activities where people are possibly splashed with water e.g. fishing, boating, sailing? If so, where?
		Visual appreciation but no contact with water such as picnicking, bushwalking, sightseeing	What areas of waterways are regularly used by people who enjoy looking at and being near the waterway?
Drinking Water		Raw Drinking Water supplies	Where do people or local governments take water from the river for water supplies?
Industrial uses		Water for Industrial Use such as power generation, manufacturing plants	What are the industries that take water from the river for their operations and where does this occur?
Cultural and spiritual values		Cultural and spiritual values	What are the cultural and spiritual values associated with these waterways?

Marine influenced areas

The Barron catchment drains directly into the Great Barrier Reef World Heritage Area and there is the potential for significant quantities of pollutants to be transported to marine and estuarine waters from Barron River sub catchments (Russell *et al.* 2000; Cogle *et al.* 2000; Moss 2006; Brodie 2007; Mitchell *et al.* 2009). During average wet season flood events, large areas of marine receiving waters are influenced by the freshwater discharge from the Barron-Trinity Inlet WQIP area. The exact area impacted depends upon the volume and duration of flood flow, as well as the direction of currents and winds. Satellite imagery shows that plumes from Wet Tropics rivers, including the Barron, can extend eastwards across the entire Reef shelf and beyond into the Coral Sea (Figure 4).

Stages of the Barron-Trinity Inlet Water Quality Improvement Plan

The development of the Barron–Trinity Inlet WQIP has relied on the following steps (Figure 5):

- Stage 1: Collation of existing information.
- Stage 2: Identification of community Environmental Values (EVs) of regional water ways.
- Stage 3: Identification of High Ecological Value (HEV) waterways (and other natural assets in modified waterways where stakeholder input was provided) of the region.
- Stage 4: Identification of Water Quality Objectives (WQOs) that will protect regional EVs.
- Stage 5: Modeling of current pollutant loads in the Barron River and Trinity Inlet catchments using E2 (WaterCast).
- Stage 6: Development of management recommendations to reduce current pollutant loads to Barron and Trinity Inlet catchment waterways.

Stage 1: Identification of existing information

The Australian Centre for Tropical Freshwater Research (ACTFR) was commissioned by Terrain NRM to undertake a desktop compilation and review of all available water quality information related to the Barron-Trinity Inlet WQIP area in 2008. The information compiled as part of this review (Mitchell *et al.* 2009) was used as an integral component of the development of the WQIP. The report is available at www.terrain.org.au.

Stage 2: Identification of regional Environmental Values (EVs)

The Barron-Trinity Inlet WQIP development process was used to establish environmental values (EVs) for freshwaters, estuarine and marine reaches of the Barron-Trinity Inlet WQIP area that were consistent with the National Water Quality Management Strategy framework and EPP

(Water). Established EVs are the values and uses of local waterways that management actions outlined in the Barron–Trinity Inlet WQIP will try to protect.

EVs are those qualities of a waterway that make it suitable to support community values and uses. EVs are categorised into aquatic ecosystems, primary industries, recreation and aesthetics, drinking water, industrial uses, and cultural and spiritual values, with further division for some categories (Table 2). These qualities require protection from the effects of pollution including waste discharges, siltation and runoff to ensure healthy aquatic ecosystems and waterways that are safe and suitable for community use. All water reaches possess at least one of the EVs listed (namely aquatic ecosystems) and more than one EV may be designated for a specific water reach (EPA 2005). There were 65 freshwater reaches as well as estuarine and marine areas identified within the WQIP area, based on NRW sub-catchment geographical information system (GIS) data and these designations were broadly treated as either “undeveloped” or “developed” reaches. These designations represented similar conditions within a river reach and this process assisted discussions on reaches with common EVs during community consultation workshops.

Environmental Value (EV) determination for the Barron-Trinity Inlet WQIP built on information in existing resource management plans, many of which had included extensive consultation (Appendix 1). The WQIP process also included:

1. Four workshops with community members at Atherton, Mareeba, Kuranda and Cairns in the Barron-Trinity Inlet WQIP area during November 2008;
2. Discussions with the Barron-Trinity Inlet WQIP Steering Committee; and
3. Further meetings with, and input from key stakeholders and the community including Traditional Owners to enable provision of comments on the draft EVs.

The Barron-Trinity Inlet WQIP EVs process also provided a form of review of previously identified EVs (Appendix 1).

EV workshops were advertised through existing community group networks and the local media. Workshop participants included Traditional Owners, councilors, local (non-farming) residents, sugarcane farmers, tropical fruit growers, banana growers, graziers, foresters, tourism operators and government and conservation representatives.

Based on the geographic information provided by workshop participants, draft EVs identified by community representatives were established for each of 65 freshwater river reaches and estuarine and marine areas within the Barron-Trinity Inlet WQIP area. The results for the draft regional EVs are provided in Appendix 2. The draft EVs demonstrate that the waterways in the Barron-Trinity Inlet WQIP area are used and valued for a wide range of community activities. All 65 freshwater waterway reaches are used and valued for their aquatic ecosystems, for their Indigenous and non-Indigenous cultural heritage, and for their amenity. All groups use and value the aquatic ecosystems that local waterways provide, as well as value waterway uses for provision of drinking water and aquatic food supplies.



Figure 11. Proposed high ecological value waterways which fall within protected areas under existing legislation (Wet Tropics World Heritage Area, National Parks, Queensland Declared Fish Habitat Area (Class A), Marine National Park (Green) and Preservation (Pink) Zones). Additional HEV waters were identified in stakeholder workshops including, for example, some State Forest areas.

The main consumers of water in the Barron basin are urban consumers, farmers and industry. In contrast, many local residents, Traditional Owners and conservation groups use and value waterways primarily for recreation and aesthetic values, as well as for cultural and spiritual purposes. Aquatic foods are obtained from 47 of the 65 freshwater waterway reaches. Estuarine and coastal reaches also had medium to high levels of use for this “human consumption” environmental value. Primary and secondary recreation were identified as an environmental value for 40 and 64 freshwater reaches respectively and were classified as medium to high in value in estuarine and coastal reaches. This difference in reaches used for activities involving direct versus indirect contact often reflected the distribution of estuarine crocodiles (*Crocodylus porosus*). Of the 46 waterways not on the delta, 22 are used for drinking water. Stock watering is undertaken in 34 of 39 reaches above the Barron Falls. Twenty-five and 24 of the 28 developed reaches above the Barron Falls are used for irrigation and farm supply respectively. Four sub-river catchment (Thomatis, Middle, Chinaman, and Hartley) estuarine reaches are used and valued for aquaculture purposes. The Barron River is also used for hydroelectric power generation.

Stage 3. Identification of regional High Ecological Value (HEV) waterways

The National Water Quality Management Strategy (NWQMS) identifies three levels of protection for waterways with different ecosystem conditions, namely:

- High ecological value;
- Slightly to moderately disturbed; and
- Highly disturbed.

This process allows the community to identify waterways with high ecological value that need to be protected (Appendix 3). The Barron-Trinity Inlet WQIP recommends that waterways which fall within 'protected' areas under existing legislation (i.e. Wet Tropics World Heritage Area, National Parks, Queensland Declared Fish Habitat Area (Class A), Marine National Park (Green) and Preservation (Pink) Zones) and other areas identified through community consultation be considered High Ecological Value waterways (Figure 11). During the workshops, a number of additional “other areas” were discussed as HEVs. These primarily fell within State Forest areas and Marine Park conservation zones. The updated HEV mapping is presented in Figure 11, with more detail contained in Appendix 3. All Traditional Owner groups emphasised the importance of preserving and returning, wherever possible, highest water quality standards in the headwaters of all waterways feeding into the Barron River and Trinity Inlet. The WQIP recommends that the DERM and Terrain NRM complete a more detailed assessment of the conservation values of the area’s waterways in the future. This assessment will allow further consultation with the community on which additional waterways could be recommended for high ecological value status. Community participants endorsed the concept of the inclusion of additional HEV areas defined through future consultation. DERM has commenced further ecological assessment in the region as part of its Aquatic Conservation Assessment Program throughout GBR catchments (www.epa.qld.gov.au/aquabamm). Results of the ACA would form an input into future updated assessments of conservation values as recommended by the WQIP.

Traditional Owner links are strong in the Barron and Trinity Inlet catchment areas

The cultures of the Traditional Owner Groups in the Barron and Trinity Inlet WQIP Area have evolved through intensive interaction with the land and its waterways, extending for tens of thousands of years. The lifestyle of these half dozen Traditional Owners and their thirty or so Clans and multiple family groups is closely associated with the continuous supply of water to rivers and creeks of the rainforest in the Barron and Trinity Inlet WQIP Area. Virtually all Dreaming stories of these traditional Owner groups contain references to water sources and listed below are some extracts of stories which demonstrate this significant and ongoing connection.

One of the most important stories of *Yidinydji* from on the Tablelands relates to the origin of Lake Eacham, an important site neighbouring and connecting to *Yidinji* Country. This link is exemplified in a story recorded by Bob Dixon, (1991) from Dick Moses at Yarrabah. It tells of two newly initiated brothers, thought to be *Guyala* and *Damari*, who broke important taboos and thereby angered the rainbow-serpent. This spirit then caused the earth to erupt, bringing about the formation of Lake Eacham and several other deep lakes (2001 Indigenous Report of the Barron Water Resource Plan).

The *Ngadjon-Jii* people are the Traditional Owners of *Bana Wiingina* (Lake Eacham). The *Ngadjon-Jii* account of the formation of this country demonstrates the link with that of the *Yidinji* people's story. Warren Canendo, a *Ngadjon-Jii* artist, tells the story of the formation of Lake Eacham:

"Two young fellas were trying to spear that wallaby. But they missed and hit a flame tree. That's a sacred tree. The young fellas not supposed to be out hunting. They weren't initiated. Their elders told them to stay put, not go out hunting. But they didn't listen. When they pulled their spear out, part of a grub came out with the spear, which was a witchetty grub. They started cutting down that tree to get more grubs. When they cut down that tree, the ground began to shake. Those two fellas had made Yamini (rainbow serpent) angry. Then the sky turned orange, then all these people back at the camp, the earth went from underneath them, sucked them in, whoosh, they all got drowned. Where they were camped became Bana Wiingina (Lake Eacham)."

Din Din is also a well-known storyplace (storywater) and sacred site - it is the *Djabuganydji* name for what is now known as the Barron Falls.

"When you go to a Storywater you've got to do the right thing. It's 'like visiting a graveyard to see my mother - I promised I'd come back, talk with you, make you happy, bring you flowers. When you visit a Storywater it's the same - you feel glad in your heart. You talk to the Storywater. You tell the water what you are going to do. If you don't introduce yourself, you'll stir it up. When you do the right thing, it'll give you what you want. Some places are dangerous - "Bana buga buga!" the old people said. Dark waters! We mustn't go there. If we do, we won't come back." Wanyarra.

Djabugay people who like some groups further north call themselves *Bama* believe *Budadji* created all the rivers and creeks of the Barron Gorge, signifying each stage of his journey (Timothy Bottoms, 1999; NQ Research Associates, 1995 in EPA, 1998). *Budadji* is the *Djabuganydji* name for the Rainbow Serpent Creator Spirit known as *Yarmini* for *Ngadjon-Jii* and several southern groups.

Specific water quality issues and threats identified through community consultation

Sediment, nutrients and pesticides were identified as perceived pollutants of concern by the community including Traditional Owners and the Barron-Trinity Inlet Steering Committee. Specific mention was made of river bank erosion, council (road) works, the importance of roads as pollutant sources, the importance of urban centres as pollutant sources and the lack of commitment to change in practices to minimise or stop the use of agrochemicals. Additional perceived pollutants of concern that were mentioned included potential acid sulfate soils (PASS) and dissolved oxygen reducing substances (including sugar and general organic matter), and effluent discharges from 8 sewage treatment plants.

Issues of concern that were identified by the community and Barron-Trinity Inlet WQIP Steering Committee as relevant to water quality for freshwater reaches include: (i) the safety of drinking water; (ii) the loss of local water bodies including wetlands, lagoons and small streams; (iii) the clearing of native vegetation on the upper reaches of the rivers and creeks and associated agricultural development; (iv) the condition of riparian zones; (v) environmental flow and water quantity; (vi) groundwater quality and quantity; (vii) weed infestations; and (viii) feral pigs. For estuarine and marine waters, additional issues of concern included: (i) coastal erosion; (ii) urban and coastal development, including development on land below flood level; (iii) sewage treatment plants; and (iv) maintaining healthy reefs, mangroves and wetlands; and (v) recognition of the benefits from involvement of Traditional Owners across such matters.

Stage 4: Establishing WQOs that will protect draft regional EVs

Draft Water Quality Objectives (WQOs) are based on the community's choices for environmental values (EVs) as well as water quality guidelines and standards to protect local waterways. WQOs are measurable indicators of the water quality characteristics needed to protect the EVs of particular waterways. They may be defined for a range of physical parameters (e.g. turbidity, suspended sediment and temperature), chemical parameters (e.g. phosphorus, nitrogen and toxicants), and biological parameters (e.g. algae, diatoms, macroinvertebrates and fish), as well as other measures of catchment condition (e.g. erosion levels, extent of riparian vegetation and channel morphology). Where more than one EV is identified for a waterway (e.g. water is used and valued for both irrigation and aquatic ecosystems), the most stringent water quality guideline for each water quality indicator is the draft WQO selected, in order to best protect all identified EVs (ANZECC 2000; EPA 2006).

Water Quality Guidelines

Water quality guidelines are technically derived, and define desirable ranges and maximum levels for certain measurable parameters that should be achieved to protect the environmental values of waterways (Dight 2009). Insufficient direct effect data are available from the Barron-Trinity Inlet catchments from which to derive locally relevant guidelines for freshwater ecosystems at this time. There are, however, a number of Water Quality guideline documents available for the various environmental values that apply to the Barron-Trinity Inlet WQIP area. For these indicators, the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC 2000) guidelines remain the principal source of information. Other available

Table 3. Water types used in the Barron-Trinity Inlet WQIP.

Water Type	Description
<i>Upland freshwater</i>	Streams and major rivers above 150 m
<i>Lowland freshwater</i>	Streams and major rivers below 150 m
<i>Lakes</i>	Deepwater habitat situated in dammed river channel, with total area >8 ha
<i>Wetlands</i>	‘Palustrine’ wetlands as per EPA wetland mapping
<i>Mid-Estuary</i>	Upstream limit = ‘estuarine’ wetlands as per EPA wetland mapping (version 1, August 2006) downstream limit = mouth of estuary = coastline
<i>Enclosed Coastal</i>	The seaward limit of the enclosed coastal water body is the cut-off between shallow, enclosed waters near the estuary mouth and deeper, more oceanic waters further out (EPA 2006).
<i>Open Coastal</i>	EC (the seaward edge of the enclosed coastal water body) to 6 km seaward (GBRMPA 2008)
<i>Midshelf</i>	Marine waters 6-24 km offshore (GBRMPA 2008)
<i>Offshore</i>	Marine waters 24-170 km offshore (GBRMPA 2008)

Table 4. Draft Water Quality Objectives for aquatic ecosystem protection of non-HEV waters.

Indicator	Water Type			
	Upland Stream	Lowland Stream	Lake	Wetland
Turbidity (NTU)	6	15	2-200	2-200
NH ₃ (µg/L)	6	10	10	10
NO _x (µg/L)	30	30	10	10
Org N (µg/L)	125	200	330	330-1180
TN (µg/L)	150	240	350	350-1200
FRP (ug/l)	5	4	5	5-25
TP (µg/L)	10	10	10	10-50
Chlorophyll a (µg/L)	0.6	1.5	3	10
Atrazine (µg/L)	13	13	13	13
Chlorpyrifos (µg/L)	0.01	0.01	0.01	0.01
Tebuthiuron (µg/L)	2.2	2.2	2.2	2.2
2,4-D (µg/L)	280	280	280	280

guidelines which do include locally relevant guidelines include: *Draft Water quality guidelines for the Great Barrier Reef Marine Park* (GBRMPA 2008), *Queensland Water Quality Guidelines* (EPA 2006), *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC 2000), *Australian Drinking Water Guidelines* (NHMRC 2004), and *Guidelines for Managing Risks in Recreational Water* (NHMRC 2006).

Identification of reaches with common water types

Appropriate water quality guidelines for aquatic ecosystems also depend on the type of water being considered (e.g. freshwater, estuarine or marine). The Queensland Water Quality Guidelines (EPA 2006) define water types to ‘create areas within which water quality is sufficiently homogenous that a single water quality guideline value can be applied to all waters within each water type’. The water types defined by EPA (2006), the GBRMPA (2008) and the National Water Quality Guidelines (ANZECC 2000) for the Wet Tropics Region were used for the Barron-Trinity Inlet WQIP, but were adjusted as per Table 3.

Draft WQOs for reaches with common EVs

The draft WQOs for waterways with high ecological value (ie HEV waters) is to ‘maintain and improve existing water quality’. The draft WQOs (Table 4) to protect the EVs of non HEV waters identified by the community are based on the relevant National, State and Regional water quality guidelines (Appendix 4) for each of the EVs identified by the community (Appendix 2). In cases where more than one EV was identified for a particular water reach, the most stringent water quality guideline was applied as the draft WQO for that water reach, to ensure protection of all EVs. Because the Barron-Trinity Inlet WQIP is primarily concerned with reducing sediment, nutrient and pesticide loads in the water entering the Great Barrier Reef, draft WQOs were established for associated parameters. These draft WQOs for the 65 freshwater reaches and estuaries and coastal waters serve as water quality targets which, if achieved, would protect the EVs that the community would like to see protected. Conversely, these draft WQOs should be considered trigger values that would indicate a potential problem if exceeded, and ‘trigger’ a management response.

Barron-Trinity Inlet WQIP draft water quality targets

Water Quality Guidelines for ecosystem protection are the most stringent available in almost all cases. Accordingly, the draft Barron-Trinity Inlet WQIP has defined draft targets for all water quality parameters as the draft WQOs for aquatic ecosystem protection (Tables 4, 5 and 6). Draft WQOs may be changed into interim targets towards achieving the WQOs in the longer term where current water quality exceeds WQOs. To determine whether local water quality in the Barron River and Great Barrier Reef marine receiving waters achieve draft WQOs set for these waters, the draft WQOs for Barron freshwaters and the two water types in inshore marine waters (open coastal; 0-6 km and midshelf; 6-24 km off the coast) adjacent to the Barron River mouth were compared against average long term (2006-2008) NRW and long term (1989-2008) Australian Institute of Marine Science data for these waters (Figure 12; B. Schaffelke pers com). This comparison shows that draft WQOs are not currently met for a range of parameters (nutrients and water clarity) in both freshwaters (Table 5) and open coastal waters, 0-6km from

the coast (Table 6). For open coastal, midshelf and offshore water bodies, De'ath and Fabricius (2008) argue that short periods of high nutrient concentrations are ecologically significant, and such values are not reflected in median values. In contrast to medians, mean annual values capture and reflect (at least partially) both the frequency and magnitude of 'water quality events' (eg floods and other events that result in high values), and annual average values are therefore used as the measure for trigger values (GBRMPA 2008).

Table 5. Comparison of draft WQO for non HEV waters with average current condition at two monitoring sites on the Barron River. All data from NRW (June 2006- May 2008 (n > 200)). Data courtesy G. Pitt, DNRW (now DERM).

Indicator	Picnic Crossing (Atherton)	Draft WQO	Myola (Kuranda)	Draft WQO
TN (µg/L)	880	150	810	240
NO _x (µg/L)	190	30	70	30
NH ₃ (µg/L)	30	6	10	10
TP (µg/L)	210	10	110	10
FRP (µg/L)	20	5	10	4

Draft EVs and WQOs also help support natural resource planning and management activities. These activities include water resource plans, local government planning schemes, riverine management plans, coastal management plans, marine park plans, regional natural resource management plans. They support and influence these activities by:

- Collating views on desired community values for waterways for use in statutory and non-statutory planning and management activities;
- Providing advice to State and local government agencies assessing development applications lodged under the Integrated Planning Act (1997); and
- Complementing codes of practice under the Environmental Protection Act (1994) which, if followed, contribute to demonstrating compliance with the general environmental duty to minimise environmental harm.

Once draft EVs and WQOs have been established, they may also be considered for inclusion into the Water EPP. However, this process involves the amendment of legislation that must be considered and approved by the Queensland Government. State and local governments, acting as an administering authority under the Environmental Protection Act (1994), must consider EVs and WQOs under the Water EPP. This occurs when decisions about approvals are made and when conditions for environmentally relevant activities (ERAs) are set under the Environmental Protection Act (1994) and the Integrated Planning Act (1997).

Table 6. Comparison of draft water quality objectives (GBRMPA 2008) in inshore marine waters in the Barron-Trinity Inlet WQIP area. Nutrient, water clarity and chlorophyll a data are averages from AIMS (1989-2008) data (B. Schaffelke pers com), pesticide data are maximum values detected at Low Isles, (2005-2008) using passive sampler techniques (J. Prange pers com). (<dl: less than detection limit; na: not available). Tabulated red colour highlights guideline exceedence in open coastal waters.

Indicator		Unit	Draft WQO (Enclosed-Coastal)	Draft WQO (Open Coastal: 0-6km & Mid-shelf 6-24 km)	Current Condition (Open Coastal: 0-6 km)	Current Condition (Midshelf: 6-24 km)
Nutrients	Particulate N	(µg/L)	na	20	20.43	13.72
	Particulate P	(µg/L)	na	2.8	4.18	2.21
Phytoplankton	Chlorophyll a	(µg/L)	2.0	0.45	0.54	0.32
Water Clarity	Secchi	(m)	1	10	5	13.72
	TSS	(mg/L)	5	2	4.09	1.43
Pesticides	Diuron	(µg/L)	0.9	0.9	na	<dl
	Atrazine	(µg/L)	0.6	0.6	na	<dl
	Chlorpyrifos	(µg/L)	0.005	0.005	na	<dl
	Endosulphan	(µg/L)	0.005	0.005	na	<dl
	Ametryn	(µg/L)	0.5	0.5	na	<dl
	Simazine	(µg/L)	3.2	3.2	na	<dl
	Hexazinone	(µg/L)	1.2	1.2	na	<dl
	Tebuthiuron	(µg/L)	2	2	na	<dl
	Diazinon	(µg/L)	0.00003	0.00003	na	<dl

Northern Trawler (D. Haynes)



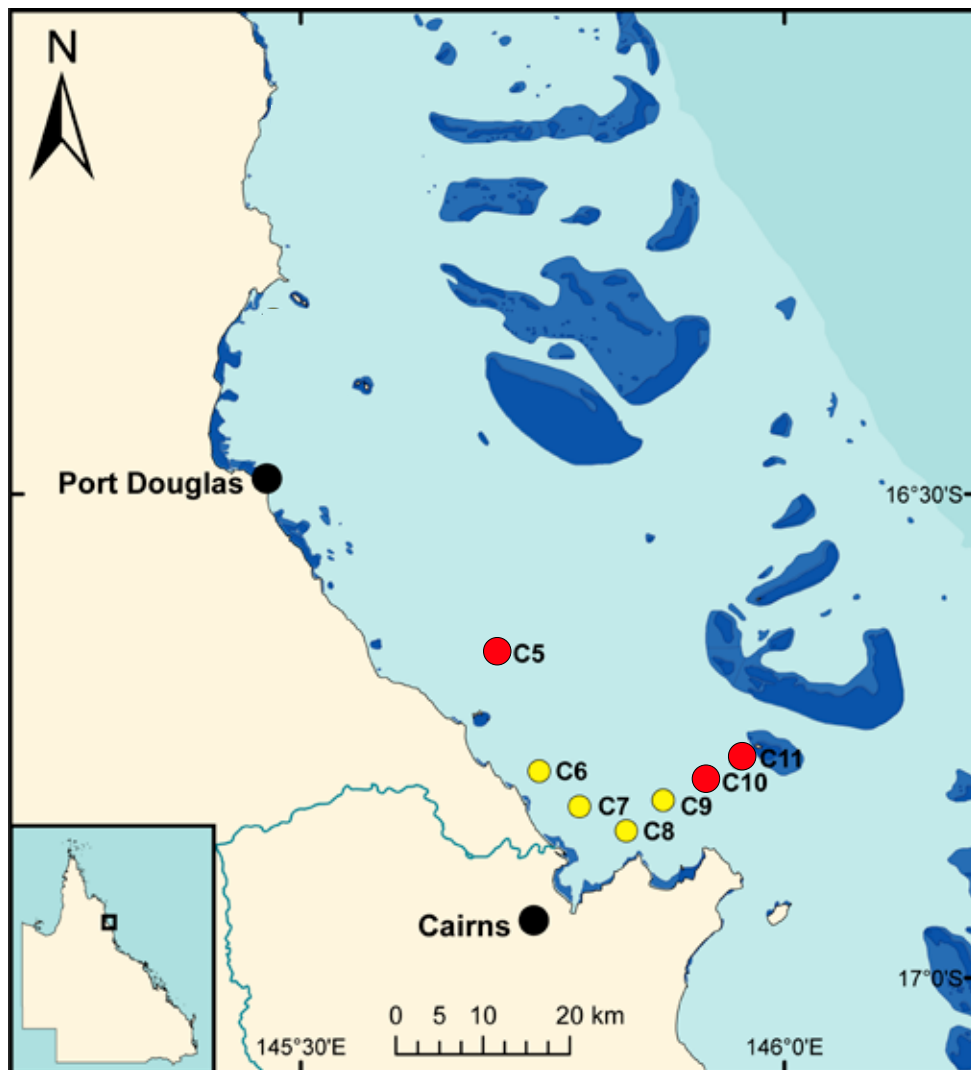


Figure 12. Map of AIMS long term (1989-2008) sampling sites used to derive data reported in Table 5. Map courtesy of B. Schaffcke (Australian Institute of Marine Science).

- Stations C5, C10, C11 in midshelf zone,
- Stations C6, C7, C8, C9 in open coastal zone.

Stage 5: Modeling pollutant concentrations, loads and targets

The Barron-Trinity Inlet WQIP is primarily concerned with reducing sediment, nutrient and pesticide loads in waters entering the Great Barrier Reef. To do this, the Barron-Trinity WQIP establishes:

- **Environmental Values** i.e. attributes we would like to protect;
- **Water Quality Objectives** i.e. a desired, future water quality condition (pollutant concentration), which, when met, will protect EVs;
- **Pollutant Loads** i.e. estimated contemporary catchment pollutant loads; and
- **Management Action Targets** i.e. targets for the separate on-the-ground management actions that will combine to reduce pollutant loads originating from the catchment.

How were loads estimated?

Due to a paucity of current, comprehensive water quality data at the sub catchment level in the Barron-Trinity area, modeling using E2 (combined with previously collected monitoring data) carried out by the Queensland Department of Natural Resources and Water (now DERM) was used to estimate the current status of pollutant loads and identify critical Barron catchment sources. Detailed information on the modeling project used in developing the Barron-Trinity Inlet WQIP is available in the list of resources at the end of this document and from www.terrain.org.au. The lack of long term monitoring data for the Barron, essential to better inform model development, is a critical deficiency in the Barron catchment. The E2 model estimated and allowed comparison of the quantity of sediments, total nitrogen and total phosphorus generated and delivered to local waterway by each land use in each subcatchment examined. The model also allowed calculation of the actual quantity of each of these contaminants compared with the actual delivery to the marine environment. This allowed an estimation of the trapping of sediments and nutrients in dams such as Tinaroo and by other catchment process. Delivery of TSS, TN and TP to the downstream marine environment was estimated to be 88-92% of that generated by different catchment land uses.

The model was calibrated with 7 gauges in unregulated sub-catchments (Flaggy Creek, Picnic Crossing, Mazlin Creek, Peterson Creek, Kauri Creek, Emerald Creek, Clohesy River). The modeled stream flow volume was within 10% of the observed stream flow volume. Model hydrology was validated by comparing flow data (not used in the calibration process) from 6 gauges on regulated streams downstream of Tinaroo Falls Dam and Copperlode Dam (Barron River @ Tinaroo Falls Dam Outlet, Barron River @ Mareeba, Barron River @ Bilwon, Barron River @ Koah, Barron River @ Myola, Freshwater Creek @ Redlynch). The predicted stream flow volume was within 10% of the observed stream flow volume for these regulated gauges.

Where are these pollutants coming from?

Monitoring and modeling indicated that total annual nutrient and sediment loads are originating from diffuse as well as point sources. Where possible, the relative contribution of individual sources of these pollutant loads was estimated (Tables 7 and 8). Potential sources of pollution considered included:

- **Point sources** including sewage treatment plants and urban development sites; and
- **Diffuse sources** including natural forests in protected areas, sugarcane, grazing, plantation forestry, banana and mixed cropping horticulture; urban development zones.

Table 7. Average land use area and modeled contribution of TSS, TN and TP by land use class (1977-2007) (Hatley *et al.* 2009).

Landuse	Area (km ²)	Area (%)	TSS (t/year)	TSS (%) ^A	TN (t/year)	TN (%) ^A	TP (t/year)	TP (%) ^A
Forest	1,178	47	35,600	46	640	40	68	27
Grazing	736	29	23,500	30	170	11	26	10
Sugarcane	145	6	2,800	4	140	9	10	4
Cropping	181	7	11,200	14	110	7	24	10
Urban	178	7	3,100	4	220	14	30	12
Plantation forestry	33	1	900	1	20	1	1	0.5
Dairying	19	<1	300	0.4	6	0.4	1	0.3
Mining	9	<1	400	0.5	15	0.9	3	1.1
STP		<1	290	0.4	280	17	88	35
Total	2,500	100	78,000	100	1,600	100	250	100

^A % of total load.

Table 8. Summary of modelled average annual pollutant sources in the Barron and Trinity Inlet catchments (1977-2007) (Hatley *et al.* 2009).

Catchment	% Total SS load	% Total N load	% Total P load
Upper	11	12	9
Middle (Mareeba)	15	8	7
Middle (Kuranda)	27	20	13
Lower	46	60	71
Total	100	100	100

Sediment and nutrients

What are current sediment and nutrient loads?

Estimated average annual pollutant loads delivered to receiving waters (including Tinaroo and Copperlode Dams) by streams and rivers in the 23 subcatchments of the Barron-Trinity Inlet WQIP area were calculated as:

- 1600 tonnes of total nitrogen per year,
- 250 tonnes of total phosphorus per year,
- 78,000 tonnes of total suspended sediment per year.

Modeling indicates that most of the pollutants originate in the lower subcatchments (Table 8).

Sources of sediment and nutrients

Modeling using E2 highlighted the importance of the contribution of urban areas in the control of nutrient losses and importance of the cropping and grazing industries in the elevated (ie higher than background) loss of sediments and nutrients and (Table 9). The resulting priority action areas are highlighted by Table 9 and include:

1. Upgrade of local STPs (Kuranda, Southern, Edmonton, Northern and Marlin Coast WWTPs) to minimise nutrient discharges;
2. Implementation of diffuse source sediment and nutrient control practices in urban landscapes;
3. Implementation of sediment loss control practices in the cropping and grazing industry;
4. Implementation of nutrient loss control practices in the cropping industry; and
5. Implementation of nutrient loss control practices in urban areas.

One of the important gaps in the modeling regards determining the contribution of infrastructure (gravel roads, road verges, culverts, drainage etc) and in stream remobilization/erosion to total sediment and nutrient loads. It is considered that their contribution is also compounded by the hardening of the catchment landscape and to the resultant increased flow rates and volumes within the system. There is clear anecdotal evidence on the Atherton tablelands and the coastal floodplain that poor infrastructure and river management is having a significant impact on sediment (and consequently nutrient) loads. Without this specific knowledge, it is important that a precautionary approach be taken that recognizes the need for significant reform and an associated works program in drainage, road and verge management. This makes improvement in infrastructure, drainage and river management a critical priority action.

Pesticides

What are current pesticide loads?

A range of pesticides including diuron, atrazine, simazine, hexazinone, and prometryn at very low concentrations have been detected in the single sampling event undertaken at the mouth of the Barron River during monitoring in 2006 (Table 10). Many of these same pesticides are detected in marine waters along the Queensland coast, but sampling at Low Isles has not detected their presence over 55 km north of the Barron River mouth (Table 6).

Sources of pesticides

The source of pesticides has not been determined in the Barron and Trinity Inlet catchments, but the agriculture industry as well as urban and transport applications all use a variety of chemicals for weed and pest animal control. Pesticides are unnatural pollutants that have only been present in the environment since the 20th century. Further refinements to the WaterCast modeling system will allow better estimation of the source and fate of these types of pollutants in the future.

Barron Trinity Inlet WQIP

Table 9. Summary of modelled delivery ratios for major Barron-Trinity WQIP catchment landuse categories (delivery ratio is calculated by dividing the % contribution to the total load by the % of the catchment occupied by the land use). (Hatley *et al.* 2009). The % contribution of STPs to total loads of nitrogen and phosphorus is also presented for comparison. (Red and yellow coloration highlights highest contributing activity, green represents no difference from background loss of sediment or nutrients).

Sediment		Upper	Middle-Mareeba	Middle-Kuranda	Lower
	Cropping	4	2	2	No data
	Dairy	1			
	Forest	1	<1	1	1
	Grazing	<1	1	2	
	Mining	no data	no data	no data	no data
	Forestry	1	<1	1	1
	Sugar	<1	<1	<1	<1
	Urban	<1	<1	<1	<1
	STP				(<1%)
Total N		Upper	Middle-Mareeba	Middle-Kuranda	Lower
	Cropping	2	2	2	No data
	Dairy	<1			
	Forest	1	<1	1	<1
	Grazing	<1	<1	<1	<1
	Mining	no data	no data	no data	no data
	Forestry	1	<1	1	<1
	Sugar	1	1	<1	<1
	Urban	2	2	2	1
	STP				(17%)
Total P		Upper	Middle-Mareeba	Middle-Kuranda	Lower
	Cropping	4	2	3	No data
	Dairy	<1			
	Forest	<1	<1	<1	<1
	Grazing	<1	1	<1	<1
	Mining	no data	no data	no data	no data
	Forestry	<1	<1	1	<1
	Sugar	1	<1	<1	<1
	Urban	2	1	2	<1
	STP				(35%)

Table 10. Concentrations of pesticides detected using passive sampling techniques at the mouth of the Barron River, January 2006 (J. Prange pers com). (<dl is less than detection limit, nd = no data available).

Pesticide	Concentration (µg/L)	Draft Water Quality Objectives for aquatic ecosystem protection of non-HEV waters (µg/L)
Diuron	0.00187	0.2
Simazine	0.00779	3.2
Atrazine	0.00324	13
Desethyl Atrazine	0.00077	nd
Desisopropyl Atrazine	0.00091	nd
Hexazinone	0.00096	75
Tebuthiuron	<dl	2.2
Ametryn	<dl	nd
Prometryn	0.00014	nd

Stage 6: Developing Recommendations for Management Actions: The basis for recommendations

Independent review of the water quality data available for the Barron and Trinity Inlet catchments has also indicated that a number of water quality pollutants are a priority in the WQIP area (Mitchell *et al.* 2009). These include (in order of priority) nitrate, fine suspended sediment, acid sulfate soils, pesticides (including the herbicides diuron and atrazine) and particulate phosphorus.

Management Action Targets

Modeling carried out for the development of the Barron-Trinity Inlet WQIP (as well as modeling carried out for WQIP development in other regions) demonstrates that targeted changes in the management of urban point source pollutants such as the upgrade of sewage treatment plants and in land use management practices and will achieve significant water quality improvements for many priority pollutants (Table 11). Additional benefits may include greater economic efficiencies in the local industries and better ecological health in the contributing freshwater systems. Key management action targets for the Barron-Trinity Inlet catchments supported by the Barron-Trinity Inlet WQIP Steering Committee focus on implementation of improved management practices associated with the agricultural industries of the Barron-Trinity Inlet WQIP area as well as with the upgrade of urban sewage treatment plants and improved management of urban development sites. Improved agricultural practices have been developed as part of an integrated package of land use management change; the so called ABCD** industry framework, and improved urban practices include water sensitive urban design (WSUD). When combined, these individual improved management practices carried out on a regional scale will help improve local water quality.

** A Practice: Cutting edge practices that have some, but require further, validation of environmental, social and economic costs/benefits prior to becoming a recommended practice.

B Practice: Currently recommended practices, often referred to as 'Best Management Practices.

C Practice: Minimum industry standards, such as "Code of Practice".

D Practice: Old practices that have been superseded and/or are considered unsustainable by industry and community standards.

Priority Pollutants Group 1

Nitrogen (nitrate, ammonia and particulate nitrogen): Modeling indicates that the major source of elevated nitrogen loss in the catchment is from urban sources including sewage treatment plants (STPs) and from cropping areas. Elevated dissolved nitrogen is sourced from urban STPs and from cropping-horticulture areas, whereas elevated quantities of particulate bound nitrogen are sourced from areas with eroding soils, especially those exposed during land development activities (e.g. conversion of grazing lands and forest to cropping lands or urban development). Poor infrastructure management is also a contributor.

Fine suspended sediments: The export of elevated quantities of fine suspended sediments from both the Barron and Trinity Inlet catchments is a major issue. Based on the proportion of land use within the catchments, modeling indicates that the major source of elevated sediment loss in the catchment is from areas grazed in the middle and lower catchments and cropping areas. These industries are estimated to contribute more sediment per km² in these catchments than would originate from natural forest.

Priority Pollutants Group 2

Acid sulfate soil (ASS) runoff: Acid Sulfate Soils (ASS) and Potential Acid Sulfate Soils (PASS) represent a particular problem in Trinity Inlet, and along the coast north of Cairns. Acid sulfate soil is the common name given to soils and sediments containing iron sulfides. If these types of soils are exposed to air when they are drained or disturbed, they produce sulfuric acid which releases aluminium and other heavy metals into adjacent waterways and groundwaters. Their presence must preclude agriculture and other development to minimise their disturbance.

Herbicide residues (simazine, atrazine, diuron): The herbicides detected in the Barron and Trinity Inlet catchment waterways are sourced from use by plantation, horticulture and sugarcane industries as well as from urban areas and better management of their use is a catchment priority. A wide range of other pesticide residues (e.g. ametryn, hexazinone, 2,4-D, MEMC) are also found in the Barron River and in marine waters offshore. The contributions of herbicide from infrastructure management is currently unknown, but warrants further consideration. Better management to reduce the loss of these pollutants is also a catchment priority, as well as being important in urban environments.

Particulate phosphorus: Modeling indicates that the major source of elevated phosphorus loss in the catchment is from horticulture cropping areas and from urban sources including sewage treatment plants (STPs).

Priority Pollutants Group 3

Dissolved oxygen reducing substances: Decay of organic wastes and plant materials in waterways may lower dissolved oxygen to critical levels reducing the number of sensitive macro-invertebrates and fish. Dissolved oxygen reducing substances include sugarcane trash, STP effluents as well as weed infestations and their control methods.

Table 11. Predicted improvement in total nitrogen and phosphorus loads from the Barron-Trinity Inlet WQIP region based on implementation of six easy steps (sugar cane), soil nutrient analysis (cropping) and upgrade of urban sewage treatment plants to tertiary standards (Hatley *et al.* 2009).

Landuse	Current loss of total N (t/yr)	Predicted loss of total N (t/yr) with BMP	Modeled % change within land use type	% contribution to total change (N)	Current loss of total P (t/yr)	Predicted loss of total P (t/yr) with BMP	Modeled % change within land use type	% contribution to total change (P)
Sugar-cane	140	120	15% reduction	-15%	10	10	not modeled	0
Cropping	110	110	not modeled	0	24	21	14% reduction	-5%
Urban	220	260	18% increase	+31%	30	34	13% increase	-7%
STPs	280	130	54% reduction	-115%	88	26	70% reduction	-102%
Other sources*	847	847		0	99	99		0
TOTAL	1597	1467	1% reduction		251	190	24% reduction	

* Includes forest, grazing, plantation forestry, dairying and mining

Table 12. Comparison of runoff rates (from Table 7) and predicted improvements (from Table 11) between urban, agriculture and forestry aggregations.

	URBAN ¹	AGRICULTURE ²	FOREST
Runoff rates (t/km ²)			
Sediment	19	35	30
Nitrogen	2.8	0.4	0.5
Phosphorus	0.66	0.05	0.06
Contribution of changed management to total change in loads (t)			
Nitrogen	-110	-20 (sugar)	0
Phosphorus	-58	-3 (other crops)	0

¹ Urban combines the WQIP categories of Urban and STP

² Agriculture combines grazing, sugar, cropping, plantation forestry and dairying for runoff rates; combines sugar and cropping for load changes.

Summary of WQIP recommendations

A. Nutrient Management

- Action 1: Upgrade of all regional Sewage Treatment Plants (STPs) to licensed discharge (tertiary) standards by 2010;
- Action 2: Broader community education associated with the use and treatment of nutrients in the urban environment by 2015;
- Action 3: Adoption of nutrient management plans by 50% of regional farmers using Nutrient Management training programs such as “Six Easy Steps” followed by one-on-one support for the implementation of appropriate actions;
- Action 4: Increase adoption of nutrient related practices so that 75% of producers are using either A or B level practices for nutrient management by 2016 through cropping system soil health programs, precision agriculture methods, government and market incentive mechanisms and education programs;

B. Pesticide Management

- Action 5: Increase adoption of pesticide related practices so that 75% of producers are using either A or B level practices for pest management by 2016 through education programs, precision application system, government and market incentive mechanisms and education programs;
- Action 6: Completion of pesticide management training by 75% of regional crop farmers using followed by one-on-one support for the implementation of appropriate actions by 2016;
- Action 7: State level review of current and likely alternative pesticides in relation to their risk to the Great Barrier Reef by 2010, consistent with current APVMA processes and procedures;
- Action 8: Review and reform of the application of pesticide in infrastructure and drainage management across the region by 2016.

C. Sediment Management

- Action 9: Where the source of sediment is identified, increase the adoption of sediment management practices so that 75% of producers are using either A or B type risk management practices to minimise sediment loss by 2016 through the provision of advice on risk management practices and their impact on farming systems, and the availability of government and market incentive mechanisms and education programs;

- Action 10: Best management practices implemented in 75% high risk riparian areas in grazing districts and urban areas with targeted restoration of at least 20% of key riparian buffer zones and floodplain wetlands at large scales to minimise stream bank erosion and incidental P loss by 2015;
- Action 11: Development, prioritisation and implementation of regional works program to reduce erosion and sediment loss in infrastructure, drainage and river assets across the catchment.

D. Additional Urban Management Actions

- Action 12: Implementation of site based erosion and sediment control plans (ESCP) and control measures (in accordance with IECA 2008 Erosion and Sediment Control Best Practice; EPA 2009: Urban Stormwater - Qld Best Practice Environmental Management Guidelines) in all urban developments by 2010;
- Action 13: Progressive integration of land use planning incorporating protection of waterway EVs in the Barron-Trinity Inlet WQIP area to minimise diffuse urban pollutant (including sediment) discharge by 2013;
- Action 14: Incorporation of Water Sensitive Urban Design (WSUD) into all developments as soon as possible to minimise loss of nutrients into the environment;

E. Acid Sulphate Soil Management

- Action 15: Completion of ASS mapping in the Barron-Trinity WQIP region by 2011;
- Action 16: Implementation by 2011 of the recommendations for a comprehensive Barron and Trinity Inlet acid sulfate soil management strategy outlined in the *Acid sulphate water quality improvement plan for the far north Queensland region (2009)*;

F. Monitoring and Evaluation

- Action 17: Development of an integrated water quality monitoring and reporting regime for the Barron-Trinity Inlet catchment (including ground waters) and adjacent marine waters to underpin delivery of the Reef Water Quality Protection Plan goals by 2010;
- Action 18: Implementation of an integrated practices benchmarking, monitoring and reporting regime in the Barron-Trinity Inlet catchment to underpin delivery of Reef Water Quality Protection Plan goals by 2010;
- Action 19: Implementation of strategic initiatives to research the efficacy and cost-benefits of priority agricultural BMPs for improving water quality in Barron-Trinity Inlet catchments by 2010;

- Action 20: Implementation of long-term monitoring of the impact of urban sewage treatment plant upgrades on pollutant discharge loads and associated water quality improvements;
- Action 21: Implementation of long-term monitoring of the influence of the Cairns tip site leachate on local water quality;

F. Research Initiatives

- Action 22: Development of refined modeling protocols for estimation of fine sediment export to the Great Barrier Reef;
- Action 23: Resolution of the veracity of historical photographs to document sediment compositional changes along the Cairns coast line;
- Action 24: Partnership research initiatives that support improved adaptive management to improve water quality in the Barron and Trinity Inlet catchments.
- Action 25: Completion of modeling of nutrient partitioning within Trinity Inlet to establish sources and sinks of local water pollutants;
- Action 26: Completion of nitrogen fixation and nitrogen replacement research in the sugar industry context by 2013;
- Action 27: Completion of review of potential research directions and their associated funding sources on the interrelationships between soil pathogens, runoff and waterway biological health by 2013;

G. Advancement of Policy and Planning Initiatives

- Action 28: Terrain to maintain continuous review of the Barron WQIP and detailed effort alignment to secure implementation of the plan's actions;
- Action 29: State government, Terrain, industry, community bodies and Traditional Owners work together to achieve the most fair and effective mechanism for delivering water quality within the State government's proposed Reef Regulations; and
- Action 30: BRICMA and Terrain NRM to continue review and adaptive implementation of the broader Barron River Integrated Catchment Plan;

How will the Barron-Trinity Inlet WQIP be implemented?

Development of the Barron-Trinity Inlet WQIP is just the start of an ongoing adaptive management process for water quality improvement in the catchments and downstream estuarine and coastal waters. The difference between this exercise and many other natural resource planning activities is that the members of the Barron-Trinity Inlet WQIP Steering Committee and Terrain NRM are committed to the implementation, monitoring and review of the plan over the long term. Additionally, Terrain has the role of supporting the Steering Committee and the two Regional Councils in integrating and aligning effort related to implementation and review of the plan.

Preliminary consultation has commenced with State Government Departments (DERM). Implementation workshops focusing on the technical detail of implementation actions will be run following the release of the final WQIP in June 2009. An essential first step will be the prioritisation of implementation actions within existing budget allocations from the Reef Rescue program. As well as this prioritisation, there will be an ongoing review and gap analysis of implementation actions as new information and knowledge becomes available over the life of the Reef Rescue program. The Barron-Trinity Inlet WQIP Steering Committee has recommended that concurrent with the public consultation process, partnership and implementation workshops be held for critical management actions. These workshops will involve industry, Indigenous and community representatives, Cairns and Tablelands Regional Councils, and State and Federal Government agencies. The workshop process will determine project leaders, timelines, budgets and partners, and the technical detail of the management actions. It is expected that a majority of projects endorsed for the first twelve months of the implementation period will be on-ground actions which have strong links to A and B management actions identified in industry best practice frameworks.

Planning for associated research activities will be undertaken in partnership with ACTFR, CSIRO and the Barron-Trinity Inlet Steering Committee. Planning and development of long term monitoring programs are currently being negotiated with the Queensland Department of Premier and Cabinet and the Reef Rescue Team in Canberra.

Legislative Framework

Achieving water quality improvement in the Great Barrier Reef lagoon will require the right mix of institutional arrangements, planning and regulatory frameworks and the fostering of innovation and beyond best practice in agricultural industries. In Queensland, a policy and planning framework underpinned by legislation is used to control water-borne point-source pollutants and urban diffuse-source pollutants; but focuses on using education, capacity building, industry codes of practice and incentive mechanisms to reduce agricultural diffuse source pollutants.

Urban development is controlled under a suite of Queensland legislation under the umbrella of the *Integrated Planning Act 1997 (IPA)*. Pollutant discharges from some intensive agricultural industries are regulated, (e.g. piggeries, feedlots) but most run-off from agriculture enterprises is unregulated as general agricultural activities are not assessable developments under that Act.

In terms of protecting water quality run-off from the mainland catchments into the Great Barrier Reef lagoon, the key legislative instruments are the IPA, the EP Act, the Coastal Act and the *Water Act 2000*. These 4 acts use both planning and assessment mechanisms.

Integrated Planning Act 1997

The objective of the Integrated Planning Act (IPA) is to seek to achieve ecological sustainability through:

- Coordinated and integrated planning at the local, regional, and State levels;
- Managing the process by which development occurs; and
- Managing the effects of development on the environment.

The IPA allows for the development of State Planning Policies, regional plans and local planning schemes and the assessment of certain types of development against these plans.

Environmental Protection (EP) Act

With respect to managing contaminants released to waterways, there are several ways the EP Act and its Regulations operate including:

- Through 22 defined environmentally relevant activities (ERAs) which require licences directly under the Act or via development approvals under IPA;
- The Environmental Protection (Water) Policy 1997 (EPP (Water)); and
- The General Environmental Duty provisions.

Because very few agricultural activities are ERAs, it is the general environmental duty that has application to diffuse source run-off into waterways. Meeting the provisions of an approved code of practice is one way of complying. Codes of practice have been approved for agriculture, sugar cane production, dairy farming, and fruit and vegetable production. EVs and WQOs developed through the WQIP are likely to be scheduled under the EPP (Water).

Coastal Act

In 2001, the State Government released the State Coastal Management Plan – State Coastal Policy. This plan is a statutory document and operates under both the *Coastal Protection and Management Act 1995* (Coastal Act) and as a State Planning Policy under IPA. The State Coastal Management Plan contains principles and policies on coastal use and development that have the potential to impact on run-off water quality as well as specifically for water quality, including wastewater discharges, waste-disposal facilities, stormwater management, groundwater quality and acid sulfate soils. The Wet Tropics Regional Coastal Management Plan (2003) provides specific details of land use issues which affect water quality and their local significance.

Reef Plan

The Reef Plan commenced in 2003 following the release of scientific evidence indicating a decline in water quality on the Great Barrier Reef. It is a 10 year joint Australian and Queensland Government initiative. Reef Plan addresses land-based sources of diffuse pollutants entering the Great Barrier Reef lagoon. It does not address urban point and non-point source pollutants. Reef Plan contains 65 actions to be implemented by a partnership of all levels of government and key stakeholders such as the 6 natural resource management bodies including Terrain NRM. Reef Plan is currently in the process of being updated to ensure its focus is on outcomes, with clear strategies and plans for achieving the outcomes underpinned by a monitoring, evaluation and reporting process (State of Queensland, Queensland Department of Premier and Cabinet, 2008). One of the actions of Reef Plan is to prepare WQIPs (such as this one) for the Great Barrier Reef catchments.

Caring for Our Country and Reef Rescue

Caring for our Country is the Australian Government's new natural resource management initiative. It is designed as an integrated package with one clear goal, a business approach to investment, clearly articulated outcomes and priorities and improved accountability. It commenced in July 2008 and aims to integrate delivery of the Australian Government's previous natural resource management programs, the Natural Heritage Trust, the National Action Plan for Salinity and Water Quality, the National Landcare Program, the Environmental Stewardship Program and the Working on Country Indigenous land and environmental program.

The objective of the Reef Rescue Plan *"is to improve the water quality of the Great Barrier Reef lagoon by increasing the adoption of land management practices that reduce the run-off of nutrients, pesticides and sediments from agricultural land."* The Plan will see all levels of government, regional NRM bodies including Terrain NRM, industry groups, Indigenous and conservation groups working in partnership. Reef Rescue has 5 components:

- Water Quality Grants (\$146 million over five years)
- Reef Partnerships (\$12 million over five years)
- Land and Sea Country Indigenous Partnerships (\$10 million over five years)
- Reef Water Quality Research and Development (\$10 million over five years)
- Water Quality Monitoring and Reporting, including the publication of an annual Great Barrier Reef Water Quality Report Card (\$22 million over five years).

Institutional Arrangements

Policy development, planning and regulatory responsibilities for improving Great Barrier Reef water quality are currently spread across the three layers of government. Within the Australian and State governments, responsibilities are spread across different ministerial portfolios (and thus agencies). Local governments in Queensland do not follow catchment boundaries and thus a range of local governments are involved. This has improved somewhat with the amalgamation of local governments in 2007-08. In the case of non-statutory planning, Terrain NRM is also

involved through the development of regional natural resource management plans and this and other water quality improvement plans.

The current policy, planning and regulatory framework is inadequate to deal with diffuse source pollution. It cannot be adequately addressed in the IPA planning framework including the coastal plans and is generally not regulated under existing legislation. The current approach is one of providing incentives to landholders to improve their management practices in line with Reef Plan, the regional NRM plans, this and other WQIPs and Reef Rescue. It uses the ABCD framework proposed initially in the Mackay Whitsunday WQIP (Drewry *et al.*, 2008) and Reef Rescue to classify landholder management practices into 4 categories with A being cutting edge and D being below acceptable practice. Regulation proposed to be introduced mid 2009 by the Queensland Government is likely to be targeted at landholders in the D category in industries that contribute the greatest pollutant loads. It may be implemented through amending the EP Act to include codes of compliance which meet the minimum General Environmental Duty under the EP Act. Before any legislative change occurs however, a regulatory impact statement should be undertaken to consider the economic and social costs on landholders of compliance and the full costs of administration.

Reasonable Assurance Statement

This section presents a brief overview of best available practices and techniques that were used to develop parts of the WQIP.

Monitoring and modeling

Management actions to reduce pollutants to waterways and the Great Barrier Reef have been modelled using the best available tools, in association with historically monitored water quality, and expertise from industry and science providers. On-farm and urban-based management actions are likely to achieve the water quality targets set in the WQIP, provided sufficient human and financial resources are available to achieve target levels of management practice adoption. The focus has been on diffuse sources and transport of pollutants using the E2 model. Historically monitored water quality data from a variety of catchment monitoring sites have been used to ensure reliability and assurance of results and to parameterise the E2 model.

Consultation and management practices

Considerable effort has been made when consulting with industry organisations, stakeholders, Traditional Owners, science providers and the community, and the establishment of EVs, management practice and implementation sections outlined in this report. Consultation has been undertaken during development of draft EVs, and development of the ABCD management practice framework and industry workshops to discuss the implementation phase of the WQIP. Extensive scientific and technical consultation was undertaken including review of reports and supporting documents. The primary result of this consultation effort to use the best available information is that a high level of confidence can be placed on the draft EVs identified, and in the specific water quality targets and targets for management practice adoption. The draft

WQIP provides the opportunity for further stakeholder review and comment prior to completion of the final plan. Provided the implementation activities are developed and resourced to the level recommended, then there is confidence that the region's land managers will achieve the management practice adoption targets and the water quality improvement targets.

Uncertainty

This section presents an overview of issues associated with uncertainty and knowledge gaps in water quality, pollutant erosion and transport, and catchment-scale modeling. There is a range of knowledge gaps and uncertainties associated with biophysical processes, water quality, load estimation, management practice adoption rates, and lag times associated with paddock-scale to end-of-catchment scale processes. Some of the knowledge gaps and uncertainties associated with biophysical processes are briefly outlined below:

- Uncertainty associated with event mean concentrations (EMCs) and load estimates. This uncertainty arises from the physical effects of changes in pollutant supply through an event (hysteresis), gauging station water height and discharge relationships, overbank flow, seasonality, antecedent conditions for pollutant transport, sample collection frequency and load calculation methods;
- Lag-times associated with reduction of pesticide, sediment and nutrient losses from improved management practice adoption. These lags arise from pollutant transport through surface and groundwater pathways, and end-of-catchment responses;
- Lag-times associated with freshwater and marine ecosystem response to reductions in pollutant loads; and
- Limits in the ability to detect real changes in water quality and effects on ecosystems at end-of-catchment.

There is uncertainty about the level of water quality improvement that will result from improved management practices. For example, the reduction of nutrient loads resulting from adoption of A and B class nutrient management and application in cane (e.g., the BSES Ltd “six easy steps”, and from variable rate fertiliser units), is not well quantified. More research is required to quantify these water quality improvements at the paddock scale.

If management practices are widely adopted throughout the management areas, there is likely to be a lag time before water quality is improved, or improvements are detected at the end of the catchments. A lag time may be dependent on many factors including time for adoption of practices, transport to, or in waterways, soil and aquifer hydraulic conductivity and groundwater system transit properties and times. There are also knowledge gaps and uncertainties associated with catchment-scale modeling. Catchment models are useful to evaluate relative differences between catchments. However, complex models have considerable uncertainty associated with input data and model outputs.

Monitoring, Evaluation and Reporting

To ensure consistency in the Great Barrier Reef region, a strategy for WQIP monitoring, modeling and reporting is being finalised. This strategy, proposed to be funded through Reef Rescue, aims to support the evaluation and reporting of progress against targets and will be

a component of a regional audit program. The Barron-Trinity Inlet WQIP recommends using this strategy to progress monitoring and evaluation via a formalised State of the Catchment report, with updates on an annual basis. The monitoring, evaluation, reporting and improvement program (MERI) will be carried out on an industry basis matching the roll out of water quality improvement projects. Thus in the Wet Tropics Region, the three main components will focus on sugar cane, grazing (including dairy), and horticulture. Ideally, each industry component will include:

- Within Reef Rescue, independent audit (measurement) of best management practice (BMP) uptake (via an ABCD framework) following intensive extension activity;
- Detailed practice analysis of the effectiveness and outcomes of BMP at selected farms/sites;
- Estimation of sub-catchment water quality improvement using the results of auditing ;
- Sub-catchment water quality improvement linked to end of catchment and marine water quality through whole of GBR scale monitoring programs ; and
- Reporting & communication at project and regional scales with integration into a Reef Report Card or similar.

Review of the Barron-Trinity Inlet WQIP is intended to coincide with the end of Reef Plan (2013). This gives the community a chance to make the management actions recommended by the Barron-Trinity Inlet WQIP work, to adapt actions as an outcome of research currently underway, and to monitor the progressive effects of improvements. Whilst, water quality improvements are expected to be realized within this time, better protection of water quality and Barron River and Trinity Inlet environments will take many years of concerted effort.

Great Barrier Reef sunset (D. Haynes).



Barron WQIP Resources

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