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OVERVIEW OF THE FITZROY BASIN AND OPPORTUNITIES FOR OFFSET TRADING

RESEARCH REPORT No. 1

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ESTABLISHING THE POTENTIAL FOR OFFSET TRADING IN THE LOWER FITZROY RIVER RESEARCH REPORTS

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These reports represent the provisional findings of the research project 'Establishing the Potential for Offset Trading in the Lower Fitzroy River'.

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Abstract

A major project is being undertaken in Queensland to design how a market-based instrument in the form of an offset mechanism can be used to achieve improvements in water quality in the lower Fitzroy River. Like other river systems draining into the Great Barrier Reef lagoon, the Fitzroy River has deteriorating water quality levels with high sediment and nutrient loads. This may cause damage to estuaries, the coastal zone and the Great Barrier Reef, although the level of scientific knowledge about the linkages between poor water quality and potential environmental damage is incomplete. There is substantial public interest in improving water quality outflows to the Great Barrier Reef lagoon.

The impacts on water quality come from a number of different sectors and regions within the Fitzroy Basin. Existing measures to improve water quality include regulatory controls over many point source discharges, and a range of education, persuasion and devolved funding grants over many non-point source discharges. The potential for introducing a market-based instrument (MBI) stems from the range of different opportunity costs for improvement actions between and within sectors, and the need to tailor incentives at the specific enterprise level. Offsets, competitive tendering and cap-and-trade mechanisms are the types of MBI mechanisms that may be used.

A key issue in designing a market-like mechanism is to predict the gains from trade and the appropriate institutional arrangements. Asymmetric information means that much of that knowledge is hidden to system planners, so a non-market valuation mechanism termed Choice Modelling will be trialed in this project. Potential MBI participants will have a trading scenario described to them, and will then be asked to identify their preferred level of involvement from several trading options. The outcomes of a series of these questions will allow the identification of the range of opportunity costs involved and the market behaviour under different institutional structures. In this report, a summary of the water quality issues in the Fitzroy Basin is presented, together with an overview of the process that will be undertaken to complete the project.

1. Introduction

The National Market-Based Instruments (MBI) Pilot program was established in 2003 under the National Action Plan for Salinity and Water Quality. The MBI pilot program is a partnership between the Commonwealth and State Governments, and is aimed at investigating better ways of encouraging improved land and water management. This is being achieved through the establishment of ten projects to test innovative ways of dealing with resource management issues. The core focus of MBI projects is to use market-like mechanisms in ways that better provide landholders and other resource managers with incentives to achieve improved resource outcomes.

One of the successful projects under that program is focused on exploring the potential for offset trading mechanisms in water quality to be applied in the lower Fitzroy River. The project will operate between July 2003 and June 2005, and is a partnership between four groups, being:

- Central Queensland University,
- CSIRO,
- Fitzroy Basin Association, and
- Central Queensland Regional Organisation of Councils.

The key goal of the project is to explore the use of market-like mechanisms to achieve improvements in water quality in the lower Fitzroy. This would create environmental benefits for the river estuary and the Great Barrier Reef (GBR) lagoon. Runoff from agriculture and other sources mean that many streams emptying in the GBR lagoon have poor water quality levels. Improvements in water quality are considered to be an important protection measure for the reef.

There are a wide range of industries that contribute pollutants and sediments to streams in the catchment of the GBR (Haynes 2001, Haynes and Michalek-Wagner 2000, Moss *et al.* 1993). This makes it difficult to identify the contribution of any particular industry or enterprise. As well the linkages between actions, water pollution and any subsequent environmental damage are not always clear (Davidson 2003). In turn, it is hard to identify remedial actions that will improve environmental outcomes. A further problem is that many of the contributions to water quality problems come from non-point (diffuse) sources, which make it very difficult to identify and control pollution actions.

Currently there are two main approaches to dealing with water quality issues in the catchment area of the GBR. The first is the regulatory approach. This is mostly applied to point source emissions, such as industry sites. The second is the use of information and activities to change community expectations and encourage voluntary compliance with new standards. While both of these approaches will remain important, there is interest in the use of market-like mechanisms in some situations to better provide incentives to improve water quality outcomes.

There are a range of market-like mechanisms that can help to deliver environmental outcomes more efficiently than regulatory approaches. They include:

- Competitive tender systems,
- Cap and trade mechanisms,
- Offset mechanisms, and
- Transferable development rights.

Taxes and subsidies can also be used to provide financial incentives to undertake desired courses of action. As a group, these mechanisms are referred to as market-based instruments (MBIs). Offset programs are systems where further development with negative environmental impacts is only allowed when some mitigating environmental protection is provided. An example of an offset would be when some wetland areas had to be protected or rehabilitated to compensate for the loss of a wetland area for a housing estate. Offsets tend to be simpler and more flexible than the specialized cap and trade mechanisms, but may need to be designed separately for each situation of interest.

In this project, the key issue is identifying where offset programs may improve water quality outcomes in the lower Fitzroy. Outcomes of the project may then be more widely transferred across other GBR catchments. This project has two key goals to achieve. The first is to identify opportunities for offset programs and to design the potential application of one. The second goal is to predict how an offset market might operate. This will be achieved by using a non-market valuation technique to present market participants with a selection of tradeoffs and observing the subsequent choices made. The tradeoffs will be drawn from the offset program that is designed.

This report is the first in a series of reports that will be produced from this research project. The report series will generate a number of final recommendations about the potential use of offset mechanisms to improve water quality in the GBR catchment zone. The focus of this report is to outline the circumstances of the case study of interest, and to identify the key issues that will be addressed in the project.

The structure of this report is as follows. Background information on the Fitzroy catchment and water quality in the river system and estuary is provided in the next section. The extent of impacts on the Great Barrier Reef is outlined in Section Three and the main sources of impacts are discussed in Section Four. The main economic issues that need to be considered are discussed in Section Five, followed by an overview of this project in Section Six, and a brief summary in Section Seven.

2. The Fitzroy Basin and Water Quality Impacts

The Fitzroy Basin drains an area of approximately 142,645 km^2 (approximately 10 percent of Queensland's land area) into the GBR lagoon and is the largest of the river basins in the GBR catchment. The Fitzroy Basin (Map 1) comprises the catchment of the Fitzroy River and its major tributaries, namely the Comet, Dawson, Issac-Connors, Mackenzie and Nogoa Rivers. The Fitzroy is one of the thirty-one river catchments which drain directly into the waters of the GBR. Of the catchments of the GBR, only the Fitzroy and Burdekin are large[1]; all others are small.

Map 1. The Fitzroy Basin

The Fitzroy catchment is home to around 185,000 people, or 5.3% of the State's population. The major regional centre, Rockhampton, has a population of 59,475 people. Other important urban centres in the basin include Emerald, Biloela and Blackwater. Gladstone and the Capricorn Coast (Yeppoon and Emu Park) are population centres adjacent to the Fitzroy catchment which are often included in analysis and planning processes because of their proximity.

2.1 Land Use in the Fitzroy Basin

The Fitzroy Basin is recognised as one of the richest areas in the State for its land, mineral and water resources, with the key industry sectors being grazing, agriculture, mining, forestry and fishing. Water resources in the basin have a number of important usages including farming, grazing, mining, recreational and urban activities. Economic activity in the basin is dominated by agriculture (grazing, dryland cropping, irrigated cotton and horticulture) worth $767.1 million in year ending March 2000, and by mining, principally coal production, worth $2687 million in 2000-01 (OESR 2002)[2]. In addition, in 1999-2000 tourism was worth $425 million, and recreational and commercial fishing worth $21 and $18 million respectively (Productivity Commission 2003). Sugarcane is not grown in the region.

Beef production in 1999-00 was worth $442 million (58% of the total contribution from agriculture) with meat processing worth another $344 million in 1996-97. Beef production is subject to considerable variation, but the gross value of production

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[1] Burdekin and Fitzroy basins together account for 64 percent of the total area of the GBR catchment (Furnas, 2003).

[2] These values relate to the Fitzroy Statistical Division which is not the same as the Fitzroy Basin area.

increased by more than 70% from 1991-92 to 1999-2000, the fastest growth rate of the industry in the GBR catchment.

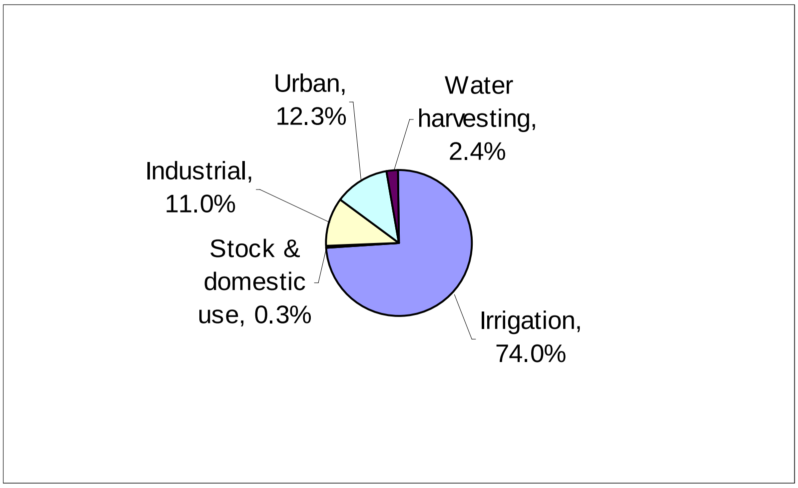
Dryland and irrigated cropping are also major agricultural activities in the area. The gross value of cotton production in the Fitzroy region was $121 million in 2000-01 (Cotton Australia quoted in Productivity Commission 2003: 91). Cotton is the highest value crop, but dryland crops (sorghum, wheat, sunflowers, etc.) are grown more extensively and cover a much larger area than cotton. Horticulture has now expanded to be valued at approximately $100 million (G. Fullelove, Department of Primary Industries, *pers. comm.* 2004) with the majority centered in the Emerald irrigation area and dominated by citrus and grape production.

From 1996-97 to 2000-01, the mining industry also grew more rapidly in the Fitzroy region than elsewhere in the GBR catchment. In contrast growth in tourism expenditure has slowed considerably since 1992 (Productivity Commission 2003).

In terms of area, rangeland grazing is the principal land use and covers 87.5% of the basin area (Jones *et al*. 2000) and 94% of the area used for agriculture (Furnas 2003). As it occupies such a large area in the basin, it is the land use which has the most impact on water quality. Irrigated agriculture, (mainly cotton and horticulture) does not cover a large area and only accounted for 0.2% of the basin area in 1996-97 (NLWA 2003). However, it relies on large scale water storage, usage and intensive fertilizer and pesticides use, which in turn can have a substantial impact on water quality, particularly in the local area.

Irrigated agriculture is the largest user of water in the basin accounting for 74% of average annual water usage between 1990-01 and 1994-05 (see Figure 1 below). Loch and Rolfe (2000) using figures from 1998-99, quote a higher value of 90%.

Figure 1. Water use in the Fitzroy Basin

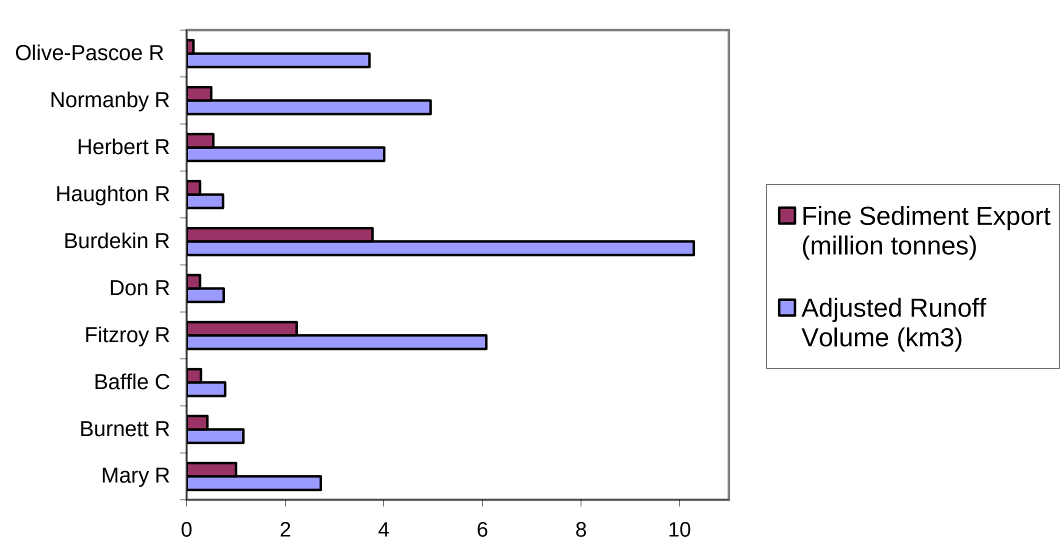


Source: FBA 2000

2.2 Terrestrial Runoff

Only 6% of the total rainfall in the basin leaves as runoff, and the Burnett River is the only GBR catchment with a lower proportion of runoff (5%) (Furnas 2003). However, the large size of the Fitzroy catchment area means that the river discharges large volumes of water and therefore has an important influence on the GBR lagoon area (Figure 2).

Figure 2. Estimated average annual runoff and sediment export from the 10 largest catchment basins in the GBR.



Source: M.Furnas (2003)

The Fitzroy Basin is characterised by large variations in river flows. About 75 % of the region's rainfall occurs during November to April (FBA 2000), causing most stream flows to occur in summer. Prolonged dry periods in the winter mean many of the waterways are ephemeral. Considerable variation occurs in the runoff estimates from the catchment. Furnas (2003) quotes an average of 6.1 million megalitres from 1968-1994; FBA (2000) use an average of 4.8 million megalitres from 1965- 1998; Whitten (2003) quotes a value of 5.7 million megalitres, and Loch and Rolfe (2000) a value of 7.1 million megalitres. Between 1968 and 1994, the median discharge was 2.7 million megalitres and ranged from 172,000 megalitres recorded in 1969 to 22 million megalitres in 1991.

Extended dry periods are commonly followed by major floods. Because of this, stream flows tend to be highly variable in quantity and quality and are unpredictable in occurrence (FBA 2000). The basin is located in the dry tropics where seasonal differences in rainfall are more marked than the wet tropics to the north, and flood events are less frequent, with moderate to significant floods occurring every 10-20 years (Furnas 2003). The most recent significant flood event in the Fitzroy Basin occurred in 1991 and was classified as a 1 in 50 year event (Jones *et al*. 2000).

The individual sub basins in the Fitzroy catchment are large enough to have different average rainfalls, soil types, land cover characteristics and runoff export dynamics. A large portion of total catchment erosion and sediment export comes from smaller areas in the catchment with erodible, bare soils or well developed gully networks (Furnas 2003).

The average annual discharge of suspended sediment, from the Fitzroy Basin into the GBR lagoon is estimated at 2,635,482 tonnes (GBRMPA 2001). Other sources use a higher figure with an estimated annual average of 4 million tonnes (Taylor and Jones 2000; CRC 2003).

Nobel *et al.* (1997:vii) report sediment data collected from 1993 to 1996 which show levels of suspended solids have a high median value 142mg/L with a range from 8mg/L to 4,395 mg/L (when conditions had been dry and meager ground cover in many grazing areas was common). Under flow condition, four values greater than 3000mg/L (three tonnes per megalitre) were recorded (Nobel *et al* 1997:vii). A summary of sediment and erosion data from the National Land and Water Resources Audit is shown in Table 1.

Table 1. Water borne and sediment transport in the Fitzroy River

Attribute	Unit	Basin value	Median Australia-wide value
Sediment supplied to rivers	t/yr	16,360,557	166,621
Sediment supply	t/ha/y	1.15	.5
Hill slope erosion	%	62.61	14
Streambank erosion	%	12.7	30
Gully erosion	%	24.69	32
Length with riverbed deposition	proportion	.19	0
European to Pre-European sediment	Ratio	21	29
Sediment export to coast	t/y	2,635,482	30,062
Contribution of sediment to coast	t/ha/y	.18	.1
Sediment delivery	Ratio	.16	.34

Source: NLWA (2003)

In the Fitzroy, nitrate concentrations are generally highest during wet season flood events, particularly during the first flush. Nitrate inputs to the river in surface runoff are diluted by large volumes of water in floods. Groundwater inputs to these rivers are unknown, but are small in relation to surface water input. There is little agricultural fertilizer used across the catchment, and most of the nitrates are coming from the soil (Furnas 2003).

Estimates of total point source nutrient loads in the lower Fitzroy indicate approximately 74.2 tonnes per year of nitrogen and 58.8 tonnes per year of phosphorus are released (Percy, Fitzroy River Water *pers comm*. 2000). This compares with diffuse loads estimated to average approx 3150 tonnes of nitrogen and 1290 tonnes of phosphous from minor flood events occurring in 1994 and 1998. Clearly diffuse sources of nutrients in the catchment far exceed point sources but point sources remain locally significant in the upper estuary during extended periods of very low flows over the barrage as residence times are long (Connell *et al.* 1981 cited in Jones *et al*. 2000).

Pesticides, including endosulfan sulphate, diuron and profenofos, are found in Emerald and Dawson irrigation areas (Jones *et al*. 2000). Insecticides used in the cotton industry are an issue of concern in waterways immediately downstream of cotton growing areas. The herbicide atrazine (primarily applied in dryland cropping) is an ecosystem health issues for streams in every subcatchment of the Fitzroy, whilst diuron, usually associated with cotton growing areas has potential for widespread contamination due to its mobility and persistence in the environment (Jones *et al*. 2000).

The National Land and Water Audit has identified the overall health of the Fitzroy catchment, as considered by biological assessment, as being relatively good with approximately 60% of sites monitored rated as in "good" condition. Approximately 20% of sites were in "poor" condition (based on physical-chemical assessment) (Jones *et al*. 2000).

Catchment ecosystem health issues of concern identified as:

- **pesticides** in local waterways of irrigation areas and also catchment wide,
- **sediment and nutrient** export generally,
- environmental concern from **heavy metal contamination** in parts of the Nogoa, lower Dawson and Mackenzie,
- catchment wide **weed infestation**,
- known areas of poor **riparian vegetation coverage**,
- potential for **blue green algal blooms** in standing waters,
- decrease of **barramundi** distribution generally, and
- localized **salinity** problems.

(Jones *et al*. 2002:12)

2.3 The Fitzroy River Estuary

Estuaries are defined as semi-enclosed coastal water bodies that represent the mixing zone between marine derived saltwater and terrestrially derived freshwater. Estuaries provide highly productive and diverse habitats for fauna and flora (Long and McKinnon 2002). The Fitzroy River estuary is shown in Figure 3.

In the Fitzroy, the size of the catchment means that flood volumes are very large relative to the size of the estuary. As a result catchment inflows not only affect the estuary, but also can affect a significant area of inshore coastal habitat, extending to the Keppel Island (an important tourist destination) and further off shore during large events (Jones *et al*. 2000).

Figure 3. The Fitzroy River estuary

Port Curtis Is

The estuary depth varies from 3 to 7 metres at mid tide and tides range from 0.3 to 4 metres. Large tides create high velocity tidal flows and the estuary is classified as tide – dominated. This means the estuary has moderate sediment trapping efficiency, naturally high turbidity, well mixed circulation and there is some risk of habitat modification due to sedimentation (NLWA 2002).

The estuary discharges into the southern Keppel Bay part of the GBR lagoon. The position of Port Curtis Island (Figure 3) semi encloses the estuary, influencing its size, quality and diversity, and directs the river out-flow to the north (Long and McKinnon 2002). Prevailing winds and the Coriolis Force in the southern hemisphere further direct the out-flow from the Fitzroy estuary northwards and into the Capricorn coast, a significant tourist destination in the region.

The Fitzroy estuary is approximately 60 kilometers long. The tidal limit was about 106 kilometers from the mouth, but in 1970 a tidal barrage was constructed at Rockhampton that has had a major impact on the estuary. The barrage has changed the hydrodynamic characteristics of the estuary, including the creation of a poorly flushed zone; has meant the loss of habitat, and has had a major impact on migratory fish, although the introduction of a fish passage has improved the situation (Jones *et al*. 2000).

The barrage prevents base flows from entering the estuary upstream of the barrage. A daily flow of 15 megalitres per day enters the estuary region via the fishway. The Water Resources Plan for the region estimated that the flow over the barrage has been reduced to 88% of predevelopment flows. The reduction has the greatest impact in years of below average rainfall (Long and McKinnon 2002).

There are 17 impoundments in rivers of the catchment, but only one major dam, with another planned. It is generally acknowledged that the barrage and other impoundments are relatively shallow and apart from the Fairbairn Dam, there is no effective trapping of sediment. Sediment that is trapped during low flows is then flushed out in high flow events (P.Long, Department of Primary Industries, *pers. comm.* 2003).

The estuary has significant wetland values and the Fitzroy delta, its floodplain and the Narrows (see Figure 3) have been formally recognized in the Directory of Important Wetlands of Australia. 1996. From limited water quality data the downstream end of the estuary is in good condition but with high turbidity (CRC 2003).

"The quality of catchment inflows to the estuary have changed significantly since European settlement but there is little available evidence that this has had major impacts on the estuary or adjacent areas. Given the huge size of the Fitzroy Basin, the estuary must have always been a highly unpredictable habitat, saline during droughts but subject to massive freshwater inflows in most years. Off shore, increased sediment loads may have impacted former seagrass areas but there is no actual evidence of this. Similarly, the increased nutrient loads may have increased phytoplankton productivity, but it is not known if this has significantly impacted the health of the system" (Jones *et al*. 2000).

Sediment loads have almost certainly increased in the estuary since European settlement but without knowing pre-settlement levels, it is not possible to determine the full extent of the increase. Sediment levels have not always been increasing. There was a reduction in the turbidity levels in the upper estuary between the 1980s and 90s. It is possible that sediment was flushed out in the 1991 flood and then dry conditions in the 90s meant there was less input. There also might have been a change in estuary morphology from the loss of a large meander (Jones *et al*. 2000:38).

At present there is little evidence to indicate that increased nutrient loads are having a major impact. Nutrient loads most likely have increased but impacts on the estuary are probably minimal due to the high turbidity during and after flood events. Offshore there is evidence of coastal phytoplankton blooms following large floods (Brodie and Mitchell 1992). However, the long term chlorophyll *a* record collected by GBRMPA (Schaffelke 1999) shows little evidence of significant blooms after smaller floods (Jones *et al*. 2000). Near Rockhampton, the estuary has high nutrient levels, which are probably associated with little tidal mixing due to the barrage, and to sewage outfalls (CRC 2003).

Levels of toxicants in the estuary appear low. The only data on the state of estuary are from sediment metal concentrations data collected by the Environmental Protection Agency (Moss and Costanzo 1998). These data indicate that concentrations of most metals in the Fitzroy estuary are consistent with those in a range of unimpacted Queensland estuaries. The levels of chromium and nickel appear to be slightly above the unimpacted range but this is thought to be a result of local geological characteristics rather than anthropogenic sources.

3. Water Quality Impacts on the Great Barrier Reef Lagoon

Recent estimates and studies have shown a continuous decline in water quality both in the water draining into the GBR as well as its lagoon (GBRMPA 2001). Against the backdrop of this threat and the fact the World Heritage Area[3] is at risk, the Great Barrier Reef Marine Park Authority (GBRMPA) has developed 'end-of-the-catchment' water quality targets to ensure the sustainable future of the GBR (GBRMPA 2001). The water quality targets are being incorporated into the strategic initiatives, such as the National Action Plan for Salinity and Water Quality and the Natural Heritage Trust. Recently, the Commonwealth and Queensland Governments undertook a joint initiative in order to halt and reverse the decline in water quality entering the GBR from diffuse sources within ten years (SQCA, 2003). However, it is yet to be designed/formulated what particular measures (regulatory and non-regulatory) at the farm level would be appropriate to reduce the pollution loads at the source.

Concerns about the water quality in the GBR lagoon have been expressed in a number of recent studies and reports (see, for instance, Furnas 2003; Productivity Commission 2003; Science Panel 2003; SQCA 2003). These concerns surfaced both from Commonwealth and State Governments through the Memorandum of Understanding signed by the Commonwealth and Queensland Governments in August 2002 and the recent release of the *Reef Water Quality Protection Plan*. Some of them provide evidence in support of a decline in water quality entering the GBR lagoon:

- The Productivity Commission in its recent study (Productivity Commission 2003) examines the water quality of the GBR lagoon in terms of sediments, nutrients and contaminants and claims a "strong evidence of declining water quality in the GBR lagoon due to higher sediment and nutrient loads" (p: XXIX).
- *Central Queensland Strategy for Sustainability* (FBA 2000) developed by the central Queensland community also laid emphasis on improving the condition of the Fitzroy Basin's riparian areas in order to protect the Great Barrier Reef.
- The Science Panel (2003) has noted, "it is possible that conclusive proof that water quality decline has damaged the GBR and associated ecosystems will only become evident after irreversible damages has occurred" (quoted in Productivity Commission 2003: XXVIII). The Science Panel (2003) also argues that sediment, nutrients and pollutants resulting from human activity in rivers draining into the GBR are significantly higher than the estimated pre-1850 conditions.

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[3] Most of the Great Barrier Reef ecosystem was inscribed onto the World Heritage Register as the Great Barrier Reef World Heritage Area (GBRWHA) in 1981 (Furnas 2003). The boundaries of the Great Barrier Reef Marine Park largely match that of the GBRWHA, and is jointly managed by the Commonwealth Government and the State of Queensland.

- The *Reef Water Quality Protection Plan*, a joint initiative of the Commonwealth and Queensland Governments to halt and reverse the decline in the quality of water entering the Reef, endorses " … the potential risk to the Great Barrier Reef from the progressive decline in water quality in the waterways entering the Reef" (SQCA 2003: 4).

4. The Sources of Impacts on the Great Barrier Reef Lagoon

A number of possible causes of declining water quality in the GBR lagoon have been identified. The Productivity Commission (2003:42) argues that "most types of water pollutant can come from multiple locations and from the activities of multiple sectors, but dry tropics catchments have the greatest (and most variable) discharges; and the principal sources of the main types of pollutants (sediments, nutrients and agricultural chemicals) appear to be diffuse (agriculture)".

Major point sources of pollution are industry, urban land use (e.g. sewage plants), aquaculture farms and off-shore activities. Non-point or diffuse sources account for the majority of discharges into the GBR lagoon. Main non-point sources of pollution are agricultural practices and terrestrial runoff. Agricultural activities include grazing (soil erosion on grazing properties) and cropping (overuse/misuse of fertilizers and chemicals by cropping industries) (Hunter *et al.* 1996).

The Productivity Commission concludes that "diffuse sources, particularly cattle grazing and crop production, are the most significant contribution to pollutant discharges into the GBR lagoon. In addition, it appears that natural runoff is an important source of sediment, and sewage accounts for a notable proportion of phosphorus discharge" (Productivity Commission 2003:XXIX). Major land uses are for agricultural, pastoral, commercial, residential and recreational purposes. Some of the major land uses in the Fitzroy Basin that impact upon the health of the rivers and thereby the Great Barrier Reef are outlined below.

4.1 Land Use Impacts in the Fitzroy Basin

By area cattle grazing is the dominant land use in the Fitzroy catchment (see Section 2.1). Over 40 percent of the GBR catchment's gross value of beef production and 36 percent of beef employment is attributable to the Fitzroy region (Productivity Commission 2003: 88).

Davidson (2003:38) recognizes that "due to the vast areas involved in pastoralism, most of the collective sediments and nutrients reaching the coast come from cattle grazing lands in the drier catchments of the Burdekin and Fitzroy rivers". According to Science Panel estimates, agriculture including grazing contributes around 80 percent of the pollution loads to the GBR lagoon (Productivity Commission 2003). Modelling by Moss *et al*. (1993) suggest that around 73 percent (51400 tonnes) of the nitrogen discharged annually from reef catchments is sourced from grazing lands and around 21 percent (14500 tonnes) from cropping lands (quoted in Science Panel 2003: 46).

Grazing has been identified as the main contributor to water quality problems in the GBR lagoon, primarily through soil erosion due to overgrazing and/or clearing of vegetation and riparian strips (GBRMPA quoted in Productivity Commission 2003). Cattle grazing can affect water quality in a number of ways, including:

- woodland removal and vegetation clearing, particularly in riparian areas,
- overgrazing, soil disturbance and stream bank erosion by cattle,
- cattle access to waterways/riparian strips, and
- applying fertilizers and herbicides to pastures.

(Productivity Commission 2003: 104)

After grazing, forestry (8,060 km^2) occupies the second largest area of land in the Fitzroy Basin (Taylor and Jones 2000), and covers 7 percent of the total GBR catchment. Furnas (2003:68) states "The forestry-associated disturbances within catchments that affect runoff include the removal of trees, destruction of undergrowth and the construction of infrastructure (e.g. logging tracks and roads) to remove logs from the forest area".

Irrigated agriculture does not cover a large area in the Fitzroy Basin (see Section 2.1), but the intensive use of inputs, means there are significant impacts on water quality. Inland cotton cropping is dependent on large-scale water storage, irrigation and significant levels of fertilizer and pesticide use. Furnas (2003:69) notes "the withdrawal and storage of irrigation water from inland reaches of rivers can have a major effect on catchment environmental flows and the downstream movement of eroded soils, nutrients and pesticides". There are opportunities for further agricultural expansion in the Fitzroy Basin, particularly in irrigation where 300,000 megalitres of further water allocations is available in the lower Fitzroy River (QNRM 2002). Sugarcane, a land use with a significant influence on water quality in other GBR catchments is not grown in the Fitzroy Basin.

Mining is a major industry in the Fitzroy catchment (see Section 2.1). However, mine and industry sites are highly regulated to minimize environmental impacts, and operators have to prepare an Environmental Management and Operating System (EMOS) for each site. Environment Australia argues that mining is not a 'major polluter' in the GBR catchment (quoted in Productivity Commission 2003).

Proposals to build magnesium processing facilities near Stanwell (west of Rockhampton) were shelved in 2003. It was expected that these facilities would have generated substantial downstream processing development, but it is currently unclear (at January 2004) if further development will proceed.

A major power generator exists at Stanwell, west of Rockhampton. The facility draws water from the lower Fitzroy, with limited waste water returning to Neerkol Creek.

Land in urban uses covers only small fraction of the total Fitzroy Basin (about 104 km^2 or 0.07 percent of the total area). Nutrient and pollutant inputs from urban and semi-urban areas (to the basin waterways) largely come as sewage discharge from treatment plants, stormwater runoff, industrial wastes and leakage from septic tanks. Of these, sewerage discharge is probably the most significant impact on water quality, and it is estimated sewage effluent alone may account for 6 percent of nitrogen and 20 percent of phosphorus loads to the GBR lagoon (Productivity Commission 2003: 27). Other urban sources of nutrients and sediments include large scale earth works.

There used to be two abattoirs and a slaughterhouse operating in Rockhampton. One large abattoir (Lakes Creek) is currently closed but may reopen. This abattoir discharges some waste, including organic and nutrient loads, into the river when operational. There is no river discharge from the other abattoir.

Tourism is the largest employer in the Fitzroy region, and in the GBR region, it accounts for 10 percent of the value of tourist expenditure and 13 percent of employment (Productivity Commission 2003: 86-7). The impact of tourism in the Fitzroy Basin on the GBR is yet to be assessed in detail. However, figures show that 85 percent of tourists visit seven percent of the reef area of Cairns and Whitsunday (Harriott, 2002). This indicates that the other 83 percent of the GBR area is accessed by 15 percent of tourists, suggesting a very low level of tourism impacts over the majority of the reef.

The Fitzroy region accounts for only 9% share of expenditure on recreational fishing (Productivity Commission 2003: 93). Both recreational and commercial fishing are of relatively low economic importance in the Fitzroy catchment (see Section 2.1).

5. Economic Issues to Consider

The export of pollutants within GBR catchments originates from both point and non-point sources. For point source pollutants (e.g. urban sewage plants and stormwater, ports, manufacturing and processing industries and aquaculture), where the source's abatement responsibility can be identified, the resulting export of pollutants has traditionally been managed through regulatory policy mechanisms. For the non-point source pollutants, such as sediment from grazing lands, identification of the source and amount of pollutant is very difficult, making targeted controls prohibitively expensive (Cason *et al.* 2003). The *Reef Water Quality Protection Plan* states that "the majority of chemical, sediment and nutrient pollutants affecting water quality in the waterways entering the Reef come from diffuse sources arising through land use activities in the Reef catchment" (SQCA 2003: 5).

Pollution problems are examples of externalities, where an external party bears an effect without having that taken into account by the causer. When externalities are spread across many parties, it becomes difficult to negotiate solutions because of the variety of impacts and different tradeoffs involved. When externalities involve biodiversity, where the benefits are often non-rival and non-excludable, public good considerations also need to be considered. Major difficulties revolve around asymmetric information, where the opportunity costs to reduce pollution loads are privately known to landholders, and the environmental benefits are rarely quantified systematically (Cason *et al.* 2003). The problems are exacerbated by the multiple parties involved, and the lack of scientific knowledge about the situation. The public good nature of the technical information means that there is little incentive for private landholders to collect the information.

Although land-based sources of pollutants in general and cattle grazing in particular have been identified as the major source of pollutants entering the GBR lagoon, there exists opportunities to improve land use management practices both at the property and landscape level. The *Reef Water Quality Protection Plan* emphasized the "need to improve the way sediment, nutrient and pesticide runoff is controlled and how wetlands and riparian habitats are protected and restored in the Reef catchment" (SQCA 2003:12). There is no incentive on the part of the land users either to reduce soil loss from grazing and farming land, or to minimize loss of nutrients applied as agricultural fertilizer. As the Productivity Commission (2003:45) noted "those who take voluntary actions to limit discharges are rarely rewarded for the benefits they provide in the GBR lagoon, while those who degrade water quality are unlikely to bear any significant part of the costs they impose on others".

Market-based instruments are often considered as being superior to other approaches (e.g. command-and-control) because they can provide land users with more tailored incentives to minimize abatement costs. This, in turn, will minimize the cost of such policies to society. MBIs are also believed to provide continuous dynamic incentives to adopt cheaper and better pollution-control technologies (Hockenstein *et al.* 1997; Ruth *et al.* 2000). However, the appropriateness of particular market-based instruments to improve the water quality outcomes in the GBR catchments is yet to be examined.

There are three groups of MBIs that could potentially be applied to water quality issues in the Fitzroy Basin. The first is a competitive tendering system, which could be applied to the allocation of government funding to ensure it generates maximum returns. The second are offset mechanisms, which can be used to ensure that any environmental losses resulting from new development are balanced by environmental gains elsewhere. The third are cap and trade mechanisms, which can be used to limit environmental damage and allocate the contributions to that damage.

Some forms of offsets (eg bubble programs) are very similar to cap and trade mechanisms in that they provide a mechanism for a group of firms to meet specified emission levels. For example, some firms in the United States are allowed to increase emissions in some production centres so long as the increases are offset with reductions in other centres (Van Beuren 2001). The South Creek Bubble Licensing Scheme on the Nepean River in New South Wales allows the three participating sewage treatment systems to adjust their individual discharges, provided the total pollutant load limit for the scheme is not exceeded[4].

[4] *See* http://www.epa.nsw.gov.au/licensing/emissionstrading.htm

Developing a MBI program would normally involve several steps.

A. Outline the issue to be addressed and identify the key cause of the problem. This ensures that the MBI will be targeted to achieve the desired goals.

B. Identify whether the issue is worth solving. This may involve cost-benefit analysis, with non-market valuation used to assess some of the environmental impacts. In some cases political or social decision systems will provide inputs to this stage.

C. Identify the key characteristics of the problem to be addressed, and select the most appropriate MBI for the task,

D. Identify the range of opportunity costs between potential participants so as to predict the structure of trading and/or the level of funding required.

E. Identify the institutional setting required to implement an MBI program and create the appropriate instruments required.

F. Engage with the prospective participants to give them some ownership of the design and implementation of the program.

Step A has been partly addressed in the review of water quality issues provided earlier in this report. Some information about the costs and benefits of addressing environmental issues in the Fitzroy Basin (Step B) are available from a series of Choice Modelling studies that have been conducted (e.g.Rolfe *et al.* 2002), and some of the institutional issues associated with water property rights in the Fitzroy have been explored in Whitten (2003). An assessment of the community values associated with protecting the Fitzroy estuary is presented in Windle and Rolfe (2004).

It is difficult to complete steps B and C without some knowledge of the opportunity costs to be assessed in step D. This information is crucial to understanding if there is much potential to reallocate compliance activities between participants and generate gains. The problems of asymmetric information mean that much of that knowledge is not revealed until a MBI program is operational. Because institutions and property rights need to be established in advance (to provide confidence for trading), it is not normally possible to make major adjustments after a MBI has been implemented. As a result, it is important to assess opportunity costs and likely market behaviour in the design stages of a MBI.

It is likely that there are major differences in opportunity costs of reducing water quality impacts across sectors in the Fitzroy Basin. Industry and mining sites may have very high opportunity costs, while urban and horticulture may have moderate costs and agriculture low costs. These differences suggest that there may be some efficiencies to be gained in trading compliance actions across the basin. There may also be some possible gains in trading compliance actions within an industry where opportunity costs vary significantly between participants.

Economic tools can be used to provide information about opportunity costs and likely market behaviour. Opportunity costs can be predicted from production models, while experimental economics can be used to gain insights into likely market behaviour under different institutional and trading rules. However it is difficult to capture the heterogeneity of different production sites (farms) and market participants (landholders) in production models and classroom experiments. An alternative mechanism to assess this information in the design stages of an MBI is to adapt a non-valuation technique termed Choice Modeling (CM) for this purpose.

CM is a stated preference technique where participants are provided with a number of alternative tradeoffs in a hypothetical market setting. Each tradeoff is described in terms of a standard set of attributes and levels, in addition to individual labels. The choice of a preferred tradeoff indicates that a particular bundle of attributes, levels and labels has higher value than the others. When enough choices are performed, statistical regression can be used to assess the internal tradeoffs made. The use of a cost variable to describe the alternatives helps to monetize the tradeoffs made so that results can be transferred to a cost-benefit analysis setting.

A single CM survey will allow the assessment of the opportunity costs associated with different actions. It will also allow predictions to be made about the likely market participation of a target group for specified actions and opportunity costs. The use of two or more CM surveys (split-samples) will also allow different institutional structures to be tested. In this case the test will be how the choices made by respondents are affected by different institutional rules across the split-sample experiments. The resulting information can then be used to design a more effective MBI program.

6. The Research Agenda

This project is focused on designing an MBI to improve water quality in the Fitzroy Basin and developing the use of CM as an integral part of the design process. The outcomes of the project should be broadly transferable to other GBR catchments.

The project will involve four key stages. In the first stage, an appropriate case study for testing an MBI will be selected. The material presented in this report has helped to focus the choices here. While mining and industrial sites are expected to have high opportunity costs of reducing water quality impacts, these sectors have relatively low contribution levels in the Fitzroy, are already highly regulated, have a limited number of participants and are not likely to grow much in the short term. The urban sector is likely to have moderate opportunity costs, a limited number of point source emissions, but makes a relatively small contribution overall. Agriculture produces the bulk of impacts on water quality, but from diffuse sources where it is hard to identify the contribution of particular enterprises to the problem. It appears likely that mechanisms to improve riparian vegetation and reduce soil loss across the agricultural sector may be suitable for consideration.

The second main component of the project will be to identify the management actions and the linkages between these and biophysical outcomes. For example, if riparian vegetation is chosen as an appropriate case study, it will be necessary to specify the width of the riparian strips, the potential use by livestock, and responsibility for fire and weed management. These will be management actions for which opportunity costs will need to be assessed. A case study will be limited to a particular industry sector and geographic region so as to make the management actions and biophysical linkages easier to identify.

The third main component of the project will be a review of MBI's dealing with water quality, and the design of the appropriate institutional structures. It is likely to be difficult to design effective MBIs where non-point sources contribute the bulk of pollution levels. It is unclear whether an offset program can just be used to balance environmental losses from new developments, or whether it can be used to generate improvements from a current situation. Gains will be highest where different sectors with varying opportunity costs are involved, but this raises issues about defining the appropriate tradeoffs and the rules for trade and enforcement.

The fourth component of the project will be the design of the CM studies. This will involve presenting potential participants with an offset scenario and different choice alternatives. Several rounds of a CM survey may be performed to test the effect of different institutional structures and assess the varying opportunity costs involved.

7. Summary

One aim of this project is to generate clear recommendations about how to implement market-based incentives for the improvement of water quality in the lower Fitzroy River. Another aim of the project is to develop the use of the Choice Modelling technique in the project design process as an alternative to the use of production models and experimental economics. The outcomes of the project should help to identify some of the opportunities to apply MBIs to GBR water quality issues, and to improve the design process for implementing an MBI.

The project commenced in July 2003. The CM studies and the review of water quality incentive programs will occur during 2004, and final results and reports will be available by July 2005. The project is being run by a steering committee comprising of a landholder and representatives from the four project partners, the Queensland Department of Natural Resources and Mines, the Queensland Department of Primary Industries, and the Institute for Sustainable Regional Development.

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