Photo courtesy of ABC

Hervey Bay City Council

Final Report

Traveston Dam EIS Review

Friday, 11 January 2008

AS / NZS ISO 9001:2000					
Revision No.	Author	Reviewer	Approved for Issue		
			Name	Date	Signature
0	N. Sanders	N. Sanders	N. Sanders	19/11/2007	
1	N. Sanders	N. Sanders	S. Walker	20/11/2007	
2	N. Sanders	N. Sanders	N. Sanders	10/01/2008	
3	N. Sanders Stuart White (ISF, UTS) Alex Kazaglis(ISF, UTS) Joanne Chong (ISF, UTS)	N. Sanders Tanzi Smith (ISF, UTS) Ron Smith(HBCC) Jamie Bunt (HBCC)	N. Sanders	11/01/2008	

NATURAL SOLUTIONS ENVIRONMENTAL CONSULTANTS PTY LTD

Brisbane Office:
Suite 16, Level 2 Central Brunswick,
Cnr Brunswick & Martin Streets
FORTITUDE VALLEY QLD 4006
PO Box 1156, Fortitude Valley Qld 4006
Tel: (07) 3124 9400
Fax: (07) 3124 9499

Cairns Office:
Level 2, 26 Florence Street
CAIRNS QLD 4870
PO Box 6935, Cairns Qld 4870
Tel: (07) 4041 3522
Fax (07) 4051 4141

Sunshine Coast Office
Suite 13, The Atrium
91 Poinciana Street
TEWANTIN QLD 4565
PO Box 1171, Tewantin Qld 4565
Ph: (07) 5442 4494
Fax: (07) 5442 4474

Townsville Office
Level 4, Northtown Tower
280 Flinders Mall (access via Ogden Street)
TOWNSVILLE QLD 4810
PO Box 279, Townsville Qld 4810
Tel: (07) 4772 5033
Fax: (07) 4772 5044

TABLE OF CONTENTS

FIGURES

TABLES

SUMMARY

S.1 SCOPE

This report is based on a reading of selected chapters of the EIS with emphasis on socioeconomic and biophysical aspects. Alternative proposals to the dam have been evaluated at length by others and are not reviewed here.

S.2 HOW CREDIBLE IS THIS EIS?

Overall, the EIS does not provide a basis on which to judge the impacts of Traveston Dam Stage 1.

The positive features of the EIS are that it provides a comprehensive biophysical inventory of the inundation area and surrounds. It also provides a credible assessment of our current state of knowledge of the more significant flora and fauna species that will be affected.

Unfortunately, despite the EIS documentation being voluminous, several key areas of impact prediction and design of mitigation measures are lacking in detail. This makes a critical evaluation of the impacts very difficult and speculative.

The major shortcomings of the EIS are:

1. Water supply security for the Fraser Coast Region is not adequately considered;
2. Justification for the dam is made on the basis of flawed and / or inadequate economic analysis;
3. The effects of downstream changes on social and economic factors has not been adequately considered;
4. Hydrological analysis probably underestimates the downstream flow impacts to a considerable degree;
5. Hydrological modelling is not linked with aquatic ecology and water quality; there is no predictive analysis of water quality or biota in the impoundment or downstream and the discussion on impacts is necessarily speculative;
6. In some cases, the evidence from research, case studies and even studies within the EIS are contrary to the conclusions in the executive summary;
7. The Mary River Water Resource Plan (WRP) is not considered to have sufficient scientific basis to provide reliable flow targets; most of the targets are expert panel derived, and there is an acknowledged lack of scientific understanding of the flow requirements of several of the iconic species;
8. Inconsistent and sometimes misleading treatment of Stage 2 and other related projects that will have cumulative impact on the Mary River (Northern Pipeline and Borumba Dam raising); these are included in the water supply benefits, but not in the costs or impacts;
9. No allowance for climate change in the modelling, which is likely to further reduce the frequency and volume of flushing flows;
10. Inconsistency about mitigation measures – many of the measures recommended in the chapters are not included in the executive summary and even fewer are included in the

cost assessment; and

11. In consideration of points 1, 2, 3, 4, 7 and 9 particularly, the downstream impacts on the Mary estuary and the Great Sandy Straits are inadequately predicted and the optimistic assessment has no evidentiary basis.

Consequently, the EIS provides some guidance on the individuals and communities that will be affected, but leaves unanswered the specific impacts. Of greater concern is that even if the impacts can be mitigated to some extent, the cumulative impacts from planned changes to the Mary River water supply scheme will more than counteract the mitigation measures for Stage 1.

S.3 WHAT ARE THE MAJOR RISKS OF THE PROJECT?

The major biophysical risks/impacts with Traveston Dam Stage 1 are:

- Economic losses particularly associated with tourism, commercial and recreational fisheries in the Great Sandy Straits and Hervey Bay;
- Substantial reduction in frequency of 'flushing' flows – minor to moderate floods; this may lead to accumulation of noxious weeds above the barrage and subsequent export to the Great Sandy Straits in larger floods; may also reduce fisheries production in the Straits and Hervey Bay;
- Loss of 487ha of bushland and riparian vegetation, of which about half is remnant. Although this is not hugely significant, the riparian vegetation is acknowledged as the major wildlife corridor network and 60ha of the remnant vegetation is endangered;
- Threats to the long term viability of rare and threatened aquatic species (Mary River Cod, Mary River Turtle and Lungfish) from direct loss of aquatic habitat, barrier impacts and loss of breeding sites. The long term future for these species cannot be predicted with our current uncertainties about their biology and efficacy of mitigation techniques;
- Substantial alteration of downstream aquatic environment, particularly in the important habitat reach between the dam and Amamoor creek – due to sedimentation, erosion from prolonged flood flows, periods of prolonged low flow and water quality;
- The dam and the downstream reaches are likely to experience episodic, major invasion of nuisance aquatic plants, which will move downstream in floods; and
- Reduction in water supply security to the Fraser Coast Region. Diversion from the Mary River from this and related projects will reduce available water from the system which is already unable to meet all flow demands. This effect is likely to be worsened by climate change.

The Stage 1 dam is unlikely to cause extinctions of rare or threatened species, nor is it likely to cause major and adverse impacts on the Great Sandy Straits. However, all of these risks / impacts are significant and the effects will be more significant if other proposed water projects for the Mary River are considered. Although the EIS is inadequate to judge either the project's singular or cumulative impacts, it is highly probable that some freshwater reaches of the Mary River will undergo major and irreversible change, and there will be some level of adverse impact on the Estuary and parts of the Great Sandy Straits.

S.4 RECOMMENDATIONS FOR FURTHER INFORMATION

The EIS does not demonstrate that the dam is sustainable on environmental grounds. We recommend that the following additional information is required to allow an informed decision to be made:

1. Revision of the hydrological analysis to rectify errors and omissions identified in this submission, and publication of probabilistic statistics to demonstrate impacts on yield and downstream flow patterns under a range of environmental and climatic scenarios – including long term climate change;
2. A comprehensive, transparent and independent assessment of current and future water security in the Fraser Coast Region in essential to ensuring water security in future. The assessment could be undertaken within a framework of Integrated Resource Planning / Least Cost Planning assessment of the supply demand balance, which would be an integral part of the Wide Bay Water future planning and investment decision making processes;
3. A rigorous, inclusive and comprehensive economic and social impact analysis demonstrates net benefits, and the results of distributional analysis are assessed against criteria of fairness and equity. The following elements should be included:
    a. comprehensive identification and quantification of linkages between dam construction and operation, hydrological impacts, ecological impacts and resultant social and economic impacts. These should be mapped dynamically (over time), and explicitly include sectoral and regional adjustment needs post-construction. Key impacts on the Fraser Coast which should be analysed include: tourism values (see below), recreational and commercial fishing, and the effect of water security for the region on future water availability and hence economic growth;
    b. best-practice, best-fit approaches to measurement and analysis would involve apply monetary, physical quantitative or qualitative measures of impacts depending on what is most appropriate to data availability and nature of impact;
    c. explicit identification of risks and uncertainties. A scenario analysis approach, which examined the implications of key risks and uncertainties (e.g. climate change), is an essential to a rigorous cost-benefit analysis of Traveston Dam. The sources of risk should be identified and evaluated.
4. Quantitative study of estuarine hydrodynamics and sediment processes in the estuary north to Urangan;
5. Quantitative risk assessment under a variety of environmental and climatic scenarios to predict:
    a. the extent and severity of water quality and aquatic weed issues in downstream freshwater reaches;
    b. habitat impacts and effects on biota, fisheries production and wetlands in the estuary and northern Great Sandy Straits.
6. Cost assessment of any negative impacts on commercial and recreational fisheries and tourism in the Hervey Bay/Great Sandy Straits area;
7. Comparison of all direct and indirect costs (including 6) and greenhouse gas emissions for delivery of water to Brisbane for both the Traveston Crossing scheme and an alternative

scheme using a desalination plant;

8. Clear and unequivocal list of the proposed mitigation techniques;
9. Descriptions and design specifications for key mitigation techniques, including fishway, turtle ramp, offtake arrangements and environmental flow regime (see below);
10. Publication of a draft Resource Operating Plan, to enable a detailed assessment of proposed environmental flow regimes; and
11. Map showing locations for compensatory plantings of riparian vegetation, including offsets for endangered vegetation.

It is critical that items 1-6 are completed before the remaining items are finalised.

1.0 INTRODUCTION

This review is provided at the request of Hervey Bay City Council.

The draft Traveston Stage 1 EIS was released for public comment between 22 October 2007 and 3 December 2007.

The dam is a declared major project under the Queensland *State Development and Public Works Organisation Act 1971* and a controlled action under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*.

1.1 SCOPE OF THIS REVIEW

This report is a strategic review, and focuses on socioeconomic (water supply security, fisheries, tourism etc) and biophysical (hydrology, water quality, geomorphology, terrestrial and aquatic ecology) aspects.

This summary of major risks is based on a reading of the following:

1. Overview (102 pages);
2. Executive summary (135 pages);
3. Project rationale and alternatives (67 pages);
4. Description of the Project (101 pages);
5. Land - topography and geomorphology (38 pages);
6. Water resources and water quality (164 pages);
7. Terrestrial environments (97 pages);
8. Aquatic environments (104 pages);
9. Matters of National Environmental Significance Report (99 pages);
10. Social Impact Assessment and Economics (196 pages);
11. Cumulative Impacts (77 pages);
12. Hazard and Risk (37 pages);
13. Flow statistics - Appendix F3 (46 pages);
14. Aquatic – Appendix F5 (26 pages);
15. Estuarine and Marine Ecology – Appendix F6 (169 pages);
16. Social and Economics – Appendix F11; and
17. Risk and Opportunity Assessment – Appendix F12 (25 pages).

1.2 HOW IS THE PROJECT DEFINED IN THE EIS?

The EIS is limited to Traveston Dam Stage 1. The project costs and impacts are all attributed just to that single project. The project as defined in the EIS includes the Stage 1 dam wall and the Stage 1 inundation area.

However, the water supply and economic benefits will accrue only if the water is delivered to urban centres, which requires the following additional infrastructure:

- Northern Region Pipeline (Traveston to Cooroy); and
- Northern Pipeline Interconnector (NPI - Cooroy to Morayfield).

This infrastructure is outside the scope of the EIS, which means that costs and impacts are underestimated.

Traveston Stage 1 will yield 70,000 ML/a, but future Mary River system diversions will more than double this figure:

- Borumba Dam raising (additional 40,000ML/a);
- Traveston Stage 2 (40,000 ML/a);
- Baroon Pocket Dam (24,000 ML/a; stage 1 diversion via NPI); and
- Lake MacDonald (unspecified additional yield via NPI).

Consequently, the cumulative impacts are substantially larger than the impacts examined in the EIS.

1.3 How Large is the Dam?

Basic technical information about the dam is shown in **Table 1**.

TABLE 1 TRAVESTON STAGE 1 STATISTICS PROVIDED IN EIS DOCUMENTATION

DESCRIPTOR	SCALE	MY COMMENT
Annual yield	70,000ML/a	*20% of median flow at site.*
Capacity	153,000ML	*More than doubles existing storage in the Mary system of 136,000ML;* *As a comparison, Lenthalls dam (post raising) is 28,000ML.*
Average depth	5m	*Water level fluctuations will expose the shore line frequently.*
Maximum depth	24m	
Length of river inundated	36.5km	*Main channel only; total river length is 310km.*
Inundation area	3,039ha	*Catchment area is 22% of the Mary Basin.*
Area affected by project activities	3,838 ha	*Includes road relocations, construction areas and inundation area.*
Offtake	'Multilevel'	*No detail provided about levels or connections to the pipeline system.*

2.0 WATER SUPPLY SECURITY IN THE FRASER COAST REGION

The Mary River is a key component of the long term water security strategy of the Fraser Coast region. The Mary River resource has been targeted as a preferred emergency supply solution for Hervey Bay City, and as a potential source for long term water supply (WBWC, 2007). The Mary River and its tributaries also provide the primary water supply for Maryborough City Council and the township of Tiaro, all of which will form part of the Fraser Coast Regional Council (FCRC) post amalgamation in March 2008. A dam at Traveston Crossing will certainly affect the streamflow of the Mary River and therefore will impact upon the ability of the River to cater for the future demands of the Fraser Coast region. The impacts of the dam with regards to water security in the Fraser Coast region have not been sufficiently assessed in the Environmental Impact Statement (EIS).

A comprehensive investigation into water security in the Fraser Coast region is essential to inform decision makers and the community of the full downstream impacts of the Dam.

The Mary River is one of the major water courses running through the Fraser Coast Region and, in addition to future water security, makes a significant contribution to the local economy and ecosystems. While the Lenthall Dam on the Burrum River provides the vast majority of drinking water to Hervey Bay City, the Mary River has been targeted in the future water strategy and makes a significant contribution to the fisheries, tourism and horticulture industries. As the local economy expands and the demand on water resources increases, the Mary River is likely to become an increasingly important resource for continuing economic prosperity in the Fraser Coast region.

Water security planning in the Fraser Coast Region occurs against a backdrop of rapid growth in population, significant uncertainty due to climate change, and a limited ability to cater for future water demands. The need for future water management in the region to balance social and economic outcomes with the ecological capacity of the regions ecosystem has been formalised in the Wide Bay Burnett Regional Plan 2006. While the Lenthall Dam has recently been raised, resulting in an almost doubling of capacity (WBWC, 2007), a range of other options, including water from the Mary River, will have to be considered in the future in order to achieve a sustainable water supply.

Rapid growth in the region can potentially affect the future water security situation through changing water demand. The Hervey Bay Local Government Area is one of the fastest growing regions in Australia, with population growth rates as high as 5 and 6%, and an average of 2.6% until 2026 (OESR, 2008). The area is also subject to annual fluctuations in population due to the substantial tourism industry upon which the local economy is heavily reliant. To date, a study has not been conducted to assess the impact of population growth on future demand for water.

The nature, extent and uncertainty surrounding future climate change may also have a significant affect on the available water resources of the region. This may occur through increasing the likelihood and severity of reduced streamflows in Queensland watercourses such as the Mary River (Walsh *et al.*, 2001). A study conducted by the CSIRO and the W.A. Department of Environment found that in Perth an 11% reduction in rainfall could result in a 31% reduction in flows (Bari *et al.,* 2005).

The Dam at Traveston Crossing will have a further impact on water security by reducing the streamflow along the Mary River and leading to potentially altered allocations to the Region. The reductions in flows during the dry months could be significant, and reduce the water available for agriculture (dairy, sugar cane, horticulture) during the periods when it is most needed. Although the EIS evaluates the affect of the dam on mean annual flow to be approximately a 3% reduction (Pg. 6-45, EIS), the bulk water provider, SunWater, has clearly stated that the river is already constrained as the projected flow regimes outlined in the Mary Water Resource Plan (Qld. Govt., 2007) fail to meet the environmental flow objectives outlined for the region (Vanderbyl, T., 2006).

A further report of hydrological modelling (Burgess, 2008) contends that the flows would not meet the Environmental Flow Objectives (EFOs) set out under the Mary Basin Water Resource Plan and that at certain times of year, mean monthly flows will be reduced to as little as 50% of the natural (pre-European settlement) flow. If Traveston Crossing Dam were constructed, the availability of additional water from the Mary River for use in the Fraser Coast region would be significantly constrained by the need for river flows to comply with the EFOs. The capacity for the current EFOs to support important ecosystem functions, both within the Mary River itself and its estuary, the Great Sandy Strait, remains a subject of major dispute, creating further uncertainty regarding future water security and the capacity of the Mary River ecosystem to continue to support key regional industries.

A comprehensive, transparent and independent assessment of current and future water security in the Fraser Coast Region is essential to ensuring water security in future. The assessment could be undertaken within a framework of Integrated Resource Planning / Least Cost Planning assessment of the supply demand balance, which would be an integral part of the Wide Bay Water future planning and investment decision making processes.

The outcomes of such an assessment would be to quantitatively assess the impact of the Dam at Traveston Crossing on the water security of the region. Also, the assessment could be designed to capitalise upon the world leading water metering being conducted in the Wide Bay Water area[1], would increase the understanding of water use now and in the future. The key elements of this comprehensive water security assessment include:

- Investigations of current water demand at the individual customer, sectoral and regional level, and projections of demand for at least the next 25 years. This would draw upon the

[1] The Region is supplied by Wide Bay Water, a utility that is an international leader in water security planning, in particular with regards to system water efficiency, and more recently with the roll-out of the Automatic Meter Reading trial (AMR). AMR is a sophisticated system of meter reading and billing that enables prompt detection of leaks, time of use pricing and increased feedback to users. This may result in an up to 10% reduction in water use across the residential sector (White and Herriman, 2006).

most recent information being provided by end-use studies around the country. Water end-uses need to be quantified for:

- Domestic water users. This could be informed in part by recent AMR trials by WBWC, and take into account the likely changes in the efficiency of stock brought about by forthcoming price changes, increasing public understanding of water efficiency, restrictions and the WELS scheme;
- Industry water use and future trends including changing technologies and economic changes on the role of water in tourism, irrigation, sugar cane and other significant water users in the region;
- Non-revenue water, including system and household leakage and how this will improve in the short term as a result of recent advancements in the monitoring of water use in the region.

- Quantification of system yield from the range of water sources supplying the region (predominantly Lenthall Dam) and how this may change over time as a result of drought and climate change;
- Study of supply and demand options that could impact water security, including demand management options and supply augmentation options. The Dam at Traveston Crossing could be characterised as an option to be considered in comparison to, for example, home retrofits, water efficient new developments, recycling and other options;
- Portfolio assessment of a suite of options that meets the supply demand gap into the future including multiple economic, environmental and social assessment criteria. Options may be ranked according to the unit cost of the option measured as the cost of the option contributing toward filling the supply demand gap; and
- Recommended investment strategy for the Fraser Coast region that draws upon the results from the portfolio assessment and selects the least cost portfolio for meeting water security into the future. This recommendation would be cognisant of environmental and social constraints on the strategy, in addition to choosing the cheapest alternatives.

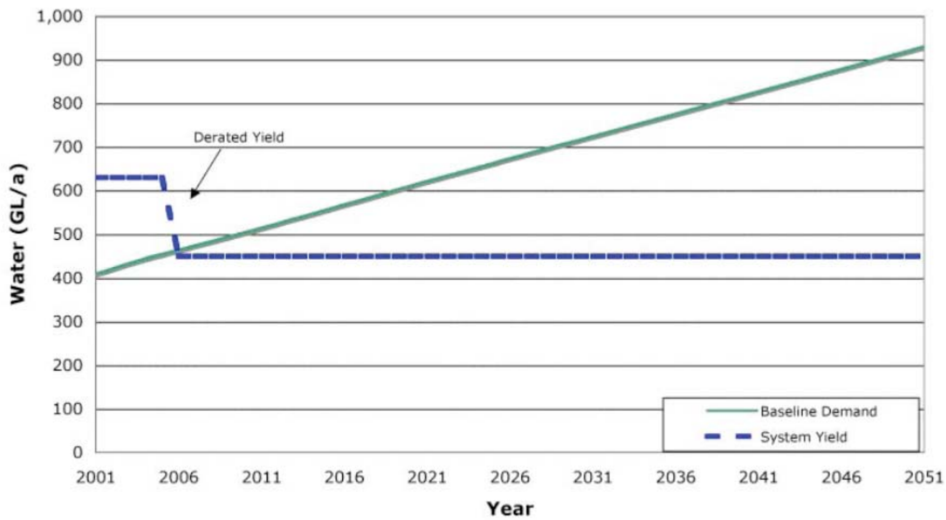
These elements of a complete assessment of water security and impacts of the Traveston Crossing Dam to the Fraser Coast region are compared with the approach taken by the EIS in **Table 2**. While the EIS adequately reported demand and supply figures for the SEQ region, this analysis was not conducted for areas downstream of the Dam where the water supply is also affected.

TABLE 2 COMPARISON OF APPROACH TAKEN BY TRAVESTON CROSSING DAM EIS AND RECOMMENDED WATER SECURITY ASSESSMENT

COMPONENT OF WATER SECURITY ASSESSMENT	TRAVESTON CROSSING DAM EIS	RECOMMENDED APPROACH FOR COMPREHENSIVE ASSESSMENT OF THE REGION
Demand	▪ Quantification of demand at 2026 and 2051 in SEQ. ▪ Inadequate documentation of assumptions regarding litres consumed per capita or per customer or how this changes over time.	▪ Quantification of demand in SEQ and for Fraser Coast region downstream on the Mary River. ▪ Complete documentation of assumptions underlying the assessment including water consumption per capita or per customer.
Yield	▪ De-rated prudent yield shown for the SEQ region.	▪ Yield estimates for the region downstream of the Dam into the future.
Options	▪ New supply and existing demand options considered for SEQ region only.	▪ Full assessment of options for both SEQ and region downstream of the Dam. ▪ Consideration of 'readiness' options and new demand management options. ▪ The impact of the Traveston Crossing Dam on the Fraser Coast region should be quantified and assessed as an option.
Portfolio assessment	▪ Options assessed based on cost for SEQ.	▪ Options should be assessed within a real options analysis framework, consistent with best practice for water security planning. ▪ Demand options and supply options should be assessed equally with regards to the ability to fill the supply demand gap (the water security objective).

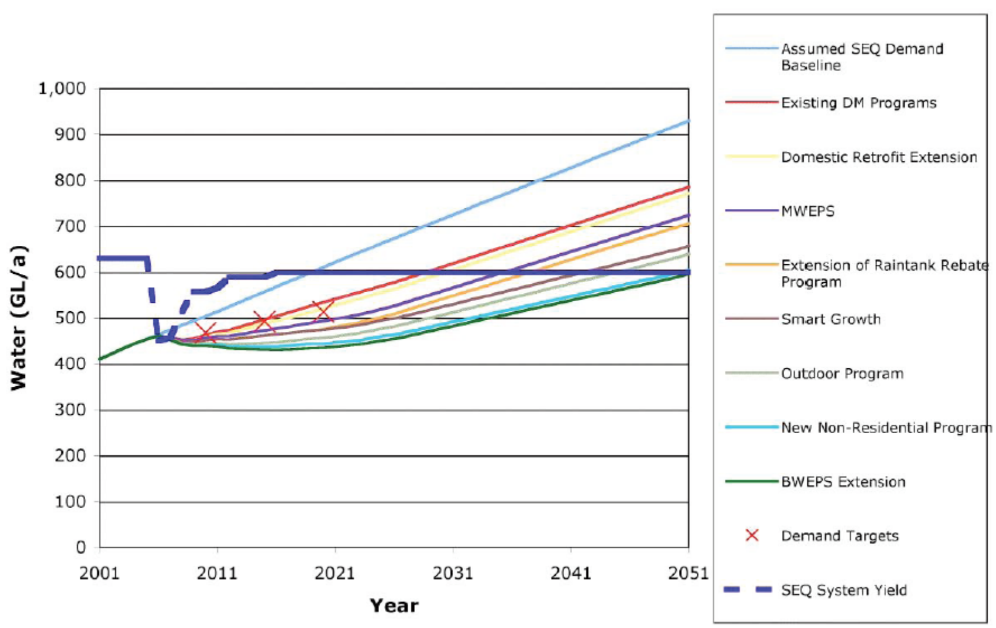
A study was conducted for the Mary River Council of Mayors in 2007 (Turner *et al.*) that follows the above description and provides a guideline to best practice reporting with regards to water security planning. In this study, the demand and yield were estimated and projected in to the future using the best available data from Government sources. The results are shown in **Figure 1**, with the yield and demand projected until 2051.

Figure 1 Projected demand and yield for South East Queensland (Tuner et al., 2007)



Multiple options were described and assessed according to their ability to contribute to water security in the future. A least cost portfolio of these options was analysed and recommended based on the least cost strategy for achieving water security into the future. The recommended strategy included a combination of existing and new demand management programs, and included the impact of a range of drought response initiatives proposed by the Queensland Government. (**Figure 2**).

Figure 2 Supply demand balance showing least cost suit of options achieving supply security until 2051



A comprehensive assessment of supply security at downstream locations on the Mary River, in particular the Fraser Coast region, is essential to informing future investment in the region but was not included as part of the EIS. A Dam at Traveston Crossing on the Mary River will result in new considerations for the supply security strategy that have not been adequately addressed in the EIS. A full assessment of these downstream impacts is required, including an Integrated Resource Planning study of the region similar to that undertaken by Turner *et al.* (2007) for SEQ Queensland.

3.0 SOCIO-ECONOMIC ANALYSIS

The analysis of economic and social impacts presented in the EIS does not consider the full range of costs, benefits, uncertainties likely to be imposed by Traveston Dam. There is a notable absence of analysis on impacts on stakeholders downstream of the dam, including the communities, industries and visitors to Hervey Bay City Council. The assessment in the EIS also fails to include a comprehensive distributional analysis of impacts on various stakeholder and socio-demographic groups.

Hervey Bay City Council contends that, due to a number of methodological issues and omissions, the EIS assessment of economic and social impacts fails to comprehensively capture the full extent of impacts, and is thus not sufficiently rigorous to support a net benefit conclusion for the Traveston Dam proposal. A consequence of proceeding on the development on the basis of insufficient impact analysis is that there could be a net social cost overall, as well as specific negative impacts on downstream regions such as Hervey Bay, with potential flow-on negative impacts to the region on the wider Australian economy and community.

A full analysis of social and economic impacts of the Traveston Crossing Dam on the Fraser Coast region is essential as there may be a net social cost overall or specific negative impacts on downstream regions.

Key issues include:

- **The proposed dam is not justified on the basis of service reliability:** The EIS analysis of SEQ householders' willingness-to-pay for improved service reliability (reduced frequency, duration and severity of water restrictions) indicates total net householder willingness-to-pay of $102 to $113 million per annum for reducing the probability of restrictions to level 4 every 100 years for 6 months, or to no mandatory restrictions ever, respectively. The NPV of capital and operational costs of Traveston Dam are approximately $2,250 million. Therefore householder willingness to avoid restrictions is not a key component of justifying the capital, operating costs and other impacts of Traveston Dam, and should not be relied upon as a justification for investment in this project;
- **Over-reliance on CGE analysis to justify conclusion:** Consequently, to justify its overall calculation of net benefits of Traveston Dam, the EIS analysis implicitly relies predominantly on the economic impact results of a methodological approach (Computable General Equilibrium modelling) that suffers from a number limitations - and in this context, results from such modelling can inform but should **not** be relied upon as the threshold decision point about whether a proposal has net benefits. For example, CGE modelling relies on the quality of input-output data available for each region. This data is not available on a local council level, and therefore CGE modelling results do not capture, and their communication can effectively obscure, the extent of local-level impacts. Other limitations are described below;

- **"Water shortage" and "industry productivity"**: The extent to which water shortages could affect businesses is based on a single qualitative survey of businesses which self-described the relationship between water shortage and productivity (ACIL 2007). Surprisingly, sensitivity testing on this assumption is not conducted, despite various issues including:
  - In calculating impacts on businesses (and hence economic potential), the EIS analysis effectively assumes that all businesses would face a proportional reduction in water availability. Even if water were to become as scarce as the model assumes, there is no logical reason why the approach would be to impose blanket rationing on all businesses (which would not take into account prior improvements in water efficiency). For example, policy developments such as scarcity pricing would have very different impacts on businesses, industry and productivity;
  - The potential for technological development, technological transfer and water efficiency is not explicitly modelled. This underestimates the innovation potential in many businesses and industries; and
  - The model assumes that in response to water scarcity, capital stock is fixed. There is no logical reason why this would be the case, and in the example above why, when faced with higher water prices, there is not a shift in capital towards less water-intensive sectors and towards more water-efficient businesses within a sector.
- **Limited assessment of economic and social impacts of dam**: Within the EIS, the identification and assessment of potential negative economic and social impacts of dam is limited to the geographic area of the dam itself. Although the EIS appears to readily assume the philosophical position that the dam will create regional connectivities, it fails to fully acknowledge existing hydrological, ecological, social and economic linkages within the region to identify or measure impacts; and
- **No detailed assessment of the capacity of the proposed environmental flows to maintain estuarine processes and productivity:** The estuary of the Mary River is the internationally significant Great Sandy Strait, a listed marine park, containing Ramsar Wetlands, areas of signifcance for migratory birds and marine species, World Heritage areas and significant commercial and recreational fisheries. The estuary plays a key role in the tourism and fishing industries which are key component of the regional economy. A methodology for determining the environmental flows required for estuaries has been recommended by the National River Health Program (Pierson, *et al.*, 2002). With respect to fisheries productivity, the EIS noted the need for more research in this area (FRC Environmental, 2007). A report released by the Fisheries Research and Development Corporation (Halliday and Robins, 2007) has outlined what such research could entail. It describes the importance of determining the impacts of changes in environmental flows on key fish and crustacean species in estuaries. The FRDC report also highlights that many of the species significant to recreational and commercial fishing and to local indigenous communities utilise freshwater habitat for part of their life cycle, or require freshwater flows for reproduction or as migratory cues (e.g. barramundi, mullet, mud crabs and banana prawns). These issues are further explored in **Section 4** of this submission.

- **No detailed assessment of the economic and social impact resulting from changes in estuarine processes and resources:** Currie (2007) used research on ecosystem services from estuaries conducted by Coastal CRC (Blackwell, 2007) to estimate the value of the ecosystem services to the regional economy. This preliminary estimate found the contribution to be in the order of $3.7 billion. The direct contribution of fisheries and tourism to the regional economy was also estimated at $96 million (Currie, 2007). The EIS (pg 15-12) suggests that in 2001 recreational fishers paid $38 million to go fishing and a further $102million on accommodation in Hervey Bay. This research on the importance of environmental flows for estuaries highlights the need to address the social and economic impacts that changes to the estuary caused by the Traveston Crossing dam may have on the Fraser Coast region.

  As noted in sections 2 and 4 of this submission, the EIS failed to comprehensively analyse the short- and long-term water security impacts or the ecological impacts for regions downstream of the proposed Traveston Dam. Consequently, analysis of how these impacts will affect local, regional and Australian economies and communities has not been conducted.

  This is a serious and disappointing shortcoming of the EIS analysis. The following section outlines an approach for rigorous and comprehensive identification and assessment of economic and social impacts, which include the impacts (including flow-on effects) on downstream local councils such as Hervey Bay.

A rigorous, inclusive and comprehensive social and economic impact assessment is recommended that includes, as a minimum:

- ***Comprehensive identification and quantification of linkages***
- ***Best-practice, best-fit approaches to measurement and analysis, and***
- ***Explicit identification of risks and uncertainties***

Hervey Bay City Council recommends that the Traveston Dam proposal should not proceed until a rigorous, inclusive and comprehensive economic and social impact analysis demonstrates net benefits and the results of distributional analysis is assessed against criteria of fairness and equity. The following elements should be included:

- **Comprehensive identification and quantification of linkages** between dam construction and operation, hydrological impacts, ecological impacts and resultant social and economic impacts. These should be mapped dynamically (over time), and explicitly include sectoral and regional adjustment needs post-construction.

  Key impacts on the Fraser Coast which should be analysed include: tourism values (see below), recreational and commercial fishing, and the effect of water security for the region on future water availability and hence economic growth.

Tourism values and potential impacts

In the context of Hervey Bay City Council, a key issue is the *importance of coastal and marine ecosystems to tourism*. As noted in section 4.3 of this submission, the reduction in flows, changes in flow regimes (timing and seasonality of flows, not just average flows) and water quality caused by the operation of Traveston Dam is likely to have significant environmental and ecological impact (which was not comprehensively analysed in the EIS).

Tourism to the Fraser Coast region, including the Fraser Island World Heritage Area, is vitally dependent on functioning riparian, estuarine, coastal and marine ecosystems around the Mary River and Hervey Bay. The tourism sector is a significant source of employment and economic activity to the Fraser Coast region. For example, in the 12 months to September 2005, the Hervey Bay / Maryborough region attracted over 3.7 million visitor nights, an increase of 25.5% from the previous year (HBCC 2006).

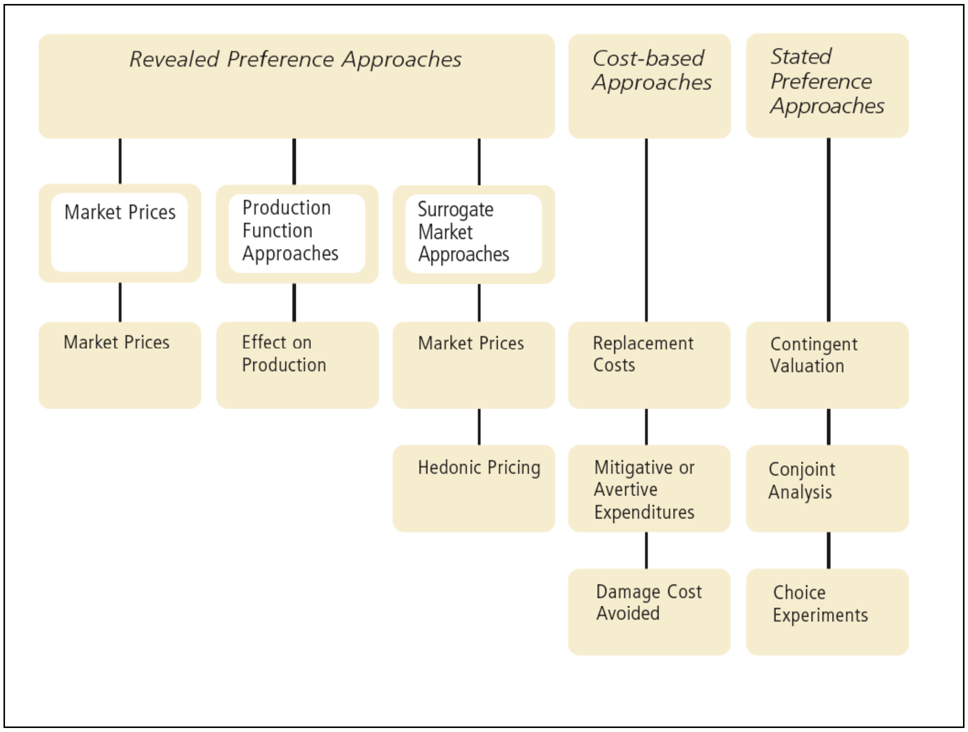
Tourism is vital not only to the immediate Hervey Bay City Council community but also represents an important component of economic activity in the Fraser Coast and Great Barrier Reef region. For example, the Productivity Commission (2003) estimated that in 1999, tourists to the Wide Bay-Burnett statistical division spent $536m (13% of total expenditure in statistical divisions that cover GBR catchments).

A comprehensive social and economic impact assessment of Traveston Dam would identify and quantify how the negative ecological impacts of the dam are likely to affect these tourism and recreational values.

- **Best-practice, best-fit approaches to measurement and analysis** would involve apply monetary, physical quantitative or qualitative measures of impacts depending on what is most appropriate to data availability and nature of impacts.

  Commonly used approaches for valuation (measuring impacts in monetary terms) are listed below. However, although monetary valuation can provide a useful metric for comparison, dollar values by themselves do not always capture values in a meaningful way. A social and economic impact assessment, which includes valuation of impacts, should be supported by other quantitative and qualitative research results – for example attitudes surveys, focus groups, and deliberative processes such as citizen's juries. Primary research and consultation with affected stakeholders is essential to accurately capture stakeholder values and the extent to which they will be impacted by Traveston Dam.

Figure 3 Valuation methods (Emerton and Bos 2003)



- **Explicit identification of risks and uncertainties**

  A scenario analysis approach, which examined the implications of key risks and uncertainties (e.g. climate change), is an essential to a rigorous cost-benefit analysis of Traveston Dam. The sources of risk should be identified and evaluated.

  These risks might relate to climate, biophysical, social, economic or institutional factors. One specific issue is the specification of rights and the regime for water sharing of water to be supplied in Traveston Dam. As discussed in section 4.1, the allocation of rights from the Mary River to the Brisbane region, and interaction with environmental flow requirements and needs, will affect the long-term water security potential for the Fraser Coast region. An analysis of social and economic impacts should explicitly take into account uncertainties surrounding allocation of future water rights to the region.

4.0 WHAT ARE THE KEY BIOPHYSICAL IMPACTS?

4.1 HYDROLOGY AND YIELD

The yield calculations are based on typical infiltration and evaporation rates. Although these losses have been the subject of media attention, the assumptions appear reasonable and in any case, are unlikely to have a substantial impact on yield. The fact is that the Mary River has historically had reliable runoff from a relatively high rainfall catchment, by S.E. Australian standards.

The hydrological component of the yield analysis is based on IQQM modelling following the extensive modelling for the Mary River Water Resource Plan. The model is calibrated against historic data.

However, the results presented in the EIS omit any quantitative risk assessment and some of the data provide a more optimistic picture of yield and flow than may be deserved. An accurate assessment of yield is critical for the cost benefit analysis as well as the water quality and ecological impacts. Given the increased drought frequency and climatic perturbations of recent years and the government's own climate change publications on the drying trend of the last 50 years, a hydrological analysis which does not account for changing conditions is not credible.

4.1.1 Limitations and Inaccuracies of the Hydrological Analysis

The flow statistics presented in the EIS provide a certain amount of information, but are restricted to flow duration curves and median daily flows. The former and associated tables are used preferentially in the EIS.

The median daily flows for each month show substantial reductions for pre-development and existing at the dam site (Figure F-3.1.12) compared to post dam – particularly for the wetter months. These results do not appear to have been given emphasis in the sectoral studies.

Even a simple time series analysis shows the variability of flow more clearly. Mean monthly flows from 1956 to 2002 show a concentration of seven events greater than 50,000 ML in the first two decades and only three events in the last three decades. The 13 years from 1973 to 1988 recorded no monthly flows greater than 50,000 ML years between. This variability is unsurprising, but has not been specifically used in the assessment of risk. As noted later, long periods between flood events represent the single largest threat to the downstream freshwaters and could potentially have significant cumulative impacts on the estuary.

Flow variability is not assessed in terms of residence time for the water, which has implications for water quality and growth of aquatic plants. An issue is that long residence times, combined with storage losses, effectively stagnate the water and concentrate pollutants, such as nutrients and salt.

4.1.2 Downstream Flow Reduction

Gross flow reductions as a result of the operation of the dam are:

- 45% reduction in **median** flow compared to natural and 24% compared to existing entitlements at the dam site;
- 25% reduction in **mean** flow compared to natural and 15% compared to existing entitlements at the dam site; and
- 6 % reduction in **mean** annual flow compared to existing entitlements to the estuary.

The comparison to mean values is used preferentially in the EIS. However, it is misleading because of the impact of large floods on the statistic. The median is a better representation of typical conditions. Similarly, existing use is approximately 36-64% of entitlements and so the impact of the scheme against actual flows is greater (i.e. higher % reductions in flow).

Gauged flows are lower than the modelled current flow used in the EIS. The gauged flow represents true current condition, whereas the modelled flow is a theoretical construct, adjusted for entitlements, rather than actual consumption. In the years 1999 to 2006, this represented an additional annual flow of between 5 and 65%, with the median change being 8%. In other words, the post dam flow reductions are significantly larger than portrayed in the EIS. Burgess[2] calculated the flow reductions due to the dam as between 11 and 74% at the dam site for the same period. Low flows are particularly affected, because under the QWI scenarios, virtually all minor freshets are trapped by the dam.

The EIS relies on the Mary River WRP as a benchmark for flow thresholds (Environmental Flow Objectives, EFOs). Some EFOs recommend by the expert panel in the draft WRP were reduced in the final WRP, to provide a 'strategic reserve' of 150,000ML/a (i.e. equivalent to Traveston Stages 1 and 2 and Borumba raising). Despite this, some 13 EFOs will not be met following Traveston Stage 1 (currently 12 are not met). The performance against these non-compliant EFOs is worsened by the dam.

Consequently, in volumetric terms, the Stage 1 dam will have a significant effect on Mary River flows, particularly in the reach below the dam. In a typical (median) year, harvesting would reduce flows at the dam site by around 30-35% compared to current.

The **moderate to higher** flow events that are impacted by the dam are between approximately 100 ML/d (approximately 2 year ARI event) and 10,000 ML/d (approximately 30 year ARI event). Only very large floods are unattenuated. This is inconsistent with statements repeated in the report and apparently relied on for the sectoral studies that medium and large floods are not altered by the dam. Most readers would conclude that floods of the order of 1 in 20 year events are large.

[2] Burgess, S (2008): *Hydrological Analysis of the Flow and Storage Data presented in the Environmental Impact Statement for the Proposed Traveston Crossing Dam*. Mary River Catchment Co-ordinating Committee.

Low flows will be highly attenuated unless there are downstream releases for environmental or irrigation water. Although the resource operations plan is not yet available, the EIS (chapter 8) assumes that:

> *'The dam will be releasing water almost every day, either through spills, to satisfy orders or to operate the fishway. Periods of no flow, even in the non-optimised scenario, will be very rare and not extend beyond three months duration. Periods of low flow, and at levels lower than current and lower again than pre-development, will increase'.*

The WRP also allows for periods of no flow at Gympie, which historically does not occur. Without the proposed Resource Operations Plan (ROP), it is not possible to assess the biological and water quality impacts of low flow attenuation.

Flows ranging from **minor freshets to moderate floods** are the most affected by the dam – because they will provide most of the yield. These types of flow include the 'flushing flows' that occur, which are typically ARI 3 month to 3 year events. These will be reduced in both frequency and volume. For example, the volume of 2-3 year ARI events will be reduced by 58% at Gympie under the WRP.

A critical period when EFOs are not met is in the period July to November, which is important for some of the rare and threatened aquatic fauna species (see **Section 2.5.1**).

4.1.3 Will flow changes affect the Estuary?

The mean flow statistics are used to assert that the impacts on the estuary and Great Sandy Straits will be minimal. There are several reasons for doubting the validity of this conclusion, including:

- The attenuation of minor floods will affect water quality, biology and sediment transport into the estuary;
- There is no estuarine hydrodynamic analysis to examine the effects of attenuation of moderate to high flows on sediment deposition; and
- There is no assessment of the reduction in organic and nutrient loads to the estuary that are important for fisheries production.

The EIS uses two models to predict a net reduction in sediment loads to the estuary of approximately 20%. However, the models do not account for 'clean water' scouring and the effects of prolonged higher flows following flood events, which may exacerbate bank erosion. It is possible that net sediment transport will decrease as predicted, but sediment and hydrodynamic processes in the estuary and Great Sandy Straits are complex and the EIS does not attempt to predict the depositional patterns resulting from flood attenuation.

The issues of sediment supply and effects on estuarine ecology are discussed in **Section 4.7**.

4.1.4 Climate Change

The two main shortcomings of the hydrological analysis are:

- Accounting for climate change (see below); and
- Dealing with cumulative impacts of other Mary River projects (see **Section 4.0**).

The hydrological analysis generally ignores climate change and the risks associated with prolonged drought.

1890-1999 data were was used for the simulations, but an extended data set from 1999-2007 was used to look at the recent drought period. However, the latter was not used to revise the yield – only to examine the impact of drought on storage levels. The presumption in the EIS appears to be that the current prolonged drought is a one-off aberration, rather than a continuing pattern.

There are no definitive predictions available for future rainfall patterns in SEQ, but a 10% reduction in annual rainfall and 20-30% reduction in runoff are typical scenarios. Burgess (2008) used a linear regression of streamflow and rainfall at the dam site to demonstrate that a 10% reduction in mean annual rainfall reduces streamflow by 31%. The effect on yield of scenarios such as this need to be analysed by QWI.

If the historic yield proves overoptimistic in the future, then the water supply benefits will have been overstated.

4.1.5 Water levels in the impoundment

The EIS includes a model of storage levels using modelled inflow, assumed infiltration and evaporation. It appears that no environmental flows have been included, which would further reduce yield and storage levels.

The EIS analysis concludes that water levels will be:

- At full supply or above: 23% of the time; and
- At half full or above: 92% of the time.

The first figure means that without environmental or other releases, there is no flow over the dam for 77% of the time.

During the recent drought, twice in the last 5 years 2002 and 2007, the dam would have been at less than 15% capacity. This means periods of 12-24 months between spills, if no environmental flows are released. Burgess (2008) examined the published data on recent flows (1999-2007) and storage volume to conclude that:

- The area of shallow water habitat for introduced, invasive, submerged aquatic plants (weed species)

- Storage losses from evaporation and seepage exceeded inflows for the majority of the 12 months between April 2006 and 2007.

4.2 WATER QUALITY

4.2.1 Water quality in the impoundment

Water quality in the dam and downstream are dealt with in descriptive terms, with a compilation of existing water quality from government sources and an intensive supplementary program for the EIS.

Nutrient (nitrogen and phosphorus) concentrations exceed water quality objectives downstream of the dam. Iron and manganese concentrations (aesthetic indicators) are also high.

The water quality assessment largely misses the mark because it is extrapolating river concentrations to storage, without attempting to predict storage concentrations. The storage concentration is a function of pollutant loads and retention time and can be used to predict the trophic status of the dam.

Based on other storages in the area and the Mary River itself, it is likely that the shallow, warm, nutrient rich water will provide new habitat for aquatic plants. The types of plant that may dominate are discussed in **Section 4.6.**

Inflows from the catchment will not be the only source of pollutants. Fluctuating water levels, coupled with wave action will allow re-entrainment of soils and sediments. A model is used in the EIS to predict the impacts of wave action and the results suggest that there will not be a significant effect. The analysis only examined suspended sediment.

However, one factor that has been overlooked is the effect of turbulence at the upstream interface of rivers and creeks with the impounded waters. This was a major influence on maintaining blue-green algal blooms in Burrinjuck Dam (NSW) during the drought of the early 1980s. The mechanism appears to be both re-entrainment of sediment and mobilisation of algal-available nutrients through alternate anoxic and oxic cycles. This mechanism has a high potential to operate with the large fluctuations expected in water level in the Traveston Dam.

Another factor in water quality is submerged and emergent macrophyte senescence (die off) during prolonged drawdown.

Many of these factors will only operate for short periods and/or infrequently, but they represent a significant risk to water quality at those times. In general, the EIS does not contemplate them and offers no contingencies.

The lower, deeper reaches of the dam are anticipated to stratify, which will create the potential for poor quality water in the hypolimnion (waters deeper than 7-10m). The EIS correctly points out that this is a typical situation for many SEQ impoundments. The only proposed mitigation measure is release via a multilevel offtake. However, the authors are confused about the impacts (EIS p6-154):

> *'Overall, the dam is not expected to impact the levels of dissolved and total metals downstream. Turnover events may lead to increased levels of dissolved iron and manganese in the hypolimnion, however management of these waters through release of epilimnion waters that meet WQOs will mitigate any potential impacts downstream.'*

Obviously, post turnover, water is of uniformly poor water quality and there is no epilimnion water to release.

The design and operation of the multi-level offtake is not specified, but there is no reason to think that a satisfactory offtake will not be constructed. The real issue is how the offtake will operate at low dam levels which may either cause mixing of hypolimnion water or reduce the volume of the epilimnion to the point where preferential discharge is not possible.

Chapter 6 refers to optimising flows and water levels, but this is not part of the proposed mitigation strategies.

4.2.2 Downstream Water Quality

The EIS offers virtually no assessment of downstream impacts on water quality – apart from basic speculation about nutrients and turbidity. There is no assessment of the significance of the impacts from operation.

Proximate downstream waters will largely be under the influence of the water quality and quantity released from the dam. In dry times, simulated drought will occur downstream due to flow changes. At these times, water quality in the pools and channel downstream will gradually deteriorate as occurs in any ephemeral system. The length and frequency of these simulated drought periods will be compounded by climate change.

A particular issue for dry periods is that if poor quality water (see **Section 4.3.1**) is released, the additional stress on aquatic biota will be high. The combined stresses of flow and water quality have not been estimated and therefore any biotic impacts are conjectural.

4.3 TERRESTRIAL AND RIPARIAN VEGETATION

Most of the 3838ha area directly affected by the project (approximately 87%) is largely cleared. The EIS quotes 424ha as the amount to be cleared, but my calculations (using EIS Figures) suggest that the total is 487ha, of which 301ha is mapped by the State Government as remnant.

The regional ecosystem (RE) surveys (vegetation mapping) appear to have been comprehensive and have resulted in a number of changes to existing mapping.

Within the remnant areas, 60ha is *endangered* (1 regional ecosystem) and 96ha is *of concern* (3 REs). The EIS notes that the endangered vegetation (12.3.1, vineforest) is probably overestimated in the bioregion, meaning that it is rarer than believed by the EPA. 27ha of the 60ha area is in very good condition and considered to be highly significant. The impact on *of concern* RE 12.3.2 is also considered significant by the EIS.

In addition to the areas that will be cleared ahead of inundation, the EIS anticipates unspecified structural changes to plant communities affected by inundation, but not cleared. The EIS also assumes (Appendix F12) that riparian communities downstream could be adversely affected by flow changes: *'para grass could eventually become more dominant over native species'*.

579 species of vascular plants were recorded in field surveys. 25 plant species were identified as listed (EIS identifies potential for 20 Endangered, Vulnerable or Rare – EVR - species).

2 EVR species were found during the surveys:

- Slender milkvine (*Marsdenia coronota*) open forest habitat; and
- Giant ironwood (*Choricarpia subargentea*) mainly riparian habitat.

The vegetation losses are probably not of major significance in a State context, but the fact that the remnant vegetation is largely riparian and forms the only major corridor network is of significance to fauna and EVR flora.

Proposed mitigation measures include shoreline planting, offset plantings for the endangered RE and plantation timbers. The latter is not intended to have a biodiversity outcome.

4.4 Terrestrial Fauna

238 potential vertebrate (birds, mammals, reptiles, amhibians, including frogs and platypus) species were assumed to be present in the area and 231 were detected – implying a comprehensive survey.

38 EVR species are listed for the local area of which the EIS suggests that 29 species with EVR or cultural status are potential occurrences in the project area. 7 EVR species were recorded in the surveys.

- Tusked frog (*Adelotus brevis*);
- Southern barred frog (*Mixophyes iteratus*);
- Elf skink (*Eroticoscincus graciloides*);
- Challenger skink *(Saproscincus rosei);*
- Grey goshawk (*Accipter novaehollandiae*);
- Australian cotton pygmy-goose (*Nettapus coromandelianus albipennis*); and
- Koala (*Phascolarctos cinereus*).

2 culturally significant species under the *Nature Conservation Act* were recorded:

- Platypus (*Ornithorhynchus anatinus*); and
- Short-beaked Echidna (*Tachyglossus aculeatus*).

The major impact will be loss of riparian areas that form the main movement corridor for many of the animals. No animal is critically endangered and the impacts are likely to be a reduction in the sub-regional population, but sub-regional extinctions are not expected.

4.5 Freshwater Aquatic Fauna

4.5.1 Species of high conservation significance (EVR)

Aquatic fauna is one of the public issues, because the Mary River system contains three iconic species that are all under threat (**Table 2**).

Table 3 Iconic Aquatic Fauna

COMMON NAME	NATURAL HABITAT	CURRENT HABITAT	MAIN THREATS FROM THE PROJECT
Mary River Cod	Mary R system	As per natural	▪ Loss of breeding habitat; ▪ Changes in flow regime, particularly annual floods; ▪ Instream barriers; and ▪ Water quality.
Lungfish	Mary and Burnett R systems	As per natural, but introduced and healthy populations in other SEQ rivers	▪ Loss of breeding habitat; ▪ Changes in flow regime; and ▪ Instream barriers.
Mary River Turtle	Mary R system	As per natural	▪ Injury/death from spillways and inlet structures; and ▪ Instream barriers.

The known biology of these species is well publicised and will not be reproduced here. A key issue with all of these species is that the impacts of dams and flow regulation are poorly understood. The project area has high quality habitat, particularly for cod, which is also affected by barriers because individuals travel long distances. There is no information available on the ability of Mary River Cod to use fishways. Cod also needs baseflow greater than at least 7ML/d, as well as trigger flows in autumn and spring. Although these could be supplied under the ROP, the EIS does not identify whether proposed flow regimes will support the cod or other EVR species.

A turtle ramp is proposed, but no design and no information as to whether it will actually be used by turtles. The Turtle ramp concept is as yet unproven.

Of note is that each of these species is relatively common in the Mary River – their rarity derives from their natural range being limited to the Mary River (plus the Burnett for the lungfish).

There are a further 3 fish (see 2.6.2) EVR species of which 2 are not native to the Mary River and one is widespread in SEQ rivers. In addition, the Southern snapping turtle is considered significant, but is not yet listed as EVR.

4.5.2 Fish

35 native species of fish are in the catchment, of which 30 were recorded in the EIS survey. 2 EVR species and 3 listed by ASFB of which 1 is natural (purple spotted gudgeon) were recorded by the EIS surveys. This suggests that the area is diverse and that the survey was successful.

The Mary system is relatively free of barriers for freshwater fish and the Mary River barrage has an effective fishway. Most existing large barriers are currently at the upper and lower ends of system (Tianana and Mary barrages downstream; Borumba, Cedar pocket, Lake McDonald and Baroon Pocket dams upstream. The latter has limited barrier impact because there is a waterfall just downstream that acts as a natural barrier).

The EIS uses a fairly generic approach to assessing impacts on fish and other aquatic fauna. However, stresses in healthy river systems such as the Mary River tend to arise infrequently – for example from drought, introduction of a major new pest species, or chemical spill. Fish kills have been observed frequently during the drought – the EIS shows an example - associated with low dissolved oxygen levels during a bloom of dense *Salvinia* beds floating on river (see **Section 4.7** below).

The EIS does not include an analysis of fish kill risk or offer mitigation measures for the likely risks that may occur with higher frequency as a consequence of the dam.

4.6 FRESHWATER AQUATIC PLANTS

The dam would be shallow, warm and with a good nutrient supply. It may not be eutrophic (the EIS does not predict trophic status), but is will certainly provide habitat for a variety of nuisance aquatic plants – notably floating and submerged macrophytes, phytoplankton (suspended algae) and possibly, cyanophtes (blue green bacteria; aka algae).

The question is not whether the lake will have excessive growth of aquatic plants, but how often, how large and what species? The EIS casts no light on this common problem for impoundments with agricultural catchments. It speculates that the open water will favour floating macrophytes with potential for invasion by noxious species – but there is no analysis to inform the reader. Predictive behaviours of aquatic plants are not modelled, so positive and negative impacts are purely speculative.

Salvinia and *Eichhornia* (water hyacinth) are major floating weeds in the catchment. They will almost certainly find additional habitat in the dam, but also in downstream reaches affected by reduced flushing flows. Wappa Dam caused a major fish kill in the Maroochy River when a flood caused the release of a large biomass of *Salvinia* that subsequently depleted downstream reaches of oxygen as it decayed.

Cabomba and *Egeria* are abundant in shallow water in other impoundments in the area. As emergent macrophytes, the main risk is that water level fluctuations may cause periodic senescence, which will release nutrients and deplete oxygen.

Generally, phytoplankton blooms would not be expected to pose a risk. However, cyanophytes are capable of forming sustained, high biomass blooms in certain circumstances. Potentially toxic aquatic plants (generally cyanophytes) obviously are an impediment to safe water supply and recreation as well as posing an aesthetic issue. Lake MacDonald has substantial cyanophyte concentrations, often exceeding Level 1 HACCP by 3 orders of magnitude. North Pine Dam (Lake Samsonvale) generally has an annual cyanophyte bloom which often requires temporary closure for water supply and recreation.

The EIS makes no attempt to predict cyanophyte growth, nor does it include a comparative evaluation of similar impoundments to evaluate likely bloom frequency. The only strategy for cyanophyte control is 'catchment management', but there does not appear to be a mitigation program, nor an indication of the targets (land use management and pollutant export) that would need to be adopted to achieve satisfactory mitigation.

The EIS acknowledges that major macrophyte die-off is predicted in large 'declines and refill events' (e.g. 1931-4). However, there is no mention that climate change is likely to increase the adverse impact.

4.7 DOWNSTREAM ENVIRONMENTAL IMPACTS ON THE GREAT SANDY STRAITS AND HERVEY BAY

4.7.1 Sediment supply to the Great Sandy Straits

The EIS includes two numerical models to estimate sediment capture by the impoundment. The model results are confusing in that the 'load' results quoted in Tables 5.24 and 5.25 are considerably higher than the 'deposition' results shown in Table 5.28 and the Executive Summary. It is not clear whether this is an error or whether 'deposition' has been calculated separately. The sediment study by Earthtech (quoted in Appendix F6) is not appended to the EIS to allow further evaluation.

In addition, the models themselves show significant variation. For example, the NRW model estimates an order of magnitude difference in current sediment loads for coarse sediment compared to CSIRO (350 kt/yr verses 23 kt/yr at the mouth).

These differences create a lack of confidence in the results quoted in the executive summary.

However, the more important shortcoming is the absence of quantitative analysis of the downstream impacts. The basic thesis of the EIS appears to be that the Mary River sediment export is substantially higher than natural and that capture by the dam will make a modest contribution to reducing this anthropogenic impact. *Prima facie*, this appears to be a reasonable assumption and is used extensively in the EIS and associated documents to assume an insignificant or even positive impact.

However, the assumption is simplistic and is not tested with any analysis of the impacts of the proposed dam on estuarine processes. In particular, it deals only with gross annual loads and fails to account for the specific changes associated with the highly variable flow regime. This issue applies to both sediment supply and downstream fisheries impacts.

The Mary Valley history of land clearing began over 150 years ago and the export patterns have long been established. Consequently, adaptation by the estuary has evolved with land use and it is possible that the predicted changes in sediment supply and floods will have unforseen impacts.

Chapter 5 accepts Brizga (2003) conclusion that clearwater scour and bed and bank degradation are two of four key impacts of dams on sediment transport. These are likely to increase sediment loads and offset the trapping effect of the dam. However, the EIS dismisses channel erosion as an impact, apparently based on the SedNet modelling. The results are not reported for both models, nor is there any serious analysis of the ability of the models to predict clearwater scour. In fact, the Earthtech reported cited in Appendix F6 specifically excluded the impacts of scour. In the light of the inconsistent model results, there is good reason to doubt the conclusions in the EIS in favour of the observed results reported by Brizga.

Despite dismissing the downstream erosion potential as minor, the EIS goes on to recommend *'replenishing existing sediment, as required'*. The recommendation on page 5-106 acknowledges that this would be experimental and would the techniques and locations would require further work. It is hard to see this as a serious mitigation strategy, given the acknowledged uncertainties. But is does suggest that the authors felt that downstream erosion **may** be a significant issue.

The EIS notes that encroachment of riparian and channel vegetation onto the bed and banks is more likely during the predicted periods of prolonged lower flows. The document also offers revegetation as a mitigation measure. However, no analysis is provided of the increased erosion potential in higher flow events due to loss of hydraulic capacity. It is highly likely that flood flows will dislodge some of these plantings and/or erode into stream banks as a consequence of increased turbulence and reduced channel capacity.

The impacts on the estuary of sediment processes are limited to a brief reference in 1 paragraph (page 5-108) and are dismissed as *'unlikely'* to occur *'over the expected life of the dam'.* The authors selectively draw on generalisations about long time scales (greater than 5,000 years) for effects to be seen, yet earlier say that catchment changes have *'significantly increased sediment delivery since European settlement [and].. accelerated deposition of material has probably occurred in parts of the northern Great Sandy Strait'.*

The Beach Protection Authority's 1989 assessment suggested that the Mary estuary is dominated by sediments derived from the river itself, and that these are tidally transported to the great Sandy Straits to Woody Island and Urangan and continuing to the north-west into Hervey Bay.

The assessment of past depositional patterns relies on analysis published by the BPA in 1989. No attempt is made to update the information using recent data or modelling techniques, or to predict the impacts of the dam itself. As a depositional estuary, the sediment characteristics and deposition patterns in the Mary are be strongly influenced by the upstream hydrology. The elimination of a large number of minor to moderate flood events may result in accelerated accumulation of sediments in periods between major floods.

The EIS acknowledges that *"Estuarine processes are complex, and include tidal hydrodynamics, processes of settling and re-suspension, flocculation and interactions with marine flow and sediment sources"*

A factor not acknowledged is the impact of the selective capture of bedload over fines within the impoundment. The Mary mouth is already dominated by fines deposition and the relative input of bedload will be reduced by the dam, particularly in the reaches closest to the dam. For example, at Fisherman's Pocket, the ratio of fines to bedload is currently 2.5:1 and will increase to 4:1 (calculations based on Figures 5.34 and 5.36; NRW model).

The risk is that a combination of reduced flood frequency and higher ratio of fine to coarse sediments will cause accumulation of fines, with consequent resuspension and further transport after floods and tidal / wind influences. The potential for this impact exists, but is neither acknowledged nor analysed in the EIS.

The main issues requiring an appropriate level of numerical analysis are:

- the impacts of altered sediment loads and particle sizes on sediment processes in the northern Great Sandy Straits, using different sediment generation models;
- likely changes in depositional patterns and particle size distribution;
- impacts of major floods on redistribution of the sediments;
- impacts on shoreline and benthic deposition patterns; and
- impacts on biota – particularly seagrasses and benthic in fauna.

4.7.2 Environmental Values of the Great Sandy Straits

The assertions in the EIS are used to support a case that the values of the Great Sandy Straits will not be affected by the dam. The inadequacies of the hydrological and sediment analyses challenge this assumption. A simplistic approach to impact assessment will not address the risks that occur through single events and combinations of events (e.g. drought, flood, weed proliferation).

The values of the Mary Estuary are acknowledged in the EIS, but there is little evidence of a precautionary approach, informed by an appropriate level of scientific investigation.

The RAMSAR listing includes specific reference to the *'sand passage estuary in relatively undisturbed condition'*, the rare *'patterned fens'* (wetlands of the Mary delta), dugong and turtles, shorebirds and fisheries. The area is also classified as a Wetland of National Importance and the EIS rates them as wetlands of state significance as well.

Much of the Mary mouth is declared fish habitat area and within the Great Sandy Marine Park. The Great Sandy Straits are a Dugong protected area. Coral is also present in the n-w GSS and into Hervey Bay, apparently relying on a sandy substratum.

The fisheries of the bay are not only important for commerce and recreation, but also are part of an ecosystem that includes iconic species – particularly whales, dugong, dolphins and turtles. Hervey Bay is one of just three humpback whale breeding areas on the Australian coast. The fisheries include finfish, oysters, crabs, sea cucumbers and prawns.

The area influenced by the Mary (see below) is part of the sea route to Fraser Island from Urangan, and for many tourists, is their first sight of the Great Sandy Straits. It is also highly visible to visitors arriving by plane. The marina and associated commercial and accommodation facilities are located on the Straits. The emerging area of River Heads provides a tourism and recreational opportunity, as well as another Fraser Island ferry terminal.

The zone of influence of the Mary is not specified in the report, but is inferred in the references to BPA (1989) cited above. The effect is potentially from the Mary mouth to the northern boundary of the Ramsar site at Woody Island and Urangan. It also extends n-w into the designated Whale Management Area within Hervey Bay and the westward extent includes the Fraser Island World Heritage Area.

The EIS takes no account of timing and flood frequency in concluding that the effects are likely to be minor. It looks at gross reductions, without assessing risks or such factors as flood pulse. The EIS concludes that *'changes to sediment loads exported from the Mary River can therefore affect habitats in the estuary, northern Strait and Hervey Bay'* but that the complex interactions render the impacts *'difficult to determine'*. This is no basis for assuming negligible impact.

The EIS acknowledges that in dry periods, *'the ecological health and productivity of mangroves is generally diminished by lack of freshwater flows and associated terrestrial nutrient input'.* In view of the lack of analysis of flow impacts on productivity, the consultants were unable to make definitive conclusions about the impacts on fisheries of the altered flow regime, present, past or future. The same applies to the direct impacts on food supply from the rivers, due to export of organic and inorganic materials during floods. The EIS provides anecdotal evidence of a link between barrage installation and low flow periods with prawn and mullet catches by commercial fishers. In the past 10 years, the EIS reports that commercial fishers have had to leave the GSS to fish, apparently associated with dry conditions.

Reduction in freshwater inflows to the estuary is suggested in the EIS as the largest risk to the ecology. The EIS acknowledges that flow reduction is associated with reduced spawning and larval recruitment of fish species. A particular risk is the potential for seagrass losses due to fines deposition and transport of biomass for the river and impoundments. The seagrass populations in the northwestern GSS are already stressed at the monitoring sites off Booral and Urangan, being rated in fair condition. The tidal wetlands have also adapted to the periodic freshwater flooding and the EIS does not address the potential impacts.

Another risk is the reduction in fisheries productivity. The EIS (Appendix F5) recommends a study *'to determine the past and present impacts of water extraction from the catchment on fisheries and to determine the relationship between flow and productivity for the Mary River Estuary'.* This expert report commissioned by QWI and published as part of the EIS effectively noted that there are no thresholds available to determine negative impacts on fisheries.

However, a subsequent addendum issued by QWI says that:

'QWI did not support this recommendation'

This suggests that the impacts are small or insignificant. One reason advanced by QWI was the *'small changes to high and medium flows'*, which is clearly unsupported by evidence. In fact the dam will substantially attenuate middle to upper level flows.

There is no justification for such a conclusion, particularly in the light of the uncertainties, errors and omissions in the hydrological and sediment analyses. The Marine consultant relied on this information and was still unable to accurately ascribe impacts. Our view is that the consultant's recommendation is correct and that the analysis should be expanded from fisheries productivity, to include ecosystem impacts, based on an appropriate level of sediment and hydrodynamic study.

5.0 CUMULATIVE IMPACTS

The EIS has a cumulative impact assessment (CIA) – which is commendable – but its scope and conclusions are too limited to add value.

The CIA has no obvious analytic basis, apart from some basic relationship diagrams and a simple risk assessment, details of which are not included. In summary:

- Most impacts are rated as positive, including habitat for the Southern barred frog and Mary river turtle (**very high**), erosion control at dam edge, water quality, and habitat management;
- Hydrological impacts are rated as overwhelmingly positive, including 'stable' base flows which were a positive impact on habitat;
- The only negative impact rated **very high** is visual; and
- Ecological impacts are rated negative **medium** or **low**, except loss of REs which is rated **high**.

Based on my review and the findings within the EIS itself, it is difficult to give credibility to these comparative ratings. Most of the ratings underestimate the probable negative impact or assume a positive impact with no compelling evidence.

A notable exception is greenhouse gas emissions. The EIS concludes in other areas that there will be a net carbon emissions reduction because of proposed offset plantings. The CIA rates greenhouse emissions as **low** and negative. This is probably more realistic because the calculated emissions omit pumping costs, construction and embodied energy.

In addition to the analytical shortcomings, the CIA does not consider the impacts of the two pipelines, Traveston Stage 2, and Borumba raising.

6.0 MITIGATION MEASURES

6.1 SUSTAINABLE DEVELOPMENT

CSIRO Sustainable Ecosystems was engaged to assist with a sustainability strategy. Many of the projects recommended under the strategy are of value for community, employment and recreation. The projects highlighted in the EIS documentation that are relevant to this review are:

- Freshwater Species Conservation Centre (FSCC) to investigate the three iconic species;
- Riverbank and wetland habitat restoration;
- Tree plantation (primarily for forestry, but the carbon sequestered is counted in the EIS as credits); and
- Sewage infrastructure for Kadanga.

Other key mitigation measures that will provide more specific mitigation are:

- Fishway (and mention of further investigations for fishways on existing dams);
- Turtle ramp (status and performance are uncertain);
- Catchment management (generic and no implementation measures) ;
- In-stream management to improve habitat (such as large woody debris in the lake); and
- Translocation plans for some species.

A large number of the recommendations in chapters do not appear in the final list of mitigation measures. More importantly, of the second list of measures above, it appears that only the fishway forms part of the project costings. There is no indication as to the affects of prolonged dry weather on the effectiveness of the mitigation measures, but it is highly likely that the fishway will be ineffective for long periods.

The FSCC is a good initiative and will be a valuable source of information in the future. My understanding is that the initial impetus for the centre came from fisheries biologists in the State Government and the tertiary sector – partly as a response to the uncertain impacts of Paradise dam. However, their intent was that the research be carried out prior to further damming in order to be able to predict the impacts.

Surprisingly, the EIS does not include an intention to formally declare part of the catchment to protect the water supply.

Carbon offsets are tabulated in the EIS and involve a simple carbon account for the cleared trees and the proposed forestry plantations. There are three flaws with this argument:

- The analysis excludes carbon from pipeline clearing, construction, embodied energy and operating costs; some comparative analyses suggest that the pipeline operation will involve equivalent greenhouse emissions to a desalination plant. However, there is no data in the EIS to confirm or otherwise;
- The analysis underestimates the areas to be cleared and does not allow for carbon sequestration in partially cleared areas; and
- Plantation forestry does not necessarily lead to permanent sequestration and is not recognised under the Kyoto Protocol.

7.0 EIS DEFICIENCIES

As noted several times in this report, the EIS is mostly an inventory, with predictive analysis almost absent for water quality and biota. The impact assessment is rudimentary, and tends to be based on average conditions, rather than the assessing risks of a highly variable system.

The major shortcomings of the EIS are:

1. Water supply security for the Fraser Coast Region is not adequately considered;
2. Justification for the dam is made on the basis of flawed and/or inadequate economic analysis;
3. The effects of downstream changes on social and economic factors has not been adequately considered;
4. Hydrological analysis probably underestimates the downstream flow impacts to a considerable degree;
5. Hydrological modelling is not linked with aquatic ecology and water quality; there is no predictive analysis of water quality or biota, in the impoundment or downstream and the discussion on impacts is necessarily speculative;
6. In some cases, the evidence from research, case studies and even studies within the EIS are contrary to the conclusions in the executive summary;
7. The Mary River Water Resource Plan (WRP) is not considered to have sufficient scientific basis to provide reliable flow targets; most of the targets are expert panel derived, and there is an acknowledged lack of scientific understanding of the flow requirements of several of the iconic species;
8. Inconsistent and sometimes misleading treatment of stage 2 and other related projects that will have cumulative impact on the Mary River (Northern Pipeline and Borumba Dam raising); these are included in the water supply benefits, but not in the costs or impacts;
9. No allowance for climate change in the modelling, which is likely to further reduce the frequency and volume of flushing flows;
10. Inconsistency about mitigation measures – many of the measures recommended in the chapters are not included in the executive summary and even fewer are included in the cost assessment; and
11. In consideration of points 1, 2, 3, 4, 7 and 9 particularly, the downstream impacts on the Mary estuary and the Great Sandy Straits are inadequately predicted and the optimistic assessment has no evidentiary basis.

Inconsistency about mitigation measures – many of the measures recommended in the chapters are not included in the executive summary and even fewer are included in the cost assessment; and consequently, the EIS provides some guidance on the individual species and communities that will be affected, but leaves unanswered the specific impacts. Of greater concern is that even if the impacts can be mitigated to some extent, the cumulative impacts from planned changes to the Mary River water supply scheme will more than counteract the mitigation measures for Stage 1.

8.0 WHAT ARE THE HIGHEST RISKS?

The actual impacts of the proposal are not possible to judge from the EIS. Consequently, in this section, I have used also used the term 'risk' because it covers issues for which the EIS provides no impact assessment.

The major risks/impacts are:

- Economic losses particularly associated with tourism, commercial and recreational fisheries in the Great Sandy Straits and Hervey Bay;
- Substantial reduction in frequency of 'flushing' flows – minor to moderate floods; this may lead to accumulation of noxious weeds above the barrage and subsequent export to the Great Sandy Straits in larger floods; may also reduce fisheries production in the Straits and Hervey Bay. Lack of flushing flows may also increase fine sediment accumulation in the estuary;
- Loss of 487ha of bushland and riparian vegetation, of which about half is remnant. Although this is not hugely significant, the riparian vegetation is acknowledged as a major wildlife corridor network and 60ha of the remnant vegetation is endangered;
- Threats to the long term viability of rare and threatened aquatic species (Mary River Cod, Mary River Turtle and Lungfish) from direct loss of aquatic habitat, barrier impacts and loss of breeding sites. The long term future for these species cannot be predicted with our current uncertainties about their biology and efficacy of mitigation techniques;
- Substantial alteration of downstream aquatic environment, particularly in the important habitat reach between the dam and Amamoor creek – due to sedimentation, erosion from prolonged flood flows, periods of prolonged low flow and water quality;
- The dam and the downstream reaches are likely to experience episodic, major invasion of nuisance aquatic plants, which will move downstream in floods; and
- Reduction in water supply security to the Fraser Coast Region. Diversion from the Mary River from this and related projects will reduce available water from the system which is already unable to meet all flow demands. This effect is likely to be worsened by climate change.

All of these impacts are significant for Traveston Stage 1. The effects will be more significant if other proposed water projects are considered.

Table 3 summarises the key impacts. The impact ratings tend to be high because the table does not show other less critical impacts.

TABLE 4 TRAVESTON STAGE 1 IMPACT SUMMARY

ISSUE	KEY IMPACTS	MITIGATION	SIGNIFICANCE OF IMPACT	CERTAINTY OF IMPACT
Inundation behind dam	Loss of 484ha of vegetation – and disruption of riparian corridor	Plantation plantings; Possible riparian plantings	**High**	**Certain**
	Loss of 60ha of endangered vegetation	Compensatory plantings	**High**	**Certain**
	Loss of aquatic habitat	Possible wetland restoration	**Moderate-high**	**Uncertain** Some impacts may be beneficial for some species and some adverse
Water flows & Water supply security	Reduced water supply security for Fraser Coast Region	None	**High**	**Certain** Level of impact not assessed in EIS
	Reduction in frequency and volume of minor (flushing) flows – build up of biomass in River	May be some environmental flows in ROP	**High**	**Certain** Level of impact dependent on environmental flow regime
	Reduction in low flows in reach below dam	May be some environmental flows in ROP	**High**	**Certain** Level of impact dependent on environmental flow regime
	Reduction in moderate to large flood volumes – poor flushing of estuary	None	**Moderate**	**Uncertain** Level of impact dependent on environmental flow regime and biotic responses
	Prolonged flows following floods	None	**Low-Moderate**	**Uncertain**
Socio-economic	Reduction in fisheries productivity and tourism revenues	None	**High**	**Uncertain** EIS does not quantitatively evaluate impacts
Water quality	Stratification causing poor water quality in hypolimnion and release downstream	Multi-level offtake	**Low-Moderate**	**Uncertain** Design and operation of the offtake is vague
	Deoxygenation in downstream reaches due to plant biomass build up.	None	**High**	**Uncertain**
Barrier effect	Fish, turtle and	Fishway and	**High**	**Uncertain**

ISSUE	KEY IMPACTS	MITIGATION	SIGNIFICANCE OF IMPACT	CERTAINTY OF IMPACT
of dam	other aquatic fauna passage	possibly turtle ramp		(effectiveness of structures and no funding commitment to turtle ramp)
Climate change	Energy for construction and operation of dam and delivery system	Plantation plantings	**Moderate-high**	**Uncertain** EIS does not consider the pipeline energy costs

The table illustrates that a number of the key impacts are uncertain. The proposed mitigation measures for high level risks/impacts are generally inadequate to affect the significance of the impact.

9.0 RECOMMENDATIONS

The EIS does not demonstrate that the dam is sustainable on environmental grounds. We recommend that the following additional information is required to allow an informed decision to be made:

1. Revision of the hydrological analysis to rectify errors and omissions identified in this submission, and publication of probabilistic statistics to demonstrate impacts on yield and downstream flow patterns under a range of environmental and climatic scenarios – including long term climate change;
2. A comprehensive, transparent and independent assessment of current and future water security in the Fraser Coast Region in essential to ensuring water security in future. The assessment could be undertaken within a framework of Integrated Resource Planning / Least Cost Planning assessment of the supply demand balance, which would be an integral part of the Wide Bay Water future planning and investment decision making processes;
3. A rigorous, inclusive and comprehensive economic and social impact analysis demonstrates net benefits, and the results of distributional analysis are assessed against criteria of fairness and equity. The following elements should be included:
    a. comprehensive identification and quantification of linkages between dam construction and operation, hydrological impacts, ecological impacts and resultant social and economic impacts. These should be mapped dynamically (over time), and explicitly include sectoral and regional adjustment needs post-construction. Key impacts on the Fraser Coast which should be analysed include: tourism values (see below), recreational and commercial fishing, and the effect of water security for the region on future water availability and hence economic growth;
    b. best-practice, best-fit approaches to measurement and analysis would involve apply monetary, physical quantitative or qualitative measures of impacts depending on what is most appropriate to data availability and nature of impact;
    c. explicit identification of risks and uncertainties. A scenario analysis approach, which examined the implications of key risks and uncertainties (e.g. climate change), is an essential to a rigorous cost-benefit analysis of Traveston Dam. The sources of risk should be identified and evaluated.
4. Quantitative study of estuarine hydrodynamics and sediment processes in the estuary north to Urangan;
5. Quantitative risk assessment under a variety of environmental and climatic scenarios to predict:
    a. the extent and severity of water quality and aquatic weed issues in downstream freshwater reaches;
    b. habitat impacts and effects on biota, fisheries production and wetlands in the estuary and northern Great Sandy Straits.
6. Cost assessment of any negative impacts on commercial and recreational fisheries and tourism in the Hervey Bay/Great Sandy Straits area;

7. Comparison of all direct and indirect costs (including 6) and greenhouse gas emissions for delivery of water to Brisbane for both the Traveston Crossing scheme and an alternative scheme using a desalination plant;
8. Clear and unequivocal list of the proposed mitigation techniques;
9. Descriptions and design specifications for key mitigation techniques, including fishway, turtle ramp, offtake arrangements and environmental flow regime (see below);
10. Publication of a draft Resource Operating Plan, to enable a detailed assessment of proposed environmental flow regimes; and
11. Map showing locations for compensatory plantings of riparian vegetation, including offsets for endangered vegetation.

It is critical that items 1-6 are completed before the remaining items are finalised.

10.0 REFERENCES

ACIL Tasman (2007). Commercial Water Use in South East Queensland. Prepared for Queensland Water Infrastrcture, May 2007.

Blackwell, B. (2007). The Economic Value of Australia's Natural Coastal Assets: Some Preliminary Findings. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management.

Burgess, S. (2008) Hydrological analysis of the flow and storage data presented in the Environmental Impact Statement for the proposed Traveston Crossing Dam. Mary River Catchment Coordinating Committee, Technical Report.

Bari, M. A., Berti, M. L., Charles, S. P. Hauck, E. J. and Pearcey, M. (2005) Modelling of streamflow reduction due to climate change in Western Australia – A case study Department of Environment, WA and CSIRO ,WA.

Cooperative Research Centre and the Fisheries Research Development Corporation.

Currie, R. M. (2007). *An Appraisal of the Economic Issues Surrounding the Traveston Proposal* REMC (Regional Ecosystems Mapping Consultancy)

Emerton, L., Bos, E. Value: Counting Ecosystems as an Economic Part of Water Infrastructure. IUCN, Gland, Switzerland and Cambridge, UK.

FRC Environmental. (2007). *Traveston Crossing Dam EIS: Estuarine and Marine Ecology*

Halliday, I. and Robins, J. (2007). Environmental flows for sub-tropical estuaries: Understanding the freshwater needs of estuaries for sustainable fisheries production and assessing the impacts of water regulation The State of Queensland, Department of Primary Industries and Fisheries, the Coastal Zone

HBCC – Hervey Bay City Council (2006). Economic Profile Hervey Bay 2006.

Pierson, W. L., Bishop, K., Senden, D. V., Horton, P. R. and Adamantidis, C. A. (2002). *Environmental Water Requirements to Maintain Estuarine Processes*, Environmental Flows Initiative Technical Report No 3, Commonwealth of Australia, Canberra.

Productivity Commission (2003). Industries, Land Use and Water Quality in the Great Barrier Reef Catchment. Research Report, Canberra.

Qld. Govt., (2007) Water Resource (Mary Basin) Plan 2006, Office of the Queensland Parliamentary Council, Queensland Government.

Turner, A.J., Hausler, G., Carrard, N., Kazaglis, A., White, S., Hughes, A., Johnson, T. 2007, Review of Water Supply Demand Options for South East Queensland, Institute for Sustainable Futures, Sydney .

White, S. and Herriman, J. (2006) Automated Metering – Scoping Paper Business and Water Savings Case, Draft for Wide Bay Water Corporation, Institute for Sustainable Futures, UTS, Sydney.

Walsh, K., Hennessy, K., Jones, R., McInnes, K., Page, C., Pittock, B., Suppiah, R., Whetton, P. 2001, Climate Change in Queensland under Enhanced Greenhouse Conditions, Third Annual Report 1999-2000, CSIRO Atmospheric Research.

WBWC, (2007) Drought Management Strategy,Wide Bay Water Corporation, Hervey Bay, Qld.

Vanderbyl, T. (2006) Mary Draft Water Resource Plan – EFO Specifications, Letter to Mr. Greg Claydon, Department of Natural Resources and Mines, 25 January 2006.