Report to Queensland Premier

Review of the Fitzroy River Water Quality Issues

Professor Barry Hart
Water Science Pty Ltd
and
Water Studies Centre, Monash University

In collaboration with
Professor Paul Greenfield, University of Queensland
Mark Pascoe, International Water Centre

November 2008

Acknowledgements

I am most grateful for the excellent cooperation and speedy responses to my many questions and requests from all involved in this review. My particular thanks to DNRW Rockhampton (Ed Donohue and his team) and Ensham Resources (Colin Moffett) for their assistance.

Also I am most grateful to Graeme Milligan and Ed Donohue (DNRW), Lindsay Delzoppo (EPA) and Alex Beavers (Premiers) for their assistance as my 'Steering Committee'.

Headline Findings

1. The decision by the EPA to issue Ensham with a Transitionary Environmental Program (TEP) that permitted the discharge of a very large quantity of mine-affected water into the Nogoa-Mackenzie-Fitzroy River system over 7 months February to September) in 2008 was justifiable.
2. However, this discharge has resulted in:
   - discomfort to the residents of Tieri, Blackwater, Bluff, Middlemount and Dysart due to the poor drinking water quality, but no serious health effects (short or long term),
   - potential discomfort to the residents of Rockhampton due to poor drinking water quality if the system is not flushed this wet season,
   - unquantified effects on the riverine biota, and a high likelihood that there will be serious adverse effects on the spawning success of Fitzroy Golden Perch when the poor quality water (high salinity) is flushed out of the river during the early part of the wet season, exactly the time when this species spawns,
   - no serious short or long term problems for agriculture (irrigation, stock watering),
   - Stanwell Power Station needing to make a range of plant modifications and gain an EPA-approved TEP relating to management of its water discharges.
3. The review has identified issues with the EPA's processes for developing the discharge licence (TEP) to Ensham, particularly limited involvement of key stakeholders, a lack of transparency, and poor communications with key stakeholders and the community during the response to this issue.
4. In the longer term there is a need to strengthen EPA's processes for establishing Environmental Authorities and Transitional Environmental Program (TEP) under the Environmental Protection Act 1994.
5. A number of management actions have been identified that should be implemented immediately to reduce the severity of the drinking water quality problems being experienced by residents Tieri, Blackwater, Bluff, Middlemount and Dysart. But flushing of the mine-affected water from system will only occur during the coming wet season.
6. The available management options are all severely constrained by the current Fitzroy Water Resource Plan (and operational rules), which has virtually all the water in Fairbairn Dam allocated to consumptive uses and no contingency allocation owned by the State. These and other anomalies should be addressed during the 10-yearly review of this plan currently underway.
7. The review identified an urgent need for Government to appoint a 'lead agency' to be the responsible 'caretaker' of river health in the Fitzroy catchment, and for this agency to develop a 'catchment management plan' and a coordinated monitoring and assessment program for the Fitzroy catchment.
8. Government needs to develop a set of Emergency Response Principles relevant to the mining industry to be applied in future situations, such as the current Ensham emergency. These principles would include the need to: identify a lead agency, undertake a risk assessment, coordinate key agencies, develop an action plan, develop a communications plan, and identify a key spokesperson.

Executive Summary

This report contains a review of the current situation regarding water quality in the Fitzroy River resulting from the discharge of 138 Gigalitres of mine-affected floodwater from the Ensham Resources Pty Ltd (Ensham) coal mine located near Emerald in Central Queensland.

The Terms of Reference (ToR) for this review are to advise the Queensland Premier on:

- any short and long-term risks to human health, aquatic ecology, agriculture and industry that could result from the mine-affected floodwaters discharged from the Ensham coal mine, and how these should be managed,
- the scope of the water quality and biological monitoring program to be undertaken by the EPA to assess the potential impacts of the mine-affected floodwater discharge from Ensham coal mine,
- any changes that might be made to conditions of Environmental Authorities (for mining activities) and associated statutory documents under the *Environmental Protection Act 1994* in order to ensure that the impacts of discharges of mine-affected waters in Central Queensland are appropriately managed and monitored,
- any other matters that might be of relevance to this issue.

This review has focused on the risks from the mine-affected water discharge from Ensham. It is recognised that there are a number of other issues relating to coal mining in the Fitzroy Catchment that are of concern to community groups, but these are not covered in this Report.

The main conclusions and recommendations of this review are listed below.

Risks to human health, aquatic ecology, agriculture and industry

Human health

Blackwater, Bluff, Tieri, Middlemount and Dysart

There is no evidence of any serious health problems in the above townships due to the elevated sodium levels in their drinking water supply. However, it is possible that the poor quality water did increase the effects of a viral gastroenteritis outbreak in the region in late August 2008.

There is considerable evidence that the residents have been adversely affected by the poor taste of their drinking water supply.

Additional major concerns are that: (a) downstream drinking water supplies appear not to have been considered by the EPA in issuing the TEP, (b) neither the Central Highlands Regional Council, Queensland Health nor the residents were informed of the impending problems early enough, and (c) media reports indicate significant community concern about this issue, a lack of trust in Government to fix the issue, and resentment with Ensham.

Rockhampton

It seems unlikely that any serious health problems will arise as a result of the current (October 2008) increased salinity and sodium concentrations in Rockhampton's drinking water supply. These concentrations are likely to increase further during November (and even December if there is a lack of rain), but provided medical practitioners and the small number of vulnerable people are well informed, and there is access to bottle water, serious health problems are unlikely to occur.

It is quite possible that Rockhampton Regional Council will experience a large increase in complaints about the poor taste of the drinking water, at least until the Fitzroy Barrage is fully flushed.

If Rockhampton's water supply decreases further in quality, problems are also expected at the Rockhampton Hospital and its Dialysis Clinics and Home Dialysis service.

There is a real possibility that blue-green algal blooms will occur in the Fitzroy Barrage in the next month of so, given that water in the Barrage is considerably clearer than normal. However, the Rockhampton Regional Council are aware of this possibility and have contingency measures in place to minimise any risks to human health from blue-green algal toxins in drinking water supplies.

Additional concerns are that: (a) downstream drinking water supplies for the major population centre of Rockhampton appear not to have been considered by the EPA in issuing the TEP, (b) neither the Rockhampton Regional Council, Queensland Health nor the residents were informed of the situation early enough, and (c) media reports indicate significant community concern about this issue, a lack of trust in Government to fix the issue, and resentment with Ensham.

Aquatic biota

Review of the possible effects on river health has been hampered by a dearth of relevant information.

It is clear that there have not been any catastrophic effects (e.g. major fish kills) on the fish population in the Nogoa-Mackenzie-Fitzroy River system during the time the Ensham mine-affected discharge occurred. This is consistent with the available evidence suggesting that most Australian adult fish species are relatively tolerant of increased salinity, and unlikely to be adversely affects by salinities up to around 1,500 µS/cm.

However, this is not true for the effects of increased salinity on the early life stages of fish (e.g. survival of eggs and larvae), where the small amount of available evidence suggests that salinities of 1,000-1,500 µS/cm are likely to cause adverse effects.

It seems quite possible that this coming wet season could result in serious adverse effects on the spawning success of Fitzroy Golden Perch because of the poor quality water (high salinity) that will be flushed out of the river during the early part of the wet season, exactly the time when this species spawns.

The results of a study by Biosecurity Queensland indicated that catfish sampled from Bedford and Tartru Weirs were in poor health. However, it was not possible to relate these back to the mine-affected water discharged to the river system.

There is no evidence of adverse effects on the aquatic biota due to heavy metals in the mine-affected water.

The available information on the sensitivity of macroinvertebrates to increased salinity levels suggests that adverse effects are unlikely to occur at levels below around 1,000 mS/cm. However, this level is based on data that mostly relate to short-term studies, and not to continual exposure over a 7-8 month period. Advice has been obtained suggesting that a rapid rise in salinity to levels of 1,000-1,500 µS/cm would adversely affect macroinvertebrate communities (particularly mayflies), given the quite low salinity (200-300 µS/cm) they normally experience.

There is insufficient information available to make an assessment of potential adverse effect on other biota, such as frogs, platypus and turtles.

Again there is insufficient information available to assess whether the increased clarity of the water in the river system as a result of the mine-affected discharge, has resulted in major changes to the aquatic ecology, including increased algal production, increased predation and changes to important food webs (i.e. what eats what).

The response of relevant Government agencies to assessing the possible impacts of the mine-affected water on the riverine biota has been tardy to say the least. The EPA is currently (November 2008) coordinating a comprehensive monitoring and assessment program (water quality, sediments and biota) to determine if there have been adverse effects in the Fitzroy River system due to the mine-affected water.

Agriculture

It is unlikely that the Ensham mine-affected water has or will caused any major problems for agriculture.

Industry

Coal industry

The coal industry is the major industrial user of water in the Fitzroy catchment. Water is used for coal processing, dust suppression, in underground operations and in industrial areas. It is unlikely that water with conductivities to around 1,500 uS/cm would cause any major problems to the coal industry. However, there is evidence that an increase in raw water salinity can lead to increased maintenance costs.

Stanwell Power Station

The mine-affected water has had no impact on electricity generation activities to date. Additionally, Stanwell Power Station expects to be able to handle likely salinity increases in their raw water over the next month or so, and do not expect any impact on electricity generation.

Options available to manage these risks

A number of sensible and feasible management options have been identified by the Technical Working Group (TWG) to address the current water quality problems in the Nogoa-Mackenzie-Fitzroy system. If implemented these management actions will have some positive effect on both

drinking water quality and river health, and will show to the community that Government is serious about this issue and prepared to do something positive about it.

However, the ultimate flushing of the mine-affected water currently in the Fitzroy system will only occur with the large flows normally expected in the wet season (December-March).

It should be noted that all the management options currently being considered to alleviate the current water quality problems are restricted to a very large extent by the water use rules (ROP) for the Nogoa-Mackenzie River system, rules that appear to be largely dictated by agricultural and industrial use of the water. These rules may need to be modified in the future to consider other legitimate users of water, such as the environment and townships, and the possible need for a State-owned contingency licence to a certain proportion of the water in Fairbairn Dam.

Option A (to address some of the issues in Bedford and Bingegang Weirs) should be implemented as soon as possible, given the time (approx. 3 weeks) for water to get from Fairbairn Dam to dilute that in Bedford Weir. Implementation of this Option would have community support in that the Government would be seen to be doing something positive.

Further, it is recommended that the Central Highland Regional Council establish a Task Force to develop a contingency plan for addressing the drinking water quality issue for Blackwater, Bluff, Tieri, Middlemount and Dysart should the Bedford and Bingegang Weirs not be adequately flushed during this coming wet season.

Option C (to address water quality issues in Eden Bann Weir and the Fitzroy Barrage) should be implemented as soon as possible.

Additionally, a contingency plan should be developed by DNRW during November to handle the possibilities that: (a) additional mine-affected water will be flushed into this system from the Isaac/Connors system, and (b) that the expected normal wet season flows will not occur and the dilution and flushing of mine-affected water from Eden Bann Weir and the Fitzroy Barrage does not occur.

An emergency water management plan should be developed by DNRW during November 2008 to improve water quality in the Nogoa-Mackenzie-Fitzroy River system between the storages. This plan will need to be innovative and not constrained by the current restrictive ROP rules.

Review of the EPA-coordinated monitoring & assessment program

The response of relevant Government agencies to assessing the possible impacts of the mine-affected water on the riverine biota has been tardy, so much so that the Premier, in October 2008, directed the EPA to establish a whole-of-government monitoring program to assess the potential impacts of mine-affected floodwater discharged from the Ensham mine on the Nogoa-Mackenzie-Fitzroy River system.

A draft Project Plan (Fitzroy Basin Water Quality Monitoring: Assessing the impact of Ensham floodwater release, Version 1.0, 28 October 2008) to undertake a comprehensive study of the water quality, sediments and biota in the system has been developed.

This review provided comments to the EPA (29 October 2008) aimed at strengthening the program. A full assessment of the final monitoring and assessment program will be made in a separate report.

Because there is little baseline information available, this study will be challenged in determining if any short-term biological impacts have occurred due to the mine-affected water. For this reason, the study should continue for at least 2 years (3 wet-dry cycles) so that any recovery in the condition of the biota can be measured. The information on the system that will be collected during this time will also be vital in the development of a more comprehensive Fitzroy catchment-wide monitoring and assessment program.

Assessment of the Government actions to manage the Fitzroy water quality issue

This current water quality issue in the Nogoa-Mackenzie-Fitzroy River system arose as a result of an emergency situation caused by flooding of the Ensham coal mine in January 2008, the desire by Ensham and Government to get the mine back into productions as rapidly as possible, and the decision by the EPA to grant Ensham a Transitional Environmental Program (TEP) to discharge a very large volume (138 GL) of mine-affected water into the Nogoa River.

Given all the factors, the decision by the EPA to issue Ensham with a Transitional Environmental Program for the mine-affected water was justifiable.

However, my assessment is that the EPA process for determining the Ensham TEP was less than adequate (for the reasons outlined in Section 3.4), and that EPA did not adequately consulted with

key stakeholders in establishing the TEP, or inform the community generally about what was happening and what the possible effects could be. The whole process lacked transparency.

My assessment is that the EPA underestimated the scale of this emergency situation (discharge of a very large volume (138 GL) of mine-affected water over a period of 6-8 months to a river system that was largely not flowing), and as a result misjudged the community reaction to what was happening.

Adequacy of the current Government actions

Government actions since late August have been mixed in their responsiveness and effect. These are summarized in the main report.

The somewhat cynical community view of the current Government response to this issue is: (a) that the establishment of the TWG and my review are welcome initiatives but they will be too late to result in any management actions to solve the immediate problem, (b) that the Government is waiting for the wet season rains to 'solve' the problem, and (c) that nothing will be learned from this issue to change Government response processes.

While it is true that flushing of the mine-affected water currently in the Fitzroy system will really only occur with the large flows normally expected in the wet season (December-March), the management actions recommended in Section 5 of this report will have some positive effect on both drinking water quality and river health. If initiated, these management actions will show to the community that Government is serious about this issue and prepared to do something positive about it.

The establishment of the Fitzroy River Water Quality Technical Working Group (TWG) in September 2008 has been a very positive move. The TWG has significantly improved the level of knowledge and data sharing, and has provided a forum for sensible discussion about possible management actions.

The EPA-coordinated monitoring and assessment program is also a welcome initiative. However, as noted in the report this would not have been needed if adequate monitoring had been required as part of the Ensham TEP. Also, it is disappointing that it has taken until November for this to have been established when the issue was well appreciated as long ago as late August.

Change needed to manage the Fitzroy water quality situation going forward?

There appears to be little more the Government can do about this current water quality issue, assuming that decisions are made quickly to initiate the recommended management actions. However, this water quality issue has highlighted a number of broader issues that need to be addressed in the longer term.

<u>TEP process</u>

The most obvious is the deficiencies in the TEP process (lack of adequate consultations between the EPA and key stakeholders, lack of transparency in the process, poor communication with the key agencies and the community about the reality of the water quality issue and what could be done about it). Largely because of the poor communications, but also because of the lack of credible monitoring information, a range of 'conspiracy' theories arose and escalated the issue.

A review of the EPA procedures for developing TEPs has been recommended, with the results (a new set of guidelines) to be published on the EPA web site.

<u>Monitoring and assessment</u>

There are a number of monitoring programs being undertaken in the Fitzroy Basin (TWG Document), but it is clear they are largely focused on the specific responsibilities of particular agencies, are not well coordinated, and are not comprehensive.

This review has identified an urgent need for the establishment of comprehensive and well coordinated long-term monitoring and assessment program to assess the ecological health of the Fitzroy River system.

<u>Fitzroy Water Resources Plan</u>

The available options to manage this water quality issue are all severely constrained by the current Fitzroy Water Resource Plan (and operational rules), which has virtually all the water in Fairbairn Dam allocated to consumptive uses, and no contingency allocation owned by the State.

DNRW should consider a more equitable balancing of water between consumptive users and the environment, and the provision of State-owned contingency allocation, during the 10-yearly review of the Fitzroy Water Resource Plan that is currently underway and scheduled to be completed in late 2009.

Caretaker of river health

Another important issue that has been highlighted by the current water quality issue is there is no well-defined 'caretaker' of river health in the Fitzroy River catchment, with the legislative authority to adequately protect the aquatic environment. The EPA, DNRW and the Fitzroy Basin Association all appear to have some responsibilities in this regard.

Government should consider the appointment of a 'lead agency' to be the responsible 'caretaker' of river health in the Fitzroy catchment, and for this agency to develop a 'catchment management plan', and a coordinated catchment-wide monitoring and assessment program.

Emergency response

It is clear that the Government processes for addressing the current Ensham emergency could be improved. Given the climate change predictions of greater variability in climate over the next 30-50 years, it is certain that similar emergency situations will occur sometime in the future.

Government should develop a set of Emergency Response Principles relevant to the mining industry to be applied in future situations, such as the current Ensham emergency. The Emergency Response Principles should include the need to: identify a lead agency, undertake a risk assessment, coordinate key agencies, develop an action plan, develop a community communications plan, and identify a key spokesperson.

Recommendations

Transitional Environment Program Process

Rec 1: that EPA undertake a review of the procedures used to develop TEPs and publish the results (a new set of guidelines) on the EPA web site. This review should consider the need for (a) criteria for prioritising the importance of the TEP, (b) undertaking a risk assessment to assist in developing the TEP, (c) a checklist that ensures that all beneficial uses of the receiving waterbody are explicitly considered, (d) a better process for identifying and including key stakeholders in the TEP process, (e) better processes for ensuring the quality of the TEPs developed (e.g. documenting the reasons for various decisions or judgements), and (f) a process for informing the community of the situation associated with potentially controversial TEPs.

Rec 2: that EPA introduce a process where they undertake random audits of the laboratories being used by mining companies for their ability to adequately sample, process and analyse water quality samples for heavy metals at trace concentrations.

Monitoring & assessment

Rec 3: that EPA include the review comments in revising the draft Project Plan (Fitzroy Basin Water Quality Monitoring: Assessing the impact of Ensham floodwater release), and include a longer timeline for the study (at least 2 years - 3 wet-dry cycles) so that any recovery in the condition of the biota can be measured.

Rec 4: that the EFAP surveys to be undertaken by DNRW this coming wet season are expanded to ensure that the effects of the flushing of higher salinity water on fish (and particularly Fitzroy Golden Perch) spawning and recruitment are measured and the implications for future years published.

Rec 5: that the Biosecurity Queensland study of the 'health' of the fish in weirs be repeated, with other fish species and other storages included, and the study design improved.

Management Actions

Rec 6: that Option A (to address some of the issues in Bedford and Bingegang Weirs) be implemented immediately, given the time for water to get from Fairbairn Dam to dilute that in Bedford Weir (3 weeks).

Rec 7: that the Central Highland Regional Council establish a Task Force to develop a contingency plan for addressing the drinking water quality issue for Blackwater, Bluff, Tieri, Middlemount and Dysart should the Bedford and Bengegang Weirs not be adequately flushed during this coming wet season.

Rec 8: that Option C (to address water quality issues in Eden Bann Weir and the Fitzroy Barrage) be implemented immediately.

Rec 9: that a contingency plan be developed by DNRW during November to handle the possibilities that: (a) additional mine-affected water will be flushed into this system from the Isaac/Connors system, and (b) that the expected normal wet season flows will not

occur and the expected dilution and flushing of mine-affected water from Eden Bann Weir and the Fitzroy Barrage do not occur.

Rec 10: that an emergency water management plan be developed during November 2008 to improve water quality in the Nogoa-Mackenzie-Fitzroy River system between the storages. This plan will need to be innovative and not constrained by the current restrictive ROP rules.

Fitzroy Water Resource Plan

Rec 11: that DNRW consider a more equitable balancing of water between consumptive users and the environment, and the provision of State-owned contingency allocation, during the 10-yearly review of the Fitzroy Water Resource Plan that is currently underway and scheduled to be completed in late 2009.

Caretaker of river health

Rec 12: that Government consider the appointment of a 'lead agency' to be the responsible 'caretaker' of river health in the Fitzroy catchment, and for this agency to develop a 'catchment management plan', and a coordinated catchment-wide monitoring and assessment program.

Emergency response

Rec 13: that Government develop a set of Emergency Response Principles relevant to the mining industry to be applied in future situations, such as the current Ensham emergency.

Contents

1. Introduction

This Report contains a review of the current situation regarding water quality in the Fitzroy River resulting from the discharge of 138 Gigalitres (130,000 Megalitres or 138 billion litres) of floodwater from the Ensham Resources Pty Ltd (Ensham) coal mine located near Emerald in Central Queensland.

The terms of reference (ToR) for this review are to advise the Queensland Premier on:

- any short and long-term risks to human health, aquatic ecology, agriculture and industry that could result from the mine-affected floodwaters discharged from the Ensham coal mine, and how these should be managed,
- the scope of the water quality and biological monitoring program to be undertaken by the EPA to assess the potential impacts of the mine-affected floodwater discharge from Ensham coal mine,
- any changes that might be made to conditions of Environmental Authorities (for mining activities) and associated statutory documents under the *Environmental Protection Act 1994* in order to ensure that the impacts of discharges of mine-affected waters in Central Queensland are appropriately managed and monitored,
- any other matters that might be of relevance to this issue.

A visit to the region was made in the period 21-23 October 2008, during which time I inspected the Ensham mine site and travelled the length of the Mackenzie/Fitzroy River from Emerald to Rockhampton, had discussions with the Mayor's of the Central Highlands Regional Council and the Rockhampton Regional Council, and attended a meeting of the Fitzroy River Technical Working Group. Also meetings were held with EPA, DNRW and Ensham Resources in Brisbane on 11 November 2008. Additionally, a large number of reports and monitoring data have been reviewed. These are listed in the Reference section.

There are a number of other issues relating to coal mining in the Fitzroy Catchment that are of concern to community groups. These include the cumulative effect of waste discharges from the large number of mines in this catchment, mining on floodplains, mining under rivers, the effect of discharges of floodwater from mines other than Ensham, particularly those in the Isaac-Connors Catchment, and future controls on flood protection measures at Ensham and other mines on floodplains. These issues are not covered in this report, except to comment on the potential impact of mine-affected water currently in the Isaac-Connors system that will eventually be flushed into the lower Fitzroy River just above Tartrus Weir.

This review has identified seven major issues associated with the current water quality issue in the Fitzroy River system:

- the current risks to human health (drinking water), aquatic ecosystems, agriculture and industry as a result of the mine-affected water discharge that has now been in the Nogoa-Mackenzie-Fitzroy River system for over 8 months (Section 4 of this report),
- the options available to manage these risks (Section 5),
- the conditions and decision-making processes associated with the discharge license (Transitional Environmental Program - TEP) issued to Ensham by the EPA (Section 3.4),

- the lack of adequate communication about the discharge and its possible consequences to key stakeholders and the community (Section 7),
- the lack of adequate monitoring (particularly biological) of the impacts of the mine-affected water in the system – a new monitoring program being coordinated by the EPA is addressed in Section 6 of this report,
- the lack of a 'caretaker' of river health and a 'catchment management plan' to guide the TEP process (Sectiion 7),
- Government response to this emergency situation, and arrangements that need to be put in place to ensure that future emergencies in the mining industry are better handled (Section 7).

2. Background

Significant rainfall fell over much of the Bowen Basin area of Central Queensland in January 2008, resulted in major local flooding (BoM, 2008). In particular, the regional towns of Emerald, Moranbah and Mackay were flooded, as were a number of coal mines in the region.

The focus of this report is the Ensham coal mine, an open cut thermal mine located approximately 35 km east of Emerald, which was inundated by floodwaters from the Nogoa River when a levee bank overtopped and then failed on the 19 January 2008. A total of approximately 150 GL of floodwater entered the mine pits during this flood.

Ensham produces 8 - 9 million tonnes of coal per annum for the domestic and export Thermal Coal markets. The company is also responsible for the direct and in-direct employment of over 3,000 people in the Central Queensland Region, providing a significant annual contribution to the local, regional and Queensland State economy through employment and support services, royalties and use of numerous services.

Following the flooding events of January 2008, Ensham sought the necessary approvals required to remove the estimated 150,000 ML of mine-affected floodwater and to secure on-going flood protection for the mining operation in order to: protect the safety of the mine and its employees from further flooding, recover Ensham's capacity to supply customers and restore its economic contribution to Central Queensland, and to safeguard over 3,000 Queensland jobs.

The Environmental Protection Agency (EPA) provided authority for the discharge of the mine-affected floodwater through the issuance of a Transitionary Environmental Program (TEP) under the *Environmental Protection Act 1994*. The TEP is covered more fully in Section 3.3.

It should also be noted that a number of other coal mines were flooded during January 2008, and discharged various volumes of mine-affected water into tributaries of the Fitzroy River system under TEP's or existing Environmental Authorities (EA) issued by the EPA.

Ensham discharged 138 GL of mine-affected floodwaters into the Nogoa-Mackenzie-Fitzroy River system over a 7-month period (February to September 2008). Details of the quality and quantity of the discharged water are provided in Section 3.2, and an assessment of the impacts of this mine-affected floodwater on downstream uses (drinking water, aquatic ecosystem, agriculture, industry) is contained in Section 4.

There has been intense community and media interest in the impacts of the mine-affected water in the Nogoa-Meckenzie-Fitzroy system, commencing around August 2008. The major concerns include:

- Health effect from the elevated sodium levels in drinking water supplied to Blackwater, Bluff and Tieri,
- The poor taste of drinking water supplied to Blackwater, Bluff and Tieri,
- Possible taste and health effects in Rockhampton's drinking water supply,
- Livestock refusing to drink water taken from the river,
- Disruption to Stanwell Power Station's operations due to higher salinity cooling water,
- Adverse effects on the aquatic biota, including fish, macroinvertebrates and turtles,
- The lack of information provided by authorities to the community,
- The EPA's processes in issuing a discharge licence to Ensham.

3. Current situation

3.1 The Fitzroy River system

The Fitzroy River catchment stretches from the Carnarvon Gorge National Park in the West to Rockhampton on the central Queensland coast, encompassing a largely sub-tropical and semi-arid region of Australia (Figure 1). The Fitzroy catchment, at nearly 150,000 km^2 in area, is the second largest in Australia after the Murray-Darling system.

Agriculture is the major land use in the catchment, with grazing the dominant use (90%) and smaller area of irrigated cotton and horticulture, dryland cropping, forestry, mining and conservation (Christensen and Rogers, 2006). Mining is dominated by coal (production 100 million tonnes/year), magnesite, nickel and historically gold and silver.

Rainfall occurs predominantly in the summer (December – March) and varies from around 800 mm/y at Rockhampton near the coast to around 516 mm/y at Emerald further inland. As a result most of the mean annual discharge of about 5,000 GL in the Fitzroy River occurs in the summer wet season. There are several large sub-catchments, including the Comet, Nogoa, MacKenzie, Connors, Isaac and Dawson contribute flows to the Fitzroy. Many of the streams in the Fitzroy catchment are ephemeral and only flow during the wet season.

The coal-rich Bowen Basin underlays a considerable proportion of the Fitzroy catchment. In total there are 37 existing coal mines in the catchment with a further 17 new mines proposed.

The major rivers that make up the Fitzroy River system include the Nogoa, Mackenzie, Dawson, Isaacs and Connors Rivers (see Figure 1).

This report focuses on the Nogoa-Mackenzie-Fitzroy Rivers, the part of the system affected by the Ensham discharge[1]. This stretch of the river is highly

[1] As well as discharge of flood waters from other mining operations into the tributaries of the Fitzroy River, following those same flood events, and in February and March overland flows that occurred during the flood events of early 2008.

regulated, with one major reservoir (Fairbairn), four weirs (Bedford, Bingegang, Tartrus, Eden Bann) and a large Barrage (at Rockhampton) all built on the river (see Figure 2 for a schematic diagram of the system). These reservoirs and weirs can hold a total of 1,660 GL when at full supply level, with Fairbairn Dam by far the largest holding around 90% of the total (Data from DNRW Rockhampton).

Figure 1: Map of the Fitzroy catchment showing the Ensham mine, major towns, major river systems, reservoirs and weirs, and roads

Flow in the Fitzroy River is very seasonal, with most of the flow occurring during the wet season from December to March. Figure 3 shows the monthly mean and median flows in the Fitzroy River at Riverslea. Comparison of these data shows that, while the general picture is of most flow during the wet, this can vary significantly

depending upon the particular year. Additionally, large flows can also occur at other times of the year.

Interestingly, the total storage (1,660 GL) in the Nogoa-Mackenzie-Fitzroy system is close to the total median annual flow (1,151 GL) and about one third the total mean annual flow (4,737 GL) in the system. However, maximum annual flows in this system are over an order of magnitude greater than the mean annual flow.

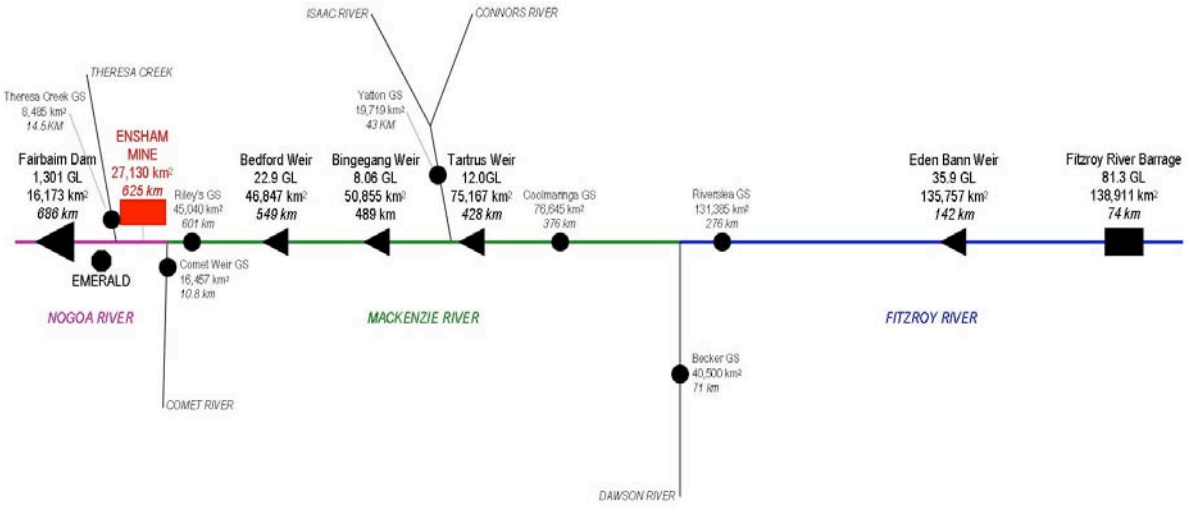

Figure 2: Schematic of the Nogoa-Mackenzie-Fitzroy river system, showing the location and full supply level volume of all weirs and reservoirs

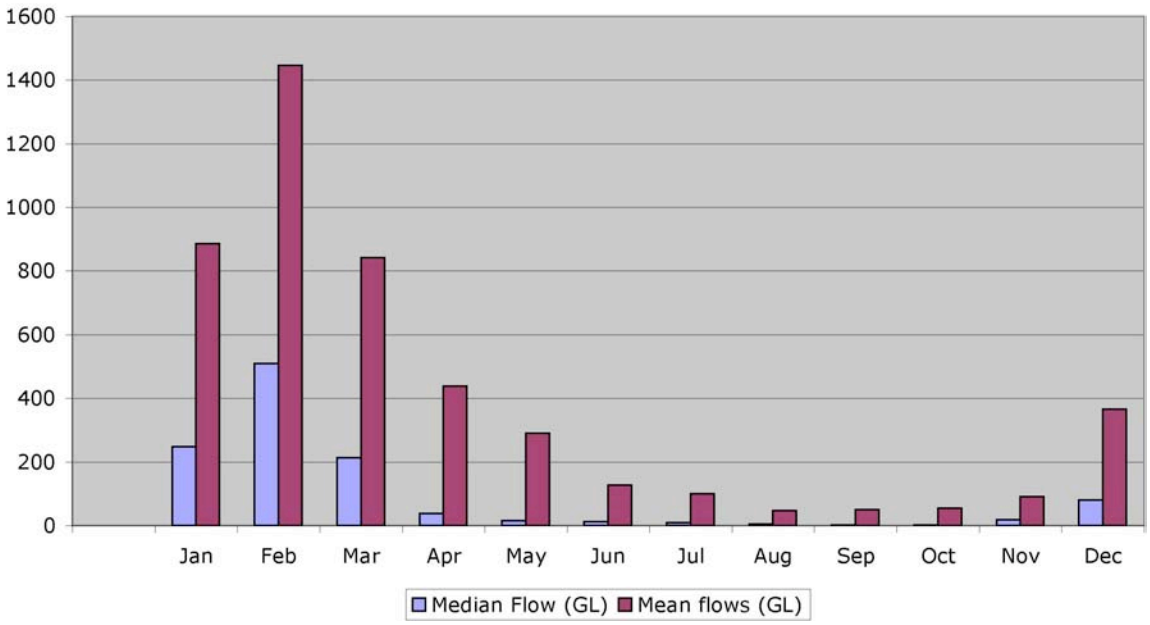

Figure 3: Long term mean and median monthly flows (Gigalitre – GL) in the Fitzroy River at Riverslea

3.2 Quality of the mine-affected water

A total of 138 GL of mine-affected water was discharged to the Nogoa River from the flooded pits over a period of around 7 months (Table 1). The floodwater was in the pits for around 16 days before discharge commenced from Pit B on 3 February 2008,

and during this time (and subsequently) it dissolved a quantity of salts, largely from the overburden[2]. Little of the coal seam was exposed to the floodwaters, a fact that is important regarding the quality of the mine-affected water eventually discharged.

Ensham have monitored the quality of the pit water since the flooding occurred. Table 2 provides a summary of the changes in quality over the period 11 June to 11 September 2008 for Pit B and Pits C & D. Figure 4 provides a map of the Ensham mine site showing the location of the pits, discharge points and monitoring sites.

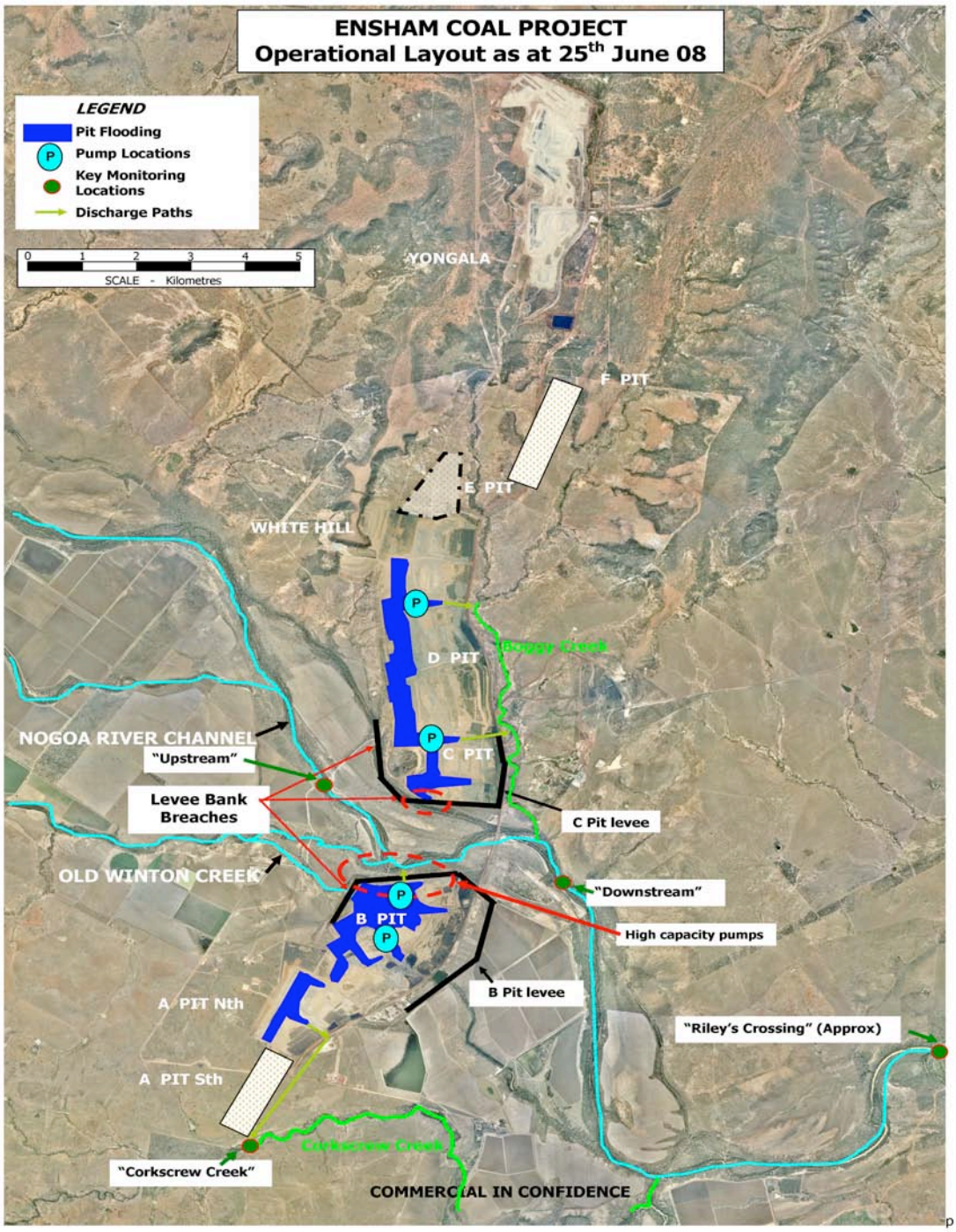

Figure 4: Map of the Ensham mine site showing the location of the pits, discharge points and monitoring sites

[2] The overburden consists mainly of sandstones and siltstones.

The composition of the dissolved salts is largely sodium chloride (ca. 60%), with smaller amounts of sodium, calcium and magnesium sulfates and bicarbonates, and low concentrations of heavy metals (Table 2). It is also important to note that the high pH (around 8), relatively low sulfate concentration and low heavy metal concentrations are evidence that acid mine drainage, often associated with coal and base metal mines, was not a major issue at Ensham.

A limited review[3] of the sampling, treatment and analysis of water samples for heavy metals was undertaken. This revealed a number of issues with the procedures used for filterable or dissolved heavy metals (e.g. samples not filtered and acidified in the field, but in the laboratory; filters were not acid washed; analytical result for ultrapure water and acid blanks not provided; calibration curves appear to be inappropriate for trace level analysis; quality assurance results not reported), so that all filterable metal concentrations must be treated as questionable.

The EPA adequately specified in the TEP(s) issued to Ensham that sampling, processing and analysis should follow procedures outlined in the Queensland EPA Water Quality Sampling and Monitoring Manual, and that the samples should be taken by an appropriately trained person. Equally, Ensham engaged consultants that had the required accreditation (e.g. NATA accredited laboratories) to do this work. However, despite all this it appears that some essential procedures were not followed.

It is recommended that EPA introduce a process where they undertake random audits of the laboratories being used by mining companies for their ability to adequately sample, process and analyse water quality samples for filterable (dissolved) heavy metals at trace concentrations.

The mine-affected pit water was discharged into the Nogoa River over a 7-month period, when the river flow was very low, and there was limited capacity for dilution to occur. Figure 5 is a graph of the flow in the Nogoa River over the period January 2008 to October 2008, measured at Riley's Crossing downstream of the mine. The discharge from Ensham is also shown (in red), and obviously makes up most of the river flow during the period April to early September 2008[4].

Table 1: Volumes of mine-affected water discharged from the Ensham mine

Location	Duration of discharge (2008)	Total volume discharged (GL)
Pit A	7 June – 9 September	8.7
Pit B	3 February – 2 September	58.1
Pits C & D	2 May – 9 September	71.4
Total	**3 February – 9 September**	**138.3**

[3] Through Ensham I asked a series of questions of the laboratory to ascertain the procedures used.

[4] The discrepancy between the volume pumped from the flooded mine and the actual flow probably represents extraction of water from the river by downstream farmers.

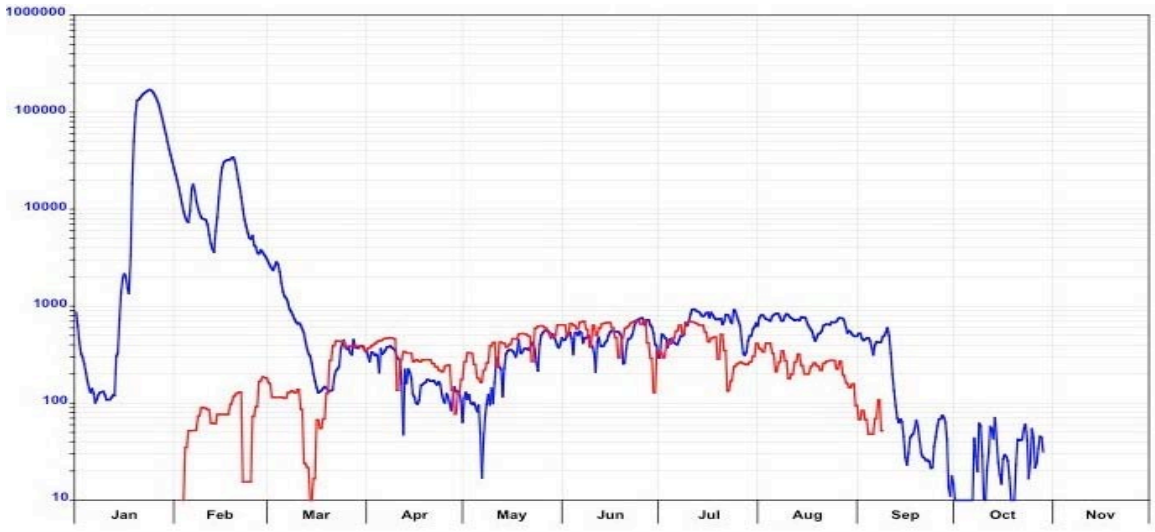

Figure 5: Flow (ML/day) in the Nogoa River over the period January 2008 to October 2008, with the discharge from Ensham also shown (in red)

Table 2: Quality of the Ensham pit water

Parameter	**Units**	**Pit B***				**Pit C&D****			
		11-Jun	8-Jul	10-Aug	11-Sep	11-Jun	8-Jul	10-Aug	11-Sep
Conductivity	uS/cm	2460	2780	3780	5320	1120	2020	5220	7660
pH		7.9	7.9	8	7.5	7.9	8.4	7.6	7.4
Turbidity	NTU	7	15	22	10	23	25	14	10
Na	mg/L	412	498	608	920	170	356	900	1390
Ca	mg/L	62	81	93	140	20	40	118	172
Mg	mg/L	62	70	88	138	17	42	126	192
Cl	mg/L	387	450	238	995	177	380	1180	1890
SO4	mg/L	409	464	315	820	90	197	579	886
HCO3	mg/L	309	182	198	567	146	232	490	604
Heavy metals*									
Aluminium	ug/L	120	280	50	80	450	180	30	90
Arsenic	ug/L	<1	1	1	3	5	5	3	4
Cadmium	ug/L	0.3	0.4	0.3	0.2	<0.1	0.5	0.4	0.4
Chromium	ug/L	<1	<1	<1	<1	1	<1	2	<1
Copper	ug/L	2	4	2	2	3	4	4	3
Lead	ug/L	<1	2	<1	1	<1	2	<1	2
Mercury	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Molybdenum	ug/L	10	10	10	9	15	18	19	15
Nickel	ug/L	3	5	4	6	2	2	5	7
Selenium	ug/L	<10	<10	<10	<10	<10	<10	<10	<10
Uranium	ug/L	4	5	6	6	2	4	9	8
Zinc	ug/L	<5	12	8	12	<5	15	12	13

* Pit B, Ramp 24; ** Pits C&D, Ramp 6, *** Total (unfiltered) heavy metal concentrations reported. The analytical methods used to obtain the filterable (dissolved) heavy metal concentrations are questionable (see text).

To ensure that water discharge approval specifications were met, Ensham purchased sufficient 'Seasonal Water Allocation' from water allocation holders, to dilute the floodwater discharged from the mine. The appropriate dilution of the floodwater discharge was then obtained by controlling the daily release rate of the 69.3 ML of purchased water, with the pumping rate of the mine floodwater discharge. This Fairbairn Dam water was released over the period 19 June to 8 September 2008. Twice daily sampling at the Ensham 'Upstream' and 'Downstream' monitoring points was used to provide control, monitoring and reporting of this process.

In terms of loads of salt added to the River system, I have estimated that the entire release from Ensham contributed around 100,000 tonne of salt to the system[5]. This compares with a load of around 184,000 tonne[6] transported in an average year by the Nogoa River and 850,000 tonne[7] transported by the Fitzroy system. Thus, the discharged load from the mine represented an additional 55% over that transported annually by the Nogoa River. However, this statistic under-represents the magnitude of the actual change in the Nogoa River during 2008, since the discharge occurred during the dry season when there was little natural flow (and hence little salt transport) in this river.

3.3 Quality of the river water

Table 3 provides a summary of the water quality in the Nogoa-Mackenzie-Fitzroy system over the period July to October 2008, as illustrated by the quality of water in Bedford and Tartrus Weirs. These data were supplied by Ensham.

As expected, the conductivity and major ions are all elevated, the turbidity is low (water clear) and the pH is elevated (possibly because of high algal productivity). The heavy metal concentrations are all very low and all (except aluminium) are below the ANZECC (2000) trigger levels for 95% ecosystem protection.

Monitoring of the conductivity (salinity) in the river system over the discharge period shows that the mine-affected water is moving very slowly through the system as a 'slug' of poor quality water of around 400 km in length. Figure 7 shows the progress of the mine-affected water through the Nogoa-Mackenzie-Fitzroy system between June and October 2008. The downstream extent of the slug is currently (end of October 2008) the Rockhampton Barrage.

It is significant that the volume of mine-affected water discharged from the Ensham mine (138 GL) is almost the same as the volume of water (117 GL) estimated to be present in the Nogoa-Mackenzie-Fitzroy system during the dry season (Data from DNRW Rockhampton)[8].

---

5 Assume average concentration 720 mg/L (1,200 uS/cm) and a volume of 138 GL.

6 Assume average concentration 180 mg/L (300 uS/cm) and an annual average volume of 1020 GL at Riley's Crossing.

7 Assume average concentration 180 mg/L (300 uS/cm) and an annual average volume of 4,700 GL at Riverslea.

8 Assumes all weirs and Barrage are at full supply level.

Table 3: Quality of the river water in Bedford and Tartrus Weirs

Parameter	Units	Bedford Weir*				Tartrus Weir**		ANZECC***
		7-Jul	9-Aug	11-Sep	1-Oct	11-Sep	1-Oct	
Conductivity	uS/cm	1250	980	1190	1060	1190	1060	20-250
pH		8.9	8.1	9.0	8.4	9.0	8.9	6.0-8.0
Turbidity	NTU	7.2	53	7.4	9.2	6.3	7.4	
Na	mg/L	236	150	197	165	196	164	
Ca	mg/L	29	27	34	32	32	28	
Mg	mg/L	24	21	29	25	27	23	
Cl	mg/L	208	181	203	196	200	185	
SO4	mg/L	152	106	142	119	141	117	
HCO3	mg/L	181	134	142	159	132	155	
Heavy metals*								
Aluminium	ug/L	100	1300	90	250	60	160	55
Arsenic	ug/L	2	<1	1	1	<1	1	24
Cadmium	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Chromium	ug/L	<1	1	<1	<1	<1	<1	1.0
Copper	ug/L	2	2	2	2	2	1	1.4
Lead	ug/L	<1	<1	<1	<1	<1	<1	3.4
Mercury	ug/L	<0.1	<0.1	1.1	<0.1	<0.1	<0.1	0.6
Molybdenum	ug/L	13	4	3	3	4	4	*****
Nickel	ug/L	1	3	2	2	1	1	11
Selenium	ug/L	<10	<10	<10	<10	<10	<10	11
Uranium	ug/L	2	2	1	1	1	1	*****
Zinc	ug/L	<5	<5	<5	<5	<5	<5	8.0

Site 500m upstream of wall, ** Site 100m upstream of wall, *** ANZECC Guidelines (2000) - thresholds for 95% protection level, **** Total (unfiltered) heavy metal concentrations reported. The analytical methods used to obtain the filterable (dissolved) heavy metal concentrations are questionable (see text), ***** no trigger value provided due to inadequate data available

3.4 Discharge licence (Transitional Environmental Program – TEP)

The EPA has issued five approvals to Ensham to permit the discharge of floodwater from the mine. These include:

- Emergency direction to discharge from mining pits B, C and D on ML7459 Ensham coal mine, 1 February 2009.
- Emergency direction to discharge from mining pits B, C and D on ML7459 Ensham coal mine, 15 February 2009.
- Draft Transitional Environmental Program for pit dewatering at ML7459, TEP Certificate of Approval number EMD 001-08, 6 March 2008[9].
- Transitional Environmental Program - Amended Certificate of Approval number EMD 001-08, 28 April 2008.

[9] This TEP was issued in response to a submission from Ensham (29 February 2008) for a TEP to permit dewatering of the flooded Ensham mine.

- Transitional Environmental Program - Amended Certificate of Approval number EMD 001-08, 2 June 2008.

The TEP Certificates of Approval were modified over time, presumably as a result of operational difficulties faced by Ensham in discharging such a large quantity of mine-affected water.

The Certificates of Approval specify (a) where the discharges can occur, (b) that the volumes released must not cause downstream flooding, (c) that physical damage to the rivers must be minimised, (d) the water quality monitoring (parameters, frequency, locations) that must be undertaken, and (e) the conditions under which the discharge must cease[10].

My assessment is that the EPA process for determining the Ensham TEP was less than adequate for the following reasons:

- There was no written assessment of the risks to the downstream water users, including aquatic ecosystems, town drinking water or industry, before the TEPs were issued[11].
- Inadequate account was taken of the impact of the mine-affected water upon any downstream values (apart from agriculture), despite the obvious fact that a very large volume of mine-affected water was to be discharged to the river system largely during the time (dry season) when there would be very low flows and limited dilution or flushing[12],
- The monitoring required of Ensham was inadequate.
  - Until the 2 June TEP monitoring was limited to surface water quality and only extended to a monitoring site in the Nogoa River just downstream of the mine lease boundary[13],
  - In the 2 June TEP, Ensham were also required to monitor surface water quality at Riley's Crossing on the Nogoa River[14],
  - I find it surprising that Ensham were not required to monitor conductivity continuously, particularly at the downstream sites[15],

---

[10] The latest TEP (2 June 2008) requires that discharge must cease if the rolling median value for the most recent five weeks (of weekly) water monitoring data at compliance points 2 (Nogoa River), 3 (Corkscrew Creek) and 4 (Riley's Crossing) exceed specified limits.

[11] Ensham did obtain advice in June 2008 on possible environmental impacts from the discharged flood water (4T Consultants, 2008), but it appears that this information was not provided to the EPA.

[12] The TEP issued on 6 March 2008 contained Condition 7 that aimed to limit heavy metal concentrations such that aquatic life was protected. However, this was removed in the TEP issued on 28 April 2008 and replaced with a Condition (7) that refers only to agricultural water quality. EPA provided me with an internal report (Review of Water Quality Guideline Values and Implications for Discharge Limits, by Glen Shultz, Ian Ramsay and Neil Tripodi, 8 May 2008) that they assert was used to inform the last of the TEPs issued to Ensham.

[13] EPA have informed me that this is normal EPA practice with discharges from mines. However, this was not a 'normal' situation.

[14] Since 10 September 2008, Ensham have voluntarily extended their monitoring program beyond Bedford Weir to include all downstream weirs to the Rockhampton Barrage. Ensham have also voluntarily conducted one set of sediment samples in each of the weirs from Bedford Weir to the Rockhampton Barrage.

[15] The Department of Natural Resources & Water now have continuous recording conductivity meters located at Theresa Creek (located at Gregory Highway, operating since 10 Feb 1994), Nogoa River (Duckponds, 2 April 1993), Mackenzie River (Riley's Crossing, 15 July to 9 October 2008), Isaac River (Yatton, 11 September 1995), Mackenzie River (Coolmaringa, 10 November 1999), Dawson

  - There was no requirement for the company (or the EPA) to undertake any biological monitoring despite the fact that the discharge was to occur during the dry season when dilution was minimal and the potential impact on the aquatic biota was high.

- The conditions under which the discharge was required to cease - if the rolling median value for the most recent five weeks (of weekly) water monitoring data exceeds specified limits - allows large fluctuations in the measured parameters to occur, and potentially short-term spikes in salinity and toxicant concentrations, which could be detrimental to the downstream aquatic biota. The large fluctuations that did occur in conductivity measured continuously at Riley's Crossing are shown in Figure 6. Use of a rolling median value for compliance, rather than an absolute value to relate to each sampling occasion, is sensible. The issue is the large time period for the median – a more sensible time period would have been a weekly.

Additionally, my assessment is that EPA did not adequately consult with key stakeholders in establishing the TEPs, or inform the community generally about what was happening and what the possible effects could be.

The issue with poor drinking water quality in Tieri and Blackwater was identified through the CHRC regular monitoring program; they appear not to have been informed that this could happen as a result of the mine-affected water discharge. Also I have not been supplied with any evidence of EPA discussions with stakeholders responsible for, or interested in, protecting the health of the aquatic biota in this system.

The lack of general information about what was happening and what the possible effects could be, that was available to the community lead to suspicion and distrust, and eventually to the development of a number of 'conspiracy' theories.

It is my belief that the EPA underestimated the scale of this emergency situation (discharge of a very large volume (138 GL) of mine-affected water over a period of 6-8 months to a river system that was largely not flowing), and as a result misjudged the community reaction to what was happening.

It is recommended that EPA undertake a review of the procedures used to develop TEPs and publish the results (a new set of guidelines) on the EPA web site. This review should consider the need for (a) criteria for prioritising the importance of the TEP, (b) undertaking a risk assessment to assist in developing the TEP, (c) a checklist that ensures that all beneficial uses of the receiving waterbody are explicitly considered, (d) a better process for identifying and including key stakeholders in the TEP process, (e) a process for informing the community of the situation associated with potentially controversial TEPs, and (f) better processes for ensuring the quality of the TEPs developed (e.g. documenting the reasons for various decisions or judgements).

River (Beckers, 14 July 1993), Fitzroy River (Eden Bann Weir, 30 November 1999).

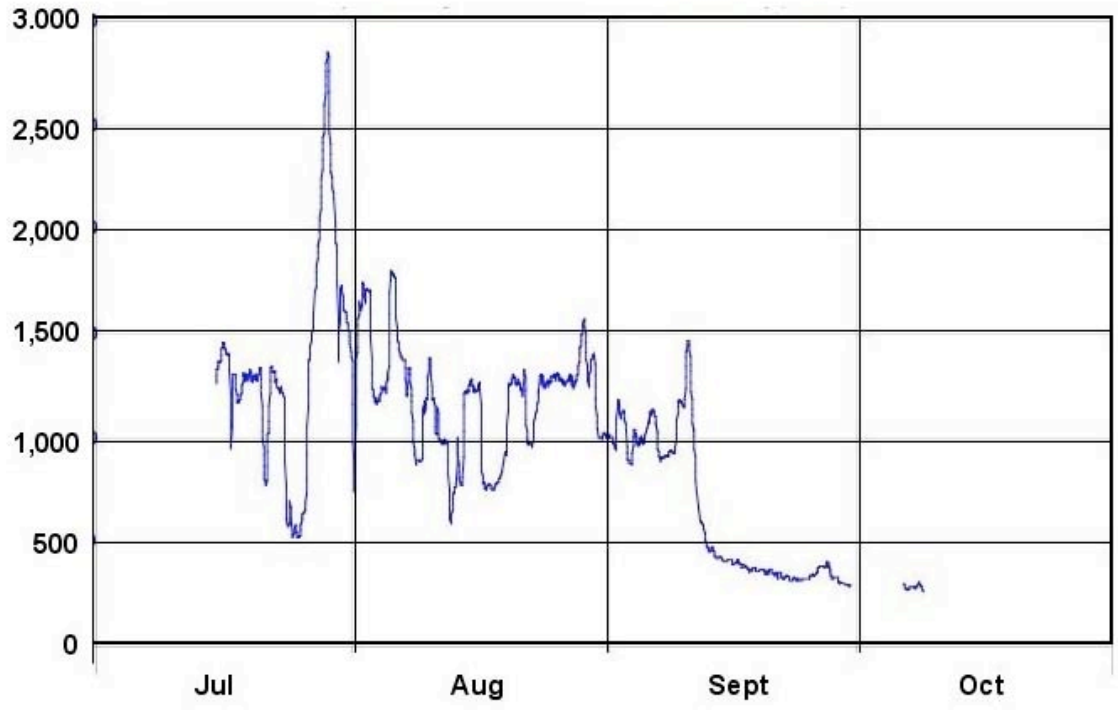

Figure 6: Continuous conductivity (uS/cm) measurement at Riley's Crossing between mid June 2008 and mid October 2008 (data provided by DNRW Rockhampton)

4. Assessment of current risks

This section contains my review of the risks to human health, aquatic ecology, agriculture and industry as a result of the mine-affected water in the Nogoa-Mackenzie-Fitzroy River system.

4.1 Human health

Blackwater, Bluff, Tieri, Middlemount and Dysart

Water is taken from weirs along the Nogoa-Mackenzie River to supply drinking water for a number of small towns. Blackwater, Bluff and Tieri obtain their water from Bedford Weir, while the towns of Middlemount and Dysart obtain their water from Bingegang Weir. The water is mostly treated (coagulation, filtration, chlorination) before use, but this treatment does not remove any dissolved material (such as sodium).

Residents of Blackwater and Tieri first expressed concern about the poor taste of the water. Subsequently, it was assessed that there could also be health problems for vulnerable members of the community due to elevated sodium levels.

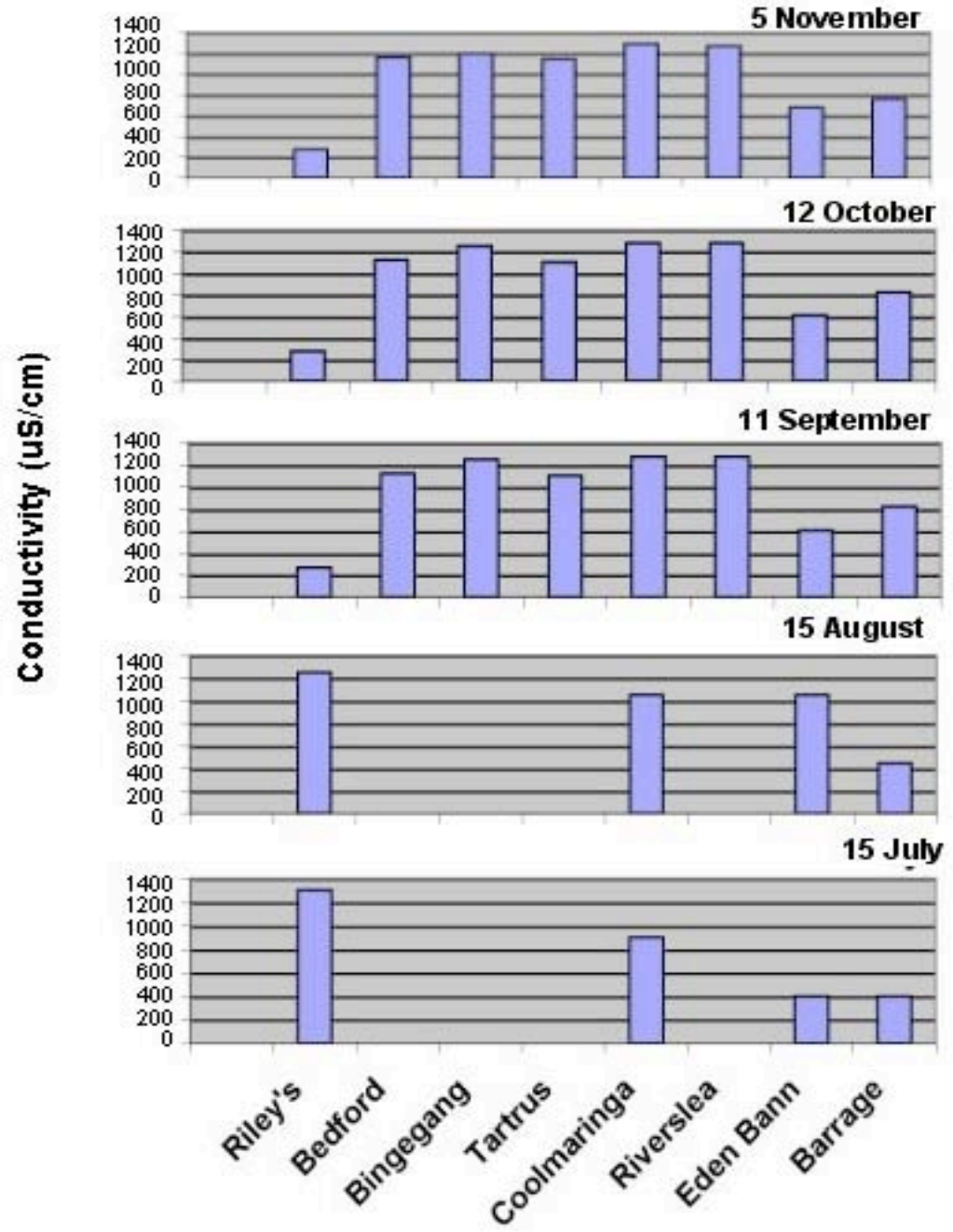

Figure 7: Plot of conductivity verses distance in the Nogoa-Mackenzie-Fitzroy river system over the period July to November 2008. The rise in conductivity at Eden Bann in August is the result of a high flow (41 GL) from the Isaac/Connors system between 20 July and 30 August 2008, that displaced mine-affected water from Tartrus Weir and water holes in the Mackenzie River and pushed this water through to Eden Bann and the Barrage.

On 26 August 2008, very soon after they were advised of the situation, Queensland Health (2008) issued a media-release advising residents of Blackwater, Bluff and Tieri that the mine-affected water had resulted in an increase in sodium concentrations to levels (around 200 mg/L). And that this could cause problems for a small number of susceptible people (e.g. those with high blood pressure, cardiovascular disease or chronic kidney failure). Further, Queensland Health sensibly recommended that these residents used bottled water until the situation had normalised.

The Australian Drinking Water Guidelines (ADWG, 2004, p442-443) recommend that based on taste considerations, sodium concentrations in drinking water should not exceed 180 mg/L. Further, while they do not propose any health-based guidelines, they do advise that *'people with severe hypertension or congestive heart failure may need to restrict their overall dietary intake of sodium further if the concentration of sodium in drinking water exceeds 20 mg/L'*.

Sodium levels in these drinking waters have exceeded the 180 mg/L level for a considerable period of time, possibly from as early as July 2008, although they appear to have dropped since the discharge ceased in early September 2008[16].

Additionally, some residents have complained to Central Highland Regional Council (CHRC) of problems with scaling on pots and hot water services (CHRC Submission, 30 October 2008).

In response to a question from me, namely have there been any reported health effects on residents of Blackwater, Bluff and Tieri exposed to drinking water with elevated sodium concentrations, Queensland Health (Paul Florien, submission 7 November 2008) provided the following response: *'Around this time (late August 2008), the Communicable Disease Control Section of the Central Queensland Population Health Unit was aware of outbreaks of viral gastroenteritis in several communities across Central and Central West Queensland, but not specifically Blackwater. Following the release of the advisories, CHRC experienced an increase in complaints, specifically alleging a link between the water and outbreaks of disease in the community. These claims were followed up then and over the following three weeks by the Public Health Physician in contact with Blackwater Hospital.*

There had indeed been an increase in presentations to hospital with vomiting and diarrhoea, with sudden onset and short duration of illness. Unfortunately, no pathological diagnosis was made, as no samples of vomitus or faeces were collected and submitted for laboratory analysis.

It is likely that viral gastroenteritis was responsible for the symptoms. It is highly likely that the decrease in palatability of the water aggravated symptoms and susceptibility to dehydration.'

Assessment

It does not appear that there have been any serious health problems in the townships of Blackwater, Bluff, Tieri, Middlemount and Dysart due to the elevated sodium levels in their drinking water supply. Sodium levels in Tieri's drinking water supply[17] were in excess of 180 mg/L between early June and late October 2008 (CHRC monitoring data). The small number of people concerned about the possible impact of elevated sodium levels on their blood pressure were advised to use alternative drinking water.

Queensland Health has advised that it is possible that the poor quality water did increase the effects of a viral gastroenteritis outbreak in the region in late August 2008.

Additionally, there is considerable evidence that the residents have been adversely affected by the poor taste of their drinking water supply. The conductivity (salinity) of drinking water supplied to the residents of Blackwater, Bluff, Tieri, Middlemount and

[16] Note that while Bedford Weir had received the mine-affected water by as early as March 2008, this water would not have been supplied to the residents of Tieri, Blackwater or Bluff until some 3-4 months later because there is considerable water storage capacity between the Weir and the treatment plants.

[17] And presumably also Blackwater, Bluff, Middlemount and Dysart.

Dysart was in excess of 1,000 uS/cm (600-700 mg/L) for around 6 months (June – November 2008).

Given the poor tasting water, it is reported that many residents resorted to bottled water for drinking. This has potentially cause hardship for particular sectors of these communities (e.g. lower socio-economic group, elderly) who may have been seriously disadvantaged in being able to access and pay for bottled water. The question of who should pay the increased cost is a relevant one.

Additional major concerns are that: (a) downstream drinking water supplies appear not to have been considered by the EPA in issuing the TEP, (b) neither the Central Highlands Regional Council, Queensland Health nor the residents were informed of the situation early enough[18], and (c) media reports indicate significant community concern about this issue, a lack of trust in Government to fix the issue, and resentment with Ensham.

Rockhampton

Drinking water for the Rockhampton community is taken from the Fitzroy Barrage and treated at the Glenmore Water Treatment Plant before distribution to approximately 66,000 residents. The treatment process involves coagulation, flocculation, sedimentation, filtration and disinfection; activated carbon treatment is sometimes used to remove tastes, odours and potential algal toxins.[19] These processes do not reduce conductivity and activated carbon does not remove a mineral taste.

It appears that the mine-affected water reached the Fitzroy Barrage in early September 2008, and during October essentially stabilised at a conductivity of around 825 uS/cm and sodium concentration around 120 mg/L (Figure 8).

Given the conductivity of the upstream water (around 1,200 uS/cm), it is inevitable that the conductivity (and sodium concentration) of water in the Barrage will increase during November 2008. However, just when the peak will occur and for how long it will last will depend upon when the wet season rains commence.

Rockhampton Regional Council issued media releases on 9 September and 14 October 2008, advising residents of the situation. Additionally, the Mayor and Councillors have also given a number of radio and television interviews.

Queensland Health (submission by Dr Paul Florian, 30 October 2008) have also expressed concern over the deteriorating quality of Rockhampton's water supply and its possible affects on the Rockhampton Hospital and its Dialysis Clinics and Home Dialysis Patients. Haemodialysis units require virtually pure water with very low ionic concentration. Complex water treatment systems are used to achieve this purity, and if the feed water quality changes significantly, there is a real probability that the product water will also change in quality.

Another area of concern is the Central Sterilising Supply Department at Rockhampton Base Hospital, where recently problems have been experienced with a residue forming on Operating Theatre equipment that has passed through the disinfection units. The residue is most likely calcium carbonate. If this persists, the hospital will need to invest in a small treatment plant.

---

[18] The Central Highland Regional Council only became aware of the poor quality water around 21 August 2008, through their routine monitoring of the Tieri water supply (CHRC Submission, 30 October 2008).

[19] See www.rockhamptonregion.qld.gov.au

Assessment

It seems unlikely that any serious health problems will arise as a result of the current (October 2008) increased conductivity and sodium concentrations in Rockhampton's drinking water supply.

These concentrations are likely to increase further during November (and even December if there is a lack of rain). But again, provided medical practitioners and the small number of vulnerable people are well informed, and there is access to bottle water, serious health problems are unlikely to occur.

It is quite possible however that Rockhampton Regional Council will experience a large increase in complaints about the poor taste of the drinking water.

If Rockhampton's water supply decreases further in quality, problems are also expected at the Rockhampton Hospital and its Dialysis Clinics and Home Dialysis service.

Given that water in the Fitzroy Barrage is considerably clearer than normal (due no doubt to coagulation of colloidal particles by the higher calcium and magnesium concentrations), there is a real possibility that algal blooms will occur in the Barrage. The Rockhampton Regional Council are aware of this possibility and have contingency measures in place to minimise the risks to human health from blue-green algal toxins in drinking water supplies.

Additional concerns are that: (a) downstream drinking water supplies for the major population centre of Rockhampton appear not to have been considered by the EPA in issuing the TEP, (b) neither the Rockhampton Regional Council, the Health Department nor the residents were informed of the situation early enough, and (c) media reports indicate significant community concern about this issue, a lack of trust in Government to fix the issue, and resentment with Ensham.

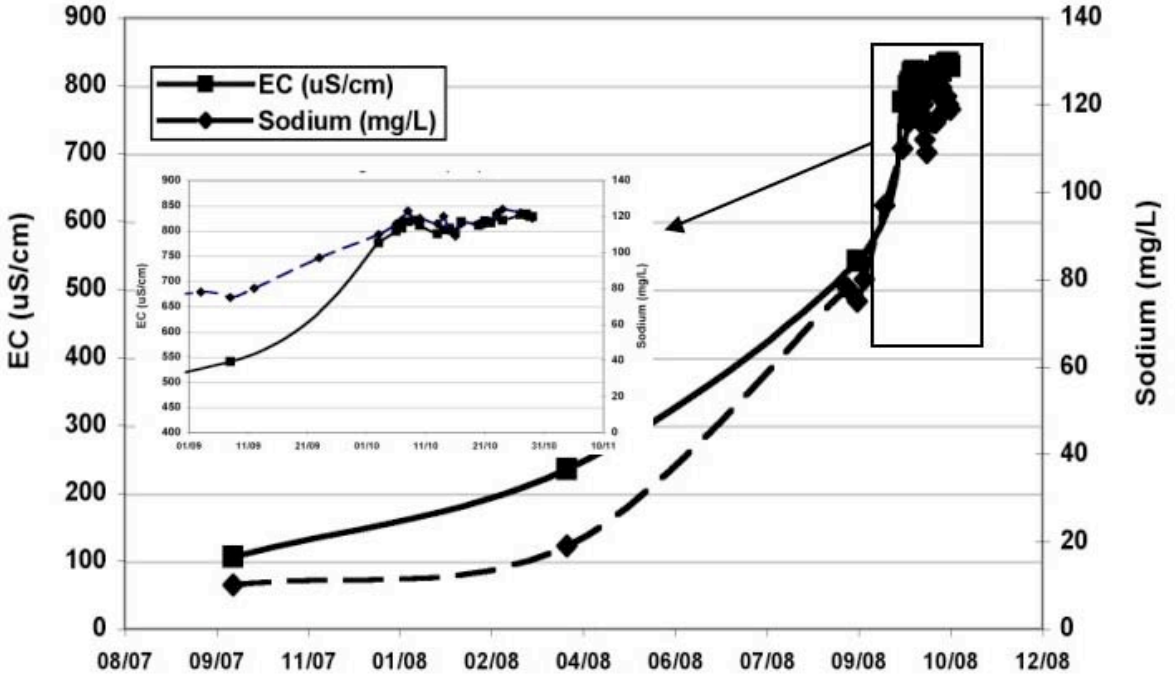

Figure 8: Conductivity and sodium concentration in the Rockhampton Barrage over the period September 2007 to October 2008. The insert shows the situation between September and late October 2008.

4.2 Aquatic ecosystems[20]

The ecological functioning in the Fitzroy Basin is primarily driven by flow, which is characterised by two main phases - wet season monsoon flood events between December and March, and low or no flow periods during the rest of the year. The wet season monsoon flows are the most dominant feature of the flow regime in the Fitzroy catchment. These flows are highly variable and unpredictable (amongst the highest variability of any rivers in the world) and as a consequence the biota has evolved a number of strategies to adapt to this environment.

The ***wet season flow events*** serve a number of ecological functions including:

- fish migration – flow events enable dispersal past minor barriers (e.g. shallow riffles) and into temporary marginal habitats within the high flow channel. Studies have shown a number of fish species, such as Hyrtls tandan (*Neosilurus hyrtlii*), respond to early wet season flow events for migration into suitable spawning grounds,
- fish spawning – the spawning of a number of fish species, such as the endemic Fitzroy golden perch (*Macquaria ambigua oriens*) and Leathery Grunter (*Scortum hillii*), are triggered by wet season flow events (spawning may occur over only 1-2 flow events) (Roberts et al., 2008),
- fisheries recruitment – the recruitment of a number of diadromous and marine fish species (e.g. Barramundi (*Lates calcarifer*) and Threadfin Salmon (*Polydactylus macrochir*)) and prawn (*Penaeus merguiensis*) populations has been demonstrated to be highly correlated with high flow events,
- reproduction of other aquatic organisms – major breeding events of many animals, such as waterbirds, are associated with extensive floodplain flows rather than elevated in-stream flows,
- primary and secondary production - temporary expansion of river into marginal habitats brings additional nutrients and organic material into the river system stimulating additional production. The wetting of marginal habitat also leads to germination of flood-dependant vegetation (e.g. Coolibah ((*Eucalyptus coolabah*) and paperbarks (Melaleuca spp.)),
- mixing of the water column and flushing and refreshing of waterholes – larger flow events flush out large waterholes common in the Fitzroy Basin. These flushes refresh waterhole water quality and reset many algal and zooplankton populations,
- temporal diversity in aquatic habitat – temporary expansion of river into marginal habitats provides a diversity of refugia habitats utilised by many animals, including fish larvae and zooplankton (e.g. Fabbro and Duivenvoorden 1996).

Low and no flow periods, which characterise the flow regime for much of the year, also influence a number of ecological functions including:

[20] The description of the ecological functioning of the Fitzroy River was supplied by Dr Bernie Cockcayne (DNRW) and Dr Leo Duivenvoorden (Central Queensland University)..

- fish spawning – stable low flow conditions provide ideal conditions for many fish species, particularly small bodied fish which attach eggs to structures, such as river bank edges, macrophytes and woody debris,
- reproduction of other aquatic organisms – many turtle species utilise sand banks exposed during low/no flow periods as egg laying sites,
- waterholes as refugia – almost all in-stream plants and animals rely on waterholes during some stage of their lifecycle. Waterholes provide a refuge against drought conditions, high water temperatures and predation from other animals, and are a dominant feature during the low - no flow period,
- riffles as habitat – riffles are generally the most productive of habitats and support a high diversity of plants and animals common in the Fitzroy River system (e.g. the 'bum breathing' Fitzroy River turtle (*Rheodytes leucops*),
- water quality decrease during low flow conditions can occur, particularly in the smaller streams of the catchment as pools start to dry up.

There are a number of ***man-made issues*** potentially threatening the aquatic ecology in the Fitzroy River system, including:

- changes to the flow regime – regulation of the Fitzroy River system has had a major effect on the magnitude, duration, timing and frequency of flows during the low flow period, and to the small to medium flow events during the wet season,
- barriers to fish migration –weirs and dams can interfere the migration of fish species, and have caused reduction (and possible extinction) of some fish species in certain regions of the river system (e.g. barramundi to many areas upstream of the Fitzroy Barrage and Golden Perch to many areas of the Nogoa-Mackenzie River system),
- changes to habitat – the water impoundments behind the dams and weirs built on the Nogoa-Mackenzie-Fitzroy River system have drastically reduced the habitat available for many native species, while at the same time providing ideal conditions for many exotic species (e.g. *Hymenachne amplexicaulis*),
- invasion of weeds – these have had a dramatic effect of riverine biodiversity (Houston and Duivenvoorden, 2003; Duivenvoorden et al., 2008),
- Water quality contamination - through both mining (e.g. acid mine drainage and agricultural activities (Dr Leo Duivenvoorden, Central Queensland University, Personal Communication, November 2008).

Thus, the mine-affected water discharged to the Nogoa-Mackenzie-Fitzroy River system, largely during the dry season of 2008, added an additional threat to the aquatic ecosystem, which has already been modified by the above pressures.

The 'health' of an aquatic ecosystem is generally assessed by undertaking a biological monitoring program, most often in Australia using macroinvertebrates as the biological indicators, and less commonly other biological indicators, such as algae, fish, platypus, turtles and bacteria.

In attempting to review the potential adverse effects of the mine-affected water on the aquatic biota in the Nogoa-Mackenzie-Fitzroy River system, I have been severely hampered by a serious lack of biological-ecological information. In particular, there is very limited baseline information on this river system, and there was no biological

monitoring undertaken during the period the Ensham mine-affected water was discharged[21].

Given the lack of biological monitoring data for this system, I have had to resort to other less satisfactory information sources to assess the current situation. A report by 4T Consultants (2008) (commissioned by Ensham) has been quite helpful.

Fish populations

No comprehensive surveys of the fish populations in the Fitzroy River system appear to have been undertaken. Biosecurity Queensland undertook a limited survey of the health of fish in Bedford and Tartrus Weirs in September 2008, the results of which are discussed below.

DNRW scientists have been studying the spawning requirements of the endemic flow-spawning fish species Fitzroy Golden Perch (*Macquaria ambigua oriens*) and Leathery Grunter *(Scortum hillii*) since 2003 as part of the Fitzroy environmental flows assessment program (EFAP) activities[22].

Monitoring has been undertaken during wet seasons in response to natural and artificial flood events, such as the first post winter flow event. Both regulated and unregulated sections of the river system are being studied. Important outcomes of this work are: (a) small flows at the beginning of the wet season are critical for spawning migration and potentially effect subsequent spawning success, (b) spawning occurs only in response to flow events when water temperatures are greater than 23.5°C, (c) spawning also only occurs during 1 or 2 events per year, (d) no spawning occurred in the regulated sections of the Nogoa-Comet-Mackenzie River system (possibly because there a very few adult fish in these sections).

Salinity effects

The available evidence (e.g. Hart et al., 1990, 1991) suggests that most Australian fish species are relatively tolerant of salinity increases, and certainly adult fish in the Nogoa-Mackenzie-Fitzroy system would be unlikely to be adversely affects by salinities up to around 1,500 µS/cm.

Unfortunately, the effects of higher salinity on spawning, survival of eggs and larvae, and migration cues of fish present in the Fitzroy River system are not known, However, it is expected that such effects would occur at lower salinity levels that effects on adult fish (ANZECC, 2000; Dr Ben Kefford, personal communications, November 2008). Tolerance studies on other fish species (trout cod, Murray cod) suggest that adverse effects are likely on early life stages (eggs, larvae) at salinities around 1,000-1,500 µS/cm (Dr Ben Kefford, Personal Communication, November 2008).

For Fitzroy Golden Perch, no work has been done on the salinity sensitivity of this fish species, or the effects of higher salinity on spawning, eggs and larvae and migration cues (Dr Bernie Cockayne, Personal Communication, November 2008). However, given that this species spawns in the very early part of the wet season, it seems quite possible that this coming wet season could result in serious adverse effects on Fitzroy Golden Perch spawning success because of the poor water (high salinity) that will be flushed out of the river.

Also of concern is the possible effect of the higher salinity water on other more

---

[21] A biological monitoring program, coordinated by the EPA, is now (November 2008) underway in the Nogoa-Mackenzie-Fitzroy system.

[22] Dr B. Cockayne, DNRW, Personal Communication, November 2008.

abundant fish species in the Fitzroy catchment, particularly the smaller bodied fish species. These species rely on both good water quality and stable low flow conditions for successful spawning.

Toxic effects

Resulting from a report of catfish in Tartrus Weir with redness of all fins, Biosecurity Queensland undertook a limited survey of Blue Catfish (*Arius graeffei*) from Bedford and Tartrus Weirs in September 2008 (Biosecurity Queensland, 2008).

The fish species were subject to pathological analysis and for exposure to heavy metals and pesticides.

The results indicated that the fish from these Weirs were in poor health. The gill pathology was consistent with poor water quality, possibly exposure to elevated heavy metal concentrations, and not to infectious bacterial or viral fish disease. The fish tissue was found to contain elevated levels of iron, aluminium and zinc. There was no evidence of exposure to a range of pesticides (organochlorines, pyrethroid, endosulphan).

It is not possible to relate the results of this study back to the mine-affected water because there is no information on: (a) water quality in the weirs at the time of sampling (e.g. was dissolved oxygen concentration low?), (b) the age of the fish, necessary to assess the potential bioaccumulation of heavy metals, (c) the health or heavy metal concentrations of the fish species before the min-affected water was added to the system.

Macroinvertebrate populations

Macroinvetebrate surveys are conducted annually by the Aquatic Ecosystems Unit of the Department of Natural Resources and Water (DNRW). The latest report of the situation in 2007 has not yet been publically released, but a draft was made available for this review (Steward, 2008).

During 2007, macroinvertebrates were sampled once in May-June at 25 sites (8 reference sites, 16 test sites, 1 long-term site) in the Fitzroy basin. These regional surveys are designed to provide an assessment of the biological condition of large bioregions, and not individual catchments or rivers. Hence, the use of this biological information for assessing the ecological condition of these rivers prior to the mine-affected water discharge is questionable.

Based on available information on the sensitivity of macroinvertebrates to increased salinity levels (Hart et al., 1990, 1991; Kefford et al., 2008; Dunlop & McGregor, 2007), it seems that adverse effects on macroinvertebrates are unlikely to occur at levels below around 1,000 µS/cm. However, this statement is based on data that mostly relate to short-term studies, and not to continual exposure over a 7-8 month period.

Advice from Dr Ben Kefford (RMIT University, Melbourne, November 2008) suggests that given the quite low salinity (200-300 µS/cm) normally in this system, a rise to levels of 1,000-1,500 µS/cm would adversely affect macroinvertebrate community structure, especially if examined at the species level. The taxa most affected would be EPT species, especially mayflies.

Other biota

No information was available to assess the possibility that other biota (e.g. frogs, platypus and turtles) have been adversely affects the mine-affected water.

Ecosystem changes

The clarity of the river water has increased since mine-affected water has been released to the Nogoa-Mackenzie-Fitzroy river system. This reduced turbidity (increased clarity) is the result of coagulation and settling of particulate matter responsible for the turbidity, due to the elevated concentrations of calcium and magnesium in the mine-affected water. Grace et al. (1997) found that calcium and magnesium concentrations in excess of around 30 mg/L clarified water in the Darling River.

The increased clarity of the water in the river system could potentially have resulted in major changes to the aquatic ecology, including increased algal production, increased predation and changes to important food webs (what eats what). Unfortunately, again there is no information on which to make an assessment of whether any such changes have occurred and if they did just how important they are.

Assessment

It is clear that there have not been any catastrophic effects (e.g. major fish kills) on the fish population in the Nogoa-Mackenzie-Fitzroy River system during the time the Ensham mine-affected discharge occurred. This is consistent with the available evidence suggesting that most Australian adult fish species are relatively tolerant of increased salinity, and unlikely to be adversely affects by salinities up to around 1,500 µS/cm.

However, this is not true for the effects of increased salinity on the early life stages of fish (e.g. survival of eggs and larvae), where the small amount of available evidence suggests that salinities of 1,000-1,500 µS/cm are likely to cause adverse effects.

It seems quite possible that this coming wet season could result in serious adverse effects on the spawning success of Fitzroy Golden Perch because of the poor water (high salinity) that will be flushed out of the river during the early part of the wet season, exactly the time when this species spawns.

It is recommended that the EFAP surveys to be undertaken by DNRW this coming wet season are expanded to ensure that the effects of the flushing of higher salinity water on fish (and particularly Fitzroy Golden Perch) spawning and recruitment are studied.

The available information on the sensitivity of macroinvertebrates to increased salinity levels suggests that adverse effects are unlikely to occur at levels below around 1,000 µS/cm. However, this level is based on data that mostly relate to short-term studies, and not to continual exposure over a 7-8 month period. Advice has been obtained suggesting that, given the quite low salinity (200-300 µS/cm) normally found in this system, a rise to levels of 1,000-1,500 µS/cm would adversely affect macroinvertebrate community structure, especially if examined at the species level. The taxa most affected would be EPT species, especially mayflies.

The results of a study by Biosecurity Queensland indicated that catfish sampled from Bedford and Tartru Weirs were in poor health. However, it was not possible to relate these back to the mine-affected water discharged to the river system.

It is recommended that the Biosecurity Queensland study of the 'health' of the fish in

weirs be repeated, with other fish species and other storages included, and the study design improved.

There is insufficient information available to make an assessment of potential adverse effect on other biota, such as frogs, platypus and turtles.

Again there is insufficient information available to assess whether the increased clarity of the water in the river system as a result of the mine-affected discharge, has resulted in major changes to the aquatic ecology, including increased algal production, increased predation and changes to important food webs (what eats what).

The response of relevant Government agencies to assessing the possible impacts of the mine-affected water on the riverine biota has been tardy to say the least. The EPA is currently (end October) gearing up to undertake a comprehensive study of the water quality, sediments and biota in the system (see Section 6 for discussion).

4.3 Agriculture

The mine-affected water is currently being used for two main agricultural activities – stock watering and irrigation.

Stock watering

It is highly unlikely that the salinity levels experienced in the Nogoa-Mackenzie-Fitzroy system over the past 8 months have caused any major problems for stock. However, the reports that stock has been reluctant to drink the mine-affected river water are probably well founded given the very low salinity the animals would have been used to.

Irrigation

It is unlikely that the salinity levels experienced in the Nogoa-Mackenzie-Fitzroy system over the past 8 months have caused any major problems for irrigated agricultural enterprises. This aspect is well discussed in the 4T Consultants (2008) report.

Assessment

My assessment is that it is unlikely that the Ensham mine-affected water has caused any major problems for agriculture. The salinity levels were not high enough to cause any long-term problems.

4.4 Industry

Two main industries are using the mine-affected water – the coal mines and the Stanwell Power Station.

Coal mines

Coal mines in the Bowen Basin use water for four main purposes: coal handling and preparation plants, dust suppression, in underground mining and in industrial areas. Recently, Moran et al. (2006) surveyed water and salt management in a number of coal mines in the northern Bowen Basin, and concluded that (a) there was no evident relationship between coal production and the use of fresh or re-cycled water, and (b) there was considerable potential for improved water management.

Some 8 of the 15 largest coal mines in the Bowen Basin obtain their water from the Nogoa-Mackenzie-Fitzroy river system (Table 4).

Assessment[23]

Coal processing

It seems there would be no significant constraints to this use at EC levels up to around 1,500 µS/cm. Most plant operators prefer to have a consistent water quality and are somewhat less concerned about the actually values. There is some evidence that the flotation process can be adversely impacted by increased concentrations of specific ions (e.g. magnesium) as opposed to the overall salinity. A salinity of around 1,300 µS/cm should not cause problems, provided it was not dominated by magnesium ions. Additionally, increased salinity of the raw water will increase maintenance costs. There is some evidence suggesting that the increase in maintenance cost is linear with increase in salinity (Moran et al., 2008).

Table 4: Coal mines sourcing raw water from the Nogoa-Mackenzie-Fitzroy river system

Mine	Company	Primary water source
Blackwater	BHP Billiton Mitsubishi Alliance	Bedford Weir
Curragh/Curragh North	Wesfarmers Curragh	Bedford Weir
Peak Downs	BHP Billiton Mitsubishi Alliance	Bingegang Weir
Ensham	Ensham Resources Ltd	Nogoa River below Fairbairn Dam
Oaky Creek, No 1 & North	Xstrata Coal Queensland	Bedford Weir
German Creek/Capcoal	Anglo Coal	Bingegang Weir
Norwich Park	BHP Billiton Mitsubishi Alliance	Bingegang Weir
Saraji	BHP Billiton Mitsubishi Alliance	Bingegang Weir

Source: Mining 2006 Update - Queensland Mining and Petroleum, November 2006.

Dust suppression

Many mine sites routinely use water with considerably higher salinity than that currently in the Nogoa-Mackenzie-Fitzroy system. Thus, it is not consider there would be any problems in using this currently higher salinity water for dust suppression.

Underground use

All underground coal mines in Australia use raw water (in some cases potable water) and not re-cycled water, for three reasons: (a) worker safety, (b) corrosion both inside and outside machines (most underground machinery is cooled with flow through water systems), and (c) hydraulic ram (roof support) performance.

It seems unlikely that use of raw water with salinity around 1,300 µS/cm for less than 12 months would cause major problems with underground mines. However, increased costs due to increased corrosion could be a problem.

[23] This assessment has been informed by the ACARP report prepared by Moran et al. (2008) and discussions with Colin Moffett (General Manager Technical, Ensham Resources).

Stanwell Power Station[24]

Stanwell Corporation relies on good quality water from the Fitzroy River Barrage for its evaporative cooling towers. The Corporation holds an annual allocation of 24 GL located in Eden Bann weir, with the water pumped to the Stanwell Power Station site from a pump station located on the Barrage at Laurelbank. Since the power station was constructed, annual usage has been typically in the range of 18 to 20 GL.

The mean conductivity (weekly records) of the raw Fitzroy River water delivered to the power station site was 213 µS/cm (maximum 406 µS/cm) over the period March 1993 to December 2007. These salinity levels have allowed the cooling systems to be operated with recycling levels of between seven and ten. This has allowed SPS to comply with the water discharge Development Approval (DA) limits for total dissolved salts of 1,450 mg/L and chloride concentration of 400 mg/L for the 'blowdown' or 'bleed' water released from the site. Typically, 1,500 to 2,500 ML of 'blowdown' water is released annually to Quarry Creek – equivalent to a daily release rate of between 4 and 7 ML/day. Water from Quarry Creek flows on to Neerkol Creek and typically disperses onto the flood plains around Gracemere.

An increase in the salinity of the input water supply results in fewer cycles of concentration being achievable in the cooling systems within the water quality constraints of the DA. Consequently, to achieve the same levels of electricity generation, larger volumes of blowdown are required along with an equivalent increase in the volumes of raw water sourced from the Fitzroy River.

When it was identified that higher salinity levels were likely to be seen in the raw water supplied to the power station, Stanwell Corporation sought a Transitionary Environmental Program from the EPA to allow higher salinity 'blowdown water to be discharge from their site.

Currently, Stanwell Power Station is operating within the limits of the TEP. The current levels of electricity generation, using raw water at the plant (November 2008) with a conductivity of 820 µS/cm, are producing daily cooling water blowdown volumes in the order of 30 ML – significantly above the original DA limit of 18 ML/day. A number of mechanical modifications have been made to the cooling system plant to allow these volumes to be handled. Since the raw water conductivity has not exceeded 1000 µS/cm, no changes have been made to the chemical characteristics of the cooling water blowdown.

To date, there has been no impact on electricity generation activities and, while it is unclear how high raw water salinity levels may rise, Stanwell Corporation do not expect any impact on electricity generation in the near future (Stanwell Corporation submission, 5 November 2008).

As part of the TEP, Stanwell is also undertaking extensive environmental monitoring of impacts of the changed blowdown arrangements within the Quarry, Neerkol and Scrubby Creek catchment. This includes independent monitoring of physical and chemical parameters in surface and ground waters in the catchment and at background locations. Detailed biological assessment is also being conducted including at a number of locations throughout the catchment. Hydrology, groundwater recharge and any associated impacts that may be associated with irrigation of various crops with this water is also being considered. This monitoring is being completed in consultation with the EPA and is intended to run until April 2009.

[24] This assessment has been informed by information provided by Steve Kerr (Principal Chemist, Stawell Power Station, 4 November 2008).

Stanwell is also communicating regularly with the broad community and with specific stakeholders who may be impacted as a result of higher discharge volumes.

Assessment

There has been no impact on electricity generation activities to date. Additionally, Stanwell Corporation expect to be able to handle likely salinity increases in their raw water over the next month or so, and do not expect any impact on electricity generation.

However, it is an unsatisfactory situation that Stanwell Power Station has had to apply for a TEP to accommodate the higher volumes and increased salinity in their 'blowdown' water discharge because of a situation that has arisen further upstream.

5. Assessment of possible management options

A number of options have been proposed to manage the current water quality problems in the Nogoa-Mackenzie-Fitzroy system[25]. These are presented in Appendix A, together with the advantages and disadvantages of each.

The most feasible options are discussed in this section.

5.1 Options to improve town water supplies for Blackwater, Bluff, Tieri, Middlemount and Dysart

Option A – Dilution of existing water in Bedford and Bingegang Weirs

This Option (Option 2a in Appendix A) would see the normal ROP normal ROP operating arrangements for Fairbairn Dam and downstream weirs applying, but with (a) additional management of released from Bedford and Bingegang weirs to improve water quality, and (b) small scale releases from Fairbairn Dam to dilute the water that is already present in the weirs.

The first part of this Option would see as much as possible of the lower quality water stored at depth in the weirs released through regulation of flow from the outlet works of weirs. This strategy would apply for releases associated with: (a) topping up downstream storages, and (b) natural inflows that trigger seasonal base flow environmental releases including overflows. Details of this Strategy are contained in the Interim Operational Strategy for the Nogoa Mackenzie Water Supply Scheme - 31 October 2008.

Added to this strategy would be the release of relatively small quantities of seasonally assigned water (water that is ordered but not used) from Fairbairn Dam to improve the quality of water in the weirs. These releases would not flush the weirs, but would certainly improve the quality.

Small natural inflows are also likely in the short term. Historically, by end of December there is about a 36% chance of 30,000 ML natural inflow to Bedford Weir and a 25% chance of 60,000 ML.

Assessment

This is a sensible and feasible Option, and should be implemented as soon as possible, given the time for water to get from Fairbairn Dam to dilute that in Bedford

[25] I am indebted to DNRW Rockhampton staff for producing many of these options and the list of advantages and disadvantages.

Weir (3 weeks). Implementation of this Option would have community support in that the Government would be seen to be doing something positive

If summer rains do not occur it will be necessary to invoke other Options (see Appendix A, Options 4 or perhaps even Option 3) to ensure the township water supplies do not deteriorate further.

Option B – Emergency options

Three options have been identified that could be implemented if the water quality in Bedford and Bingegang Weirs deteriorates further. These are:

- Pump poorer quality water from Bedford Weir and store in private farm dams for later use or release back when flows are higher (Appendix A - Option 4),
- Trucking 'drinking' water supply supplies (Appendix A - Option 5a),
- Mobile desalination plant (Appendix A - Option 5b).

These are fully discussed in Appendix A.

5.2 Options for the lower Fitzroy and the Fitzroy Barrage

Option C – Normal ROP operational arrangements, with additional release management of Eden Bann Weir (Appendix A – Option 6b)

This Option aims to achieve better water quality at the intake works for Rockhampton Regional Council and Stanwell Power Station than would be achieved if just the normal operational rules applied, and may result in operation outside the existing ROP rules.

The normal ROP operating arrangements for Eden Bann Weir and the Fitzroy Barrage would apply, except where it is otherwise determined that a release: (a) should be delayed because it was likely that it would worsen the quality of water at the Rockhampton Regional Council and Stanwell Power Station intakes, or (b) should occur because it was likely that the release would improve the quality of water at the Rockhampton City Council and Stanwell Power Station intakes. The strategy details are contained in the Interim Operational Strategy for the Lower Fitzroy and Fitzroy Barrage water supply schemes dated 28 October 2008.

The water quality in Eden Bann Weir and the Fitzroy Barrage, while elevated compared to normal water quality levels, has been and remains considerably better than the quality in the Mackenzie River Weirs. However, it appears that there has been no consideration of other possibilities that could result in more mine-affected water from upstream being flushed into Eden Bann Weir and the Fitzroy Barrage, for example a small flow event in the Isaac/Connors system could flush mine-affected water reportedly in that system (S. Christensen, Personal Communication, October 2008) into Tartrus Weir, and then flush this water plus the mine-affected water current in Tartrus Weir further downstream.

Based on historical data there is a quite reasonable probability that large natural flows will occur in this system. For example, by end of December there is about a 50% chance of in excess of 122 GL natural inflow to Eden Bann Weir[26], a 75% chance of 162 GL by end of January, and 75% chance of about 440 GL by end of February.

[26] Note – Eden Bann Weir retains a volume of 40 GL at full supply level.

Assessment

This is a sensible and feasible Option and should be be adopted now.

It is also recommended that a contingency plan be developed during November to handle the possibilities that: (a) additional mine-affected water will be flushed into this system from the Isaac/Connors system, and (b) that the expected normal wet season flows will not occur and the dilution and flushing of mine-affected water from Eden Bann Weir and the Fitzroy Barrage does not occur.

5.3 Options for reducing the risk to the aquatic biota

The Options discussed in the Sections above all focus on management actions to improve water quality in the various storages, mainly with the aim of improving drinking water quality.

As discussed in Section 4.2, the Nogoa-Mackenzie-Fitzroy River system currently has mine-affected water in over 400 km of its length from at least Bedford Weir to the Fitzroy Barrage. Unfortunately, the lack of data and information has made it difficult to properly assess the effects of this mine-affected water on the aquatic biota in the system. However, the small amount of evidence available suggests that there will have been adverse impacts of the macroinvertebrate communities and probably of some fish species. The increased clarity of the water currently in the river system will have resulted in changes to the aquatic ecology, but the implications of these changes can only be speculated at this stage.

Obviously, the management options being considered will result in some improvement in the quality of the water in the river system between the storages, although the actual level of improvement has not been quantified.

Assessment

It is both surprising and disappointing that no Options have been formulated that specifically target the improvement of water quality in the Nogoa-Mackenzie-Fitzroy River system, such that the risks to the aquatic biota are minimised.

It is recommended that options to improve water quality in the Nogoa-Mackenzie-Fitzroy River system, not just the storages, be developed with some urgency during November 2008.

5.4 Recommended management options

A number of sensible and feasible management options have been identified by the Technical Working Group (TWG) to address the current water quality problems in the Nogoa-Mackenzie-Fitzroy system. If implemented these management actions will have some positive effect on both drinking water quality and river health, and will show to the community that Government is serious about this issue and prepared to do something positive about it.

However, the ultimate flushing of the mine-affected water currently in the Fitzroy system will only occur with the large flows normally expected in the wet season (December-March).

It should be noted that all the management options currently being considered to alleviate the current water quality problems are restricted to a very large extent by the water use rules (ROP) for the Nogoa-Mackenzie River system, rules that appear to

be largely dictated by agricultural and industrial use of the water. *These rules may need to be modified in the future to consider other legitimate users of water, such as the environment and townships, and the possible need for a State-owned contingency licence to a certain proportion of the water in Fairbairn Dam.*

It is recommended that Option A be implemented as soon as possible, given the time for water to get from Fairbairn Dam to dilute that in Bedford Weir (3 weeks). Implementation of this Option would have community support in that the Government would be seen to be doing something positive.

It is recommended that the Central Highland Regional Council establish a Task Force to develop a contingency plan for addressing the drinking water quality issue for Blackwater, Bluff, Tieri, Middlemount and Dysart should the Bedford and Bengegang Weirs not be adequately flushed during this coming wet season. Such a contingency plan will involve more detailed examination of Option B above, and Options 4 or perhaps even Option 3 in Appendix A.

It is recommended that Option C be implemented as soon as possible.

Additionally, it is recommended that a contingency plan be developed by DNRW during November to handle the possibilities that: (a) additional mine-affected water will be flushed into this system from the Isaac/Connors system, and (b) that the expected normal wet season flows will not occur and the dilution and flushing of mine-affected water from Eden Bann Weir and the Fitzroy Barrage does not occur.

It is recommended that an emergency water management plan be developed with some urgency during November 2008 to improve water quality in the vast bulk of the Nogoa-Mackenzie-Fitzroy River system between the storages. This plan will need to be innovative and not constrained by the current restrictive ROP rules.

6. Assessment of the proposed EPA monitoring program

The response of relevant Government agencies to assessing the possible impacts of the mine-affected water on the riverine biota has been tardy, so much so that the Premier, in October 2008, directed the EPA to establish a whole-of-government monitoring program to assess the potential impacts of mine-affected floodwater discharged from the Ensham mine on the Nogoa-Mackenzie-Fitzroy River system.

A draft Project Plan (Fitzroy Basin Water Quality Monitoring: Assessing the impact of Ensham floodwater release, Version 1.0, 28 October 2008) has been prepared. The stated purpose of the monitoring program is *'to assess the potential impact(s) of mine water discharged from the Ensham Resources coal mine on waterways and related environmental values in the Fitzroy Basin; the environmental values of particular interest include: aquatic ecosystems, primary industries (irrigation and stock watering), and drinking water.*'

I have reviewed the draft and provided comments to the EPA (29 October 2008). aimed at strengthening the program. The most relevant comments were:

- The study design is a traditional one, and includes sampling of water quality, sediment and biological indicators at a number of control and impacted sites over time,
- The selection of water quality, sediment and biological (macro-invertebrates, fish) indicators is sensible, although the use of turtle indicators needs to be better justified,

- The suggested frequency of sampling (WQ - fortnightly; sediments – quarterly; biology – quarterly) is reasonable,
- The selected indicators and the frequency of sampling should be reviewed after the first full round of measurement of all indicators is completed,
- There is a need for a conceptual diagram indicating how the study will be able to assess any potential impacts from the mine (compared with effects due to other influences),
- The selection of the location of the control and test site needs further justification,
- The analysis of the collected data to show whether adverse effects have (or are) occurred is too vague. Additional information on the following is required:
  - *Surface water* - It is proposed to compare the surface water quality with ANZECC Guidelines for the Protection of Aquatic Life and with the Australian Drinking Water Guidelines for drinking water to decide if adverse effects have occurred. This should be sufficient provided that the uncertainty in the measured indicators is available – this will require that replicate water samples are collected and analysed.
  - *Sediments* - It is proposed to compare the sediment quality with the ANZECC guidelines. This should be sufficient to assess whether heavy metals levels in the sediments are such that they could cause toxic effects to the biota. Again, the comparison of measured data with the guidelines (thresholds) would be more robust if the uncertainty in the measured indicators is available.
  - *Biological indicators* – This is the area that still needs considerable work. Just how the data from the test sites will be assessed is still unclear. Comparison with control (reference) sites is commonly employed, however the draft has little detail on how this will be done and whether the data will be sufficient to be able to detect ecologically meaningful effect sizes. Power analysis was mentioned in the draft but no detail was provided.
- It is not clear in the draft who (agency) will be doing what work and what their credentials are.
- It would be useful to list who has been consulted in developing this program.
- It is not clear how this monitoring program with other monitoring that is also going on in the Fitzroy catchment (e.g. DNRW, FBA).
- The timescale of the study is unclear.
- As noted above, because there is little baseline information available, this study will be challenged in determining if any short-term biological impacts have occurred due to the mine-affected water. For this reason*, it is recommended that the study continues for at least 2 years (3 wet-dry cycles) so that any recovery in the condition of the biota can be measured.* The information on the system that will be collected during this time will also be vital in the development of a more comprehensive Fitzroy catchment-wide monitoring and assessment program.

A full assessment of the final monitoring and assessment program will be made in a separate report.

7. Conclusions

The conclusions of this review are summarised below under each of the Terms of Reference. Additionally, I have provided comments in Section 7.4 on the adequacy of Government actions in addressing this issue, and on what changes might be needed in those cases where Government response was less than adequate.

7.1 Risks to human health, aquatic ecology, agriculture and industries

Human health

Blackwater, Bluff, Tieri, Middlemount and Dysart

There is no evidence of any serious health problems in the above townships due to the elevated sodium levels in their drinking water supply. However, it is possible that the poor quality water did increase the effects of a viral gastroenteritis outbreak in the region in late August 2008.

There is considerable evidence that the residents have been adversely affected by the poor taste of their drinking water supply.

Additional major concerns are that: (a) downstream drinking water supplies appear not to have been considered by the EPA in issuing the TEP, (b) neither the Central Highlands Regional Council, Queensland Health nor the residents were informed of the impending problems early enough[27], and (c) media reports indicate significant community concern about this issue, a lack of trust in Government to fix the issue, and resentment with Ensham.

Rockhampton

It seems unlikely that any serious health problems will arise as a result of the current (October 2008) increased salinity and sodium concentrations in Rockhampton's drinking water supply. These concentrations are likely to increase further during November (and even December if there is a lack of rain), but provided medical practitioners and the small number of vulnerable people are well informed, and there is access to bottled water, serious health problems are unlikely to occur.

It is quite possible that Rockhampton Regional Council will experience a large increase in complaints about the poor taste of the drinking water, at least until the Fitzroy Barrage is fully flushed.

If Rockhampton's water supply decreases further in quality, problems are also expected at the Rockhampton Hospital and its Dialysis Clinics and Home Dialysis service.

There is a real possibility that blue-green algal blooms will occur in the Fitzroy Barrage in the next month of so, given that water in the Barrage is considerably clearer than normal. However, the Rockhampton Regional Council are aware of this possibility and have contingency measures in place to minimise any risks to human health from blue-green algal toxins in drinking water supplies.

Additional concerns are that: (a) downstream drinking water supplies for the major population centre of Rockhampton appear not to have been considered by the EPA in issuing the TEP, (b) neither the Rockhampton Regional Council, Queensland

[27] The Central Highland Regional Council only became aware of the poor quality water around 21 August 2008, through their routine monitoring of the Tieri water supply (CHRC Submission, 30 October 2008).

Health nor the residents were informed of the situation early enough, and (c) media reports indicate significant community concern about this issue, a lack of trust in Government to fix the issue, and resentment with Ensham.

Aquatic biota

Review of the possible effects on river health has been hampered by a dearth of relevant information.

It is clear that there have not been any catastrophic effects (e.g. major fish kills) on the fish population in the Nogoa-Mackenzie-Fitzroy River system during the time the Ensham mine-affected discharge occurred. This is consistent with the available evidence suggesting that most Australian adult fish species are relatively tolerant of increased salinity, and unlikely to be adversely affects by salinities up to around 1,500 µS/cm.

However, this is not true for the effects of increased salinity on the early life stages of fish (e.g. survival of eggs and larvae), where the small amount of available evidence suggests that salinities of 1,000-1,500 µS/cm are likely to cause adverse effects. *It seems quite possible that this coming wet season could result in serious adverse effects on the spawning success of Fitzroy Golden Perch because of the poor quality water (high salinity) that will be flushed out of the river during the early part of the wet season, exactly the time when this species spawns.*

The results of a study by Biosecurity Queensland indicated that catfish sampled from Bedford and Tartrus Weirs were in poor health. However, it was not possible to relate these back to the mine-affected water discharged to the river system. This study should be repeated with other fish species and other storages included and a better study design.

There is no evidence of adverse effects on the aquatic biota due to heavy metals in the mine-affected water.

The available information on the sensitivity of macroinvertebrates to increased salinity levels suggests that adverse effects are unlikely to occur at levels below around 1,000 µS/cm. However, this level is based on data that mostly relate to short-term studies, and not to continual exposure over a 7-8 month period. Advice has been obtained suggesting that a rapid rise in salinity to levels of 1,000-1,500 µS/cm would adversely affect macroinvertebrate communities (particularly mayflies), given the quite low salinity (200-300 µS/cm) they normally experience.

There is insufficient information available to make an assessment of potential adverse effect on other biota, such as frogs, platypus and turtles.

Again there is insufficient information available to assess whether the increased clarity of the water in the river system as a result of the mine-affected discharge, has resulted in major changes to the aquatic ecology, including increased algal production, increased predation and changes to important food webs (i.e. what eats what).

The response of relevant Government agencies to assessing the possible impacts of the mine-affected water on the riverine biota has been tardy to say the least. The EPA is currently (November 2008) coordinating a comprehensive monitoring and assessment program (water quality, sediments and biota) to determine if there have been adverse effects in the Fitzroy River system due to the mine-affected water.

Agriculture

It is unlikely that the Ensham mine-affected water has or will cause any major problems for agriculture.

Industry

Coal industry

The coal industry is the major industrial user of water in the Fitzroy catchment. Water is used for coal processing, dust suppression, in underground operations and in industrial areas. It is unlikely that water with conductivities to around 1,500 uS/cm would cause any major problems to the coal industry. However, there is evidence that an increase in raw water salinity can lead to increased maintenance costs.

Stanwell Power Station

The mine-affected water has had no impact on electricity generation activities to date. Additionally, Stanwell Power Station expects to be able to handle likely salinity increases in their raw water over the next month or so, and do not expect any impact on electricity generation.

7.2 Options available to manage these risks

A number of sensible and feasible management options have been identified by the Technical Working Group (TWG) to address the current water quality problems in the Nogoa-Mackenzie-Fitzroy system. If implemented these management actions will have some positive effect on both drinking water quality and river health, and will show to the community that Government is serious about this issue and prepared to do something positive about it.

However, the ultimate flushing of the mine-affected water currently in the Fitzroy system will only occur with the large flows normally expected in the wet season (December-March).

It should be noted that all the management options currently being considered to alleviate the current water quality problems are restricted to a very large extent by the water use rules (ROP) for the Nogoa-Mackenzie River system, rules that appear to be largely dictated by agricultural and industrial use of the water. These rules may need to be modified in the future to consider other legitimate users of water, such as the environment and townships, and the possible need for a State-owned contingency licence to a certain proportion of the water in Fairbairn Dam.

Option A (to address some of the issues in Bedford and Bingegang Weirs) should be implemented as soon as possible, given the time for water to get from Fairbairn Dam to dilute that in Bedford Weir (3 weeks). Implementation of this Option would have community support in that the Government would be seen to be doing something positive.

Further, it is recommended that the Central Highland Regional Council establish a Task Force to develop a contingency plan for addressing the drinking water quality issue for Blackwater, Bluff, Tieri, Middlemount and Dysart should the Bedford and Bingegang Weirs not be adequately flushed during this coming wet season.

Option C (to address water quality issues in Eden Bann Weir and the Fitzroy Barrage) should be implemented as soon as possible.

Additionally, a contingency plan should be developed by DNRW during November to handle the possibilities that: (a) additional mine-affected water will be flushed into this system from the Isaac/Connors system, and (b) that the expected normal wet season flows will not occur and the dilution and flushing of mine-affected water from Eden Bann Weir and the Fitzroy Barrage does not occur.

An emergency water management plan should be developed by DNRW during November 2008 to improve water quality in the Nogoa-Mackenzie-Fitzroy River system between the storages. This plan will need to be innovative and not constrained by the current restrictive ROP rules.

7.3 Review of the EPA-coordinated monitoring & assessment program

The response of relevant Government agencies to assessing the possible impacts of the mine-affected water on the riverine biota has been tardy, so much so that the Premier, in October 2008, directed the EPA to establish a whole-of-government monitoring program to assess the potential impacts of mine-affected floodwater discharged from the Ensham mine on the Nogoa-Mackenzie-Fitzroy River system.

A draft Project Plan (Fitzroy Basin Water Quality Monitoring: Assessing the impact of Ensham floodwater release, Version 1.0, 28 October 2008) to undertake a comprehensive study of the water quality, sediments and biota in the system has been developed.

This review provided comments to the EPA (29 October 2008) aimed at strengthening the program. A full assessment of the final monitoring and assessment program will be made in a separate report.

Because there is little baseline information available, this study will be challenged in determining if any short-term biological impacts have occurred due to the mine-affected water. For this reason, the study should continue for at least 2 years (3 wet-dry cycles) so that any recovery in the condition of the biota can be measured. The information on the system that will be collected during this time will also be vital in the development of a more comprehensive Fitzroy catchment-wide monitoring and assessment program.

It is recommended that the EPA include the review comments in revising the draft Project Plan (Fitzroy Basin Water Quality Monitoring: Assessing the impact of Ensham floodwater release), and include a longer timeline for the study (at least 2 years - 3 wet-dry cycles) so that any recovery in the condition of the biota can be measured.

7.4 Assessment of the Government actions to manage the Fitzroy water quality issue

This current water quality issue in the Nogoa-Mackenzie-Fitzroy River system arose as a result of an emergency situation caused by flooding of the Ensham coal mine in January 2008, the desire by Ensham and Government to get the mine back into productions as rapidly as possible, and the decision by the EPA to grant Ensham a Transitional Environmental Program (TEP) to discharge a very large volume (138 GL) of mine-affected water into the Nogoa River.

Given all the factors, the decision by the EPA to issue Ensham with a Transitional Environmental Program for the mine-affected water was justifiable.

However, my assessment is that the EPA process for determining the Ensham TEP was less than adequate (for the reasons outlined in Section 3.4), and that EPA did not adequately consulted with key stakeholders in establishing the TEP, or inform the community generally about what was happening and what the possible effects could be. The whole process lacked transparency.

My assessment is that the EPA underestimated the scale of this emergency situation (discharge of a very large volume (138 GL) of mine-affected water over a period of 6-8 months to a river system that was largely not flowing), and as a result misjudged the community reaction to what was happening.

Adequacy of the current Government actions

Government actions since late August have been mixed in their responsiveness and effect, and include the following:

- Both the CHRC and Queensland Health acted promptly and appropriately when the drinking water quality issue at Blackwater and Tieri became known in late August 2008, and have issued adequate warnings and advice to residents.
- Further, the Rockhampton Regional Council acted swiftly in hosting a multi-agency meeting on 12 September 2008, and in providing adequate warnings and advice to residents, when it became clear that further releases of water from Weirs upstream could compromise drinking water quality in the Rockhampton region.
- The multi-agency meeting, coupled with political representation to the Premier, resulted in the establishment of the Fitzroy River Water Quality Technical Working Group (TWG, 19 September 2008) and my appointment as independent reviewer (14 October 2008).
- The Fitzroy River Water Quality Technical Working Group is chaired by DNRW, with members from EPA, Primary Industries and Fisheries (DPI&F), Queensland Health, Central Highlands Regional Council, Isaac Regional Council, Rockhampton Regional Council, Ensham Resources, Stanwell Corporation, SunWater, Fitzroy Basin Association, Local conservation council and Central Queensland University. The TWG was established *to coordinate the evaluation of key water quality monitoring data within the Fitzroy River system and facilitate interagency communication, collaboration and advice on management strategies to return water quality to normal conditions with an initial focus on the region between Emerald and the Fitzroy Barrage*[28]. They have provided a very informative 'Weekly Update' bulletin since 20 October 2008.
- The EPA are currently (November 2008) coordinating a monitoring and assessment program aimed at assessing the potential impact(s) of mine-affected water discharged from the Ensham coal mine on environmental values (aquatic ecosystems, irrigation, stock watering and drinking water) in the Fitzroy Basin.

[28] The specific functions of the TWG are: (a) identify the water quality data that the members are collecting, (b) establish the data sets to focus on for alerting decision makers to water quality concerns, (c) collate data, (d) review/analyse the data, (e) make recommendations based on the review/analysis of the data, including management strategies and any additional monitoring required, (f) communicate data and any recommendations/outcomes within their relevant agencies, including any subsequent public advice, and (g) assist in ensuring a coordinated approach to communication to the community

The somewhat cynical community view of the current Government response to this issue is: (a) that the establishment of the TWG and my review are welcome initiatives but they will be too late to result in any management actions to solve the immediate problem, (b) that the Government is waiting for the wet season rains to 'solve' the problem, and (c) that nothing will be learned from this issue to change Government response processes

While it is true that flushing of the mine-affected water currently in the Fitzroy system will really only occur with the large flows normally expected in the wet season (December-March), the management actions recommended in Section 5 of this report will have some positive effect on both drinking water quality and river health. If initiated, these management actions will show to the community that Government is serious about this issue and prepared to do something positive about it.

The establishment of the TWG has been a very positive move. Tte TWG has significantly improved the level of knowledge and data sharing, and has provided a forum for sensible discussion about possible management actions.

The EPA-coordinated monitoring and assessment program is also a welcome initiative. However, as noted in the report this would not have been needed if adequate monitoring had been required as part of the Ensham TEP. Also, it is disappointing that it has taken until November for this to have been established when the issue was well appreciated as long ago as late August.

Change needed to manage the Fitzroy water quality situation going forward?

There appears to be little more the Government can do about this current water quality issue, assuming that decisions are made quickly to initiate the recommended management actions. However, this water quality issue has highlighted a number of broader issues that need to be addressed in the longer term.

<u>TEP process</u>

The most obvious is the deficiencies in the TEP process (lack of adequate consultations between the EPA and key stakeholders, lack of transparency in the process, poor communication with the key agencies and the community about the reality of the water quality issue, and what could be done about it). Largely because of the poor communications, but also because of the lack of credible monitoring information, a range of 'conspiracy' theories arose and escalated the issue.

A review of the EPA procedures for developing TEPs has been recommended, with the results (a new set of guidelines) to be published on the EPA web site.

<u>Monitoring and assessment</u>

There are a number of monitoring programs being undertaken in the Fitzroy Basin (TWG Document), but it is clear they are largely focused on the specific responsibilities of particular agencies, are not well coordinated, and are not comprehensive.

This review has identified an urgent need for the establishment of comprehensive and well coordinated long-term monitoring and assessment program to assess the ecological health of the Fitzroy River system[29].

[29] DNRW does survey the Fitzroy River system annually through the Statewide Ambient Biological Monitoring and Assessment Program. However, while useful this program based as it is on one biological component of the ecosystem (macroinvertebrates) is far from comprehensive.

Fitzroy Water Resources Plan

The available options to manage this water quality issue are all severely constrained by the current Fitzroy Water Resource Plan (and operational rules), which has virtually all the water in Fairbairn Dam allocated to consumptive uses, and no contingency allocation owned by the State.

It is recommended that DNRW consider a more equitable balancing of water between consumptive users and the environment, and the provision of State-owned contingency allocation, during the 10-yearly review of the Fitzroy Water Resource Plan that is currently underway and scheduled to be completed in late 2009.

Caretaker of river health

Another important issue that has been highlighted by the current water quality issue is there is no well-defined 'caretaker' of river health in the Fitzroy River catchment, with the legislative authority to adequately protect the aquatic environment. The EPA, DNRW and the Fitzroy Basin Association all appear to have some responsibilities in this regard.

It is recommended that Government consider the appointment of a 'lead agency' to be the responsible 'caretaker' of river health in the Fitzroy catchment, and for this agency to develop a 'catchment management plan', and a coordinated catchment-wide monitoring and assessment program.

Emergency response

It is clear that the Government processes for addressing the current Ensham emergency could be improved. Given the climate change predictions of greater variability in climate over the next 30-50 years, it is certain that similar emergency situations will occur sometime in the future.

Government should develop a set of Emergency Response Principles relevant to the mining industry to be applied in future situations, such as the current Ensham emergency. The Emergency Response Principles should include the need to: identify a lead agency, undertake a risk assessment, coordinate key agencies, develop an action plan, develop a community communications plan, and identify a key spokesperson.

8. Recommendations

Transitional Environment Program Process

Rec 1: that EPA undertake a review of the procedures used to develop TEPs and publish the results (a new set of guidelines) on the EPA web site. This review should consider the need for (a) criteria for prioritising the importance of the TEP, (b) undertaking a risk assessment to assist in developing the TEP, (c) a checklist that ensures that all beneficial uses of the receiving waterbody are explicitly considered, (d) a better process for identifying and including key stakeholders in the TEP process, (e) better processes for ensuring the quality of the TEPs developed (e.g. documenting the reasons for various decisions or judgements), and (f) a process for informing the community of the situation associated with potentially controversial TEPs.

Rec 2: that EPA introduce a process where they undertake random audits of the laboratories being used by mining companies for their ability to adequately sample, process and analyse water quality samples for heavy metals at trace concentrations.

Monitoring & assessment

Rec 3: that EPA include the review comments in revising the draft Project Plan (Fitzroy Basin Water Quality Monitoring: Assessing the impact of Ensham floodwater release), and include a longer timeline for the study (at least 2 years - 3 wet-dry cycles) so that any recovery in the condition of the biota can be measured.

Rec 4: that the EFAP surveys to be undertaken by DNRW this coming wet season are expanded to ensure that the effects of the flushing of higher salinity water on fish (and particularly Fitzroy Golden Perch) spawning and recruitment are measured and the implications for future years published.

Rec 5: that the Biosecurity Queensland study of the 'health' of the fish in weirs be repeated, with other fish species and other storages included, and the study design improved.

Management Actions

Rec 6: that Option A (to address some of the issues in Bedford and Bingegang Weirs) be implemented immediately, given the time for water to get from Fairbairn Dam to dilute that in Bedford Weir (3 weeks).

Rec 7: that the Central Highland Regional Council establish a Task Force to develop a contingency plan for addressing the drinking water quality issue for Blackwater, Bluff, Tieri, Middlemount and Dysart should the Bedford and Bengegang Weirs not be adequately flushed during this coming wet season.

Rec 8: that Option C (to address water quality issues in Eden Bann Weir and the Fitzroy Barrage) be implemented immediately.

Rec 9: that a contingency plan be developed by DNRW during November to handle the possibilities that: (a) additional mine-affected water will be flushed into this system from the Isaac/Connors system, and (b) that the expected normal wet season flows will not occur and the expected dilution and flushing of mine-affected water from Eden Bann Weir and the Fitzroy Barrage do not occur.

Rec 10: that an emergency water management plan be developed during November 2008 to improve water quality in the Nogoa-Mackenzie-Fitzroy River system between the storages. This plan will need to be innovative and not constrained by the current restrictive ROP rules.

Fitzroy Water Resource Plan

Rec 11: that DNRW consider a more equitable balancing of water between consumptive users and the environment, and the provision of State-owned contingency allocation, during the 10-yearly review of the Fitzroy Water Resource Plan that is currently underway and scheduled to be completed in late 2009.

Caretaker of river health

Rec 12: that Government consider the appointment of a 'lead agency' to be the responsible 'caretaker' of river health in the Fitzroy catchment, and for this agency to develop a 'catchment management plan', and a coordinated catchment-wide monitoring and assessment program.

Emergency response

Rec 13: that Government develop a set of Emergency Response Principles relevant to the mining industry to be applied in future situations, such as the current Ensham emergency.

9. References

ADWG (2004). Australian Drinking Water Guidelines, National Health & Medical Research Council, Canberra.

ANZECC/ARMCANZ (2000a) 'Australian and New Zealand Water Quality Guidelines.' (Australia and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand: Canberra)

Biosecurity Queensland (2008). Fitzroy catchment fish sampling and health assessment – Final report, Biosecurity Queensland, Department of Primary Industries and Fisheries, Brisbane, 12pp.

BoM, 2008. Central and Western Queensland Floods, January 2008, Bureau of Meteorology, Queensland, 85pp.

Duivenvoorden, L.J., Houston, W., Kinear, S., Black, R., Goedee, A., Stitz, L., Rosin, C., Black, L. and Lowry, R. (2008). Ecological considerations of spray control for hymenachne. In S. Kinnear, J. Rolfe and R. Miles (Eds.), Ecological, economic and social considerations of spray control for Hymenachne, Technical Report Land and Water Australia, Canberra.

Dunlop, J.E. and McGregor, G. (2007). Setting water quality guidelines for salinity and sediments in freshwater streams in Queensland, Natural Resource Sciences, Department of Natural Resources & Water, Brisbane (http://www.wqonline.info/products/infoanddata.html#TechnicalReports).

Christensen, S. and Rogers, C. (2006). Central Queensland Strategy for Sustainability – 2004 and beyond, Fitzroy Basin Association, Rockhampton, 238pp.

4T Consultants (2008). Blended water release program – Report on potential environmental impacts, Report by 4T Consultants Pty Ltd for Ensham Resources Pty Ltd, June 2008, 49pp.

Fabbro, L.D. and Duivenvoorden, L.J. (1996). Profile of a bloom of the cyanobacterium *Cylindrospermopsis raciborskii* (Woloszynska) Seenaya and Subba Raju in the Fitzroy River in tropical Central Queensland. *Marine Freshwater Research* 47, 685-94.

Grace, M.R., Hislop, T.M., Hart, B.T. and Beckett, R. (1997). Effect of saline groundwater on the aggregation and settling of suspended particles in a turbid Australian river, *Colloids & Surfaces* 120: 123-141.

Hart, B.T., Bailey, P., Edwards, R., James, K. Swadling, K., Meredith, C., McMahon, A. and Hortle, K. (1990). Effects of saline discharges on aquatic ecosystems, *Water Research* 24: 1103-1117.

Hart, B.T., Bailey, P., Edwards, R., James, K. Swadling, K., Meredith, C., McMahon, A. and Hortle, K. (1991). Biological effects of saline discharges to streams and wetlands: a review, *Hydrobiologia* 210: 105-144.

Houston, W. and Duivenvoorden, L.J. (2002). Replacement of littoral native vegetation with the ponded pasture grass *Hymenachne amplexicaulis*: effects on plant, macroinvertebrate and fish biodiversity of backwaters in the Fitzroy River, Central Queensland, Australia. *Marine Freshwater Research* 53, 1235-1244.

Kefford, B.J., Dunlop, J.E., Horrigan, N,. Zalizniak, L., Hassell, K.L., Prasad, R., Choy, S. and Nugegoda, D. (2006). Predicting salinity-induced loss of biodiversity, Project No. RMI 12, Final Report to Land and Water Australia. Canberra (http://www.wqonline.info/products/infoanddata.html#TechnicalReports).

Moran, C., Cote, C. and McIntosh, J. (2006). Northern Bowen Basin water and salt management practices – Volume 1 (Final Report), Australian Coal Association Research Program, Report C15001, pp133

(http://www.acarp.com.au/abstracts.aspx?repId=C15001)

Queensland Health (2008). Increased levels of sodium in Tieri, Blackwater and Bluff drinking water supply, Media Release, 26 August 2008.

Roberts, D.T., Duivenvoorden, L.J. and Stuart, I.G. (2008). Factors influencing recruitment patterns of Golden Perch (*Macquaria ambigua oriens*) within a hydrologically variable and regulated Australian tropical river system. Ecology of Freshwater Fish (in press).

Steward, A. (2008). Ambient Biological Monitoring and Assessment Program – 2007 Report, Aquatic Ecosystems Unit, Water Quality & Monitoring, Department of Natural Resources & Water, Brisbane, 96pp.

Appendix A: Advantages and disadvantages of the potential management options

A.1 Options for the Mackenzie River Weirs

Option 1: No intervention – Normal ROP Operational Arrangement

Under this option there would be no intervention, with weirs drawn down to nominal operating level and water supplied to the townships from the weirs with no further dilution. Releases from Fairbairn Dam will occur under normal operating rules to maintain weir levels at nominal operating level. In summary the Nogoa-Mackenzie Water Supply System would be operated in accordance with current arrangements in the Fitzroy ROP, no specific arrangements would be made to enable additional releases from Fairbairn Dam to create inflows to Bedford Weir, no specific arrangements would be made to enable additional releases from Mackenzie River weirs.

This option includes the previous implemented modifications to town water supply intake works to ensure that better quality water near the surface can be accessed.

Under normal operating arrangements, DNRW do not anticipated that releases from Fairbairn Dam will be required to top up Bedford Weir before the end of the wet season, even without any natural inflows.

Assessment

This is essentially a 'business as usual' option with the hope for a good wet season.

Option 2: Normal ROP Operational Arrangement (Option 1), except also apply additional release management arrangements for Bedford and Bingegang weirs to manage water quality (this is the Interim Operational Strategy dated 31 October 2008)

This Option would see the normal ROP operating arrangements for Fairbairn Dam and downstream Weirs applying, and as much of the lower quality water stored at depth in the Weirs as possible released through regulation of flow from the outlet works of Weir storages.

This release strategy applies for releases associated with: (a) topping up downstream storages, and (b) natural inflows that trigger seasonal base flow environmental releases including overflows. Details of this Strategy are contained in the Interim Operational Strategy for the Nogoa Mackenzie Water Supply Scheme - 31 October 2008.

This Option 2 seeks to achieve better water quality in the Weirs than achieved under Option 1, when the opportunity arises. Under low to medium flow conditions, it is anticipated that poorer quality water at depth in the weir storages will persist until there is a larger flushing flow event. Operationally, this Option would aim to (a) scour as much of the poorer quality water in the weirs as possible under normal operating arrangements and low to medium flow conditions, without worsening downstream quality, and (b) reduce the risk of water quality deterioration as the weirs draw down, prior to significant natural flushing flows.

DNRW do not anticipate that releases for topping up downstream storages will be required for several months, as the storages are currently full or near full. Releases associated with small natural inflows are the most likely in the short term. Historically,

by end of December there is about a 36% chance of 30,000 ML natural inflow to Bedford Weir and a 25% chance of 60,000 ML.

Assessment

This is a sensible and feasible Option. However, if summer rains do not occur it may be necessary to invoke other Options (e.g. Option 2a and Option 4) to ensure the township water supplies do not deteriorate further.

Option 2a: Same as Option 2, except also apply small scale release from Fairbairn Dam if water quality in weirs worsens to intolerable levels

This is an extension of Option 2, to provide for the possible situation that the water quality in the weirs worsens to 'intolerable' levels. In this case small releases would be made from Fairbairn Dam to improve the quality of water in the Weirs available to the townships. The releases are much smaller than the releases proposed for Option 3, and are not intended to flush the weirs.

The water available for release is seasonally assigned and is located between Fairbairn Dam wall and the upstream limit of Bedford Weir. Seasonally assigned water is water that is ordered but not used (i.e. is allowed to flow through the system).

Assessment

This is a sensible and feasible Option. It could be argued that the drinking water currently supplied to Blackwater, Bluff and Tieri is already 'intolerable', and given the 3-7 week time for water to get from Fairbairn Dam to dilute that in Bedford Weir, this should be being planned for now.

Option 3: Release of water from Fairbairn Dam to flush Mackenzie River weirs

This Option would see the release of 30,000 to 70,000 ML from Fairbairn Dam (volume required is dependant on the mixing dynamics in Weirs) at about 1,500 ML/day to flush Bedford and Bingegang Weirs. The water available for release is seasonally assigned and is located between Fairbairn Dam wall and the upstream limit of Bedford Weir. Seasonally assigned water is water that is ordered but not used (i.e. is allowed to flow through the system).

If this Option was adopted, the Weirs on the Mackenzie River should be operated in accordance with the arrangements in Option 2.

The Fairbairn Dam is capable of releasing up to 1,500 ML/day, although the flow reaching Bedford Weir will be dependent on upstream consumptive usage. Under the existing ROP rules, Fairbairn Dam only releases water to top up Bedford Weir if this Weir is at or below its nominal operating level. Currently, the level in Bedford Weir is well above this level.

A seasonal assignment arrangement similar to that adopted by Ensham for diluting its releases would be required to implement this Option. Assuming the market price for seasonal assignment water in this system is say $100 per ML, a volume of 30,000 ML would cost about $3 million, although the actual cost will depend on market forces, including the presence of willing sellers.

Assessment

At this stage it does not seem that Option is feasible. I understand that the maximum amount that could be seasonal assigned into the Bedford Weir pond within the current ROP rules is in the order of 3,450 ML. It would therefore require considerable expenditure to secure the 30,000-70,000 ML required.

However, this Option should remain as a contingency Option should the wet season rains be less than required, and be re-evaluate (against the trucking and desalination Options (5 and 6) if needed in March 2009

Option 4: Pump poorer quality water from Bedford Weir and store in private farm dams for later use or release back when flows are higher

This option involves pumping poorer quality water out of Bedford Weir into nearby farm dams. There is a 5,400 ML storage adjacent to Bedford Weir, which is currently empty. If Option 4 was implemented, this would need to be coupled with (a) Option 2 and wait for natural inflows, or (b) Option 3 with release of water from Fairbairn Dam to top up Mackenzie River Weirs and improve water quality.

Although pump and diversion works have been installed at Bedford Weir, only small pump capacity (45 ML/day) is understood to be currently operational. Other works capable of 450 ML/day are currently not operational.

Water pumped out of Bedford Weir would need to be seasonally assigned. Assuming the market price for seasonal assignment water in this system is say $100 per ML, 5,000 ML will cost about $0.5 million.

While the Fitzroy ROP provides for seasonal assignment into the Bedford Weir pond, as at 23 October 2008, the maximum amount that could be seasonal assigned into the Bedford Weir pond within the ROP rules is in the order of 3,450 ML.

Assessment

This is a sensible and feasible Option. It is also the preferred option of the Central Highland Regional Council, the authority responsible for providing safe and palatable drinking water to the communities of Blackwater, Bluff and Tieri.

The main objections to this Option appear to be the result of the rather restrictive water use rules for this Nogoa-Mackenzie River system, rules that appear to be largely dictated by agricultural and industrial use of the water. These rules may need to be modified in the future.

However, given the current situation of less than adequate drinking water for the three towns in question, it is recommended that this option be further developed during November 2008 and implemented as soon as possible. Implementation of this option would have community support in that the Government would be seen to be doing something positive

A.2 Options for town water supplies

Option 5a: Trucking 'drinking' water supply supplies

This option considers supplementing the supply to Middlemount, Dysart, Blackwater, Bluff and Tieri from Bedford and Bingegang Weirs with an additional 'drinking' water supply trucked from another nearby town's water supply

Dysart and Middlemount currently obtain their town water supplies from Bingegang Weir, while Blackwater, Bluff and Tieri obtain their water supplies from Bedford Weir. The Emerald Town Water Supply is not affected by the poorer quality water currently affecting Bedford Weir and Bingegang Weir.

The cost to truck water from Emerald at a rate of 10 litre/person/day to Dysart, Middlemount, Tieri and Blackwater (total population 11,700) has been estimated be around $100,000 per month. Some temporary storage infrastructure would also need to be installed to store the trucked water (not connected to town water supply network).

Assessment

This is a sensible and feasible Option that could be implemented rapidly if the water quality in the two Weirs deteriorates further. Obviously funding would have to be found to implement this Option. It is recommended that this option be part of a contingency plan should the water quality deteriorate further.

Option 5b: Mobile desalination plant

This Option would involve installation of a mobile desalination plant to supply either: (a) supplemented 'drinking' water only (would require residents to collect the water), or (b) desalinated town water through the existing town reticulation system.

Desalination plants to provide an output of about 100 kilolitre/day (or equivalent to about 9 litre/person/day for the total populations of Dysart, Middlemount, Tieri and Blackwater) are available and multiple units of this capacity can increase the capacity. The combined lease, operation and maintenance cost for such a plant would be about $20,000 per month. Company's that set up these plants can monitor the plants performance remotely and will provide technical backup advice if required.

For comparative purposes, a reverse osmosis desalination plant providing an output of about 1.5 ML/day (1,500 kilolitre /day or equivalent to 130 litre/person/day for the total populations of Dysart, Middlemount, Tieri and Blackwater) would cost about $100,000 per month ($66,000 per month leasing plus $30,000 per month operation and maintenance) plus the cost of brine disposal. Such plants are available commercially, generally in a transportable container and are used for mining and construction camps.

Assessment

This is a sensible and feasible Option. Obviously funding would have to be found to implement this Option. It is recommended that this option be part of a contingency plan should the water quality deteriorate further.

Option 5c: Other Town Water Supply Options

A number of pipeline options have been considered, including: (a) extension of Gregory Pipeline to Tieri, (b) extension of Burdekin to Moranbah Pipeline to Tieri, (c) extension of Pipeline from German Creek Mine to Tieri, and (d) reverse flow reticulation system to supply these towns from either the Eungella pipelines or the Burdekin/Moranbah pipeline.

Generally, these options involve the extension of existing pipelines, which involves major capital expenditure and a delay for procurement and construction. By their nature such works are permanent capital works.

The existing pipelines generally deliver untreated water, and to supply the townships with drinking water, the raw water could be delivered to the existing water treatment plants in each town, treated and reticulated through the town.

An alternative to supplying the whole town water supply from these pipelines, would be to supply a supplemented 'drinking' water supply only to the towns, requiring lower capacity pipelines which could be installed at a significantly lower cost. Such an arrangement might require a new low capacity treatment plant to be installed in each town. Alternatively, the raw water might be stored to allow the treatment plant to operate for periods at its minimum capacity. Storage of this treated water stored then allows residents to collect this drinking water from distribution points.

Complications arise from the need to treat this drinking water and keep it separate from the existing town water supply networks that continue to treat and supply the poorer quality water for purposes other than drinking.

Assessment

This is not a feasible Option at this stage. Preliminary cost estimates suggest that extensions of existing pipes, even for drinking water supply only, is cost prohibitive compared to other options as a solution to this temporary problem.

A.3 Options for the lower Fitzroy and the Fitzroy Barrage

Option 6a: No intervention – normal ROP operational arrangements

Under this Option, the Lower Fitzroy and Fitzroy Barrage water supply schemes would be operated in accordance with arrangements in the Fitzroy ROP. In summary, each storage supplies consumptive water from its pond, Eden Bann Weir would supply the reach upstream of the Fitzroy Barrage pond by releases, and when the Fitzroy Barrage falls to its nominal operating level (0.4 metres below full supply level), releases would be made from Eden Bann Weir to maintain the level in the Fitzroy Barrage at its nominal operating level.

The water quality in Eden Bann Weir and the Fitzroy Barrage, while elevated compared to normal water quality levels, has been and remains considerably better than the quality in the Mackenzie River Weirs.

Monitoring of water quality in Eden Bann Weir and Fitzroy Barrage has indicated that the water quality is highly variable throughout both storages.

Assessment

This is essentially a 'business as usual' option with the hope for a good wet season.

Option 6b: Same as Option 6a, except apply additional release management arrangements for Eden Bann Weir (the Interim Operational Strategy dated 31 October 2008)

This Option aims to achieve better water quality at the intake works for Rockhampton Regional Council and Stanwell Power Station than would be achieved under Option 1 if the opportunity arises. Implementation of this option may result in operation outside ROP rules

Under this Option, normal ROP operating arrangements for Eden Bann Weir and the Fitzroy Barrage would apply, except where it is otherwise determined that a release: (a) should be delayed because it was likely that it would worsen the quality of water

at the Rockhampton Regional Council and Stanwell Power Station intakes, or (b) should occur because it was likely that the release would improve the quality of water at the Rockhampton City Council and Stanwell Power Station intakes. The strategy details are contained in the Interim Operational Strategy for the Lower Fitzroy and Fitzroy Barrage water supply schemes dated 28 October 2008.

The water quality in Eden Bann Weir and the Fitzroy Barrage, while elevated compared to normal water quality levels, has been and remains considerably better than the quality in the Mackenzie River Weirs. However, it appears that there has been no consideration of other possibilities that could result in more mine-affected water from upstream being flushed into Eden Bann Weir and the Fitzroy Barrage, for example a small flow event in the Isaac/Connors system could flush mine-affected water reportedly in that system (S. Christensen, Personal Communication, October 2008) into Tartrus Weir, and then flush this water plus the mine-affected water current in Tartrus Weir further downstream.

Based on historical data there is a quite reasonable probability that large natural flows will occur in this system. For example, by end of December there is about a 50% chance of in excess of 122 GL natural inflow to Eden Bann Weir[30], a 75% chance of 162 GL by end of January, and 75% chance of about 440 GL by end of February.

Assessment

This is a sensible and feasible Option, and should be adopted. Additionally, I recommend that a contingency plan be developed during November to handle the possibilities that: (a) additional mine-affected water will be flushed into this system from the Isaac/Connors system, and (b) that the expected normal wet season flows will not occur and the dilution and flushing of mine-affected water from Eden Bann Weir and the Fitzroy Barrage does not occur.

Option 6c: Release of water from Fairbairn Dam to improve water quality in Eden BannWeir and Fitzroy Barrage

This Option would involve the release between 150 GL and 250 G of waterL from Fairbairn Dam (at about 1,500 ML/day) to flush mine-affected water from Eden Bann Weir and the Fitzroy Barrage. It should be noted that this water is seasonally assigned (i.e. ordered but not taken up by irrigators) and would be located between Fairbairn Dam wall and the upstream limit of Bedford Weir.

If this Option was adopted, Eden Bann Weir should also be operated in accordance with the arrangements in Option 6b above.

DNRW Rockhampton have assessed that this Option is unlikely to significantly improve the quality of water in Eden Bann Weir for the following reasons: (a) Fairbairn Dam is only capable of releasing a maximum of 1,500 ML/day, with the flow reaching Bedford Weir and downstream Weirs dependent upon upstream consumptive usage and the state of downstream storages and waterholes, (b) the volume required to flush Eden Bann Weir and the Fitzroy Barrage will be dependant on the mixing dynamics in these storages, but could be in excess of 200 GL[31], (c) the release of 100 GL at 1,500 ML/day will take more than 2 months (mid January),

[30] Note – Eden Bann Weir retains a volume of 40 GL at full supply level.

[31] The capacity of Bedford, Bingegang, Tartrus and Eden Bann weirs plus waterholes is estimated to be approximately 110 GL, and with the Fitzroy Barrage the total volume is in excess of 190 GL.

while the release of 200 GL will take more than 4 months (mid March), and (d) it is probable based on historical records that significant natural inflows would have occurred by the end of February.

A seasonal assignment arrangement similar to that adopted by Ensham for diluting its releases would be required. The cost of 200 GL of water has been estimated to be in excess of $20 million. Additionally, removal of 200 GL of water from Fairbairn Dam would mean significantly less water for farmers around Emerald with considerable socio-economic impacts on the Emerald and surrounding communities.

Assessment

This is not a feasible Option at this stage given: (a) the time for water to travel from Fairbairn dam to Eden Bann Weir and the Fitzroy Barrage, (b) the cost to purchase the water, and (c) the reasonable probability that the impending wet season flows will flush the system. However, this Option should remain as a contingency Option should the wet season rains be less than required to flush the storages, particularly given that if this occurs the large Rockhampton community will face the prospect of drinking water that is less than adequate.

Appendix A: Advantages and disadvantages of the potential management options*

Option	Identifier	10. Advantages	Disadvantages
1	No intervention – Normal Resource Operation Plan (ROP) arrangements	• In accordance with the ROP • No impact on water entitlement security • Low cost	• Requires a significant natural flow event for flush weirs and make a difference • If no natural inflows occur, the stored water quality will deteriorate as the better quality surface waters are drawn off for consumptive purposes and through evaporation • Water will not be released from Fairbairn Dam to top up Bedford Weir before end of wet season, even without any natural inflows
2	Option 1, with additional release management arrangements for Bedford and Bingegang Weirs to manage water quality (the Interim Operational Strategy 31 October 2008)	• In accordance with the ROP • No impact on water entitlement security • Low cost – only requires some additional operational and monitoring effort • Improved stored water quality for small to medium flow events in the short term • Limits downstream progression of poorer water quality	• Requires a significant natural flow event for flush weirs and make a difference • If no natural inflows occur, stored water quality will deteriorate as the better quality surface waters are drawn off for consumptive purposes and through evaporation
2a	Option 2, with small scale release from Fairbairn Dam if water quality in weirs worsens to intolerable levels	• If water quality worsens to 'intolerable' levels, will improve quality of water available to towns • Delays need to secure seasonal assignment water compared to option 3, therefore increased opportunity for natural flows to improve water quality • Small volume of seasonal assignment water may be easier to secure than larger volume for Option 3 • High cost if needed, but likely to be lower than cost for large flushing release under Option 3, because of delayed need for releases and therefore increased opportunity for natural	• Preparatory planning required to establish level at which water quality is 'intolerable' • Uncertainty over volume and rate of releases • Increasing public concern as water quality worsens to intolerable levels

		flows to flush without need for releases, and cost of seasonal assignment likely to be lower because of smaller volume sought	
3	Release of water from Fairbairn Dam to flush Mackenzie River weirs	• May make substantial improvement to water quality in Bedford and Bingegang Weirs within 3-7 weeks of commencement of releases (time depends on mixing dynamics) • Will improve quality of water at town water supply intakes	• Quantity of water required to be seasonally assigned is not certain because of the uncertainty re mixing dynamic. This uncertainty is lessened by the release of poorer quality water through the weir outlets as part of this option • Water released will not be available for productive use (e.g. irrigation etc) in Nogoa system – potential socio economic impacts on Emerald community • Poorer quality water currently in Bedford and Bingegang Weirs will be flushed downstream • Need for willing sellers in market already subject to previous seasonal assignment • High cost • Reasonable prospects of natural inflows to Bedford by January 2009, making release of water from Fairbairn Dam unnecessary • Probability of substantial inflows into Fairbairn to 'replace' the released water is much less than at locations further downstream.
4	Pump poorer quality water out of Bedford Weir and store water in private farm dams for use by owner(s) of these dams	• Will achieve more rapid water quality improvement in the weirs than natural inflows into a full storage or releasing to a full storage • The pumped water may be able to be productively used (from the farm dam) • Would removal of some of the poorer quality water from the Mackenzie River, reduce the extent of poorer quality water passing downstream	• Will require securing arrangements with owner of farm dam(s), and securing seasonal assigned water in market that has already experienced seasonal assignment of water • High cost • ROP may limit extent that this option may be implemented • Reasonable prospects of natural inflows to Bedford by January 2009 in which case pumping water out of the storage not needed
5a	Trucking 'drinking' water supply supplies	• Low cost Option (relative to other options) that	• Possible adverse public perception

		can be easily terminated when water supplies return to normal • Low capital cost – preliminary estimate of cost of storage facilities might be in range of $100,000 to $200,000 • If water quality deteriorates in any town and can't be used for drinking, supplies can be obtained quickly • Reduces urgency to address water quality in Bedford and Bingegang Weir	• Residents would need to collect water from distribution points in town rather than having water delivered to homes
5b	Mobile desalination plant	• Desalination plants can be leased until no longer required • Cost is comparable to cost of trucking water and lower than other options	▪ For drinking water not connected to town water supply network, likely that temporary storage infrastructure needed to store the desalinated water ▪ For drinking water, residents would need to collect water from distribution points in town rather than having water reticulated to homes. ▪ Requirements in relation to disposal of brine
5c	Other Town Water Supply Options	• Provides an alternative/additional supply if future water supply and water quality problems occur	• Very high cost of extending existing major pipelines • Uncertainty with availability of water allocations at critical periods • For low capacity drinking water supply pipelines, method of treating alternate raw water sources not clear • Potential to contaminate supplemented drinking water if use existing treatment works to treat both supplemented drinking water from alternate source and a larger volume of raw poorer quality water for purposes other than drinking
6a	No intervention – normal ROP operational arrangements	• In accordance with the Resource Operation Plan. • No impact on water entitlement security. • Low cost. • High probability of significant natural flow event by January	• Water quality continues to deteriorate, affecting town water supplies • A significant natural flow event required for significant flushing of Eden Bann Weir and Fitzroy Barrage. If no natural inflows occur, stored water quality will

			deteriorate through evaporation.
6b	Option 2, except apply additional release management arrangements for Eden Bann Weir (the Interim Operational Strategy 31 October 2008)	• No impact on water entitlement security. • Low cost – only requires some additional operational and monitoring effort. • Potential improved water quality at the Rockhampton Regional Council and Stanwell Power Station intakes if opportunity presents. • High probability of significant natural flow event by January.	• A significant natural flow event required for significant flushing of Eden Bann Weir and Fitzroy Barrage. If no natural inflows occur, stored water quality will deteriorate through evaporation.
6c	Release of water from Fairbairn Dam to improve water quality in Eden BannWeir and Fitzroy Barrage	▪ May improve quality of water in Eden Bann Weir and Fitzroy Barrage in 4 to 5 months if wet season essentially fails. BOM forecasting suggests failure of wet season unlikely at this time.	▪ The quantity of water required to be seasonally assigned is substantial and would be expected to have a significant impact on production in the Nogoa Mackenzie system -potential socio economic impacts on Emerald community ▪ Extremely unlikely required volume will be available for seasonal assignment ▪ Need for willing sellers, in market already subject to previous seasonal assignment ▪ Very high cost ▪ Good prospects of natural inflows to Eden Bann Weir by January 2009, and release of water from Fairbairn Dam not needed/not beneficial ▪ Probability of necessary substantial inflows into Fairbairn to “replace” released water much less than at locations further downstream. ▪ Poorer quality water stored in Bedford and Bingegang weirs passes downstream - may be an initial worsening of water quality before any improvements

* This information was provided by DNRW Rockhampton.