THE IMPORTANCE OF WATER IN THE GLADSTONE INDUSTRIAL AREA

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Submitted to Water in Mining Conference

November 14-16, 2006

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ABSTRACT

The Gladstone region, as one of the most industrially intense regions in Australia, uses significant quantities of fresh water. Awoonga Dam, situated on the Boyne River, is the only major source of water in the region. The current typical annual usage is 53 GL (Porteous 2006) and approximately 80% of the water is used by heavy industry (Gladstone Area Water Board 2004). Until relatively recently, there has been ready and easy access to raw water for industrial use. The recent drought, which resulted in severe water restrictions in 2002 and 2003, emphasised the importance of water for a dominant industrial region like Gladstone. Although now in the process of changing, the typical contractual arrangements in the past have provided little financial incentive for efficient water use.

From research undertaken on potential water re-use opportunities, several key questions have emerged related to water management in an industrial region such as Gladstone. This paper highlights these key questions, presents findings from recent regional strategies and assesses the potential for water re-use. Even though there is no clear-cut financial incentive for re-using water, there could be stronger regional and risk mitigation drivers for doing so. Initiatives to incorporate adaptive capacity through collaborative industrial synergies would allow for robustness and resilience in water security, leading to long-term sustainable water management across the Gladstone region.

Key words:

Regional synergies, water efficiency, adaptive capacity, Gladstone.

Acknowledgements:

The research reported here is supported by the Centre for Sustainable Resource Processing (www.csrp.com.au), which has been established under the Australian Commonwealth Co-operative Research Centres Program.

INTRODUCTION

Situated on the Central Queensland coast, the Gladstone region is one of the major industrial hubs of Australia. The region generates about 27% of Queensland's and 8% of Australia's total volume of exports, which is valued at over $A5 billion annually (GEIDB 2006). All of the fresh water for the region is supplied by Awoonga Dam on the Boyne River and approximately 80% of the water is used for heavy industrial purposes (Gladstone Area Water Board 2004). In 2004 annual water usage was 44 GL (Gladstone Area Water Board 2005) whilst more recently reports indicate annual water usage is 53 GL (Porteous 2006). Until relatively recently, there has been ready and easy access to raw water for industrial use. This has been a critical feature of the development of this region, as a secure source of water is essential for maintaining plant production and attracting new industries to the region. The recent drought which resulted in severe water restrictions in 2002 and 2003 emphasised the importance of water for a dominant industrial region like Gladstone. Also until recently, the typical contractual arrangements between the water authority and the industrial operations were on a 'take-or-pay' basis. Contracts of this nature require the purchaser to pay for a minimum amount, even if the purchaser uses less than this, thus guaranteeing revenue for the water authority independent of water usage. Given the significant infrastructure costs for dam construction or dam raisings, including a 'take-or-pay' clause in long-term contracts allows for secure repayments. Provided a ready water supply is available, such arrangements present little financial incentive for efficient water use.

The concentration of large industries in close geographic proximity provides an ideal setting for developing regional resource synergies where by-products (materials, water, energy) from one industry are re-used by one or more industries in the region. Employing this practice results in improved utilisation of by-products, which would otherwise be discharged to landfill, atmosphere, or marine environments, and displacement, and therefore reduction, in the use of virgin feed materials (Corder et al. 2006). The Gladstone region has a number of successfully operating regional synergies. Such an example is the re-use of the Calliope River sewage treatment plant effluent at the Queensland Alumina Limited refinery. There is, however, the expectation that more synergy opportunities are available which would lead to substantial sustainability benefits. Recognising the importance that regional synergies can make towards sustainable minerals processing, the Centre for Sustainable Resource

Processing (CSRP) has been funding a project that aims to provide practical support for the identification and evaluation of future synergies in the Gladstone region. This project is one of a program of three regional synergies projects being funded by the CSRP. One of these projects has very similar objectives to the Gladstone project except its region of focus is the Kwinana Industrial Area in Western Australia whilst the other is aimed at developing an engineering and technology platform for the identification, evaluation and implementation of synergy projects. In all these projects, water re-use or recycling is a key element and each project is investigating, within its own context, the opportunities for reducing raw water consumption through water re-use initiatives. A paper reporting on enhancing water efficiency in the Kwinana Industrial Area, conducted as part of the CSRP Kwinana regional synergies project, is presented elsewhere in these proceedings (van Beers, Bossilkov, & van Berkel 2006)

During the course of the Gladstone regional synergies project, opportunities for water re-use initiatives have been analysed and evaluated. In undertaking this research, several key questions have emerged related to water management in an industrial region such as Gladstone. The aim of this paper is to highlight these key questions, present findings from recent regional strategies and assesses the potential opportunities for water risk management in the region. The potential for water re-use schemes is analysed within the context of resilience of water security, which is considered a key ingredient in sustainable regional water management.

GLADSTONE REGION

Overview

Gladstone is situated on the central Queensland coast approximately 540 kilometres north of Brisbane. The region has a population of about 50 000 which extends from Tannum Sands in the south to Yarwun in the north. Major industrial operations have been part of the Gladstone region since Queensland Alumina Limited commenced operation in 1967. In 1993, a 21 000 hectare industrial land bank, known as the Gladstone State Development Area, was established to secure a large area of suitable land for major industrial development over a 30-50 year timeframe (GEIDB 2006). Ready access to a deep-water port as well as world-class road and rail transport infrastructure make Gladstone an attractive location for heavy industry.

Today there are several major industries operating in the region and they form an association called the Gladstone Area Industry Network (GAIN). GAIN comprises:

- Queensland Alumina Limited (the world largest alumina refinery at 3.9 Mt/yr)
- NRG - Gladstone Power Station (the largest coal–fired power station in Queensland at 1680 MW)
- Cement Australia (largest cement kiln in Australia (1.6Mt/yr) and a newly refurbished quick lime kiln (300 kt/yr))
- Boyne Smelters Limited (largest aluminium smelter in Australia (540 kt/yr))
- Orica Chemicals (produces ammonium nitrate (soon to be 600 kt/yr), sodium cyanide (60 kt/yr) and chlorine)
- Comalco Alumina Refinery (capacity of 1.4 Mt/yr)
- Central Queensland Port Authority (largest multi-cargo port in Queensland)
- Gladstone Area Water Board (operator of the Awoonga Dam)
- Queensland Energy Resources Limited (Stuart Oil Shale Project)
- Transpacific industries (waste management)

The locations of these industries are shown in Figure 1.

Figure 1

Water usage

In the Gladstone region, water use is predominantly for industrial purposes. This is illustrated in Table 1 where water used for cooling towers, process purposes and ash and red mud disposal amount to just under 80% of water use from Awoonga Dam. The domestic use is small, less than 16% (as it is grouped with light industry use). More recent figures indicated that industry uses about 83% (Porteous 2006). Interestingly, over half the water used across the entire region is in evaporative cooling towers (54%) whilst water used for process purposes (13%) is less than a quarter of that used in cooling towers. The large loss of water through evaporative cooling towers has lead to investigations into seawater and air cooling systems. There is also a significant loss of water to the environment (6%). A significant contribution to this amount was due to seepage and evaporative losses from the flow of water in an open creek from Awoonga Dam to the Callide Power Station. The recent construction of a pipeline will eliminate the natural water losses which previously occurred in the open delivery of water to the power station (Anon 2005).

Table 1

Based on the information in Table 1, plus the water data supplied by the major industries in the CSRP Gladstone regional synergies project (Corder 2005), the yield from Awoonga Dam for 2004, an indicative break-down of water use amongst the major industries and local councils was estimated. These results are presented in Figure 2. As these data were collated from a range of sources, the figures represent an indicative distribution of water across the Gladstone region and do not represent the results from a detailed regional water balance.

Figure 2

Gladstone regional synergies project

As mentioned in the Introduction, the CSRP is carrying out a project to provide practical support for identifying and evaluating by-product and utility synergies in the Gladstone region. This project forms part of an overall program of research that also includes a similar project in Kwinana in Western Australia and a research project that aims at developing an engineering and technology platform for the identification, evaluation and implementation of synergy projects. The Sustainable Minerals Institute at The University of Queensland is managing the Gladstone project while the Centre of Excellence in Cleaner Production at Curtin University of Technology is managing the Kwinana project. The engineering and technology platform project is a collaborative research effort involving both the Sustainable Minerals Institute and the Centre of Excellence in Cleaner Production. Further details on these projects are presented in Corder (2005), van Beers, Bossilkov, & van Berkel (2005) and van Berkel, Bossilkov, & Harris (2006).

The Gladstone regional synergies project commenced in early 2004. During the project's first year, material flow data were collected from the GAIN sites, interviews were conducted with site personnel and independent research was undertaken to identify a list of synergy opportunities. These were categorised in short-term (could be relatively easily implemented) and long-term opportunities (need more research but ultimately could have large benefits). Of the short-term opportunities, the initiatives for water re-use were considered to satisfy good sustainable development objectives but did not have a compelling financial benefit. Summaries of these initiatives are presented later in this paper. These synergies show that it is possible to make moderate savings in fresh water in the Gladstone region through the implementation of water re-use schemes.

IMPACTS OF RECENT DROUGHT

Gladstone experienced its worst recorded drought between 1996 and 2002 (Gladstone Area Water Board 2004). In 2002, water restrictions were imposed for the first time and, in response to these restrictions, industry introduced water efficiency measures. Examples of the water efficiencies measures introduced at Queensland Alumina Limited (QAL) were described in a paper by Stegink et al. (2003). That paper presented several measures that QAL employed to reduce water consumption on the introduction of 10% and 25% water restrictions, including the effluent re-use scheme. In this industrial synergy, a pipeline was build so that secondary treated effluent from the Calliope River sewage treatment plant could be re-used as a substitute wash water at QAL. QAL continues to receive approximately 2 500 ML/year from the sewage treatment plant (Porteous 2006). Other operations in the region implemented on-site water efficiency measures to reduce water use. The new Comalco Alumina Refinery, which was under construction at the time, included a design to accommodate either fresh or sea water in their cooling towers (Adams 2003).

A benefit from the drought was that water efficiency measures introduced during the drought continued after it broke in February 2003. For instance, Boyne Smelters Limited (BSL) set an internal target to reduce water use in 2003 by 25% of their allocation amount of 904 ML. By the end of that year BSL had used 616 ML, a reduction of 32% (www.comalco.com 2003). A number of water efficiency projects planned for implementation with the onset of 50% water restrictions were not implemented after the drought. Once water was readily available again and thus production was no longer at risk, there was little justification in pursuing these projects. Threaten by production losses during the drought, a number of operations developed strategies for securing future water sources if the Awoonga Dam dropped to low trigger levels in the future, for instance moving to sea water cooling or building a reverse osmosis plant. After cyclone 'Beni' broke the drought, water reserves were replenished to five years' supply at forecast usage rates (Stegink et al. 2003).

REGIONAL WATER STRATEGY STUDIES

In recent years, Queensland state government bodies have undertaken regional water strategy studies in recognition that secure and sustainable water supplies are imperative for both domestic and industrial regional growth. These studies have proposed alternative paths for the long-term security of water supplies to meet the region's predicted future requirements. In addition, the Queensland Competition Authority conducted a review of the pricing policies of the Gladstone Area Water Board (GAWB) to ensure that as a monopoly service provider it does not abuse its monopoly power. The outcomes from all of these studies have the potential to significant affect the future water management practices of the region.

Gladstone Area Water Board Strategic Water Planning Project

In mid-2003, GAWB initiated a major review of future potential water strategies by undertaking a 'Strategic Water Planning Project'. The review was in response to a number of factors such as changed expectations of GAWB, its customers and stakeholders from the 1996 to 2003 drought, the decreasing yields due to low rainfalls in the catchment areas and the trends indicating a significant decrease in the region's rainfall over the last 40 years (Gladstone Area Water Board 2004). The general aim of the review was to identify the potential options for meeting regional future water needs.

A wide range of alternatives was considered as potential options to secure water for the region. The evaluation process comprised five criteria (reliability, selling price, water quality, environmental impacts and social implications) with weightings (35%, 25%, 20%, 10% and 10% respectively) that were assigned based on stakeholder and GAWB board input. Eleven potential new surface water options and two desalination techniques were initially considered, and after a preliminary review and screening, the most viable options were assessed against the evaluation criteria.

The highest ranked option to meet future requirements was the construction of a 20 000 to 30 000 ML/yr pipeline from the Fitzroy Barrage, supported by a new weir at Rockwood Crossing. The next ranked options in order were a weir on Baffle creek, raising the Awoonga Dam to 45 m followed by a large desalination plant (Gladstone Area Water Board 2004). The study also analysed supply substitution options such as seawater cooling of the alumina refineries and air cooling of the Callide Power Station, indicating that neither of these options would be currently financially viable for their industrial customers. The resulting action plan from the study highlighted the need for better water efficiency measures, to investigate and develop supply augmentation options and improve reliability.

Central Queensland Regional Water Supply Strategy

At a similar time to the GAWB study, the Queensland State Government Department of Natural Resources and Mines commenced a strategy initiated through the Central Queensland Regional Water Supply Study. The aim of this study was to assessed "current water availability and future demands, and how they could be best met on a regional basis"(Dept of Nat. Res. & Mines 2005).

For the Gladstone region, the draft strategy concluded that supply should be adequate until 2020, unless growth is greater than expected or Awoonga Dam becomes "seriously depleted". Under these circumstances alternative supplies may be required as early as 2013. As stated in the report, the future urban and industrial demands will be met primarily by a pipeline from the Lower Fitzroy system, with potential for conjunctive use with the Awoonga Dam scheme.

However, as outlined in the report several factors could affect these projected scenarios resulting in shortfalls in supply, as early as 2013-14. Such factors included not being able to renegotiate with customers to reflect usage or Awoonga Dam does not receive sufficient inflows. For the base case scenario in conjunction with these factors, the projected shortfall by 2010 could be 600 ML/yr, by 2015 between 2 000 ML/yr and 4 000 ML/yr, and by 2020 between 7 000 ML/yr and 15 000 ML/yr. Larger shortfalls would be projected for the higher demand scenario. These figures emphasised the significant pressure that could be imposed on water resources in the Gladstone region if demand or supply varies from the projected scenario.

Water pricing

In April 2004, the Premier and Treasurer directed the Queensland Competition Authority (QCA) to review the pricing practices applied by the Gladstone Area Water Board (GAWB). As GAWB is a monopoly service provider, this direction was made under the provisions of the *Queensland Competition Authority Act 1997* "to ensure that a monopoly service provider does not abuse its monopoly power" (Queensland Competition Authority 2005). Although the Authority was not directed to set prices for GAWB customers, it was directed to advise customers confidentially of future maximum indicative prices GAWB would be entitled to charge under the authority's recommended pricing practices (Queensland Competition Authority 2005).

A key recommendation from the authority was to employ a two-part tariff (access and volumetric) that applied separately to storage and delivery for each customer. The recommendation stated that a 100% 'take-or-pay' component should be included in the access charge based on contracted volumes, which can be varied in response to customer requests. A further recommendation was penalty charges to volumes in excess of 110% of the contracted amount. Thus, the QCA were recommending a significant change from the traditional 'take-or-pay' contractual arrangements with industrial customers. This should allow, as GAWB stated in their Strategic Water Planning Project report, customers "greater control of their overall costs". The QCA report stated that a pricing practice of this nature would allow customers to trade unused contract volumes but also suggested that these opportunities might be limited when GAWB has additional capacity for new customers. GAWB are in the process of implementing a new pricing structure.

Common features of regional studies

The findings from these studies take a supply-side perspective. The GAWB report states that as a service provider they could work with their customers to help manage water efficiency measures, such as investing in sea water or air cooling, which would reduce fresh water consumption making it available to other customers. Their analysis surmised that neither of these options was viable, due to higher costs and possible technology limitations.

A government authority investing in equipment that is situated on an industrial site and indirectly saves dam water would not be common and possibly a precedent in Queensland. This highlights the underlying premise that the contribution of government owned water authorities to sustainable use of fresh water is from the supply side and they have little influence or control on opportunities for water re-use. In fact, commercial authorities that are monopoly service providers reporting directly to the relevant Minster rather than to a government department have the expressed goal of being financially viable. As water is their product, selling more water makes them more financially viable or commercially responsible.

Nonetheless, there appears to be an onus for GAWB to employ environmentally sustainable business practices. They state that they try to achieve this “by planning, developing, operating and maintaining the infrastructure required for supplying water in a sustainable manner, while minimising the impact its operations have on the environment” (www.gawb.qld.gov.au 2006). There appears to be conflicting goals and recent figures have indicated that state governments, across Australia, are receiving sizeable dividends and tax payments from government trading enterprises (Hannan 2006). For a complete and sustainable water management across a region, all aspects of the water cycle need to be considered. This is not suggesting that the abovementioned strategy reports have ignored water efficiency measures, as they clearly have not, but implies a regional perspective is needed for sustainable water use over the full water cycle.

RISK MANAGEMENT

Managing the security of water sources is important for an industrial regional like Gladstone. This can be achieved by allowing market forces to operate or introducing additional volume. In the former, the operations could either pay higher prices for water as demand increases or invest in water efficiency measures. This could make it difficult for operations to continue and may not be beneficial for the region long-term. In the latter, a new source of water could be secured from outside the region, as concluded in the regional water studies, or wastewater could be treated and re-used.

Re-using wastewater in an example of industrial synergies, where a by-product from one operation is re-used at another operation. Industrial synergies are an example of industrial ecology, an approach where industrial systems begin to mimic natural ecosystems. In natural ecosystems, wastes generated in one part of nature are re-used or consumed by another part of nature, thus producing an ecology cycle. Extending this concept further, nature also builds into the ecosystem resilience or the ability to absorb shocks, through its adaptive capacity. One mechanism for achieving adaptive capacity is to have functional redundancy in the ecosystem. For example, plant communities generally contain a mix of species exploiting various resource niches. Whilst there is generally one dominant species in each niche a number of sub-dominant species also exist. If the dominant species is removed, for example by a disease, the sub-dominant species are able to compete to become dominant in the niche.

This “functional redundancy” ensures resilience and that the ecosystem continues to be an effective user of available resources following the shock.

Resilience in a system will help with future risk management. Better water resilience would lead to more sustainable regional water management, allowing industry and community to be more prepared for any shocks in water supply. Industrial synergies are one way of achieving this resilience and can take the form of one-on-one synergies or collaborative synergies. In one-on-one synergies, wastewater from one site is re-used, possibly after treatment, at another neighbouring site. In collaborative synergies wastewater from one or more sites are treated at a purpose-built facility and the resulting higher quality water is then re-used by sites in the region.

A number of opportunities have been identified in the Gladstone region for one-on-one synergies, similar to the QAL effluent re-use synergy described previously. A brief overview of these water re-use opportunities follows.

One-on-one synergy opportunities

Three potential water synergy opportunities across the Gladstone region are:

- re-use of effluent from the South Trees sewage treatment plant
- re-use of effluent from the Yarwun sewage treatment plant
- re-use of effluent from Boyne Smelters Limited and the Boyne sewage treatment plant

In all of these opportunities, the water would be re-used at the two alumina refineries, either QAL or the Comalco Alumina Refinery. Provided certain requirements are met, alumina refineries are able to use low quality water which requires minimal treatment. For the current QAL effluent re-use scheme, the secondary treated effluent is chlorinated both at the sewage treatment plant and at QAL. Similar schemes could be used for each of these three one-on-one synergy opportunities. If not, a higher level of treatment, such as reverse osmosis, would be required to produce water of suitable quality for re-use.

To estimate the price of fresh water that would justify the capital and operating costs, a simple cost-benefit analysis was performed for each of these potential schemes. The price of water was calculated for project net present values (NPV) equal to zero at various years into the future. The discount rate was set at 15% and the operating costs were set at $40/ML, which is similar to those used for the pipeline in the QAL effluent re-use scheme (Doak 2004). For comparison purposes, the calculations were repeated on two lower discount rates of 5% and 10% and repeated at a discount rate of 15% for high quality treatment (integrated membrane system) using indicative capital and operating costs supplied by Cooper (2006). A summary of the results is presented in Table 2 for both minimal treatment and high quality treatment (figures in parentheses). Given the approximate nature of the cost-benefit analysis, the estimated water prices are only reported to the nearest $0.1/kL.

Table 2

South Trees sewage treatment plant effluent water re-use

The South Trees sewage treatment plant is situated on the southern edge of Gladstone. A potential opportunity is to re-use the effluent from this plant at the QAL refinery which is situated approximately 5 kilometres away. Even though the current rated capacity of the South Trees sewage treatment plant is 5 000 equivalent persons (EP), with the expected growth in the population in the catchment area the discharge is expected to increase to approximately 1.4 ML/day by 2011 (10 000 EP) and approximately 2.5 ML/day by 2021 (15 000 EP).

The cost of the new pipeline and pumping station with the capacity to transfer up to 2.5 ML/day to QAL was estimated at just over $2 million in a study conducted by consultants for the local council (Corder 2005). The cost-benefit analysis was calculated using the 2011 scenario of 1.4 ML/day. These results, presented in Figure 3, suggest that to achieve an NPV equal to zero after 2 years, a typical criterion for a project of this size, the price of water would need to be about $2.5/kL to warrant the capital investment for a discount rate of 15%. This would produce a payback period (time to repay capital costs) of about 18 months. If, however, a more lenient criterion of NPV equal to zero over the life of the project (assumed to be 20 years) was applied given the environmental and community benefits, the analysis estimates that the price of water would need to be about $0.7/kL. For high quality treatment, the estimated prices of water to justify the project for zero NPV after 2 years and 20 years are about $5.4/kL and $1.7/kL respectively.

Figure 3

Yarwun sewage treatment plant water re-use

A similar scheme would be to re-use the effluent from the Yarwun sewage treatment plant at the Comalco Alumina Refinery (CAR). Typically this plant discharges between 1 to 2 ML per day (Murrell 2005). Calliope Shire Council and CAR have had discussions regarding re-using the treated effluent (Corder 2005).

The estimated cost of constructing a pipeline and a new pump station for re-using 1.5 ML/day of effluent was $1 500 000 (scaled from the South Trees study) (Corder 2005). The analysis from the simple cost-benefit, presented in Figure 4, estimates that for an NPV equal to zero after 2 years, the necessary price of water is about $1.7/kL to warrant investment in the project at a 15% discount rate. This would produce a payback period of about 18 months. If a more lenient financial hurdle was applied, such as zero NPV over a 20 year period, because of the project's environmental and community benefits, the analysis estimates that a price of water of about $0.5/kL is necessary to warrant the investment. For high quality treatment, the estimated prices of water for project justification at zero NPV after 2 years and 20 years are about $4.5/kL and $1.5/kL respectively.

Figure 4

Re-use of effluent from Boyne

A water re-use opportunity investigated during the 2002 drought was the pumping of effluent from Boyne Smelters Limited plus some of the effluent from the nearby Boyne sewage treatment plant to QAL for use in their final wash process. Approximately 0.5 ML/day of effluent discharges from Boyne Smelters to Spillway Creek and a certain fraction, approximately 1.5 ML/day, of effluent from the Boyne sewage treatment plant was available for re-use. At the time of the drought, Boyne Smelters estimated that the capital works cost to implement this project was approximately $1.8 million. This project did not proceed once the drought broke in early 2003.

Again, on a similar cost-benefit basis, the estimated price of water to produce a zero NPV after 2 years is about $1.6/kL and for zero NPV over a 20-year timeframe the estimated price is about $0.4/kL. The results are presented in Figure 5. For high quality treatment, the estimated prices of water to justify the project for zero NPV after 2 years and 20 years are about $4.3/kL and $1.4/kL respectively. As these calculations are based on a capital works estimate of $1.8 million in 2003, the higher capital work costs to implement this project now would mean a slightly higher price of water to justify the project.

Figure 5

Collective efficiency gains

If all strategies were implemented the possible savings in Awoonga Dam water would be in the range of 4.5 to 5.5 ML/day, or roughly 1 600 to 2 000 ML/yr. These amounts could make a significant reduction in the potential future shortfalls, 2 000 ML/yr to 4 000 ML/yr by 2015, identified in the Central Queensland Regional Water Supply Strategy report. Simple cost-benefit analysis illustrates that for these re-use projects to proceed if only minimal treatment is required, the price of water would need to be well over $1/kL for typical small project financial justification. For the operations on a ‘take-or-pay’ contract, there is probably no financial incentive to pursue these re-use schemes. However, the simple analysis also illustrated that over the realistic lifetime of the infrastructure, a positive return (that is, NPV greater than zero) could be achieved for the minimal treatment case at a discount rate of 15% for water prices between about $0.4 to $0.7/kL. These prices are comparable with current incremental water selling prices (Gladstone Area Water Board 2004). The results on the lower discount rates did not have a large effect in the water prices, as illustrated in Figure 3 to Figure 5. The results of high quality water treatment illustrated that the price of water would still need to be well over a $1/kL to produce a positive NPV over the realistic lifetime of the infrastructure. The estimated prices of water for the minimal and high quality treatment cases are only indicative, but do provide a comparison between the prices of water for a typical project justification of positive NPV after 2 years with a more lenient justification of positive NPV over the realistic lifetime of the infrastructure, assumed here to be 20 years.

If an operation were to adopt a more lenient return-on-investment for a minimal treatment water re-use project that would have common good for the surrounding environment and community, there would still be some financial benefit over the life of the project. No doubt there would be some loss in the opportunity cost – that is, the money could have been invested elsewhere for a greater return. Many major mining companies do take this approach for projects with significant sustainability benefits, realising the reputation and ‘common good’ benefits demonstrate responsible business practices.

In this analysis, the assumption has been that the wastewater would be suitable after minimal treatment. If this were not the case, the additional treatment necessary to improve the water quality would reduce the viability of any water re-use project. This was illustrated by the results from the high quality treatment analysis. Nevertheless, the results demonstrate that water re-use synergies are financially feasible if organisations are willing to offset the lower than normal return-on-investment for projects with wider regional benefits that cannot be quantified but ultimately project a positive reputational image.

Collaborative synergy opportunities

Even though one-on-one water synergies provide an efficient means of re-using water, they do create limitations. It is difficult for a third party to access recycled water once the infrastructure for a one-on-one synergy is in place. From a regional viewpoint, a more flexible approach in terms of maximising the amount of water for re-use is to build a central wastewater re-treatment facility. Such facilities provide greater flexibility for water re-use and build in redundant capacity.

In the Gladstone region, there is the potential to develop a centrally located water re-treatment facility that could service the industries in the Gladstone State Development Area. Operations such as Orica, Comalco Alumina Refinery, Cement Australia, Transpacific Industries and the Yarwun sewage treatment plant are all conveniently located and all their effluent discharges could feed a collaborative water treatment facility. Operations further away such as the Gladstone Power Station or new operations to the Gladstone State Development Area could conceivably have their effluent pumped to this facility. A facility of this nature could collect effluent from industries and local sewage treatment plants and re-treat the water to various industrial standards, for instance wash-down water, process water or demineralised water. During the course of the Gladstone regional synergies project, discussions have been had with GAWB on the potential for such a facility.

The two obvious benefits would be reduced raw water usage from Awoonga Dam and no or very limited discharge of wastewater to the environment from the operations feeding the facility. In addition, the resulting sludge or waste from the facility could be used as alternative fuel at the local cement kiln. As cement kilns operate at high temperature, of the order of 1800 degrees Celsius, and have relatively long residence times, of the order of 4 to 6 seconds, waste materials are used as alternative fuel sources. The Gladstone cement kiln, owned and operated by Cement Australia, has an active alternative fuels program, which partially replaces coal with tyres, solvent based fuels and spent cell linings from Boyne Smelters Limited (Corder et al. 2006). In short, the wastewater including its contaminants could be virtually totally re-used. Without detailed information on the available wastewater and the required level of treatment, it is not possible to perform cost-benefit calculations similar to those presented for one-on-one synergies. However, the improved economies-of-scale would at least partially offset the higher costs of treatment for producing high quality water compared with equivalent one-on-one synergies.

The other significant benefit that a facility of this nature brings is an increase in resilience to water security. It provides an additional water source from within the region. This allows greater capability of adaptability in water use. Being able to have a second source of good quality water in addition to Awoonga Dam builds in a level of redundancy that makes the region less prone to outside 'shocks' such as fresh water shortages from a severe drought. 'Once through water use' means that operations are reliant on the one source of water, Awoonga Dam.

Any major change in the operating conditions in a region in which industrial synergies are being implemented may by considered analogous to a shock to an ecosystem. These shocks could be countered be adaptive capacity, similar to natural eco-systems. As a consequence, existing synergies should be made more robust and synergies that were not considered attractive may become so. Better water resilience through adaptive capacity would lead to more sustainable regional water management, allowing industry and community to be more prepared for any shocks in water supply. Opportunities to recycle water in a flexible manner will deliver adaptive capacity across a region and should improve future water security. This flexibility could be achieved through collaborative industrial water synergies using multi-user water treatment facilities. Such a facility could be part of the service provided by the water authority or could be initiated by a group of operations concerned about water security. This would consequently improve regional resilience in terms of water security and therefore significantly contribute to a more sustainable level of regional water management.

CONCLUSIONS

Water is critical for the industries of Gladstone and the Gladstone industries are critical to Australia's export market. From a risk management perspective, all possible avenues for ensuring secure water sources across the region need consideration. The analysis presented in this paper highlighted that although measures have been taken to investigate secure water sources, the approaches have not been from a regional perspective across the full water cycle. Although arrangements are changing, historically the business drivers have not been effective mechanisms for moving towards regional sustainable water goals. Strategies for sound risk management will contribute to the sustainable development of the Gladstone region. These strategies would balance supply side with demand side and encourage sustainable water practices within a realistic commercial framework. The opportunity to build in adaptive capacity through collaborative industrial synergies, similar to natural eco-systems, would allow for robustness and resilience in water security. This would be a significant step to achieving long-term sustainable water management across the Gladstone region.

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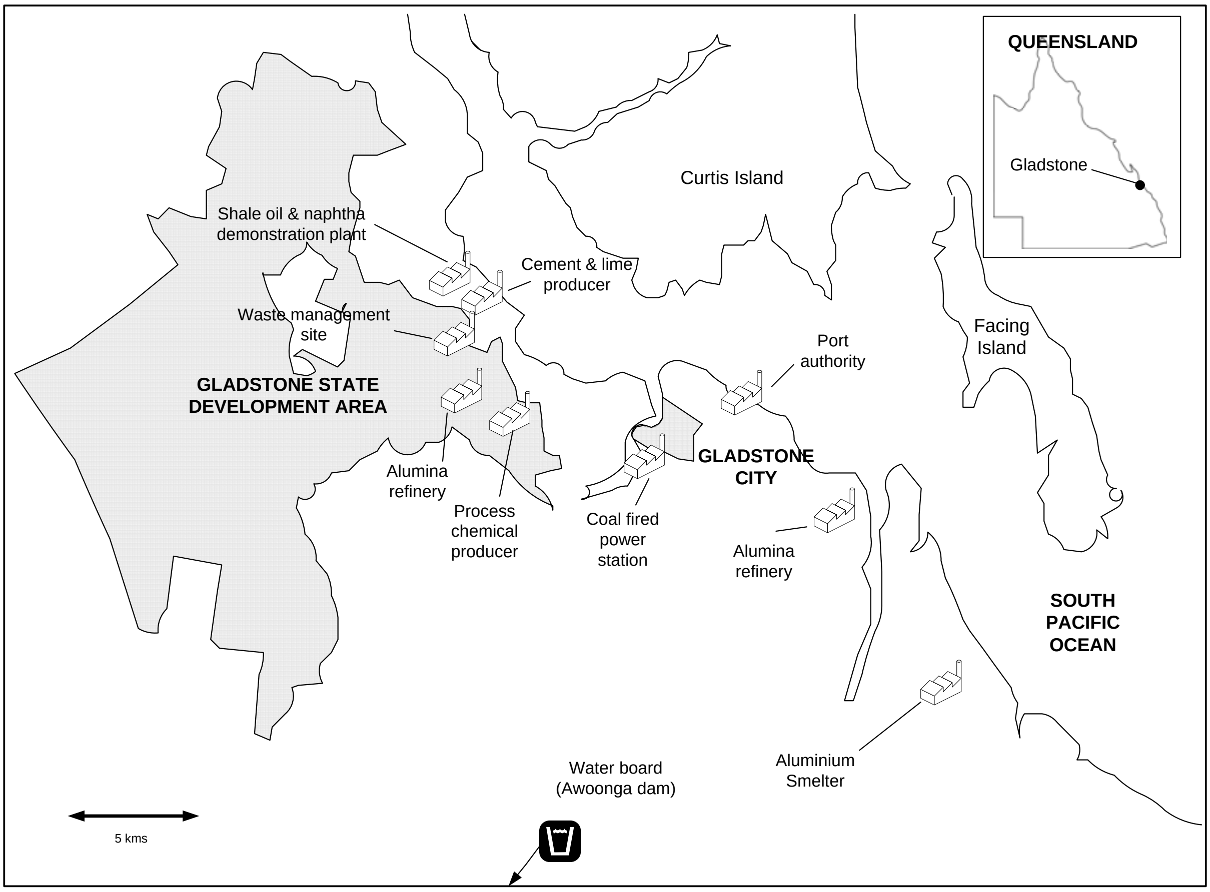

Figure 1 Location of Gladstone industrial region

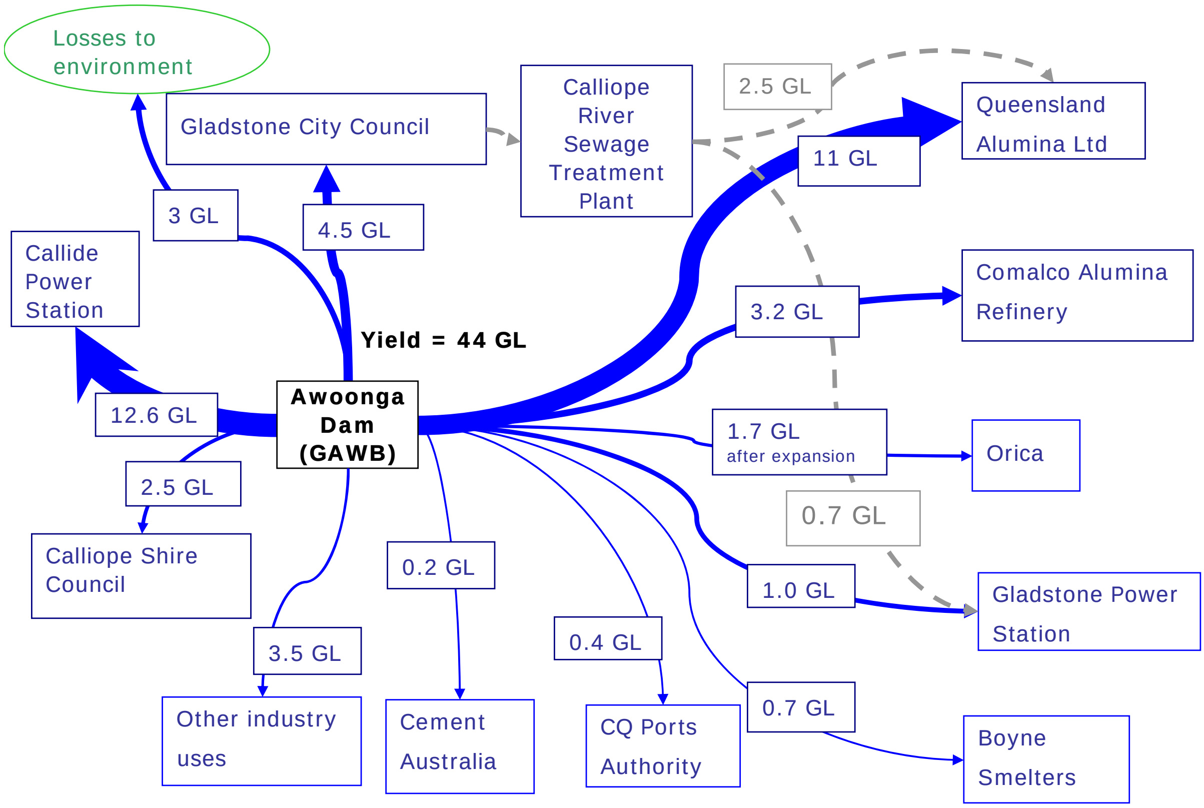

Figure 2 Indicative annual water use of heavy industry and local councils – the numbers in this figure are only indicative and do not represent the results from a detailed regional water balance[1]

[1] Yield estimate from p6 of GAWB 2005 annual report (Gladstone Area Water Board 2005); GAIN industry figures from Corder (2005) except GPS, QAL, BSL and CAR which are from Porteous (2006); Callide Power Station figure from p3 of SunWater (2005); council splits based on population from Dept of State Dev., Trade and Innovation (2005).

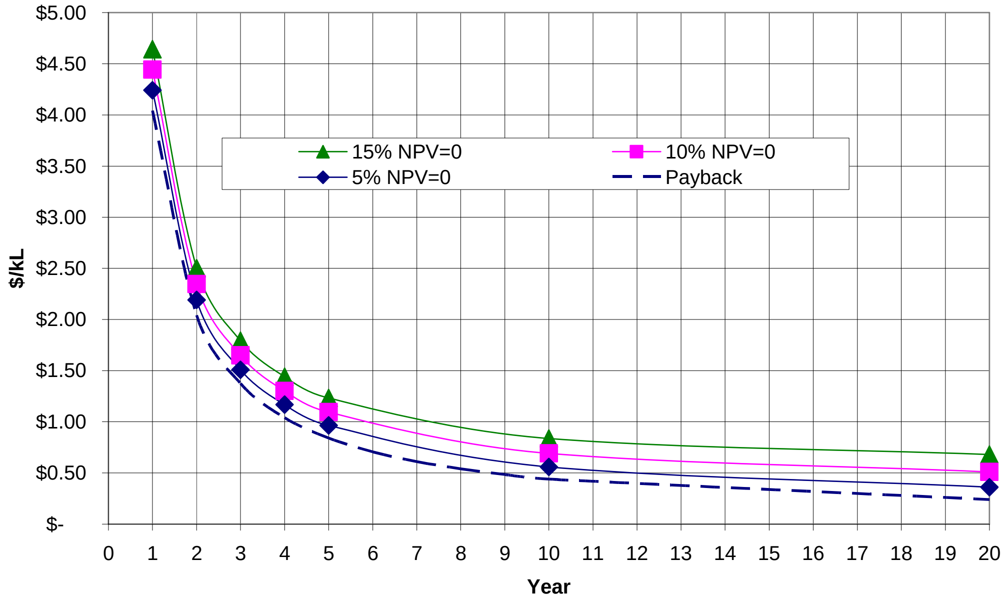

Figure 3 South Trees sewage treatment plant effluent re-use at Queensland Alumina Limited (minimum treatment)

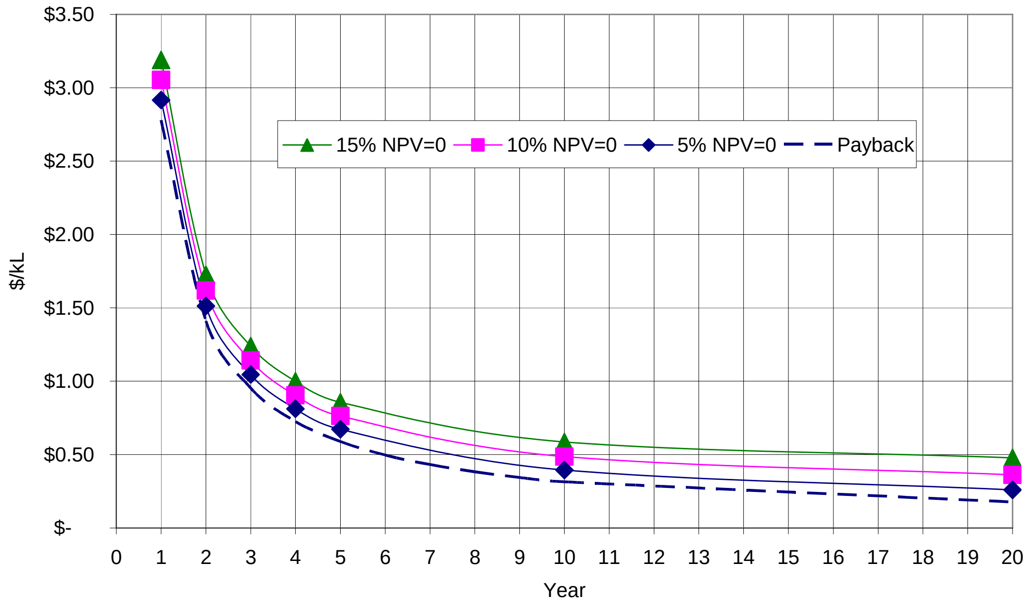

Figure 4 Yarwun sewage treatment plant effluent re-use at the Comalco Alumina Refinery (minimum treatment)

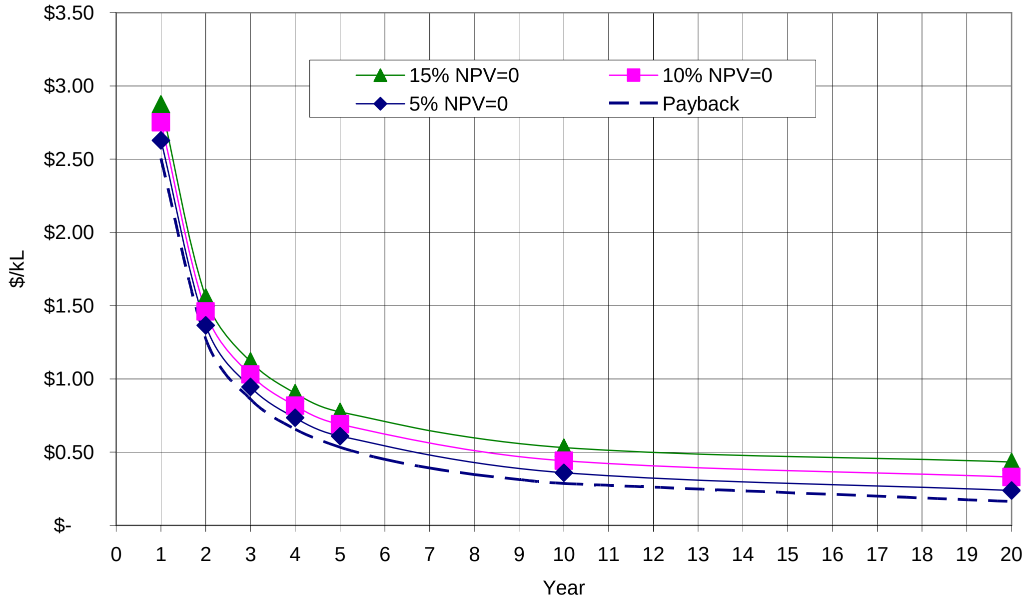

Figure 5 Boyne wastewater re-use at Queensland Alumina Limited (minimum treatment)

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Table 1 Distribution of water use across Gladstone region (modified from (Gladstone Area Water Board 2004)).

Cooling towers	54%
Process purposes	13%
Ash and red mud disposal	11%
Domestic and light industry use	16%
Other losses to environment	6%

Table 2 Summary of cost-benefit analysis at discount rate of 15% for one-on-one synergies with minimal treatment and with high quality treatment (figures in parentheses) - Note: given the approximate nature of the calculations, estimated prices are only reported to the nearest $0.1/kL.

	Capital Cost	Water price at NPV = 0 in year 2	Water price at NPV = 0 in year 20
South Trees effluent re-use at Queensland Alumina Limited	$2 045 000 ($4,145,000)	~$2.5/kL (~$5.4/kL)	~$0.7/kL (~$1.7/kL)
Yarwun effluent re-use at the Comalco Alumina Refinery	$1 500 000 ($3,600,000)	~$1.7/kL (~$4.5/kL)	~$0.5/kL (~$1.5/kL)
Boyne wastewater re-use at Queensland Alumina Limited	$1 800 000 ($4,600,000)	~$1.6/kL (~$4.3/kL)	~$0.4/kL (~$1.4/kL)