

Centre for
Sustainable
Resource
Processing

Project 3C1: Developing Local Synergies in the
Gladstone Industrial Area

Potential Synergy Opportunities in the Gladstone Industrial Region

GD Corder¹

April 2005

¹ Centre for Social Responsibility in Mining, Sustainable Minerals Institute, The University of Queensland, Queensland, Australia 4072

This project is carried out under the auspice and with the financial support of the Centre for Sustainable Resource Processing, which is established and supported under the Australian Government's Cooperative Research Centres Program. The Centre for Sustainable Resource Processing is a joint venture between Alcoa, ANSTO, CSIRO, Curtin University of Technology, Newmont, Rio Tinto, University of Queensland, University of Sydney, WMC, Xstrata, OneSteel, Orica, Rocla, Central TAFE, Ausmelt, Environment Australia, Hatch, Kwinana Industries Council, Minerals Council of Australia, NSW Minerals Council, Tesla, Gladstone Area Industrial Network and URS.

Contributors to this project

GAIN



**THE UNIVERSITY
OF QUEENSLAND**

Executive Summary

This document presents the findings from Year One of the “Developing Local Synergies in the Gladstone Industrial Area” project. The project is funded by the Co-operative Research Centre for Sustainable Resource Processing (CSRP) and the Gladstone Area Industry Network (GAIN) industries, which are associate members of the CSRP.

The initial sections of this document present an overview of the Gladstone industries (Section 2), briefly summarise two previous sustainability studies (Section 3) and describe the existing industrial synergies (Section 4).

From the collation of input-output data from each of the GAIN sites, by-products and synergies opportunities for each site were identified (Section 5). This data and information formed the basis for producing tables of potential short-term and long-term synergy opportunities (Section 6).

A synergies workshop was held in early December with the aim of preparing a prioritised list of potential industrial synergy opportunities (Section 7). The synergy opportunities were analysed and evaluated to identify the short-term and long-term industrial synergy opportunities with the best potential. The two main short-term synergies that were identified:

- consolidation of waste for alternative fuel; and
- water efficiency synergies;

These key synergy opportunities were developed into project proposals (Section 8) for presentation to the GAIN Executive Committee at the end of the first year of the project, April 2005. These proposals sought to identify potential benefits (financial, environmental and community), regulatory constraints and estimated costs of the implementing these opportunities.

The other potential short-term synergy opportunities identified were ammonium nitrate solution as fertiliser, biomass as an alternative fuel source and a central crushing facility for construction fill.

In the longer term, there are significant opportunities involving the effective re-use of the large waste streams:

- red mud
- fly ash
- gaseous emissions, such as carbon dioxide and sulphur dioxide.

The aim of the project in its second year is to continue to facilitate the implementation of the short-term synergy opportunities that have been identified while monitoring the technological developments related to waste and by-product re-use for the long-term synergies.

Table of Contents

1.	Introduction.....	1
2.	Gladstone Industrial Area	2
2.1	Overview.....	2
2.2	Gladstone Industry Area Network Industries	2
2.2.1	Queensland Alumina Limited.....	2
2.2.2	NRG - Gladstone Power Station.....	2
2.2.3	Cement Australia	3
2.2.4	Boyne Smelters Limited	3
2.2.5	Orica Chemicals.....	3
2.2.6	Comalco Alumina Refinery	3
2.2.7	Central Queensland Port Authority.....	3
2.2.8	Gladstone Area Water Board.....	4
2.2.9	Queensland Energy Resources Limited (QERL).....	4
3.	Recent Sustainability Studies.....	5
3.1	Sustainable Gladstone	5
3.2	By-Products Mapping Study.....	6
4.	Current Industrial Synergies	9
4.1	Alternative Fuels Strategy at Cement Australia.....	9
4.2	Secondary Effluent Re-use at Queensland Alumina.....	10
4.3	Waste Transfer Facility at Queensland Alumina	10
4.4	Power Station Flyash as a Cement Additive at Cement Australia.....	11
4.5	Caustic Soda from Boyne Smelters to QAL and QER	11
4.6	Current Synergy Map.....	11
5.	GAIN By-Products and Synergy Opportunities	13
5.1	Introduction.....	13
5.2	Queensland Alumina Limited	13
5.2.1	Input-Output Summary	13
5.2.2	Major By-products	13
5.2.3	Potential Synergies.....	13
5.3	NRG – Power Station.....	14
5.3.1	Input-Output Summary	14
5.3.2	Major By-Products.....	14
5.3.3	Potential Synergy Opportunities	15
5.4	Cement Australia	16
5.4.1	Input-Output Summary	16
5.4.2	Major By-Products.....	16
5.4.3	Potential Synergy Opportunities	16
5.5	Boyne Smelters Limited	17
5.5.1	Input-Output Summary	17
5.5.2	Major By-Products.....	17
5.5.3	Potential Synergy Opportunities	18
5.6	Orica Australia	19
5.6.1	Input-Output Summary	19
5.6.2	Major By-products	19
5.6.3	Potential Synergies.....	20
5.7	Comalco Alumina Refinery	20
5.7.1	Input-Output Summary	20
5.7.2	Major By-Products.....	20

5.7.3	Potential Synergy Opportunities	21
5.8	Central Queensland Port Authority.....	22
5.8.1	Input-Output Summary	22
5.8.2	Major By-Products.....	22
5.8.3	Potential Synergy Opportunities	22
5.9	Gladstone Area Water Board	22
5.9.1	Major By-Products.....	22
5.9.2	Potential Synergy Opportunities	23
5.10	Queensland Energy Resources Limited	23
5.10.1	Major By-products	23
5.10.2	Potential Synergy Opportunities	23
5.11	General Synergies	23
6.	Summary of Synergy Opportunities	24
7.	Outcomes from Synergies Workshop	26
7.1	Introduction.....	26
7.2	Objectives of Workshop	26
7.3	Workshop Process.....	27
7.4	Summary from group sessions.....	28
7.4.1	Groups.....	28
7.4.2	Short-Term Synergies	29
7.4.3	Long-Term Synergies	30
7.4.4	Other Findings	31
7.5	Selected short-term and long-term synergies.....	31
8.	Proposals for Key Synergy Opportunities	34
8.1	Introduction.....	34
8.2	Consolidation of Wastes for Alternative Fuel	34
8.2.1	Objective and overview	34
8.2.2	Benefits	34
8.2.3	Regulatory Constraints.....	36
8.2.4	Costing	37
8.2.5	Project Plan	38
8.3	Water Efficiency Synergies	39
8.3.1	Introduction.....	39
8.3.2	South Trees Sewage Treatment Plant Effluent Water Re-use	39
8.3.3	Yarwun Sewage Treatment Plant Water Re-use.....	41
8.3.4	Trade Waste Re-use	43
8.3.5	Seawater Re-use.....	44
8.3.6	Summary	46
8.4	Short-Term Synergy Opportunities.....	46
8.4.1	Liquid Ammonium Nitrate Re-use	46
8.4.2	Biomass as an Alternative Fuel Source	47
8.4.3	Central Crushing Facility	48
8.5	Long-Term Synergy Opportunities.....	49
8.5.1	Red Mud Initiative	49
8.5.2	Ash Initiative.....	50
8.5.3	Emissions Initiative.....	51
9.	Conclusions.....	53
10.	Future Direction	54
11.	Acknowledgements.....	55
12.	Glossary	56

13. References.....	57
14. Appendix.....	59
14.1 QAL Input-Output Summary	60
14.2 NRG Input-Output Summary	61
14.3 Cement Australia Input-Output Summary	62
14.4 BSL Input-Output Summary	63
14.5 Orica Input-Output Summary	64
14.6 CAR Input-Output Summary	65
14.7 CQPA Input-Output Summary	66

List of Figures

Figure 1	Main Page of By-Products Database	7
Figure 2	Current By-Product Synergies Map	12
Figure 3	Synergy Grouping Chart	27
Figure 4	Overview of Consolidation of Alternative Fuels	38

List of Tables

Table 1	Summary of Short-Term Synergy Opportunities.....	24
Table 2	Summary of Long-Term Synergy Opportunities	25
Table 3	List of Attendees	26
Table 4	Ratings of Short-Term Synergies.....	29
Table 5	Ratings of Long-Term Synergies	30
Table 6	Other Synergy Opportunities – Calliope Group	31
Table 7	Example of Potential Alternative Fuels from Industry and Estimated Fuel Costs.....	36

1. INTRODUCTION

This report is a summary of the findings from the first year of the “Developing Local Synergies in the Gladstone Industrial Area” project which is funded by the Co-operative Research Centre for Sustainable Resource Processing (CSRP) Project 3C1. The Gladstone Area Industry Network (GAIN) industries are associate members of the CSRP.

The project aims to enhance local synergies between industrial operations and associated activities in the Gladstone region, and to assist these operations to achieve greater efficiencies in energy, water and materials consumption, and reductions in waste and emission generation. To achieve this aim the project is investigating opportunities for the re-use or recycling of waste and by-products from one industry to another industry within the Gladstone region. Coupled with this objective is also the identification of opportunities for re-use and recycling on-site. If wastes or by-products can be recycled or re-used on-site this is an efficiency means of achieving sustainable resource processing. As many sites already conduct on-site eco-efficiency assessments, greater opportunities are likely to occur with waste and by-product exchanges between industries.

The main objectives of this report are to present:

- a brief description of the Gladstone Area Industry Network (GAIN) industries;
- a review of the related sustainability studies conducted on the Gladstone region;
- an overview of the current industrial synergies in operation at the start of this project in April 2004;
- for each GAIN site a brief description of the main by-products plus the potential synergies opportunities;
- the input-output summary for each GAIN site;
- the outcomes from the synergies workshop held on 1st December 2004; and
- the proposals developed from the key synergies opportunities that were identified in the December workshop

2. GLADSTONE INDUSTRIAL AREA

2.1 Overview

Gladstone, situated on the central Queensland coast some 540 kilometres north of Brisbane, has a population of about 50,000 in the region 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. Today there are several major industries operating in the region and they form an association called the Gladstone Area Industry Network or GAIN. GAIN comprises:

- Queensland Alumina Limited, the world largest alumina refinery;
- NRG - Gladstone Power Station, the largest coal-fired power station in Queensland;
- Cement Australia, with the largest cement kiln in Australia and a newly refurbished quick lime kiln;
- Boyne Smelters Limited, the largest aluminium smelter in Australia
- Orica Chemicals, which produces ammonium nitrate, sodium cyanide and chlorine;
- Comalco Alumina Refinery, the first alumina refinery constructed in Australia since 1985;
- Central Queensland Port Authority, the largest multi-cargo port in Queensland;
- Gladstone Area Water Board, the operator of the Awoonga Dam; and
- Queensland Energy Resources Limited, formerly the Stuart Shale Oil Project.

A brief description of each of the GAIN industries is presented in the next section.

2.2 Gladstone Industry Area Network Industries

2.2.1 Queensland Alumina Limited

Queensland alumina limited (QAL) has been operating since 1967 and is the largest alumina refinery in the world. Annually, the refinery processes about 8 million tonnes of bauxite through a four-stage Bayer process, producing about 3.7 million tonnes of alumina. This represents about 10% of the world alumina production. Recent major modifications to the plant include the installation of stationary calciners, which significantly reduce energy consumption and fugitive dust emissions.

QAL is the largest natural gas consumer in Queensland and one of the largest users of electricity in the state. It is also a significant employer in the Gladstone region, employing 950 staff and 350 contractors.

2.2.2 NRG - Gladstone Power Station

Situated a few kilometres from the centre of Gladstone, the power station is the largest coal-fired station in Queensland and has been operating since 1976. Coal is delivered by rail from central Queensland.

The total generating capacity of 1680 MW is provided by six 280 MW turbogenerators, each of which output 16,200 volts that is converted by transformers

to 132,000 or 275,000 volts for transmission. The plant's largest customer is the Boyne Aluminium Smelter, which consumes about half the available electricity. Any power reserves are transmitted to the Queensland electricity grid.

2.2.3 Cement Australia

Cement Australia clinker plant is situated at Fisherman's Landing, north-west of Gladstone, and has been operating for about 25 years. The plant uses approximately 2,000,000 tonnes of limestone, mined from the nearby East End mine and transported by rail to Fisherman's Landing. This produces about 1,500,000 tonnes of clinker annually.

In 2004 the old clinker kiln was re-commissioned to produce quick lime. Planned production of quick lime is 300,000 tonnes per annum. Over recent years Cement Australia has employed an alternative fuels strategy to reduce the consumption of coal, the main fuel for the kiln.

2.2.4 Boyne Smelters Limited

Situated on Boyne Island about 20 kilometres south of Gladstone, Boyne Smelters has been operating since 1982. Using the Hall-Heroult process, the smelter produces 540,000 tonnes of aluminium annually. The smelter uses over 1,000,000 tonnes of calcined alumina from QAL, 200,000 tonnes of petroleum coke, 46,000 tonnes of liquid pitch and over 7,600,000 MWh of electricity to produce the aluminium.

2.2.5 Orica Chemicals

The Orica chemical plant is situated about 7 kilometres north-west of Gladstone on a site of 50 hectares of which 20 hectares is developed. The plant produces 220,000 tonnes of ammonium nitrate, 38,000 tonnes of sodium cyanide and 9,000 tonnes of chlorine annually. A major expansion of the ammonium nitrate plant is currently in progress and when complete, ammonium nitrate production will be 600,000 tonnes per annum. The plant has been operational since 1990 and about 150 people are employed at the site.

2.2.6 Comalco Alumina Refinery

Situated in the Yarwun area, north-west of Gladstone, the Comalco Alumina Refinery (CAR) is the first new alumina refinery in Australia since 1985. Alumina production commenced in late 2004. Operating at design capacity, the first stage of CAR will produce 1.4 million tonnes per annum of alumina from 2.25 million tonnes of Weipa bauxite per annum. A further two stages can be added to the refinery enabling production of over 4 million tonnes of alumina per annum.

2.2.7 Central Queensland Port Authority

The Central Queensland Port Authority (CQPA) is an amalgamation of the Gladstone Port Authority and Rockhampton Port Authority, which came into effect from 1st July 2004. In 2003 -2004 year the CQPA operated ports handled just under 40,000,000 tonnes of coal plus other exports such as woodchip, magnesite, calcite, and magnetite in much lower quantities. Over 15,000,000 tonnes of material were exported through non-CQPA operated ports. A significant expansion of the RG Tanna Coal terminal is in progress which on completion will increase the capacity by 8,000,000 tonnes in 2005/06 and a further 6,000,000 tonnes in 2006/07 (Gladstone Region Project Status Report, September 2004a).

2.2.8 Gladstone Area Water Board

As the statutory body that owns and operates the Awoonga Dam, the Gladstone Area Water Board's (GAWB) main responsibility is the supply of water to industry and local community in the Gladstone region. It is classified as a Category 1 commercialised Water Authority under the *Water Act 2000* and is responsible to the Queensland State Minister for Natural Resources and Mines. The dam is situated approximately 30 kilometres south of Gladstone and is the only major water source for the Gladstone region.

Other activities of GAWB include planning, developing, operating and maintaining the infrastructure for supplying water from the Awoonga dam, the only major water source for the Gladstone region. GAWB only recently joined GAIN.

2.2.9 Queensland Energy Resources Limited (QERL)

Queensland Energy Resources Limited acquired the Stuart Shale Oil Project in April 2004 after Southern Pacific Petroleum/Central Pacific Minerals went into receivership in late 2003. A demonstration plant, known as Stuart Stage 1, was in operation to produce shale oil and naphtha from oil shale. In July 2004 the new owners announced the completion of Stage 1 with a new focus of conducting extensive research and design studies for the next phase. The facility is currently on care and maintenance.

3. RECENT SUSTAINABILITY STUDIES

Two recent studies, completed in 2001, have concentrated on highlighting the potential for sustainability in the Gladstone region and formed the basis of the initial research for this report. These are:

- Sustainability Report for the Gladstone Region 2001 – Better Gladstone, Better World; Leading the Gladstone Region towards Sustainability (Sustainability Report for Gladstone Region, 2001b).
- By-Products Mapping Study - co-ordinated by the Gladstone Region Sustainability Group and were both completed in 2001 (By-Products Mapping Study, 2001a).

Both these studies were co-ordinated by the Gladstone Region Sustainability Group and Gladstone Area Promotion and Development Limited.

3.1 Sustainable Gladstone

The main aim of the Sustainability Report was to establish a list of indicators as the starting point for a sustainability roadmap for the Gladstone region. By being able to measure the state of the Gladstone region at any one time using these indicators, the report stated it would be possible to make good decisions about policy relating to sustainable development. The development of “Better Gladstone, Better World” was undertaken by the Gladstone Regional Sustainability Group in partnership with the Sustainable Industries Division of the Environmental Protection Agency. Three categories, environment, economic and social, each with five sustainability indicators were identified:

Environment

- Indicator 1: Air Quality
- Indicator 2: Energy Consumption
- Indicator 3: Water Quality and Consumption
- Indicator 4: Bio-diversity and Landscape Quality
- Indicator 5: Waste and Recycling

Economic

- Indicator 6: Industry and Infrastructure Development
- Indicator 7: Employment and the Economy
- Indicator 8: Agri-Business (Grazing, Horticulture and Forestry)
- Indicator 9: Building and Planning
- Indicator 10: Tourism and Hospitality

Social

- Indicator 11: Health and Welfare
- Indicator 12: Education and Training
- Indicator 13: Population and Culture
- Indicator 14: Law and Order

- Indicator 15: Families

Separate chapters in the report provide details of each indicator, along with associated data. In each chapter, supporting data to establish a measure for the associated indicator along with related sustainability initiatives are presented. These provided a benchmark for the Gladstone region at the time of the report and against which future change could be measured. Using the report as a basis, the objective was to produce a limited number of headline indicators to highlight the main issues and trends in the Gladstone region.

The report is an excellent information source, providing relevant data, analysis and commentary on sustainability issues in the region. One of the future aims was to use the indicators to monitor how Gladstone moves towards a sustainable regional program. To date, there appears to have been little progress along this road since the completion of this study. The complete report is available in pdf format at www.sustainablegladstone.com/index_indicators.htm.

3.2 By-Products Mapping Study

The By-Products Mapping Study was a product of the partnership between Gladstone Area Promotion and Development Limited (on behalf of the Gladstone Region Sustainability Group) and the Australian Greenhouse Office. The aim of the study was to encourage the reduction of greenhouse gas emissions and to promote and facilitate sustainable development in the Gladstone region. Two of the major contributors to green gas emissions are the transport and consumption of raw materials and the transport and disposal of wastes. This study investigated the potential for minimisation of wastes and exchange of by-products within the Gladstone region. The report stated that achieving a reduction in waste generation and improved re-use of by-products would not only reduce greenhouse gas emissions but also make good business sense by reducing disposal, transport and remediation costs, as well as the costs of product losses.

The main focus of this study was collating existing information on the various waste stream types and quantities of by-products being generated in the region so that this information could be stored in an Access database. The aim was to make the database available across the region so that synergies could be more easily identified between industries and organisations. That is, a company or organisation could easily find out if another company or organisation in the region is producing one of their feed materials as a by-product, and thus initiate the first steps in creating a synergy between the two entities.

Figure 1 illustrates the main page of the database. The user selects an industry and a shire of interest to generate either a by-products or raw materials report.

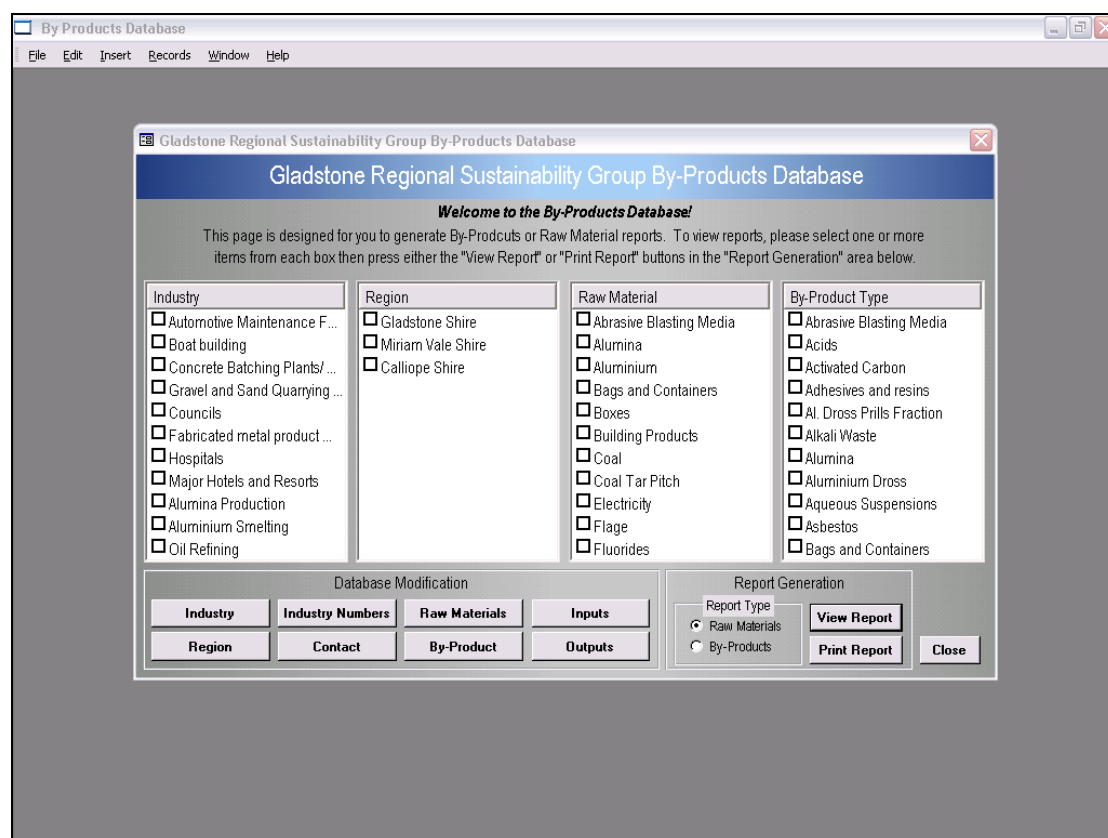


Figure 1 Main Page of By-Products Database

One of the main challenges of the study, as reported by the authors, was the collating of information of wastes and by-products from medium to large industries, the main target of the study. These challenges were attributed to commercial sensitivities, lack of resources within the organisation and other undisclosed reasons. Consequently, the Access database although a very good platform for storing and presenting the waste, by-product and raw material data, did not contain all the desired information at the end of the study.

The By-products Mapping Study report provides an excellent overview of the industries and related factors across the region plus discussion of possible waste and by-product re-use or synergy opportunities. Some of the important opportunities relevant to the GAIN industries were:

- Integration of wastewater collection, treatment and re-use
- Integration of heat recovery to reduce energy use and CO₂ generation
- Recovery of metals from wastes
- Sequestration of CO₂ to improve carbon credits
- Recovery of combustibles for energy use
- Enhanced recovery and re-use of construction, demolition and road building wastes
- Development of a technology innovation program in the region to maximise use of secondary resources (by-products and waste).

Environmental, economic and social benefits of by-products re-use were listed and recommendations for the future activities, which included as critical the updating of the database, were outlined in the report. In fact since the completion of the report some of the opportunities listed in the report have been implemented as synergies (refer to Section 4).

The By-Products Mapping Study provides an excellent basis for identifying synergic opportunities within the Gladstone region and forms the basis for the initial phase of Project 3C1 “Developing Local Synergies in the Gladstone Industrial Area”.

4. CURRENT INDUSTRIAL SYNERGIES

There are already several examples of waste or by-product re-use among the GAIN industries. These are:

- An alternative fuels strategy at Cement Australia
- Secondary effluent re-use at Queensland Alumina
- A waste transfer facility at Queensland Alumina
- Re-use of power station flyash as a cement additive at Cement Australia
- QERL and Queensland Alumina's re-use of caustic soda from Boyne Smelters.

4.1 Alternative Fuels Strategy at Cement Australia

Cement Australia is partly owned by the Holcim group which has an internal and voluntary policy to use non-traditional raw materials and fuels for clinker production. The policy known as the "Alternative Fuels and Raw Materials" (AFR) policy aims to provide environmental, economic and social benefits by reducing greenhouse gas emissions and using wastes and by-products as a fuel source which not only reduce costs but replace coal which would otherwise fuel the kiln (www.holcim.com 2004). Holcim is one of the principal companies behind the global sustainable cement initiative. One of the aims of this initiative is to develop generally applicable best practice guidelines for selection and use of alternative fuels and raw materials in cement industry (www.wbcsd.org/DocRoot/1IBetslPkgEie83rTa0J/cement-action-plan.pdf).

The main reason that cement kilns can be used to destroy wastes and by-products while extracting the calorific heating value is due to the high temperatures (1500 to 1800 degrees Celsius) and long residence times (> 4 to 6 seconds). Such conditions can destroy complex organic compounds and neutralise harmful mineral elements.

Over a number of years Cement Australia has been using domestic tyres as an alternative fuel source in their cement kiln. There have been several attempts to find the most suitable feeding arrangement and individual tyres are now fed the kiln in a regulated manner. Handling whole tyres is easier than shredded tyres whilst uncontrolled additions of tyres can affect the combustion process within the kiln. As old tyres are typically disposed of in landfill, where they can cause contamination and have a tendency to 'float', using them as a fuel source is more in line with good sustainability practices. In addition, tyres as a fuel source can improve the process of clinker production because the steel fibres present in the tyre are a beneficial iron replacement.

Cement Australia also uses solvents as an alternative fuel. These are provided by Teris (Aust) Pty Ltd in Victoria, another company that is part of the Holcim group. Teris specialises in the production of Solvent Based Fuel, a stable, homogenous fuel prepared from liquid, solid, and sludgy hazardous and combustible waste (www.cemaust.com.au 2004). The solvents are transported by rail from the Teris plant in Dandenong, Victoria to Gladstone. Solvent based liquid fuels and tyres reduce coal consumption by about 5% (www.cemaust.com.au 2004).

Copper slag is also added to the cement kiln and provides both heating value as well as iron.

In July 2004, a trial of spent cell linings from the Boyne aluminium smelter commenced. The spent cell linings (SCL) which have been accumulating at the smelter provide heating value in the kiln as well as containing silica, alumina and fluoride which benefit the manufacture of cement clinker (Using Alternative Fuels and Materials in Cement Production - Spent Cell Lining Trial 2004b).

Cement Australia also have a licence to dispose of waste generated on-site in the cement kiln.

4.2 Secondary Effluent Re-use at Queensland Alumina

In 2002, Gladstone suffered one of the worst droughts ever known in the region. Given that major industries and the community rely on water from a single water source, Awoonga Dam, the ramifications of the water shortage were immense. The seriousness of the water shortage resulted in the Gladstone Area Water Board initially imposing 10% water restrictions, in April 2002, which were then increased to 25% water restrictions, in October 2002. If not for heavy rains in February 2003, water restrictions of 50% may have been imposed.

As a large consumer of water (approximately 38 ML per day in 2001), QAL was faced with a significant loss of revenue if they were forced to operate with 25% less water than usual. As a consequence, QAL decided to fund a project to build an 8.5 km pipeline so that secondary treated effluent from the Calliope River Sewage Treatment Plant could be used at QAL as process water in the final wash process. The quality of water was suitable for the task because it did not affect the process. Although the Gladstone City Council and QAL had been discussing the possibility of re-using the secondary treated effluent prior to the drought the project was dependent on the council gaining access to State Government funding through the Local Government Capital Works Subsidy Scheme. Due to the severity of possible water restrictions QAL decided that the project should proceed without the subsidy. The available water from the secondary treated effluent of 6.5 ML/day (some of the effluent was already being used by the Gladstone Power Station for ash conditioning) was equal to the increase in water restrictions from 10% to 25%. An additional benefit was the reduction in raw water usage from Awoonga Dam of 6.5 ML/day.

Not only was QAL receiving effluent water that was suitable for use in the plant, but the secondary treated effluent was no longer discharging into the Calliope River. As a result, the Council will no longer need to construct tertiary treatment facilities should treatment of secondary effluent be required by the EPA (Doak 2004b).

The success of this project illustrates the benefits that can be achieved by all parties when synergy opportunities are realised. In this case, severe water restrictions were the catalyst for getting this project not only started but also completed in a very short time. The project received the 2003 Gladstone Regional Environment Excellence Award, a high commendation at the Engineering Excellence Awards 2003 (Engineers Australia, Queensland Division) and contributed to Gladstone's win in the 2002 Queensland's Tidiest Town awards (Stegink et al. 2003).

4.3 Waste Transfer Facility at Queensland Alumina

In June 2003, Transpacific Industries, a Queensland-based waste management company that handles the sorting and segregation of materials, operating in conjunction with QAL, opened a waste transfer facility at the QAL site. One of the

main incentives for constructing the waste transfer facility was to prevent waste from going to landfill, a non-sustainable solution for the future.

Most of QAL's waste is now sorted at the facility for reusing, recycling or reselling. Apart from old asbestos waste, which is handled by specialists, and red mud and fly ash, which are discharged to their respective dams, all other waste is delivered to the facility where it is weighed on a weighbridge before being placed on a concrete pad for sorting by hand.

After six months of operation, QAL reported the total elimination of waste going to QAL landfill. At this time, early 2004, the reported recycle rate was about 85% of wastes, which were mostly metal, cardboard and wood, and the facility was cost neutral. Most of the recovery costs are recouped from the reselling of scrap metal. Another item that is successfully recycled is old gloves. Of the 30,000 gloves that were recovered in 2003, 25,000 were recycled at an off-site facility before returning to QAL (www.qal.com.au 2004). By mid-2004 the recycle rates at the facility were reported to be over 90% with the facility now operating as cash positive.

4.4 Power Station Flyash as a Cement Additive at Cement Australia

Pozzolanic Enterprises, a subsidiary of Cement Australia, collects fly ash from the Gladstone power station for use as cement additive in Cement Australia operations, including the operation at Gladstone. Fly ash has chemical and physical properties, in particular its sphericity and fine size that are beneficial in concrete production.

Pozzolanic selects fly ash that meets the required specifications and this represents about a third of all the fly ash that is produced by the power station. The remaining fly ash is discharged to local bunds.

The collection of fly ash from power stations for use as a cement additive is not only common practice but a synergy where both parties benefit. The power stations dispose of less fly ash to local bunds and the cement operations have an improved product as well as using less limestone, a non-renewal resource.

4.5 Caustic Soda from Boyne Smelters to QAL and QER

Spent cell linings from the aluminium reduction cells can be processed into kiln grade spar through the COMTOR™ process. By treating the spent cell linings in this manner, leachable fluorides and cyanides present in the spent cell linings are removed and the kiln grade spar is stored in a clay-lined land fill (Comalco Gladstone Sustainable Development Report 2003). The current alternative solution for spent cell linings is as an alternative fuel for the cement kiln at Cement Australia, as discussed in Section 4.1. One of the by-products of the process, caustic soda (sodium hydroxide), has been used at QAL and QER, when its demonstration plant was operating.

4.6 Current Synergy Map

A schematic diagram illustrating the by-product exchanges is presented in Figure 2.

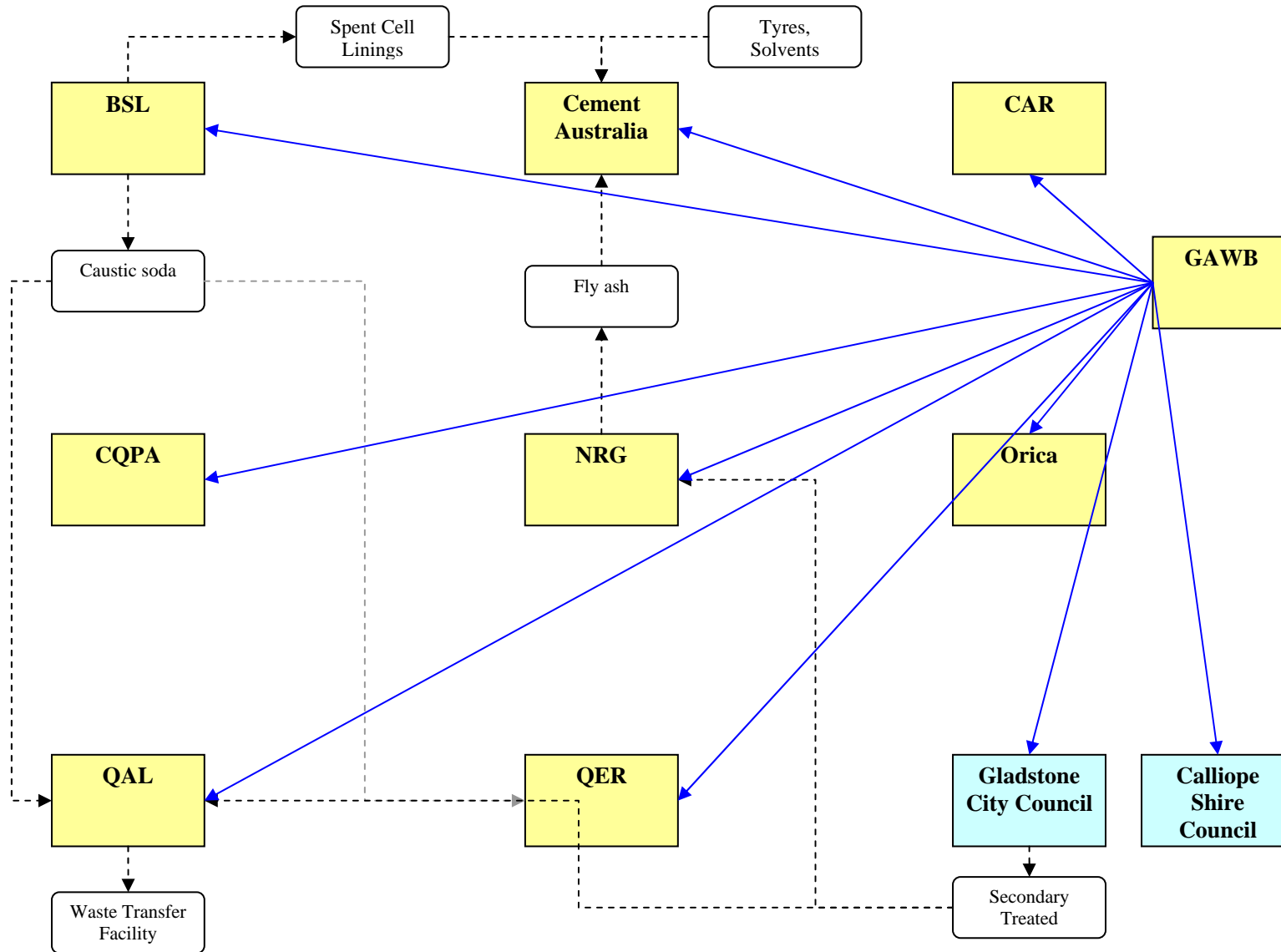


Figure 2 Current By-Product Synergies Map

5. GAIN BY-PRODUCTS AND SYNERGY OPPORTUNITIES

5.1 Introduction

One of the milestones in the first six months of the project was to collect input-output data from each of the GAIN sites and identify the potential synergy opportunities for each site. This process was done in collaboration with the main contacts at each of the GAIN sites.

This section presents on a site-by-site basis the major by-products and potential synergy opportunities for the GAIN industries.

This section, the table in Section 6 and the input-output data presented in Section 14 were the basis for the synergies workshop, held on 1st December 2004. The main objective of the workshop was to produce a prioritised list of synergy opportunities. GAIN environmental representatives and representatives from the local councils and EPA Sustainable Industries attended the workshop.

5.2 Queensland Alumina Limited

5.2.1 Input-Output Summary

The input-output summary is presented in Section 14.1.

5.2.2 Major By-products

In June 2003 a waste transfer facility, operated by Transpacific Industries, was opened at QAL. Apart from old asbestos waste, which is handled by specialists and red mud and fly ash, which are discharged to their respective dams, all other waste is delivered to the facility. Here it is weighed on a weighbridge before being placed on a concrete pad for sorting by hand. By early 2004 recycle rates at the facility were reported to be 85% with the facility operating as cash neutral. By mid-2004 the recycle rates were over 90% and the facility was operating as cash positive.

The main waste streams from QAL are neutralised bauxite residue or “red mud” and fly ash:

- QAL produces about 3 million tonnes per year of neutralised bauxite residue or red mud. The red mud, which is neutralised with sea water at the plant, is pumped to a dam adjacent to Boyne Island smelters. Potential applications for red mud have included treatment for acid mine drainage and the removal of heavy metals and phosphates from wastewater. However, although QAL have investigated possible uses for the red mud with other companies none of these possible applications have reached fruition.
- Approximately 150,000 tonnes of fly ash are produced annually by QAL; which is stored in nearby dams. Until now possible re-use of fly ash, for example as a cement additive, has not been investigated. Potential re-uses for fly ash and bottom ash are presented in the Sections 5.3 and 5.7.

5.2.3 Potential Synergies

5.2.3.1 Short Term

One potential synergy is re-use of waste saltcake from Smorgonsteel, which uses a rotary furnace to recover aluminium from the Boyne Smelters’ dross and prills (refer to Section 5.5.1). In the past, waste saltcake was sent to Landfix at Port Alma or to land fill. Neither of these options is now viable and as a result Smorgonsteel are

currently stockpiling waste saltcake. One possible avenue is to extract the alumina from the saltcake by sending it to QAL. Before QAL could accept this waste, it would be necessary to reduce the saltcake chloride content. Although there may be little benefit for QAL in terms of additional alumina in accepting the waste saltcake, it would be an acceptable solution for a waste product that is part of the bauxite-alumina-aluminium life cycle.

5.2.3.2 Long Term

Potential long term synergy opportunities would be related to red mud and fly ash and further descriptions on these possible opportunities are discussed in Sections 5.7.1 and 5.7.3.

Another opportunity is to generate power through the efficient capture of waste heat, which could be used in the generation of steam or a desalination or water purification process.

5.3 NRG – Power Station

5.3.1 *Input-Output Summary*

The input-output summary is presented in Section 14.2.

5.3.2 *Major By-Products*

As with most coal-fired power stations the main by-products are fly ash and bottom ash although there are other lower volume by-products such as fabric filters that currently go to land fill.

- Approximately one third of all fly ash that is generated is collected by Pozzolan Enterprises, a subsidiary of Cement Australia, for use as a cement additive. Fly ash has chemical and physical properties, in particular its sphericity and fine size that make it a beneficial additive to concrete in both plastic and hardened states. Pozzolan only take the fly ash that meets the required specifications. NRG has a commitment to supply the remaining fly ash to landholders of the local bunds. This synergy benefits both parties as the power station does not have to dispose of all the fly ash whilst the cement industry can improve its product quality and use less limestone, a non-renewable resource. However, there is still a significant quantity (over 300,000 tonnes) of fly ash that is not collected by Pozzolan. This is currently discharged to local bunds but may well have some beneficial use elsewhere.
- Similarly, bottom ash is currently disposed to local bunds and typically about 52,000 tonnes are generated annually.
- Sulphur dioxide, nitrogen oxides, particulates and carbon dioxide are part of the emissions from a power station. As the black coal that is burnt in the power station has a low sulphur content, the total sulphur dioxide emissions are relatively low. On the other hand the amount of nitrogen oxides emitted is relatively high at 41,000 tonnes per year. Over 9,000,000 tonnes of carbon dioxide are emitted per year and although there are no enforceable restrictions on CO₂ emissions at present there well may be in the future.
- For the conventional sub-critical pulverised fuel power station, which are prevalent in Australia, the efficiency is about 36% (Pagan et al. 2003). Therefore, nearly two thirds of the burnt fuel generates waste heat which if it

could be captured could be utilised as energy substitute. Higher efficiencies can be achieved with supercritical (40%), ultra supercritical (47%) and integrated gasification combined cycle (50%) (Pagan et al. 2003).

5.3.3 Potential Synergy Opportunities

5.3.3.1 Short Term

The most likely short term synergy is the use of fabric filters as an alternative fuel source at the cement kiln at Cement Australia. Approximately 40 tonnes of fabric filter bags are disposed of each year to land fill. They are unable to be burned at typical incinerator temperatures as they release toxic fumes. At the elevated cement kiln temperatures of 1500 to 1800 degree Celsius, it may be possible that toxic fumes are not released and, therefore, the filters could be used as an alternative fuel.

NRG has also been investigating the use of biomass fuel from local companies such as Austicks, the only maker of ice-cream sticks and coffer stirrers in Australia. Although the heat valuing of the fuel would be minor, NRG could then purchase Renewable Energy Certificates as a result of using a renewable energy source. The Renewable Energy (Electricity) Act 2000 states that electricity retailers must purchase a certain number of these certificates to avoid paying a penalty.

5.3.3.2 Long Term

Several long-term synergy opportunities are possible.

- As fly ash is the main by-product from the power station there is an incentive to find alternative re-uses. One possible use for fly ash is in the construction of strong lightweight bricks. A current research with the Cooperative Research Centre for Sustainable Resource Processing is the combination of red mud or bauxite residue and fly ash to produce a ready-mix concrete. Another alternative that is currently being investigated by Pozzolan Enterprises is the use of fly ash as a soil additive, possibly in conjunction with lime dust. Fly ash could also be used as a road base material. Although though there may be several possible uses for fly ash, the transportation costs may mean that it is not economic to use the Gladstone Power Station by-product because of the power station's remoteness from the closest large market, which is South-east Queensland. If, however, the final product had superior properties (such as stronger lighter fly ash bricks) then the potential market may be willing to pay a higher price and thus absorb the additional transport costs.
- Bottom ash could also be used for producing light weight strong bricks, soil additives and road base material. Again, transportation cost considerations and product properties would also apply to bottom ash.
- Methods for recovering emissions such as sulphur dioxide and carbon dioxide are not cheap and likely to be prohibitively expensive on power stations built 30 years ago. In theory, the flue gases can be wet scrubbed using lime to produce gypsum or sulphuric acid but with relatively low sulphur-content coal, as is the case for coal from the Bowen Basin, this is not economically feasible. As discussed in Section 5.7.3.2, red mud could be used to absorb carbon dioxide as the alumina in the red mud could have "active sites" for attracting and attaching gas molecules, such as carbon dioxide. Effectively the red mud acts as a "molecular sieve"

(www.gc3.cqu.edu.au/burn-coal-cleanly/index2.php 2004). Alcoa are currently conducting research into potential use of red mud as an absorbent for carbon dioxide.

- If waste heat could be captured there is potential to use it to generate steam which could then be supplied to associated industries. Waste heat could also be used to possibly run a desalination process. At this stage the cost of retrofitting equipment to utilise the waste heat to generate steam or purified water may not be economically feasible. However, as a means of reducing greenhouse gas emissions in the case of steam generation, or providing an alternative water source in the case of desalination, the use of waste heat may be a realistic alternative.

5.4 Cement Australia

5.4.1 Input-Output Summary

The input-output summary is presented in Section 14.3.

5.4.2 Major By-Products

The main by-product is lime dust from the quick lime kiln. There are relatively few other by-products and most of the by-products that do exist can be burnt in the clinker kiln. Cement Australia has a licence to co-process certain types of by-product material.

- Lime dust which is a by-product generated in making quick lime can be recycled on-site by adding it to the clinker kiln. To recover lime dust so that it could be added back into production streams would require additional or modified storage, materials handling and blending equipment. An attractive alternative is to sell the by-product lime dust, possibly as a soil additive.
- Although Cement Australia produce few by-products, the clinker kiln can use alternative fuels or by-products from other industries, such as tyres, solvents and spent cell linings - which are currently under trial conditions. The high temperature, long residence times and oxidising conditions in the kiln destroys most complex organic compounds and neutralises inorganic constituents (Using Alternative Fuels and Materials in Cement Production - Spent Cell Lining Trial 2004b). Not only is the use of alternative fuels preventing wastes such as tyres from going to landfill but there is a reduction in non-renewal fuel resources such coal, gas or oil.

5.4.3 Potential Synergy Opportunities

5.4.3.1 Short Term

The two main short-term synergy opportunities are the use of more alternative fuels and lime dust as a soil additive.

- Alternative fuels would not only replace the coal that is currently being used but would also allow for the disposal of hazardous by-products from other industries. These industries could possibly pay Cement Australia for disposing of their by-products and this could then compensate for the additional infrastructure for the storage and delivery of alternative fuels to the kiln. To make this viable there needs to be a significant regular quantity of any potential alternative fuel to warrant the expenditure of new infrastructure and to provide consistent feed to the kiln. Changes in the fuel

source can have a detrimental effect on clinker chemistry. In addition, community response and regulatory requirements must both be satisfied for any new alternative fuel source.

- An alternative use of lime dust is to take advantage of its inherent alkali properties and use it as an additive to soils with high acidities. Pozzolanic Enterprises, a subsidiary of Cement Australia, are investigating the potential for combining lime dust with fly ash or bottom ash to produce a soil additive that would increase pH of soils and retain moisture. This combination of lime and fly ash could be a good soil additive that would also result in beneficial uses for by-products from the cement and power industries.

5.4.3.2 Long Term

No substantial long term synergies related to Cement Australia have been identified, although other synergies such as those that reduce CO₂ emissions, apart from alternative fuels or raw materials, could be attractive in the future.

5.5 **Boyne Smelters Limited**

5.5.1 *Input-Output Summary*

The input-output summary is presented in Section 14.4.

5.5.2 *Major By-Products*

There are several by-products produced by BSL and some of these are either recycled or treated on-site or off-site.

- In 2003 over 3000 tonnes of aluminium dross and prills were generated and sold to Smorgonsteel for recycling. There is considerable financial incentive, given the relatively current high price, to reduce the generation of dross and prills.
- Burn-off butts are recycled and combined with petroleum coke and liquid pitch to produce new carbon anodes. Of the 3838 tonnes of burn-off butts generated in 2003 less than 2%, 74 tonnes, were not recycled. Apart from recycling butts, the best solution is to reduce generation of burn-off butts because this will reduce consumption of petroleum coke, a raw material. Comalco is investigating the possibilities in this area.
- All of the caustic soda produced at BSL through the COMTOR™ process is re-used at QAL and was re-used at QER when the demonstration plant was in operation.
- Met coke dust (<1mm), which is generated from crushing met coke in the carbon anode process, is currently stockpiled. Over 1000 tonnes is generated annually and as it has a reasonable calorific value, 11 MJ/kg, it could be made into briquettes for fuel.
- Met coke fines (>1mm and <5mm) which are currently used in landfill and therefore are non-toxic, have a reasonable calorific value, 16 MJ/kg. Although the material has heating value the generation rates are low, as just under 300 tonnes were produced in 2003.
- Refractory bricks, which comprise mostly alumina and silica and are considered inert, are currently stockpiled on site. Over 2680 tonnes were stored in 2003. A possible use could be as a construction material.

- Nearly 3000 tonnes of scrap aluminium was generated and sold to Smorgonsteel for recycling. As with aluminium dross and prills there is considerable financial incentive to reduce generation of scrap aluminium. Comalco are investigating.
- Spent cell linings (SCL) are a major hazardous by-product, containing fluoride and cyanide. These are stored on site or processed using the COMTOR™ plant to produce kiln grade spar (KGS). Nearly 13,300 tonnes of SCL were generated in 2003. By processing the SCL through the COMTOR™ plant the leachable fluoride and cyanides are removed and the resulting inert KGS is stored in a clay-lined landfill ready for final disposal. KGS could be used as a road base material but at this stage there is no ready market. As long term storage of SCL is a significant liability, Comalco has investigated various methods for disposing of SCL. The most likely option at present, and trials have already commenced, is using SCL as alternative fuel in the clinker kiln at Cement Australia. The carbon content in SCL provides fuel value whilst the silica, alumina and fluoride components assist the clinker production process. The high kiln temperature decomposes the relatively low levels of cyanide (< 0.1%) in the SCL and the fluoride component will be permanently encapsulated within the clinker.
- Tar has historically been stockpiled although the 2002 and 2003 initiative resulted in all of stockpiled tar being stored in landfill. Recycling of tar now results in about 20% (61 tonnes in 2003) of new arisings not returning to the process. Tar, which is highly viscous, has a high calorific value (about 40 MJ/kg), making it a potential alternative cement kiln fuel. It can, however, produce noxious emissions such as dioxins.
- Due to the severe drought at the end of 2002 when 25% water restrictions were imposed, water saving initiatives were commenced which resulted in 225 ML of water savings compared with previous year, 2001.
- Inorganic fluorides, organic perfluorocarbons (from “anode effects”) and carbon dioxide are significant gaseous emissions. Fluoride emissions from roofs in the reduction lines and gas treatment plant are an area that BSL are continually attempting to improve. Projects are underway to improve BSL’s efficiency in the greenhouse gas emissions from perfluorocarbons and carbon dioxide.

5.5.3 Potential Synergy Opportunities

5.5.3.1 Short Term

The main synergy opportunities for the Boyne Smelters are outlined below.

- Producing briquettes of the met coke dust and met coke fines would improve their handling and transportation properties. These briquettes could be a possible fuel source to the cement kiln. This would reduce the amount of landfill generated as well as providing an alternative fuel source.
- Tar could be used as a fuel source provided the noxious nature of the tar does not create emission non-compliance. As well as the calorific value of the tar, it would be advantageous not to have to store a noxious waste.

- The trial of spent cell linings as an alternative fuel source began in July 2004. The re-use of SCL would also prevent the need to produce kiln grade spar and its associated storage problems.

5.5.3.2 Long Term

A number of long-term solutions are also possible.

- Although an estimate of the waste heat was not available, there could be opportunities to harness the waste heat from the carbon anode plant. See Section 5.3.3.2 for the discussion on potential re-use of waste heat.
- During the drought in 2002, BSL were able to reduce water usage to match the 25% reductions imposed by the Gladstone Area Water Board. These reductions were achieved by implementing a range of strategies such as including the re-use of water in the Metals Products area and in the compressor houses (Comalco Gladstone Sustainable Development Report 2003). There are, however, opportunities to re-use water from the local water treatment facility but no incentive to build infrastructure with current availability of water. However, if it were necessary to reduce water consumption by one third of 2001 water usage levels then an alternative water source, such as a reverse osmosis plant to treat sea water, would be necessary.

5.6 Orica Australia

5.6.1 Input-Output Summary

The input-output summary is presented in Section 14.5.

5.6.2 Major By-products

Several by-products are produced in the ammonium nitrate, sodium cyanide and chlorine plants.

- Fertiliser solution comprising 60% ammonium nitrate solution is produced from waste and drain material in a series of boilers. Although the current market for this by-product is the local sugar industry (Bundaberg sugar), the demand is seasonal, approximately 4 months a year, requiring storage and maintenance for the remainder of the year. Consequently, Orica are seeking alternative local customers who would purchase this by-product all year round.
- Cyanide product is wrapped in polypropylene stored in bags and shipped in wooden boxes to customers, who return all the packaging to Orica. The boxes are decontaminated and accumulate on site at a rate of about 300 tonnes each year. These boxes do contain glue making them unsuitable for mulch but could be an alternative fuel source. The polypropylene and bags are sent to Brisbane for treatment in sodium hypochlorite before being sent to landfill.
- Brine filter cakes are used for land reclamation by the CQPA and therefore constitute a minor existing synergy. Orica are currently working with the EPA as these filter cakes are now considered a regulated waste and thus special exemption is required to continue with their disposal in this manner.
- Waste oils and grease, potentially contaminated with cyanide, are treated and recycled.

- A number of other by-products are produced in relatively low volumes, some of which are currently being recycled off-site (such as scrap steel) but others could be sent to a local waste transfer facility.

5.6.3 Potential Synergies

5.6.3.1 Short Term

The possible short term synergy solutions are listed below.

- Burning the storage boxes at the kiln at Cement Australia would be an effective disposal method because energy is being extracted from waste derived from a renewable resource. The regulatory requirements required to implement this synergy should be relatively straightforward. Waste oils and greases and the bags used for shipping the cyanide product could also be used as an alternative fuel source at the cement kiln. The polypropylene wrapping may also be suitable as an alternative fuel source.
- If an all year round local market can be identified for the 60% ammonium nitrate solution then Orica would not have to store and maintain large quantities of the solution for about two-thirds of the year.
- Being part of a collective purchasing scheme for commodities, such as caustic soda, could have advantages as it could allow for collective purchasing power as well as more systemic transportation of goods, reducing the number of trucks on local roads. Currently trucks deliver caustic soda every 90 minutes to Orica. At present, individual industries organise their own purchasing of goods.

5.6.3.2 Long Term

Possible longer term synergy opportunities are listed below.

- Re-use of water from the local waste water treatment facility is a possibility.
- Although an estimate of the waste heat was not available, there could be opportunities to harness the waste heat from a steam plant. Potential re-use of waste heat was discussed in Section 5.3.3.2. An example of waste heat re-use is at CSBP's operation in Kwinana in Western Australia where the waste heat from the ammonia plant is released at higher temperatures to then generate electricity for other plants on their own site.

5.7 Comalco Alumina Refinery

5.7.1 Input-Output Summary

The input-output summary is presented in Section 14.6.

5.7.2 Major By-Products

A conscious effort has been made by CAR to minimise the number and quantity of by-products. One of the main aims is to recycle, re-use or re-sell all by-products and wastes so that none ends up as landfill. There are, however, some characteristic alumina refining by-products that may have potential synergy opportunities:

- Neutralised bauxite residue or "red mud", as it is commonly known, will be a significant by-product with an estimated annual generation rate of just under 1,110,000 tonnes. The bauxite residue will be neutralised at the plant, pumped approximately 10 kilometres, de-watered and discharged into the red mud dam

which is adjacent to the proposed Aldoga aluminium smelter. Although a great deal of work has previously been done to find beneficial uses for red mud, the most practical solution is still to store the residue in dams. Possible uses for red mud are as:

- a neutralisation agent for acid mine drainage
 - an additive to fertiliser as the residue has the ability to “lock up” heavy minerals and has a very high phosphate retention capability
 - a possible cheap building material
 - a possible absorbent material for scrubbing flue gas which would also neutralise the bauxite residue
- As part of the original design of the refinery, water was to be added to the fly ash and transferred as slurry to the red mud dam. However, negotiations have been underway with Transpacific Industries (TPI) to take all the fly ash. By not storing the fly ash in the red mud dam another 2.5 million tonnes of storage or additional 2 years of storage life would be gained, resulting in significant cost savings. The main potential use for fly ash is a cement additive. Its pozzolanic characteristics mean that it can react with lime to form a cementitious compound that is easier to use when wet and increases the strength of the concrete. Other uses are as a building material such as bricks, filler material for rubber, thermoplastics, and fibreglass, and as asphalt for road construction. One of the problems with the generation of fly ash in this locality is that Gladstone is a considerable distance from a large market, namely south-east Queensland (about 500 kilometres). Consequently transport costs may limit the attractiveness of the fly ash as a feed material to other processes.
 - A percentage of lime, about 10% or 8000 tpa, is oversized and therefore cannot be used in the process. A good solution is to re-crush to correct size and add to fresh lime bin.

The other main waste that cannot be disposed of in a standard manner are fluorescent tubes as they contain mercury. At the TPI-run waste transfer facility at QAL, a fluorescent bulb grinder is used to destroy the tube and collect but not recover the mercury. Chemsal, a company in Victoria, offer a service of recycling fluorescent tubes and HID (high intensity discharge) lamps. The tubes and lamps processed to recover glass, aluminium components and phosphor containing mercury, which is then recovered by distillation for re-use (www.chemsal.com.au/file/lamps.pdf 2004).

5.7.3 Potential Synergy Opportunities

5.7.3.1 Short Term

The main short term synergies, re-use of fly ash and re-crushing of lime, now probably rely on TPI’s capabilities to find a possible market (fly ash) or provide a service (lime). At present, there is not a shortage of fly ash for use as a cement additive.

5.7.3.2 Long Term

One possible potential longer term synergy for using red mud is as an adsorbent for the power station flue gases. The residual alumina in the bauxite residue could provide a suitable site for absorbing carbon dioxide as the alumina has “active sites”

for attracting and attaching gas molecules (www.gc3.cqu.edu.au/burn-coal-cleanly/index2.php 2004). This is not at present proven technology, certainly at full-scale, and consequently research work would need to be undertaken to demonstrate that the process was feasible. Alcoa is currently conducting research into potential uses for red mud, including its use as an absorbent of carbon dioxide. If successful, the fully absorbed red mud can be stored in the red mud dam. In the longer term there are also opportunities for using fly ash as a building material, road base material, or as soil additive.

As in a number of other sites around Gladstone, there will be significant quantities of waste heat, predominantly around the stack and the calciner which will operate at about 160 °C and 150 °C respectively. If it is possible to successfully harness the waste heat without comprising the process (by allowing the stack temperature to get too low) then there would be an opportunity to use this heat to generate process steam. Although probably not currently economically justifiable compared with coal-fired boiler steam, a steam-generated-from-waste-heat system may well be feasible with the introduction of a carbon tax or some equivalent.

5.8 Central Queensland Port Authority

5.8.1 Input-Output Summary

The input-output summary is presented in Section 14.7.

5.8.2 Major By-Products

Approximately 360 000 m³ of material is dredged from the harbour each year for navigational purposes. Approximately half is disposed of to reclamation areas and the other half placed in an approved sea disposal site. Disposal at sea can be the most economical way to dispose of the dredged material depending upon volumes to be dredged and distance between the site to be dredged and the sea disposal site (Birleson 2004).

As the port is effectively a transfer point for loading cargo there are few by-products in the same sense as the other industries. The two possible by-products areas;

- Dredged material or sand that is currently used as land fill could be used as an aggregate. As sand is used as feed stock to the cement plant, it may be possible to replace at least some of it with dredged material.
- Coal fines collect in the ponds at the R G Tanna port. Mining companies are currently investigating methods for recovering coal fines for redistribution back to company stockpiles. The value of the lost coal is probably low and may not be worth recovering.

5.8.3 Potential Synergy Opportunities

At this stage the possible synergy opportunity is the potential use of dredged sand as an aggregate or a substitute for sand to the cement plant.

5.9 Gladstone Area Water Board

5.9.1 Major By-Products

GAWB have only recently joined GAIN and were not involved on the initial input-output data collection. As yet no GAWB representative had attended the GAIN Environment group.

5.9.2 Potential Synergy Opportunities

The main synergy opportunities related to GAWB are with water management and alternative water sources.

Other opportunities that are related to water but do not directly involve the GAWB would be the re-use of treated effluent from local sewage treatment plants, such as South Trees (GCC), Boyne Island, or the new Tannum plant which will produce tertiary treated effluent. Although treated effluent can be used for irrigation purposes, it may be safer from a community viewpoint to use it as process water in industry. This would almost eliminate any contact of the treated effluent with the community and the Awoonga dam water that industry was using for process water could then be used for irrigation purposes.

5.10 Queensland Energy Resources Limited

5.10.1 Major By-products

There are no current by-products from the QERL site as the facility is now under care and maintenance. As a result there is not much opportunity for QERL to participate directly in regional synergies in the foreseeable future. QERL are commencing a full pre-feasibility study on the operation and Stuart resource.

5.10.2 Potential Synergy Opportunities

For a full-scale oil shale plant there are a number of potential synergy opportunities such as:

- Recovery of ammonia from the sour gas, which is a mixture of hydrogen sulphide and ammonia, for use as a chemical feedstock;
- Use of red mud as a backfill for the mine;
- Use of waste heat (temperatures of 500 degrees Celsius) to pre-heat shale, generate steam and, if possible, use excess steam to generate electricity that could be sold back to grid;
- Feed old tyres to the process to extract their oils and in doing so reduce consumption of non-renewable oil shale; and
- Use processed shale, which could have similar properties to fly ash, as a cement additive.

5.11 General Synergies

There are a number of general synergies that have no particular connection with one company or industry:

- Collective purchasing of common commodities such as caustic soda
- Common “warehouse” or library of documents and reports for all of GAIN industries
- High speed internet link between industries and associated companies to allow for “real time” communications.

6. SUMMARY OF SYNERGY OPPORTUNITIES

The potential short-term and long-term synergy opportunities are summarised in Table 1 and Table 2.

Table 1 Summary of Short-Term Synergy Opportunities

Synergy	Source	By-product	Annual Amount	Receiver	Notes
Alternative fuel	Orica	Decontaminated boxes	300 tonnes	Cement Australia/NRG	Possible simple fuel source
Alternative fuel	Orica	Contaminated oils and grease	0.2 tonne	Cement Australia	Possible better disposal
Alternative fuel	Orica	Bags and containers	50 - 100 tonne	Cement Australia	Possible better disposal
Alternative fuel	BSL	Met coke fines and dust	1381 tonnes	Cement Australia	In briquette form
Alternative fuel	BSL	Waste tar	61 tonnes	Cement Australia	High heating value
Alternative fuel	BSL	Spent cell linings	13,290 tonnes	Cement Australia	Trial in progress
Alternative fuel	CAR	Oily waste	910 tonnes	Cement Australia	Possible better disposal
Alternative fuel	NRG/CAR	Fabric Filters	~70 tonnes	Cement Australia	Possible toxic fumes
Alternative raw material	CQPA	Dredged sand	~360,000 tonnes	Cement Australia	Possible silica source
Alumina recovery	Smorgonsteel	Used saltcake	~3,000 tonnes	QAL/CAR	High chloride levels
Biomass	Sawmills/Austicks	Waste wood	Not known	NRG	Increase renewal energy certificates
Collective purchasing	Single supplier	Caustic soda	666,000 tonnes	CAR/NRG/Orica/QAL	Improved logistics
Fertiliser	Orica	60% Ammonium nitrate	1,200 tonnes	GCC/CSC/Farmers	Currently sell to Bundaberg sugar which is seasonal
pH control	Cement Australia	Lime dust from lime kiln	Not known	Rural industries	Combined with fly ash as soil additive
Road base	BSL	Refractory bricks	2,682 tonnes	Government	Could use in dam walls
Water re-use	GCC/CSC	Treated effluent	Not known	CAR/Orica/BSL	Substitute for raw water

Table 2 Summary of Long-Term Synergy Opportunities

Synergy	Source	By-product	Annual Amount	Receiver	Notes
Steam generation	Any industry	Steam from waste heat (cogeneration) *	Large	Any industry	Need efficient capture and possible upgrade of heat
Desalination	Port Curtis	RO, mechanical or thermal technology	Many ML	Any industry	Possible use waste heat as energy source
CO2 removal	NRG and others	Carbon dioxide	Over 10,000,000 tonnes	Various	Need efficient capture with new technologies
SO2 scrubbing	NRG	Gypsum - flue gas desulphurisation *	29,000 tonnes SO2	Cement Australia	Too difficult with current technology
Lightweight bricks	NRG/CAR/QAL	Fly ash	~500,000 tonnes	Various	Volume and distance important factors
Road base					
Soil enhancement					
Bricks	QAL/CAR	Red mud	~4,000,000 tonnes	Various	Volume and distance important factors
CO2 sequestering					
Environmental control					

* These are only examples of possible by-products from these synergies - proper technology assessments need to be conducted to identify the best recovery options.

7. OUTCOMES FROM SYNERGIES WORKSHOP

7.1 Introduction

The information presented in Sections 5, 6, and 14 formed the basis for the synergies workshop, which was held from 8am to 12pm on 1st December 2004 at the Gladstone Engineering Centre. The main aim of this workshop was to identify synergy opportunities that had the best potentials in terms in benefits and ease of implementation. The outcomes from this workshop were presented to the GAIN Executive Committee on 2nd December 2004.

The invitees were:

- GAIN environmental committee or other nominees;
- Gladstone City Council an Calliope Shire Council; and
- EPA Sustainable Industries division.

The list of attendees is presented in Table 3.

Table 3 List of Attendees

Name	Company/Institution
Alastair Pilbeam	(EPA)
Albena Bossilkov	(CECP)
Alicia Duddy	(NRG)
Charlie Sotiris	(CSC)
David Brereton	(CSRSM)
David Smirk	(CAR)
George Bennetts	(NRG)
Glen Corder	(CSRSM)
Glen Pryce	(BSL)
Greg Anderson	(CQPA)
Jillian Cowan	(Orica)
Jodie Orr	(NRG)
Judy Horsfall	(CQPA)
Krishnamohan Knaduri	(EPA)
Kylie Davey	(QAL)
Robin Evans	(CSRSM)
Tom Boarder	(GCC)
Victoria Thorn	(Cement Australia)

CECP – Centre for Excellence in Cleaner Production, Curtin University
 CSRSM – Centre for Social Responsibility in Mining, University of Queensland

7.2 Objectives of Workshop

The main objectives of the workshop were to:

- Generate a prioritised list of potential short-term and long-term industrial synergy opportunities.
- Identify the major benefits and possible obstacles in implementing these synergies.

- Propose an action plan for the next three months of the project.

7.3 Workshop Process

Prior to the workshop, all attendees were supplied with a table, presented in Section 6 that summarised the potential short-term and long-term synergy opportunities as well as the input-output summaries from each of the GAIN sites.

In the first half of the workshop two groups were formed based around the Gladstone City Council and Calliope Shire Council with an EPA Sustainable Industries representative and a Centre for Social Responsibility in Mining (UQ) in each group.

Each group was asked to rate the potential short-term and long-term synergies in relation to

- Benefit (is this a good synergy to do); and
- Achievability (how easy is this synergy to do)

with a rating of:

- high;
- medium; or
- low

The aim of the process was to identify the synergies that had the best potential of successful in the short-term and long-term. Figure 3 illustrates in graphic form the likely success of a synergy evaluated using the above process. The closer a synergy was to the top right corner that more attractive it was as an opportunity. Each group was given approximately 90 minutes to rate all the short-term and long-term synergies plus any additional synergies that arose from the group discussions.

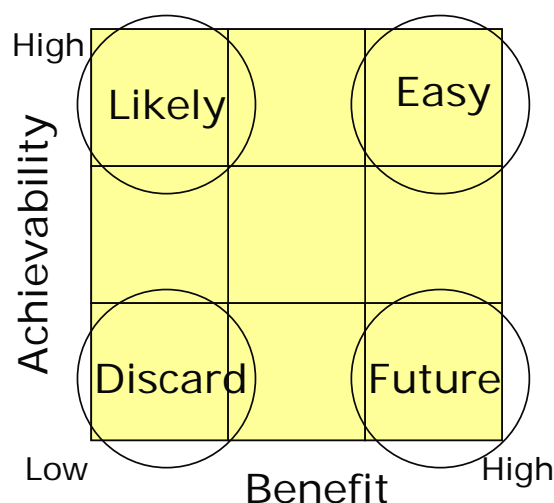


Figure 3 Synergy Grouping Chart

After the group sessions, each facilitator reported on the ratings for each synergy and other related findings from the group sessions. Of particular interest were the synergies that rated in the high benefit or high achievability sections – the top row and right-hand column in Figure 3.

Based on the ratings from each group, the potential synergies with the best chance of success were identified. Any possible obstacles that were identified were also reported.

7.4 Summary from group sessions

7.4.1 Groups

The two groups were:

- Gladstone City Council – George Bennetts (NRG), Judy Horsfall (CQPA), Greg Anderson (CQPA), Kylie Davey (QAL), Tom Boarder (GCC), Krrishnamohan Knaduri (EPA), Alicia Duddy (NRG), Robin Evans (CSRM)
- Calliope Shire Council - David Smirk (CAR), Alastair Pilbeam (EPA), Charlie Sotiris (CSC), Glen Pryce (BSL), Jillian Cowan (Orica), Victoria Thorn (Cement Australia), Jodie Orr (NRG), Albena Bossilkov (CECP), David Brereton (CSRM)

7.4.2 Short-Term Synergies

The benefit and achievability ratings of the short-term synergies are presented in Table 4. Where significant differences exist between the ratings from the two different groups, this was generally attributed to a lack of information within a group regarding a specific operation.

Table 4 Ratings of Short-Term Synergies

Key	Synergy	By-Product	Gladstone Shire			Calliope Shire		
			B	A	Comments	B	A	Comments
S1	Alternative fuel	Decontaminated boxes	M	H		M	M	Product stewardship
S2	Alternative fuel	Contaminated oils and grease	L	L		H	H	
S3	Alternative fuel	Bags and containers	L	L		H	M	50 -100 tonnes
S4	Alternative fuel	Met coke fine and dust	M	M		H	M	4,500 tonnes (briquette)/could go to CAR
S5	Alternative fuel	Waste tar	M	L		H	M	Teris could handle it and convert into liquid
S6	Alternative fuel	Spent cell linings	H	H		H	H	Transport issues
S7	Alternative fuel	Oily waste	L	L		L	H	
S8	Alternative fuel	Fabric Filters	M	H	70t from NRG	H	M	Also CAR/BSL/BSL/CA; 30 -40 tonnes collectively; need more research
S9	Alternative raw material	Dredged sand	H	L	Aggregate	M	M	CAR stage 2 – other major construction to take sand
S10	Alumina recovery	Used saltcake	M	L		H	L	
S11	Biomass	Waste wood	H	M	1,000 – 2000 tonnes; sawmills 70,000 tonnes	M	M	70,000 tonnes
S12	Collective purchasing	Caustic soda	H	M		L	L	
S13	Fertiliser	60% Ammonium nitrate	L	L		H	M	
S14	pH control	Lime dust from lime kiln	H	L		M	L	
S15	Road Base	Refractory bricks	M	L		M	H	Up to 8,000 tonnes/construction fill
S16	Water re-use	Treated effluent	H	H		H	H	

Note: B – Benefit; A – Achievability; H – High; M – Medium; L - Low

7.4.3 Long-Term Synergies

The benefit and achievability ratings of the long-term synergies are presented in Table 5. There was only limited time to evaluate these longer-term synergies.

Table 5 Ratings of Long-Term Synergies

Key	Synergy	By-Product	Gladstone Shire			Calliope Shire		
			B	A	Comments	B	A	Comments
L1	Steam generation	Steam from waste heat (cogeneration)	H	L	Limited time to evaluate – general feeling was that long-term synergies had a high benefit but were much harder to implement.	-	-	Limited time to evaluate – only discussed red mud and fly ash options.
L2	Desalination	RO, mechanical or thermal technology	H	L		-	-	
L3	CO2 removal	Carbon dioxide	H	L		-	-	
L4	SO2 scrubbing	Gypsum - flue gas desulphurisation	H	L		-	-	
L5	Lightweight bricks	Fly ash	H	L		-	-	
L6	Road base		H	L		H	M	
L7	Soil enhancement		H	L		-	-	
L8	Bricks	Red mud	H	L		-	-	
L9	CO2 sequester		H	L		-	-	
L10	Environmental control		H	L		H	M	

Note: B – Benefit; A – Achievability; H – High; M – Medium; L - Low

7.4.4 Other Findings

Other similar synergies and comments that arose during the course of the group sessions are reported in Table 6 and the rest of this section.

Table 6 Other Synergy Opportunities – Calliope Group

Synergy	By-Product	B	A
Recycle used containers	General containers	M	L
Alternative fuel	Create central collection point	H	H
Used saltcake	To red mud dam	H	M/L
Lime	Lime dust to CAR lime supply	M	M
Construction material	Collective crush concrete bricks	M	H
Trade effluent	Orica to CAR	H	H
Salt water	CAR to Orica cooling towers	H	H
Red mud	Cyanide tailings/Mt Morgan treatment	H	M

Note: B – Benefit; A – Achievability; H – High; M – Medium; L - Low

Other comments from the Gladstone City Council group sessions were:

- The need to include other adjacent regions such as Rockhampton and the coal fields as potential contributors and beneficiaries from the Gladstone synergies project.
- Maintain a focus on the efficiencies of supply of common raw materials as well as by-products e.g. the opportunities for the power station to expand the supply of demineralised water beyond their site to a number of industries in the Gladstone region.
- Identify alternative uses for buffer and reclaimed lands around operating sites.
- The possibility of fish farming using the heated cooling water from the power station.
- The supply of steam from the power station to the Gladstone City Council Hanson Road waste facility for sterilisation of waste.
- To give priority to occupational health and safety issues in by-product synergies.

7.5 Selected short-term and long-term synergies

Based on the results from the group sessions presented in Section 7.4, the high benefit and high achievability synergies were identified. From this list the synergies that had both a high benefit and high achievability were considered to be the opportunities with the best potential.

After the presentation of results from the two groups, the following two short-term synergies were identified as having the best potential for success:

- The consolidation of wastes for alternative fuels – the main idea of this synergy is to have a central facility for collecting and blending all the low volume wastes so that a sizeable alternative fuel source is available for operations such as Cement Australia. This would provide a more efficient disposal method of wastes, which in many cases are treated and sent to landfill, and an opportunity for Cement Australia, or other appropriate

industries, to use alternative fuels instead of burning non-renewal fuels such as coal.

- Water re-use or minimisation – Potentially there are several possibilities of water re-use including
 - Using treated effluent from Yarwun and South Trees plants as process water in nearby industries
 - Using the trade waste water from Orica to CAR
 - The re-using of sea water from the CAR red mud dam for new seawater cooling towers at Orica – the current plan is to return sea water from the red mud dam to Port Curtis via a pipeline.

Other short term synergies that were worthy of further investigation but did not rate as highly as those above were:

- Orica's ammonium nitrate solution as fertiliser – demand of liquid ammonium nitrate as a fertiliser is expected to increase as the change in the regulations now class solid ammonium nitrate as security sensitive ammonium nitrate. Liquid ammonium nitrate solution is not subject to the same regulation.
- Biomass as an alternative fuel source – the power station has already investigated the possibility of using wood waste, from such industries as Austicks, as a source of fuel and therefore improving the power station's position with regard to renewal energy certificates. The more significant source of material is sawmill waste, currently stockpiled at various locations.
- Central crushing facility for construction fill – refractory, kiln grade spar and other by-products that might be useful construction material could be collected and crushed in a central facility.

The selected long-term synergies were:

- Red mud opportunities – this synergy would incorporate a research component by trialling red mud to address the acid mine drainage problem at Mt Morgan. The aim of the project would be to use a by-product material, such as red mud, instead of virgin material, such as lime, to remediate the acid mine drainage problem. Stimulus for such a project should not come from the alumina industry but from an appropriate outside body or government organisation. In addition, the work that Orica have undertaken in the use of red mud to minimise the impact of cyanide tailings could develop into a similar-style project.
- Fly ash – this synergy involving the uses of flyash and bottom ash, such as construction material, road base or soil additive, may need enticements from government so that a case can be developed for more effective use of ash. About one third of the power station flyash is currently collected by Pozzolanic Enterprises for use as a cement additive whilst the remainder is sent to local ash bunds.
- SO₂ and CO₂ (much longer term) – a longer term synergy is the capture and re-use of sulphur dioxide for the production of sulphuric acid or gypsum. The basis for a synergy of this nature is capturing the large amount of

sulphur dioxide that is emitted to the atmosphere in the Gladstone air shed and producing a useful by-product that would be available to the local market. In the same vein the capture and re-use (possible sequestration with red mud) of carbon dioxide is another possible longer term synergy. The introduction of a carbon tax would be the single biggest driver for this synergy.

The outcomes from this workshop were presented to the GAIN Executive Committee on 2nd December 2004.

8. PROPOSALS FOR KEY SYNERGY OPPORTUNITIES

8.1 Introduction

The main goal by the end of the first year of the project (April 2005), as defined by the project agreement, was to complete and submit project proposals for a few specific industrial regional synergies initiatives to GAIN for endorsement.

Over the first three months of 2005, detailed project proposals were prepared for the two main potential synergies that were identified from the December workshop (Section 7):

- Consolidation of alternative fuels synergies
- Water efficiency synergies

The detailed project proposals:

- defined the main objective of the industrial synergy
- presented the benefits (financial, environmental and community) of implementing the industrial synergy
- identified any regulatory constraints that need to be addressed
- produced an estimated costing
- outlined a project plan and timeframe

Simplified project proposals were also prepared for the other short-term synergies that were identified during the workshop whilst more general proposals were prepared for the main longer-term synergy initiatives – refer to Section 7.5.

8.2 Consolidation of Wastes for Alternative Fuel

8.2.1 Objective and overview

To realise the collective alternative fuel benefits of wastes and by-products via a central collection and blending facility.

The main aim of this synergy initiative is to extract heating value from waste and by-products which are generated in low volumes by using a central collection facility to prepare a homogenous alternative fuel in significant quantities and on a regular basis. This alternative fuel could then be used as a coal replacement for the local industries.

8.2.2 Benefits

8.2.2.1 Financial

The main financial incentive for alternative fuels is to reduce the use, and therefore cost, of coal. Current steaming coal prices range from \$50 to \$70 per tonne (Grant-Taylor 2005). For an operation like Cement Australia which uses about 285,000 tonnes of coal per year a 5% reduction in coal consumption would result in a savings somewhere between \$700,000 and \$1,000,000.

A 5% reduction in coal consumption will require an alternative fuel that will supply the equivalent amount of heating. For the case of Cement Australia, 5% of their annual coal consumption is approximately equal to 425,000 GJ of energy, assuming a calorific coal value of 30 MJ/kg.

In addition, special feeding systems need to be constructed and installed to feed alternative fuel material. This is typically capital intensive and thus alternative fuels are required in large enough quantities and must be available on a regular basis to warrant the investment in such systems. Currently, Cement Australia has operating systems in place for feeding liquids (solvent-based fuels system) and particulate material (pneumatic system for calcined spent cell liners from Boyne Smelters). Cement Australia also have a de-commissioned conveyor feed system which could be used for feeding solids material, such as shredded alternative fuels, to their clinker kiln. The estimated cost of re-commissioning this system is between \$2 and \$3 million (Schwarer 2005). Because of the cost of installing a new feed system, the user of the alternative fuel can charge a fee for receiving the alternative fuel.

Another important factor is the effect that alternative fuel has on the process and emissions. As alternative fuels cannot compromise the quality of the final product nor can they create emissions that violate the environmental regulations, appropriate tests and trials are conducted to ensure that there are no adverse process or emission effects. This process was recently undertaken with the spent cell linings.

There are also benefits for the generators of the wastes and by-products. One of the biggest potential benefits is the reduced risk associated with the disposing of hazardous materials. Instead of treating hazardous materials to reduce their danger to the environment before possibly going to landfill, these materials could be transported, a relatively short distance, to a central waste facility for processing into an alternative fuel. In many cases, this should present a more acceptable path for disposal of hazardous waste materials. To make this path more financially attractive, the fees for removing a hazardous waste for treatment within a few kilometres of the site would need to be equal or less than the current disposal methods. Industries face significant charges for the disposing of wastes to landfill. Some of these wastes could be processed into alternative fuels.

A regional waste facility operated by a waste management company, similar to the waste transfer facility at QAL on a regional scale, could be the central hub for the collection of industrial waste for re-use, recycle or re-selling. (The old Ticor site, which was acquired by Transpacific Industries Pty Ltd, is a possible location for a regional waste facility.) By collecting many low volume wastes, the facility would be able to prepare, by possibly crushing, blending and mixing, a significant alternative fuel source. To utilise the calorific potential of low volume wastes such a facility like this is essential. Neither Cement Australia nor probably any other user of alternative fuels are interested in investing time and money to receive only small quantities of waste as an alternative fuel source.

Table 7 illustrates some of the available waste that could be used as an alternative fuel source and the potential fuel and financial savings. This table shows that the amalgamation of wastes generated in low volumes could produce a realistic alternative fuel source, provided these materials did not violate process and emission constraints.

Table 7 Example of Potential Alternative Fuels from Industry and Estimated Fuel Costs

<i>Alternative Fuel</i>	<i>Source</i>	<i>Annual Amount (t)</i>	<i>Spec Calorific Value (MJ/kg)</i>	<i>Energy (GJ)</i>	<i>Equivalent Coal (t)*</i>	<i>Annual Fuel Savings**</i>
Boxes	Orica	300	16	4800	160.0	\$11,200
Bags and Containers	Orica	75	5	375	12.5	\$875
Contaminated oils & grease	Orica	0.2	40	8	0.3	\$19
Metcoke fines and dust ¹	BSL	4500	15	67500	2250.0	\$157,500
Waste tar	BSL	61	40	2440	81.3	\$5,693
Oily waste	CAR	910	30	27300	910.0	\$63,700
Fabric filter bags	BSL/CAR	70	10	700	23.3	\$1,633
TOTAL				103123	3437.4	\$240,620

* assumed calorific value of coal = 30MJ/kg;

** estimate coal price = \$70/tonne

Although no quantities have been identified, small to medium size businesses could provide another source of wastes that could be converted to alternative fuels.

The other main potential source of alternative fuel is domestic waste. From the 2001 census results there are approximately 14,000 households in the Gladstone and Calliope Shires (www.abs.com.au 2001). Based on indicative figures (www.orer.gov.au 2001) this could equate to a significant quantity, possible thousand of tonnes per annum, of alternative fuel. An added incentive is that there is increasing demands in the region to prevent waste from ending up in landfill.

8.2.2.2 Environmental

The main environmental benefits of using alternative fuels are:

- Safer removal of wastes, some of which are being treated and sent to landfill at significant cost to the waste generator.
- Reduction in coal consumption, a non renewal resource, and likely reduction in generation of CO₂
- Reduction in emissions through the use of alternative fuel compared with coal

8.2.2.3 Community

One of the main benefits of this initiative is that it will reduce the quantity of waste going to land fill. This is an important consideration as the life of the landfills in the region is limited. As local councils are discouraging disposal to landfill, alternative methods of waste disposal will have community benefit.

8.2.3 **Regulatory Constraints**

There should be no unusual regulatory requirements for implementing this synergy. The main issues with regulation compliance are in:

¹ Cement Australia and BSL have has discussions regarding this waste as an alternative fuel

- transportation and handling of regulated wastes
- storage of hazardous and regulated wastes
- stack or clinker kiln emissions

The main component of this synergy would be the collection, transportation and processing of wastes which would be handled by one or more waste management companies. These companies should be familiar with the necessary licensing requirements and the associated process for obtaining these licences.

In summary, although there may be a number of regulations that need to be satisfied for generating alternative fuels from wastes, the process for obtaining the necessary licences is expected to be well defined.

In principle, the local EPA supports an industrial synergy of this nature which should lead to an efficient and cost effective reduction in wastes from both industry and the community.

By extracting energy from waste that would normally go to landfill, the Gladstone region would be following the principles of the waste hierarchy, outlined in the Environmental Protection (Waste Management) Policy 2000, Environmental Protection Act 1994 – that is, recovering energy from waste is better than disposing waste to landfill.

8.2.4 Costing

The main areas of costing are:

- Charges associated with waste removal - the cost of disposal of some wastes are in the order of ten of thousands dollars to hundreds of thousands of dollars over the region. The disposal of fabric filters in of the order of ten of thousands of dollars whilst the annual disposal costs of hazardous wastes, such as those contaminated with cyanide or nitrates, is of the order of hundreds of thousands of dollars. These indicative costs suggest that there is sufficient incentive for industry to dispose of waste in a more environmental friendly and less costly manner.
- Costs of producing a homogenous alternative fuel – If the success of the waste transfer facility at QAL is an indication, then a regional waste transfer facility should be a viable financial venture. One of the capabilities of this facility would be the preparation of alternative fuel from waste. The preparation in producing blended wastes to the desired specifications to meet the alternative fuel requirements does require further research – CQU through the PELM centre are intending to fund a Masters project in this area. Other similar style facilities exist such as the Eastern Creek UR-3R Facility in NSW. Similar to the TPI-operated waste transfer facility at QAL, long term contracts between all parties appear to be a requirement for a successful regional waste facility. This would allow the operator of the facility to invest in the necessary infrastructure for producing homogenous alternative fuels.
- Savings on the consumption of traditional fuel (coal) – with the expected increasing coal prices there is a stronger financial driver to use more alternative fuel. A 5% to 10% savings in coal consumption at Cement Australia would produce an approximately financial savings of about \$700,000 to \$2,000,000 per annum, assuming the price of coal is in the range

of \$50 to \$70 per tonne (Grant-Taylor 2005). Based on a initial cost of commission the existing conveyor feed system of \$3,000,000 at Cement Australia and an annual savings of \$900,000 (coal savings less operating cost), the return on investment is 20% for equipment lifetime of 6 years. This analysis is based on the assumption that Cement Australia would receive the alternative fuel for free.

Figure 4 is a schematic illustrating the waste flows and an alternative fuel flows with associated benefits.

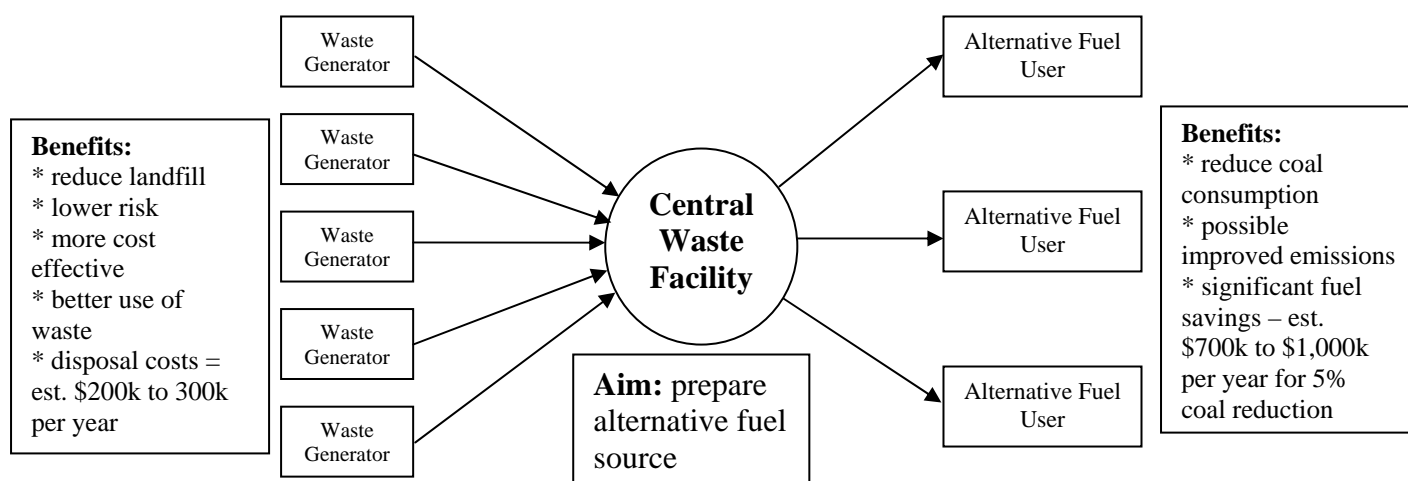


Figure 4 Overview of Consolidation of Alternative Fuels

8.2.5 Project Plan

The proposed plan for this project is to:

- July 2005 – complete research into similar facilities in Australia and overseas to identify factors for success and potential obstacles (SMI)
- October 2005 – identify and quantify wastes from small to medium businesses in the Gladstone region and other waste sources in neighbouring region, such as Rockhampton (SMI)
- December 2005 – complete detailed composition analysis including calorific value of potential alternative fuel wastes in Gladstone region – analytic testing to be funded by waste generators. CQU are planning to fund a Masters student to investigate technical area of combining wastes to produce an alternative fuel (CQU/SMI)
- April 2006 – Aim to conduct trial of sample homogenous alternative fuel produced by waste from Gladstone region (Cement Australia/waste company/CQU)
- September 2006 – Final report on consolidation of waste for alternative fuel project report (SMI).

8.3 Water Efficiency Synergies

8.3.1 Introduction

The document presents the proposal for four water re-use schemes to minimise water usage from Awoonga dam:

- Effluent re-use from the South Trees sewerage treatment plant;
- Effluent re-use from the Yarwun sewerage treatment plant;
- Re-use of trade waste water from Orica at the Comalco Alumina Refinery; and
- Re-use of the sea water from Comalco Alumina Refinery 'red mud' dam as cooling water at Orica.

8.3.2 South Trees Sewage Treatment Plant Effluent Water Re-use

8.3.2.1 Objective

The objective of this scheme is to reduce consumption of water from the Awoonga Dam by utilising the secondary treated effluent water from the South Trees Sewage Treatment Plant at QAL.

In December 2004 Kellogg Brown and Root (KBR) submitted a report (KBR 2004) to the Gladstone City Council on planning for the existing and future water and wastewater infrastructure requirements for Gladstone City up to 2030. Part of this planning study included the two existing council wastewater facilities, Calliope River Sewage Treatment Plant and the South Trees Sewage Treatment Plant. As part of this study, KBR investigated the possible options for effluent from the South Trees plant, one of which was re-use of the effluent at QAL and the other was installing a bio-nutrient removal capabilities.

The South Trees STP plant has a current rated capacity of 5,000 equivalent persons (EP) and currently discharges secondary treated effluent at a rate of approximately 0.48 ML/day. With the expected increase in population in the catchment area (Glen Eden, O'Connell, South Trees and 50% of Kirkwood) the discharge is expected to increase to about 0.72 ML/day in 2006, about 1.39 ML/day in 2011 and about 2.48 ML/day in 2021.

8.3.2.2 Benefits

Financial

In conducting this study, KBR investigated and analysed the potential to transfer the effluent to QAL or to convert the existing plant to bio-nutrient removal (BNR) capabilities to meet expected stricter EPA discharge regulations. The financial analysis for these two options is summarised below:

Option 1–Discharge of effluent to QAL via a 5.5 km pipeline and associated pump station

- This option applies if all plant effluent is discharged to QAL for reuse, and nitrogen and phosphorus reduction is not required.
- Construct a 5.5 km pipeline from South Trees STP to QAL, and effluent pumping station at South Trees STP.
- Duplicate existing plant by 2010 to increase capacity to 10,000 EP.

- Further augment plant in 2021 to 15,000 EP capacity.

Option 2–Conversion and augmentation of existing plant to BNR capabilities

- Convert the existing plant to BNR capability by 2008;
- Construct new 5,000 EP BNR plant by 2010; and
- Further augment plant in 2021 (as BNR facility) to 15,000 EP capacity.

To compare the two options, KBR performed a cost analysis with the capital works of each option commencing in the same year. The total estimated cost for option 1 was \$9,445,000 (from Table 11.4, KBR 2004) and for option 2 was \$10,050,000 (from Table 11.5, KBR 2004). NPV analyses based on construction programs and costs were also conducted to rank the options on a financial basis. At three discount rates used (4%, 6% and 8%) the options rated the same and at the 6% discount rate the difference of 0.3% was less than the accuracy of the estimates. In essence there was no financial advantage of one option over the other. Even when the analysis was repeated taking into consideration the possible government subsidies (40% of capital cost for re-use facilities and 40% for additional costs of including a BNR facility) the difference at the 6% discount rate was 3%, which was less than the accuracy of estimates.

As both options were of equal costs, KBR recommended that option 1, the re-use at QAL, was considered the more appropriate option as it was considered that with time it will become more difficult to discharge to waterways, especially to waterways that discharge to marine environments.

In terms of expected savings in GAWB water, the additional 1.39 ML/day of effluent expected to be discharged in 6 years (2011) would net a savings of approximately \$420 per day, assuming an approximate price of \$300 per ML of Awoonga Dam water (GAWB 2004). Even if QAL only paid for the pipeline the payback period would be of the order 6 to 10 years depending on whether or not a government subsidy could be secured. On a take-or-pay basis for GAWB water there would be no financial incentive to use treated effluent.

The benefit of such a system is during periods of water restriction, as was the case with the Calliope River effluent re-use scheme. Under these circumstances, the value of 1 ML of water could be directly related to the reduction in production if that 1 ML of water were not available. Based on recent data, QAL use about 13,100 ML of Awoonga Dam water per year, so 1.39 ML per day is about 3.8%. Assuming a similar reduction in production, this would result in a drop in alumina production of about 2,780 tonnes per week or about \$390,000 per week, assuming about \$140 per tonne of alumina (Russell 2005). In addition the fresh water savings of 3.8% would make a considerable contribution to any future water reduction targets.

Environmental

The environmental implications of re-using the South Trees STP effluent at QAL are:

- By 2011 approximately an additional 1.4 ML per day of Awoonga Dam, increasing to approximately an additional 2.5 ML per day in 2021, would be available for other industrial or community uses. On current water usage at QAL this would result in a reduction of about 4% to 7%.
- Treated effluent would not be discharged to a waterway that discharges to a marine environment

Community

The main community benefit is that additional Awoonga Dam water, about 1.4 ML per day (or 510 ML per year) in 2011 and about 2.5 ML per day (or about 905 ML per year) in 2021, is available to the community or other industries. Based on an usage of 255 L/EP/day ((KBR 2004), water would then be available to an additional 5,490 persons in 2011 and an additional 4,310 persons in 2021.

8.3.2.3 Regulatory Constraints

The regulatory considerations would be very similar to that for the Calliope River STP effluent re-use project completed in 2002 (Doak 2004b).

In principle, the local EPA supports an industrial synergy of this nature which leads to efficient re-use of water and thus reduces water consumption from Awoonga Dam.

8.3.2.4 Costing

The costing of the project has been summarised in Section 8.3.2.2 and is presented in detail in Section 11.3 in (KBR 2004).

8.3.2.5 Project Plan

As there is no technical research component to this project, no research plan is proposed. When necessary, appropriate support could be provided through the Gladstone Regional Synergies Project to assist in the implementation of this water re-use scheme. The water re-use scheme should be a straightforward engineering project and the plan is presented in Section 11.3 in (KBR 2004).

From a research perspective, the interest is related to the risk aspect of the business case for justifying this project.

8.3.3 Yarwun Sewage Treatment Plant Water Re-use

8.3.3.1 Objective

The objective of this scheme is to reduce consumption of water from the Awoonga Dam by utilising the secondary treated effluent water from the Yarwun Sewage Treatment Plant in the Yarwun industrial estate at the Comalco Alumina Refinery (CAR).

The effluent from the Yarwun STP, which has a capacity of 2000 EP, typically discharges between 1 to 2 ML per day (Murrell 2005). Currently this is used for irrigation purposes on-site. Calliope Shire Council and CAR have had discussions regarding re-using the treated effluent in the red mud washing process at CAR, similar to the re-use of the Calliope River STP effluent at QAL.

8.3.3.2 Benefits

Financial

There would probably be little or no financial benefit in implementing a scheme based on current water prices, especially under a take-or-pay system. The benefit of this scheme is during periods of water restrictions. By re-using Yarwun Sewage Treatment Plant effluent, CAR would be virtually guaranteed 1 to 2 ML of process water per day.

The additional production rate as a direct result of re-use water with water restrictions in place would be likely to justify the capital cost in a matter of weeks. This is illustrated by the analysis below.

Based on the:

- estimated water savings of 1 to 2 ML/day (between 10 to 20% of fresh water usage),
- an assumed cost of \$400 per tonne of alumina (Clark 2005),
- the estimated cost of constructing a pipeline and a new pump station of \$2,500,000², and
- expected operating costs of \$40/ML (based on data presented by Doak (2004a)),

the payback period for installing the infrastructure would be between 2 to 5 weeks.

This analysis is based on an annual alumina production of 1,325,000 tonnes and assumes a roughly linear relationship between water use and alumina production (that is a 10% reduction in water will result in a 10% reduction alumina production).

Even though future water reduction targets have not been set at CAR as it is still in the commissioning phase, re-using effluent water would be a significant contributor to meeting the future Rio Tinto water target of “a ten percent reduction in fresh water withdrawn per tonne of product from 2003 to 2008” (www.riotinto.com 2003).

Environmental

The environmental implications of re-using the Yarwun STP effluent and Yarwun industrial estate trade wastewater at CAR are the availability of an additional 1 to 2 ML per day for other industrial or community uses.

Community

The main community benefit is the same as the main environmental benefit in that about 1 to 2 ML per day of additional Awoonga dam water would be available to the community or other industries.

8.3.3.3 Regulatory Constraints

The regulatory considerations would be very similar to that for the Calliope River STP effluent re-use project completed in 2002 (Doak 2004b).

In principle, the local EPA supports an industrial synergy of this nature which leads to efficient re-use of water and thus reduces water consumption from Awoonga dam.

8.3.3.4 Costing

The estimated costs have been presented in Section 8.3.2.2. If water restrictions were in place, the estimated pay back period would be between 2 to 5 weeks which would result in a substantial RIO or NPV over the life of the equipment.

8.3.3.5 Project Plan

As there is no technical research component to this project, no research plan is proposed. When necessary, appropriate support could be provided through the Gladstone Regional Synergies Project to assist in the implementation of this water re-use scheme.

² From KBR report ~3500m @ \$290/m + \$500,000 PS + \$1,000,000 at CAR

This water re-use scheme should be a straightforward engineering project, similar to the project of Calliope River Sewage Treatment effluent re-use at QAL.

From a research perspective, the interest is related to the risk aspect of the business case for justifying this project.

8.3.4 Trade Waste Re-use

8.3.4.1 Objective

The objective of this scheme would be to use the trade waste water for Orica at the Comalco Alumina Refinery (CAR). This trade waste pipeline runs along the CAR front boundary.

Orica typically discharges on average about 0.75 ML per day through the trade waste facility. This treated water is eventually pumped to storage tanks near the corner of the Landing Road and Port Cutis Way and then discharges to The Narrows. With the expansion in ammonium nitrate production to over 600,000 tpa, the trade waste flowrate is expected to double (Cowan 2005).

8.3.4.2 Benefits

Financial

The financial benefits of this scheme would be similar to that of re-using effluent from the Yarwun sewage treatment plant. That is, there is little or no incentive in terms of savings based on the price of water, especially under a take-or-pay system, but substantial savings if water restrictions are in place resulting in reduced alumina production.

As the Orica trade waste pipeline runs pass the front of CAR and Hanson Road, minimal equipment and piping would be required for CAR to access this waste water.

One condition of re-using the trade waste is that the quality would satisfy the proposed duty. About 1.5 ML/day will be available at the completion of the ammonium nitrate expansion in 2006 (www.orica.com.au 2004).

As for the re-use the Yarwun STP effluent, re-using the Orica trade waste would make a significant reduction in fresh water consumption per tonne of product.

Environmental

Similar to re-using the Yarwun STP effluent, the environmental implications of re-using the Orica trade wastewater at CAR are:

- an additional 0.75 up to 1.5 ML per day (on completion of the Orica expansion) would be available for other industrial or community uses.
- trade waste water would not be discharging to The Narrows.

Community

The main community benefit is that about 0.75 up to 1.5 ML per day (on completion of the Orica expansion) of additional Awoonga dam water would available to the community or other industries.

8.3.4.3 Regulatory Constraints

As the trade waste water would be no longer discharging to The Narrows, no regulatory constraints are anticipated.

In principle, the local EPA supports an industrial synergy of this nature which leads to efficient re-use of water and thus reduces water consumption from Awoonga dam.

8.3.4.4 Costing

Based on an estimated cost for piping, pumps and auxiliaries to transfer the waste water from the trade waste pipeline at the front boundary of CAR to the appropriate part of the plant (presumably the red mud washing process) of \$1.5 million³ and the expected water savings of 0.75 to 1.5 ML/day (7.5% to 15% of fresh water usage), the payback period based on the savings in alumina production during time of water restrictions is about 2 to 4 weeks, assuming an alumina price of \$400 per tonne. This would result in a substantial RIO or NPV over the life of the equipment.

8.3.4.5 Project Plan

As there is no technical research component to this project, no research plan is proposed. When necessary, appropriate support could be provided through the Gladstone Regional Synergies Project to assist in the implementation of this water re-use scheme.

As for the Yarwun STP effluent re-use scheme, this would be a straightforward engineering project.

Also as for the other projects, the research interest is related to the risk aspect of the business case for justifying this project.

8.3.5 *Seawater Re-use*

8.3.5.1 Objective

The objective of this scheme is to reduce consumption of water from the Awoonga Dam by utilising sea water from the Comalco Alumina Refinery 'red mud' dam in sea-water cooling towers at Orica.

CAR uses seawater in the transportation and neutralisation process of the red mud. After treatment at the residue storage area, approximately 0.5 ML/hr of sea water is returned to the ocean in a pipeline that runs along the CAR/Orica border (Clark 2005). Some of this seawater could be used in new cooling towers that will be installed as part of the Orica ammonium nitrate expansion. This should result in a significant savings in fresh water; currently 54% of the region's water is used in evaporative cooling of industrial processes (GAWB 2004).

The nitric acid plant that has been purchased by Orica for their expansion has equipment (two or three pumps and a heat exchanger) suitable for using salt water and sea water cooling towers (Cowan 2005).

8.3.5.2 Benefits

Financial

As for the other water re-use proposals, the financial benefits of this proposal are extremely strong if fresh water is not available resulting in reduced production of ammonium nitrate. Sea water cooling towers could be installed for the 300,000 tpa ammonium nitrate expansion that will increase Orica's production of ammonium nitrate to 600,000 tpa. If sea water cooling towers were not installed and water restrictions were such that production had to be reduced by 10% then the drop in

³ Scaled estimate based on estimate for Yarwun STP re-use scheme.

revenue due to loss production would be about \$350,000 per week, assuming an ammonium nitrate price of \$300 per tonne (Cowan 2005).

In addition, the fresh water savings would make a substantial contribution to the Orica target of 25% reduction in fresh water usage per tonne of product by 2010.

Environmental

If fresh water cooling towers were installed in the new plant which will produce 300,000 tpa of ammonium nitrate, the expected evaporative and blowdown losses would be of the order of 2 to 3 ML/day (*this is an only estimate as it has not yet been possible to obtain a more accurate figure from Orica*). If sea water cooling towers were installed then this amount of fresh water would be available for other industrial or community uses.

Community

The main community benefit is that about a few extra ML per day of additional Awoonga dam water would be available to the community or other industries.

8.3.5.3 Regulatory Constraints

There are no expected regulatory constraints. Some minor issues with sea water cooling were discussed in “Water in Mining” paper on proposed water reduction measures at QAL (Stegink et al. 2003).

In principle, the local EPA supports an industrial synergy of this nature which leads to efficient re-use of water and thus reduces water consumption from Awoonga dam.

8.3.5.4 Costing

The estimated additional capital investment for sea water cooling towers compared with fresh water cooling towers is about \$10,000,000. This figure is based on the estimated additional cost to convert CAR cooling towers to sea water and the relative difference in cooling water flowrate between the two sites. The scaling formula for cost of equipment from “Plant Design and Economic for Chemical Engineers” (Peters et al. 2003)⁴ was used to arrive at this estimate.

If seawater cooling was installed in the new nitric acid plant, then half the ammonium nitrate production or 300,000 tpa would be produced from a seawater cooled plant. If under severe water restrictions it was possible to continue to operate the seawater cooled plant but not the fresh water cooled plant then approximately an additional 6,000 tonnes of ammonium nitrate per week (300,000 tpa equivalent) could be produced compared with if both plants were fresh water cooled. Therefore, the additional revenue would equal approximately \$1,800,000 per week, assuming an ammonium nitrate price of \$300 per tonne (Cowan 2005). After 6 weeks of water restrictions the additional revenue would have covered the costs of the sea water cooling towers.

As for the other water re-use schemes, the benefits of this scheme are apparent during severe water restrictions. The other significant benefit is the scheme’s contribution to the 2010 water reduction target.

⁴ (cost of equipment a) = (cost of equipment b) * (capacity a/capacity b)^{0.6}

8.3.5.5 Project Plan

As this stage there does not appear to be any technical research component to this project, and therefore no research plan is proposed. When necessary, appropriate support could be provided through the Gladstone Regional Synergies Project to assist in the implementation of the sea water cooling towers.

This project should be a straightforward engineering project.

As for the other projects the research interest is related to the risk aspect of the business case for justifying this project.

Due to the pressures of completing the expansion as soon as feasibly possible, the new plant will be initially commissioned with a fresh water cooling system. The complication of installing and commissioning a sea water cooling system would delay the project at a time when there is high demand for ammonia nitrate. However, at some stage in the future the new plant could be converted to a sea water cooling system, especially as some of the installed equipment is suitable for handling salt water.

8.3.6 *Summary*

The implementation of any of these proposals as projects can not be justified on current water price strategies and the assumption that there will always be sufficient Awoonga Dam water for all industries and the community. The benefit in implementing these projects is that a certain fraction of the water supply will be almost guaranteed during any future water reductions. Implementation of any these water re-use schemes is analogous to taking out insurance and the cost of the project is the premium; during any water restrictions in the Gladstone region, industries that are re-using water have a far better chance of remaining at full production. It is this aspect of these projects that is of interest from a research perspective; the balance between the risk of lost production compared with the chance of water restrictions over the life of the operation.

The other important factor is that these water re-use projects would make considerable contributions to the corporate water targets for the future. These projects are a relatively cost effective means for producing significant reductions in water use per tonne of product.

If all strategies were implemented the possible savings in Awoonga Dam water is estimated to be in the range of 4 to 7 ML/day.

8.4 **Short-Term Synergy Opportunities**

8.4.1 *Liquid Ammonium Nitrate Re-use*

8.4.1.1 Objective and overview

To distribute the fertiliser solution comprising 60% liquid ammonium nitrate, a by-product from the Orica ammonium nitrate process, to local agriculture industry.

Solid ammonium nitrate is now classed as security sensitive whilst liquid ammonium nitrate is not subject to the same regulation. Consequently, the demand for liquid ammonium nitrate as a fertiliser is expected to increase.

8.4.1.2 Benefits

The current market for this by-product is Bundaberg Sugar. As the demand is seasonal, approximately 4 months a year, Orica are required to store the liquid ammonium nitrate for the remainder of the year. The fertiliser solution is sold through Incitec Pivot; Orica owns 70% of this company. Selling the product year-round to a local customer would be in Orica's interests.

The local agriculture industry would be able to purchase a fertiliser solution without the concerns of dealing with a security sensitive product.

8.4.1.3 Regulatory Constraints

As this by-product is currently being transport and sold to Bundaberg sugar the same regulatory constraints should apply to customer in the local area.

8.4.1.4 Costing

If this by-product is sold all year round the maintenance and storage costs would be significantly reduced. Instead of storing the by-product for up to eight months a year the storage time would be much less, possibly a week to a month. No estimates on these costs have been produced at this stage.

8.4.1.5 Project Plan

As there is not a significant research component with this project, there is no research plan but appropriate support could be provided through the Gladstone Regional Synergies Project.

This proposed support plan is to:

- Liaise with Incitec Pivot on potential markets for the fertiliser – July 2005

8.4.2 *Biomass as an Alternative Fuel Source*

8.4.2.1 Objective and overview

To use biomass from the local timber industry as an alternative renewable energy source for the power station.

By using biomass as a renewable energy source, the power station will be able to generate renewable energy certificates in line with the *Renewable Energy (Electricity) Act 2000*. The act requires generators to produce an additional 9,500 gigawatt hours of extra renewable electricity per year by 2010. Renewable Energy Certificates are generated for every MWh of electricity generated from a renewable resource.

8.4.2.2 Benefits

Sawmill wood waste from the surrounding area could be potentially used as a renewable energy source. With increasing coal prices and increasing Renewable Energy Certificates prices, there is significant incentive to use biomass as an alternative fuel source.

8.4.2.3 Regulatory Constraints

There should be no unusual regulatory requirements for implementing this synergy.

8.4.2.4 Costings

No costings on this proposal have been conducted. The power station has been investigating the viability of wood waste as a renewable energy source.

8.4.2.5 Project Plan

There appears to be little research in the project and as such the Gladstone Regional Synergies project would only play a supporting contribution in its implementation.

8.4.3 Central Crushing Facility

8.4.3.1 Objective and overview

To collect and process (crushing and screening) by-products, such as kiln grade spar and refractory, that would be suitable for construction purposes.

8.4.3.2 Benefits

Currently by-products that are could be suitable as construction material are typically stored on site. For instance at Boyne smelters there are about 8,000 tonnes of refractory and over 17,000 tonnes of kiln grade spar (KGS), stored in a mono cell for easy access in the future. Supplying construction material is not part of Boyne smelters core business, so a more attractive option is to allow a contractor to remove the by-product and prepare the construction material at their local central facility. The TPI facility at the old Ticor site could be a possible central facility that could fairly cheaply prepare aggregate (using crushing and screening equipment) for used in the Gladstone region. Unlike a quarry there would be no mining costs for the raw material only the transport costs.

This synergy would solve the problem of by-product storage at site and could provide what should be relatively cost effective construction material to the local councils for road, bunds, fill etc.

8.4.3.3 Regulatory Constraints

As the material is inert and not a regulated waste, there should be no major regulatory constraints.

8.4.3.4 Costing

There are similar models operating elsewhere in Australia (see www.resourceco.com.au). The recycler or resource recovery company would be paid to remove the by-product for a similar cost that is no more than the cost of storing it on site. By providing a financial incentive for a recycler to remove the by-product, they then have a greater margin to sell the recycled product at a cost-effective price.

Based on expected prices of between \$8 and \$10 per tonne, the expected revenue could be between about \$200,000 and \$250,000 for 25,000 tonnes of material currently at Boyne smelters. The current annual production of KGS is around 11,000 tonnes which could substantially decrease if Cement Australia continues to receive spent cell lining as an alternative fuel source. As a consequence, the available material that could be used for construction purposes or road base could be more of the order of 5000 tonnes per year.

8.4.3.5 Project Plan

As there is not a significant research component with this project, there is no research plan but appropriate support could be provided through the Gladstone Regional Synergies Project.

The proposed support plan is to:

- Work with relevant industries and local councils to establish the potential market in the region for aggregate – October 2005.

8.5 Long-Term Synergy Opportunities

8.5.1 Red Mud Initiative

8.5.1.1 Objective and overview

The objective of this initiative is to investigate the options for re-use of red mud not only from a technical perspective but from a regulatory, financial and liability perspective.

The make-up of red mud means that it can be the solution to environmental degradation, such as the acid mine drainage problem at Mt Morgan mine site. Although its alkalinity and iron hydroxide absorbent properties lend it to treating acid mine drainage problems, there are other non-technical factors such as financial and legal liability that limit the re-use options of this by-product. What is different about red mud compared with other neutralant materials such as quicklime is that red mud is a large volume by-product from the alumina industry. Other potential materials that are industrial by-products, such as lime kiln dust and magnesium oxide dust, are produced in much lower quantities.

8.5.1.2 Benefits

The main benefit of this strategy would be to identify a market for red mud and in doing so produce a more sustainable solution than using other products produced from “virgin” material to solve environmental degradation.

A research programme of this nature would need to investigate several different aspects of the remediation process for environmental degradation. Some of the factors that are currently known obstacles for re-using wastes or by-products include:

- Transportation costs – as the approximate cost for the disposal of red mud is about \$5/tonne, there is little incentive for a refinery to dispose of or re-use red mud in another manner beyond a certain distance as the transport costs make it uneconomic. If some incentives were introduced, such as tax deductions, for re-using a by-product this would make alternative solutions more attractive.
- Liability – a major concern with the re-use of red mud, especially if it is to be used to remediate environmental degradation, is the liability implications. This can be a strong disincentive for alumina refineries not to consider alternative uses for red mud but to continue to store the material in the red mud dam.
- Market demand – as re-use of red mud is not part of the alumina industry’s core business, the successful re-use of red mud should be driven by outside organisations such as government departments or organisations. By creating a demand for red mud from outside the industry, this avoids the perception that the alumina industry is trying to find another “home” for its waste.

The initial case study would be at Mt Morgan where, if remediation was successful, it would become an iconic site reference; a large volume by-product from the alumina industry would have provided the solution to a major Queensland mining industry environmental problem.

8.5.1.3 Project Plan

At this stage, discussions have been initiated with Comalco regarding the potential funding of this strategy and related projects through the Rio Tinto Foundation. Projects associated with the strategy could be run through the Centre for Sustainable Resource Processing as they align with the vision and mission of this centre. This proposed plan is:

- October 2005 – Prepare a detailed project proposal for investigating the known obstacles for the re-use of red mud.

8.5.2 *Ash Initiative*

8.5.2.1 Objective and overview

The objective of this initiative is to investigate realistic opportunities for fly ash and bottom ash from coal-fired power stations.

About a third of the fly ash generated by the power station is already collected by Pozzolanic Enterprises for use as a cement additive. Although a number of opportunities for fly ash and bottom ash have been identified, such as light-weight bricks, road base stabilisation and soil additives there are few cases in Australia where ash had been used in producing these products in a commercial manner.

8.5.2.2 Benefits

The benefit of this initiative is to attempt to find alternative uses for fly ash and bottom ash as it becomes more difficult to dispose of the ash to local bunds. Although this allows for reclamation of land it is not envisaged that this practice can continue well into the future although currently the power station has contract obligations to the port authority to supply fly ash for this purpose.

Fly ash is classified as a regulated waste unless the fly ash is used, or intended to be used, as a raw material in a commercial manufacturing process (ecoaccess 2004). Under these circumstances it is not necessary for the transportation of fly ash to comply with the appropriate regulations on waste tracking. So the re-use of waste in the construction industry essentially removes the regulated waste tag for fly ash, thus meaning fewer regulations to satisfy compared with storage in local bunds.

The problems facing the re-use of fly ash are not dissimilar to that of red mud. Both by-products can be re-used but are in competition with other more readily available and cheaper raw materials. Under current licensing and operating conditions there is little or no incentive to change traditional practices of continuing to send fly ash that is not used in the cement industry to local bunds. However, there are two likely drivers for creating change: if the properties of fly ash can produce some superior quality in the product in which it is re-used (such as strong light weight bricks) or changes in the regulations for the disposal of regulated waste limit (or eventually prevent) the disposal of ash to local bunds.

As mentioned above several possible re-uses of both fly ash and bottom ash have been investigated and identified, but as yet the business case to implement such alternative uses for ash is limited, especially if the ash is not generated near large potential markets. One of the projects within the Co-operative Research Centre for Sustainable Resource Processing aims to develop the necessary chemical and structural understanding of geo-polymers made from waste products, including fly ash, so that a

significant share of the ready mixed and precast concrete market can be captured for a given industrial region.

Other potential products that re-use flyash:

- TecEco technologies produce Tec, Enviro and Eco-cements using significant quantities of flyash
- Pozzolanic Enterprises are investigating the potential to use fly ash as a soil additive
- Road base for local councils and Main Roads

8.5.2.3 Project Plan

The plan for this initiative is to monitor the developments on re-use opportunities for fly-ash from other research institutes in Australia and around world especially in Europe where recycle rates are high. On the assumption that a number of possible opportunities will become available with time, it will be necessary to then further investigate the opportunities most suitable for the Gladstone region. Transportation costs to the nearest large market of south-east Queensland would be an important factor in this evaluation process. By the time there are sufficient opportunities to conduct the evaluation process (within 3 to 5 years), there should a much better understanding of the regulatory, liability and administrative requirements for implementing industrial synergies.

The proposed plan is:

- October 2005 – Prepare update on related technical developments of fly ash and bottom ash re-use and produce plan for future research work.

The proposed reinstatement of the Gladstone ash committee should assist in the identification of alternative uses for both bottom ash and fly ash.

8.5.3 *Emissions Initiative*

8.5.3.1 Objective and overview

The objective of this initiative is to investigate in the longer term the possible methods for reducing sulphur dioxide and carbon dioxide to the Gladstone air shed.

Currently there are about 47,000 tonnes of sulphur dioxide and about 16,000,000 tonnes of carbon dioxide emitted to the atmosphere annually. These figures include the expected emissions from the Comalco Alumina Refinery. Although all industries are within their current licence limits undoubtedly in the future there will be greater demands on the major industries to reduce their emissions, especially as more new industries become established in the Gladstone region. Added to this is the expected extra burden of reducing carbon dioxide emissions or purchasing carbon credits. Such changes may not occur in the immediate short-term but initiatives to counter these almost certain tightening of emission limits must began now so that measures are in place when the changes become legislation.

8.5.3.2 Benefits

Based on current limits, there is no apparent business case, for instance in NPV or ROI terms, to commence projects that would reduce sulphur dioxide or carbon dioxide limits. Two important factors that are very difficult if not impossible to incorporate into a standard financial analysis but could lead to justifying a case for

reducing these gaseous emissions are environmental impacts (including future environmental legislation) and community perception.

There are possible methods for reducing gases that also provide an additional benefit to the regions apart from the lower concentration in the air shed:

- In flue gas desulphurisation (FDG), the mixing of limestone and water with flue gases from coal combustion produces a slurry that absorbs the sulphur dioxide, which is then oxidised to produce calcium sulphate or gypsum. This synthetic gypsum could be a replacement for some of the 75,000 tonnes per annum of gypsum that is currently being used by Cement Australia. Assuming a 90% recovery, the 29,000 tonnes of sulphur dioxide emitted annually from the power station could be converted to over 40,000 tonnes of gypsum. Over the next five years, consumption of FGD gypsum will rise at a faster rate than most other forms of gypsum (www.roskill.com/reports/gypsum 2004) so there could be a wider market for this by-product. The other by-product that can be generated from FGD is sulphuric acid. In addition if there is sufficient market demand for gypsum or sulphuric acid, it would then possible with FGD to burn cheaper high sulphur coal to increase production of the by-product.
- Research is currently being conducted by Alcoa on the sequestering of carbon dioxide with “red mud” (residue carbonation) as a means of neutralisation (Cooling et al. 2002). Although this is still in the trial phase, if full-scale operation proves successful it could be an ideal solution for the Gladstone region. The mineral carbonation of the red mud should be an efficient manner to lock away carbon dioxide so that no further treatment is required (www.gc3.cqu.edu.au 2002).

8.5.3.3 Project Plan

The plan for this initiative is to continue to monitor developments in the methodologies for reducing sulphur dioxide and carbon dioxide emissions and environmental regulations that may ultimately affect levels of emissions of these gases. The proposed plan is:

- October 2005 – Prepare update on related technical developments of gaseous emission capture and re-use.
- April 2006 – Prepare report on opportunities for emissions capture and re-use within the expected operating constraints up to 2011.

9. CONCLUSIONS

The Gladstone region shows significant potential to take advantage of industrial synergy opportunities. To implement industrial synergies there must be a number of perceived benefits ranging from improved utilisation of by-products that will reduce the consumption of raw materials, to better community relations through the minimisation and disposal of wastes. Whatever benefits can be achieved through industrial synergies, it is important that industries can justify any new synergy in terms of a sound business case. The business case must demonstrate either financial benefits or risk management advantages. A simple financial analysis may be based on company IRR or NPV criteria. Alternatively, the business case may be justified by the identification of a significant reduction in the company's risk profile, for instance through reducing the risk of environmental damage or community outrage. In particular, improvements such as reducing emissions have the potential to allay community concerns about environmental issues and improve community relations.

Based on the analysis conducted in this project, the key potential synergy opportunities in the short term are:

- Consolidation of waste for alternative fuel;
- Water efficiency synergies;

The other potential short-term synergy opportunities are the use of ammonium nitrate solution as fertiliser, biomass as an alternative fuel source and a central crushing facility for construction fill.

In the longer term, initiatives will investigate the opportunities for the utilisation of large waste streams red mud, fly ash and gaseous emissions, carbon dioxide and sulphur dioxide.

10. FUTURE DIRECTION

As the project enters its second year, the aim is to continue to develop the path forward for the key synergy opportunities in conjunction with the industries and organisations, such as councils and EPA. To achieve this, the project will continue to facilitate the implementation of the short-term synergy opportunities whilst monitoring the technological developments related to waste and by-product re-use for long-term synergies.

One research aspect of interest in the facilitation of the short-term synergies is the business case for marginal projects. For most of the identified short-term synergies (for instance the effluent re-use schemes), the next step in implementing these opportunities would be a straightforward engineering design – that is, no further technical research is necessary. What is of interest is the justification process for a potential synergy, such as an effluent re-use scheme, especially if the project does not satisfy the standard company return-on-investment criteria. For the effluent re-use synergies, the business case would revolve around the risk or chance of water restrictions and the implications on production if water restrictions were imposed. That is, there would be no return-on-investment for an effluent re-use strategy if there were never any future restrictions on Awoonga Dam water; conversely, if water restrictions were imposed it is likely the return-on-investments would be extremely substantial given the potential loss in production. Documenting, interpreting and identifying the various companies' decision-making process associated with a risk-versus-reward project, such as effluent re-use, could provide a greater understanding of the true business case for new projects involving synergies.

For the longer-term synergies, it will be imperative to keep abreast of technological developments and regulatory and legislative changes that could produce sufficient financial incentive for implementing these synergies. Advances in technology or changes in regulations could turn a by-product from a hazardous waste or an emission into a feed that produces a valuable product. All of the major waste streams in the Gladstone area, red mud, fly ash and gaseous emission such as carbon dioxide and sulphur dioxide, could feasibly be one of the feed constituents to producing a valuable product. However, at present the business cases for re-using these by-products with known technology are not sufficient to stop current disposal practices. As with the successful commercialisation of most new technologies, some degree of risk must be negotiated if a paradigm shift is to occur in the management of large volume wastes or by-products.

11. ACKNOWLEDGEMENTS

This research report is the first outcome of the research project entitled Developing Local Synergies in the Gladstone Industrial Area, commissioned by the Centre for Sustainable Resource Processing to The University of Queensland (through its Centre for Social Responsibility in Mining). The authors wish to acknowledge the contributions of industry representatives from the GAIN Environment and Waste Committee and the GAIN Executive Committee to the formulation of this project, in particular the past chairperson, Mr George Bennetts (NRG), and the current chairperson, Mr David Smirk (Comalco), of the GAIN Environment committee. In addition, the authors also wish to acknowledge the contributions of other members of the research team, in particular Prof Rene van Berkel (Curtin University of Technology) and Prof David Brereton, Prof Don McKee and Mr Robin Evans (The University of Queensland), as well as Prof Warren Thorpe (Central Queensland University) for providing a base at the Process Engineering and Light Metals Centre for the main researcher, Dr Glen Corder, when in Gladstone.

12. GLOSSARY

aluminium dross	by-product from casting operation; essentially comprising metal and oxidised metal
aluminium prills	type of dross which includes a recyclable proportion of aluminium
anode	carbon block made from petroleum coke, liquid pitch and recycled anodes weighing between 940 kg to 1200 kg used in aluminium smelting process
anode effects	when the level of the dissolved aluminium oxide in the aluminium reduction cell drops too low and the electrolytic bath itself begins to undergo electrolysis.
bottom ash	coarse particles by-product from the coal-fired power stations that forms at the bottom of the boiler
burn-off butts	remainder of carbon anode
caustic soda	Sodium hydroxide
fabric filters	filter bags that trap flue gas dust and particulates
fly ash	fine particles by-product from the coal-fired power stations
kiln grade spar	end product from the COMTOR™ plant which processes spent cell linings
met coke dust	coke by-product from anode production less than < 1mm
met coke fines	coke by-product from anode production between 1mm and 5mm
oil shale	shale containing hydrocarbons that yield petroleum by distillation
red mud	bauxite residue
saltcake	by-product in process of recovering aluminium from aluminium dross
spent cell linings	by-product from aluminium reduction cell reconstruction process.

13. REFERENCES

- Anon. (2001a). "By-Products Mapping Study." Gladstone Area Promotion and Development Limited.
- Anon. (2001b). "Sustainability Report for Gladstone Region - 2001." Gladstone Area Promotion and Development Limited.
- Anon. (2003). "Comalco Gladstone Sustainable Development Report."
- Anon. (2004a). "The Gladstone Region Project Status Report (September 2004)." Gladstone Area Promotion and Development Limited.
- Anon. (2004b). "Using Alternative Fuels and Materials in Cement Production - Spent Cell Lining Trial." Cement Australia.
- Birleson, N. (2004). "Personal Communication."
- Clark, S. (2005). "Personal Communication."
- Cooling, D. J., Hay, P. S., and Guilfoyle, L. "Carbonation of Bauxite Residue." *2002 Alumina Quality Workshop*, Brisbane.
- Cowan, J. (2005). "Personal Communication."
- Doak, S. "Gladstone - A City Steeped in Industrial Effluence!" *Regional Water and Technology Forum*.
- Doak, S. "Gladstone's Water Crisis." *Local Government Association of Queensland (LGAQ) Waste and Water Conference*, Brisbane.
- ecoaccess. (2004). "Determinations for the management of regulated wastes." Queensland Government, Environmental Protection Agency.
- GAWB. (2004). "Securing the Gladstone Region's Future: Water." Gladstone Area Water Board.
- Grant-Taylor, T. (2005). "Coal prices steaming ahead." *The Courier Mail*, Brisbane.
- KBR. (2004). "Water and Wastewater Planning Studies - 2030 (Wastewater Final Report)." Kellogg Brown and Root Pty Ltd.
- Murrell, C. (2005). "Personal Communication."
- Pagan, R. J., Praad, P., Diniz da Costa, J. C., and van Berkel, R. "Cleaner Production Applications for Coal Utilisation." *National Environment Conference*, Brisbane.
- Peters, M. S., Timmerhaus, K. D., and West, R. E. (2003). *Plant Design and Economics for Chemical Engineers*, Mc Graw Hill, New York.
- Russell, M. (2005). "Personal Communication."
- Schwarer, M. (2005). "Private Communication."
- Stegink, H. D. J., Lane, J., Barker, D. J., and Pei, B. "Water Usage Reductions at Queensland Alumina." *Water in Mining Conference*, Brisbane, Australia, 293-299.
- www.abs.com.au. (2001). "Australian Bureau of Statistics."
- www.cemaust.com.au. (2004). "Cement Australia Web Site."
- www.chemsal.com.au/file/lamps.pdf. (2004). "Recycling of Fluorescent Tubes & HID Lamps."
- www.gc3.cqu.edu.au. (2002). "Mineral Carbonation: Sequestering CO₂ the way nature intended."
- www.gc3.cqu.edu.au/burn-coal-cleanly/index2.php. (2004). "Gladstone Centre for Clean Coal."
- www.holcim.com. (2004). "Holcim Home Page."
- www.orer.gov.au. (2001). "Guideline for Determining the Renewable Components in Waste for Electricity Generation."
- www.orica.com.au. (2004). "Production Expansion at Yarwun Ammonium Nitrate Plant."

www.qal.com.au. (2004). "QAL Home Page."

www.riotinto.com. (2003). "Future Targets."

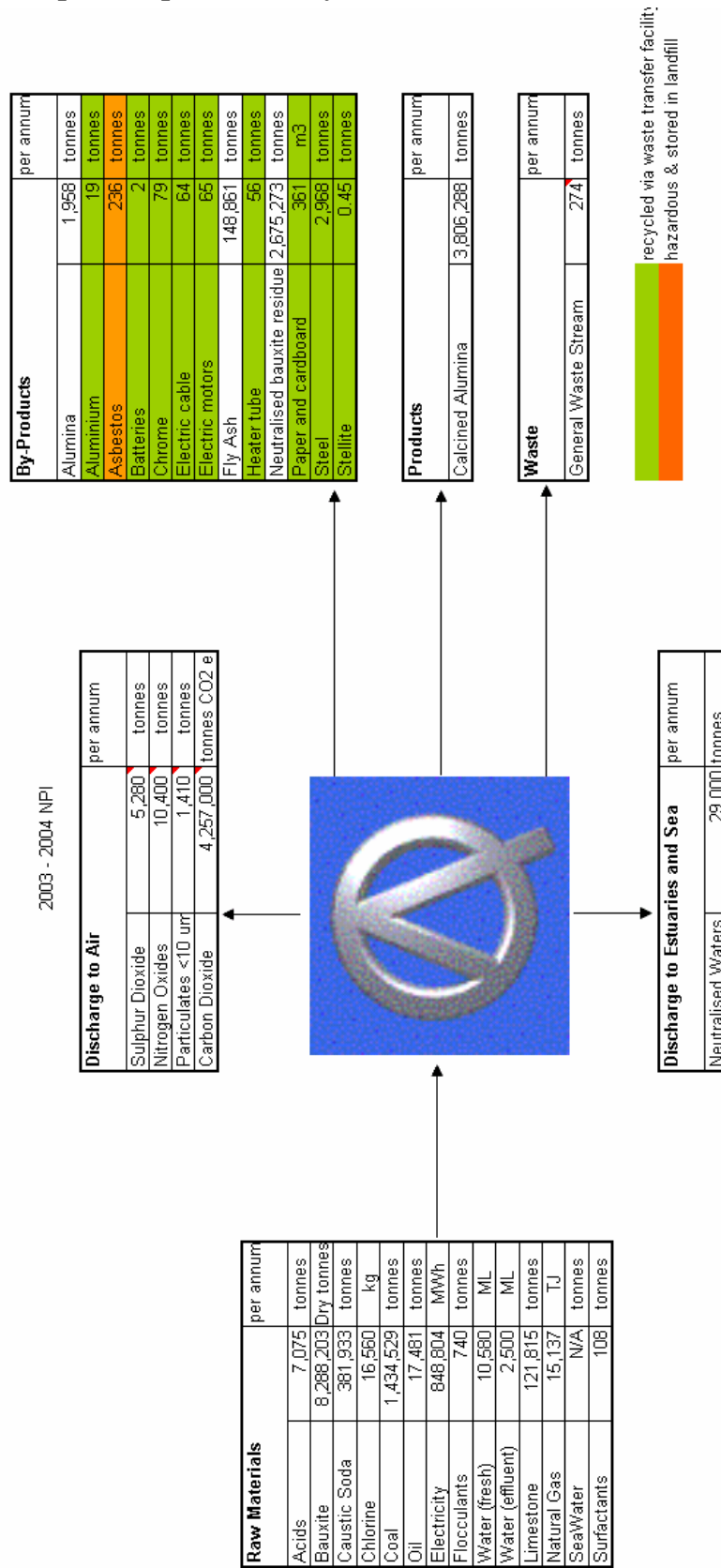
www.roskill.com/reports/gypsum. (2004). "Sharp rise in synthetic gypsum consumption."

www.wbcd.org/DocRoot/11BetslPkgEie83rTa0J/cement-action-plan.pdf. "The cement sustainability initiative."

14. APPENDIX

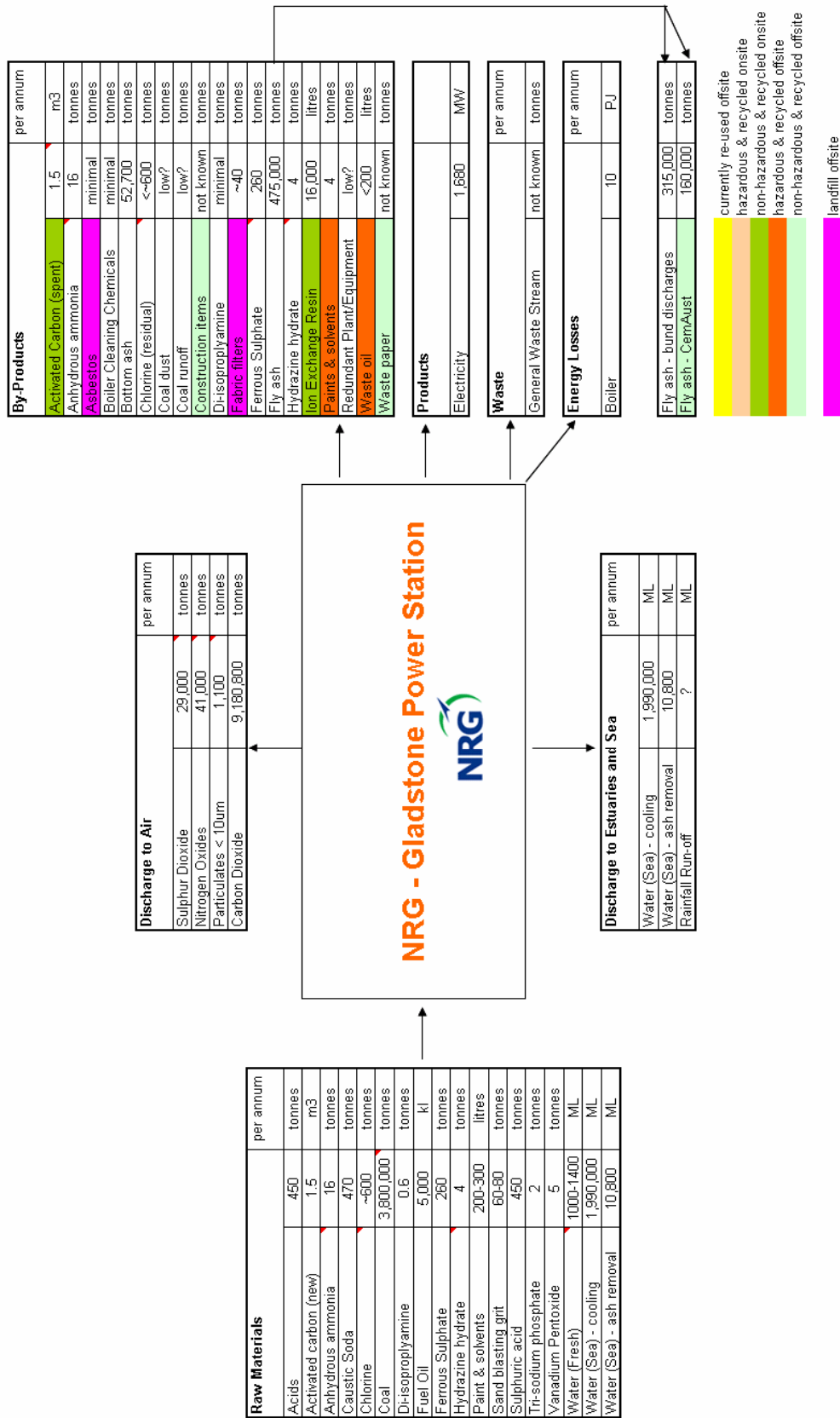
14.1 QAL Input-Output Summary

Annual Rate of Inputs/Outputs - QAL



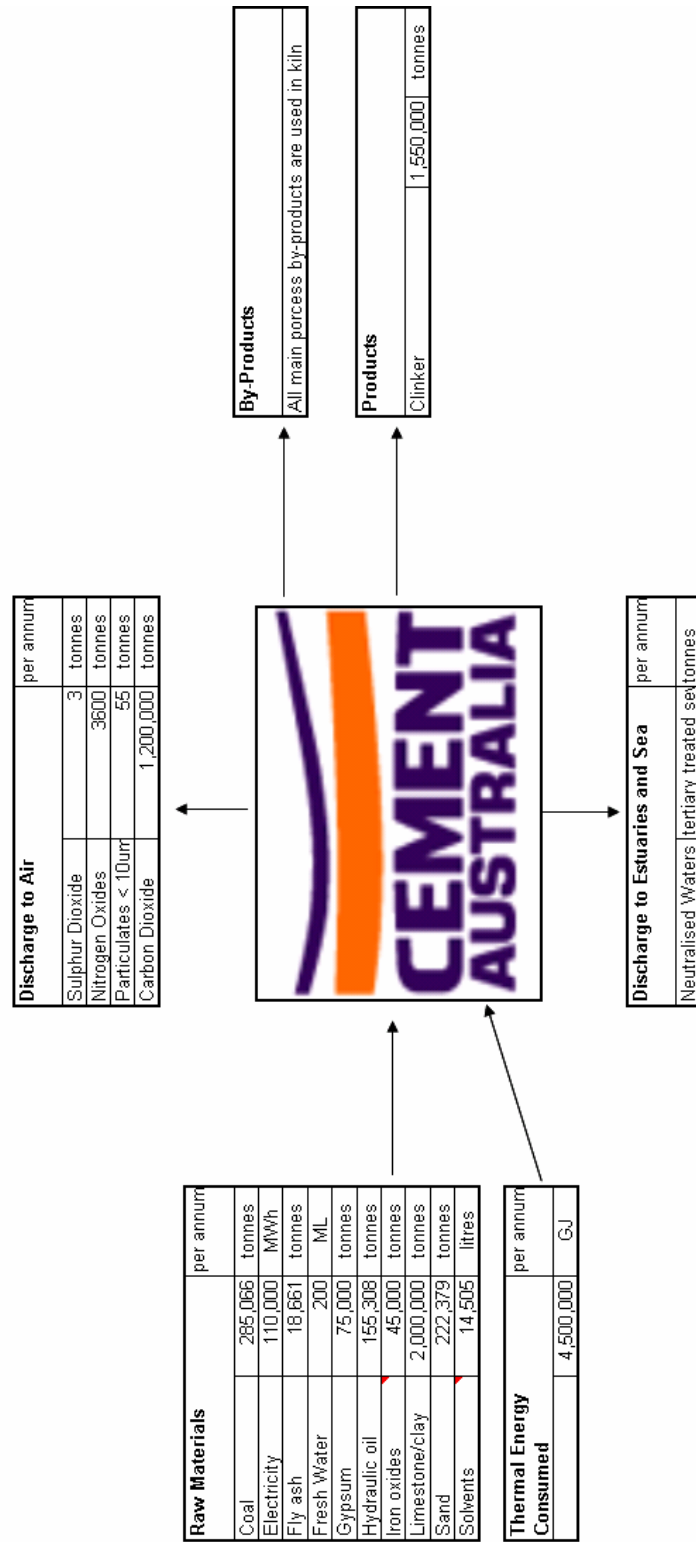
14.2 NRG Input-Output Summary

Annual Rate of Inputs/Outputs - NRG Gladstone Power Station



14.3 Cement Australia Input-Output Summary

Annual Rate of Inputs/Outputs - Cement Australia



Raw Materials	per annum
Coal	285,066 tonnes
Electricity	110,000 MWh
Fly ash	18,661 tonnes
Fresh Water	200 ML
Gypsum	75,000 tonnes
Hydraulic oil	155,308 tonnes
Iron oxides	45,000 tonnes
Limestone/clay	2,000,000 tonnes
Sand	222,379 tonnes
Solvents	14,505 litres

Thermal Energy Consumed	per annum
	4,500,000 GJ

Discharge to Air	per annum
Sulphur Dioxide	3 tonnes
Nitrogen Oxides	3600 tonnes
Particulates < 10µm	55 tonnes
Carbon Dioxide	1,200,000 tonnes

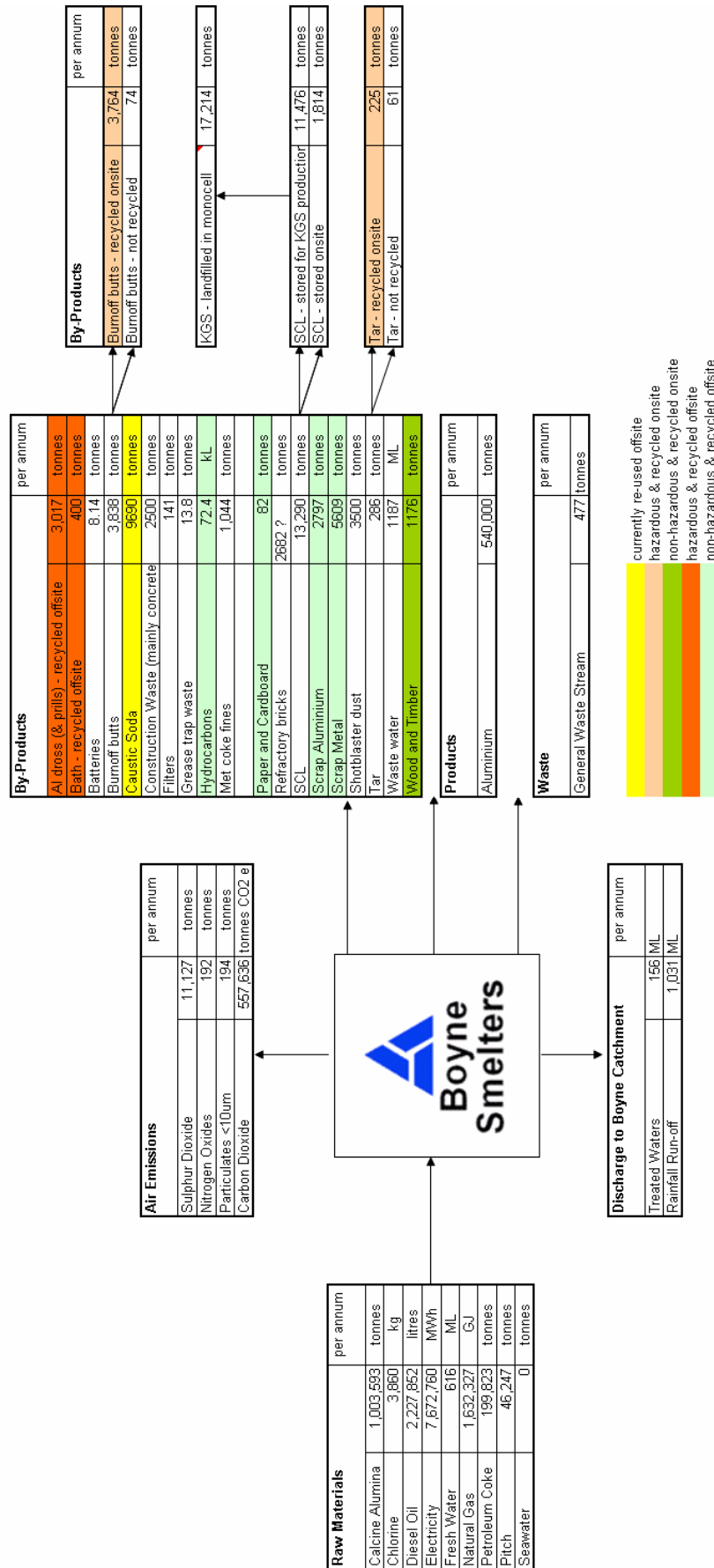
Discharge to Estuaries and Sea	per annum
Neutralised Waters	tertiary treated sea tonnes

By-Products
All main process by-products are used in kiln

Products	
Clinker	1,550,000 tonnes

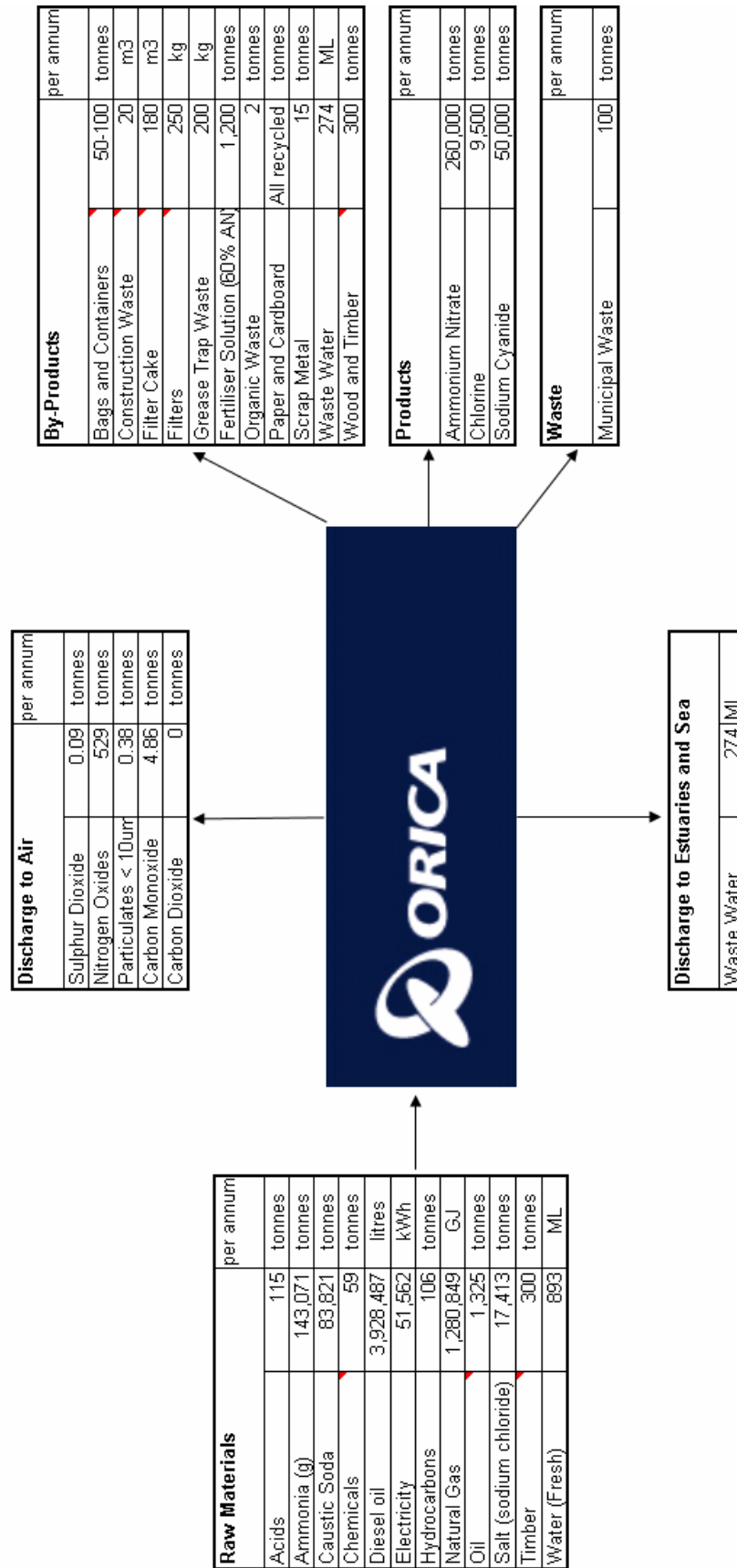
14.4 BSL Input-Output Summary

Annual Rate of Inputs/Outputs - Boyne Smelter Limited



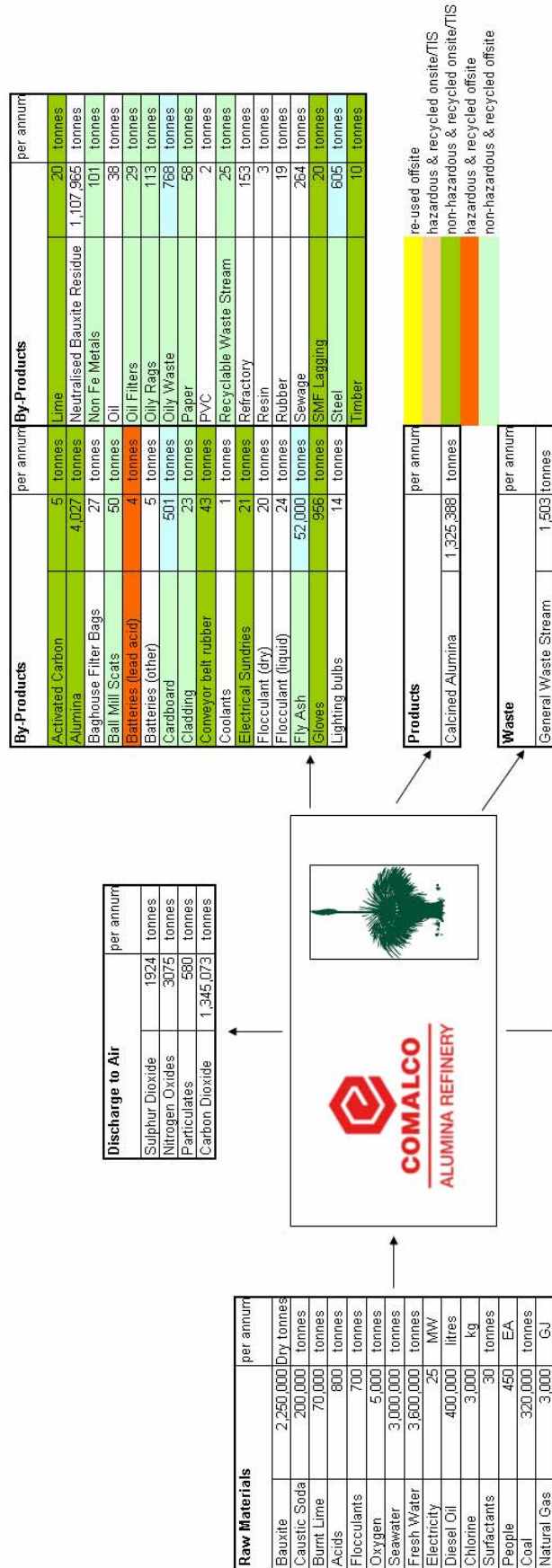
14.5 Orica Input-Output Summary

Annual Rate of Inputs/Outputs - Orica Chemicals



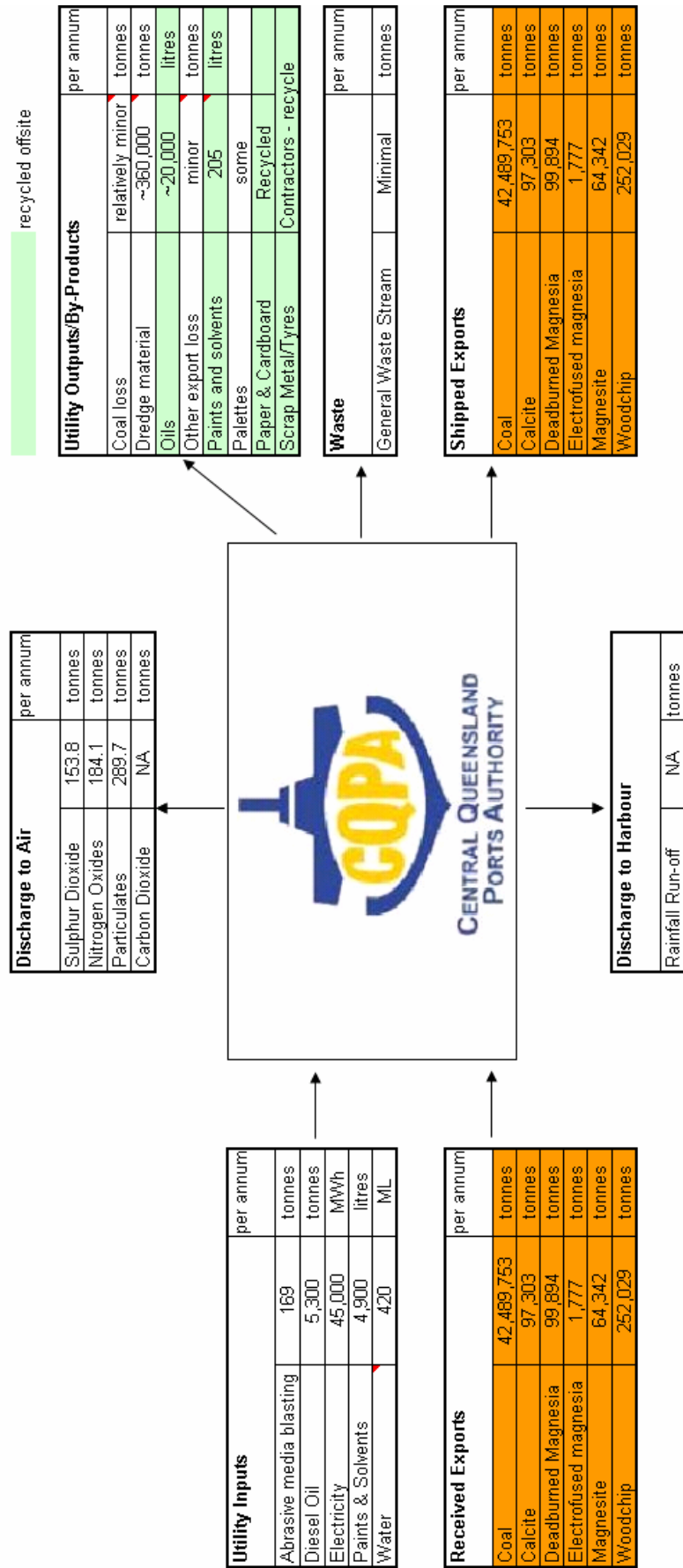
14.6 CAR Input-Output Summary

Annual Rate of Inputs/Outputs - Comalco Alumina Refinery



14.7 CQPA Input-Output Summary

Annual Rate of Inputs/Outputs for CQPA



Export from GPA handled cargos for 2003/2004 financial year data on web site